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A Planning-Decision Model for Surplus Commodity Removal Programs

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The prototype model developed in this paper is a deterministic simulation system, used to develop alternative commodity purchase plans and to show their differential impacts in terms of costs, tradeoffs, and benefits. The model incorporates systems of demand parameters to account for economic interdependence among commodities, alternative decision criteria to reflect different emphasis on program objectives, and various constraints to account for program operating restrictions and requirements. The operation of the model is illustrated by a hypothetical example based on Section 32 purchases for the School Lunch Program. The empirical results are reasonably realistic and provide ample evidence to demonstrate the model's usefulness and versatility.

Keywords: Decision model, Food, Model, Policies, Programs, Purchases, Simulation.

One aspect of the administrative decision process inherent in certain authorized Government programs is the planning phase. This paper describes a prototype model that can be used as an aid in that aspect of the decision process for a particular program, namely, surplus commodity removal under Section 32 of the *Agricultural Adjustment Act of 1935*, as amended.

It is useful to characterize the administrative decision process as generally consisting of three major parts. The first part is usually termed the planning phase of the decision process. It consists of selecting a given plan or course of action from the set of feasible alternatives. A feasible alternative plan is one which meets the imposed restrictions of the problem and satisfies the objectives to a greater or lesser extent. A major aspect of this part of the process is usually directly concerned with, or related to, budget allocation. The second part of the process concerns implementation of the selected plan, while the third part deals with assessment and evaluation of the actual impacts of the selected course of action. This suggested ordering appears to be a logical sequence, and while the parts are not independent, it seems reasonable to separate them for purposes of analysis and modeling. The present exposition focuses only on the first part, dealing with the plan-selection phase of the planning-decision process.

In any given program the authorizing legislation usually specifies or implies one or more *goals* or *objectives* that are to be attained by the program. These goals or objectives may be independent or interdependent and they may be complementary or competitive. To achieve the specified goals, provision is made for certain *instruments*, which are the variables subject to control by the administrative agency. Control of these variables is most often achieved through funds provided by a *budget*. More often than not, the task is complicated further by the imposition of certain limitations on how the objectives can be attained or conditions that must be satisfied in fulfilling the objectives. These conditions are called *restrictions* or *constraints*. The final element of the plan-selection process concerns the possible *impacts* of a given plan. These consist of both quantitative and qualitative effects. The former include most economic effects while the latter include political effects.

The Specific Problem—Section 32

Section 32 of the Agricultural Adjustment Act of 1935, as amended, provides authorization and funds for the Department of Agriculture to encourage export and domestic consumption of agricultural products for the purpose of contributing to market price stabilization, through actual market entry or announcements that the Department stands ready to enter the market (*5*, pp. 17,18).

Funds are appropriated annually by the Congress. The amount available for use under Section 32 is equal to 30 percent of customs receipts collected during the preceding calendar year, plus unused balances of up to \$300 million. Funds actually obligated and expended on commodities depend on the market situation, volume of surpluses, and availability of potential outlets.

The original legislation and subsequent amendments give authorization and responsibility to the Secretary and the Department of Agriculture for the various programs and activities. Responsibility for carrying out the programs and coordinating the various activities has been delegated to USDA's Agricultural Marketing Service (AMS) and its Administrator.

It seems reasonable to presume that the intent of the original legislation was primarily to provide some means of support for those commodity subsectors that were economically depressed and without adequate alternative means of support. And it seems reasonable to infer that inherent in the legislation was the presumption that the specified market-oriented activities would enhance the prices and incomes of commodity producers. Thus, we may say that one of the major implied objectives of the program was to enhance producer prices and income for those commodity sectors determined to be economically depressed.

Since the inception of Section 32, certain specifications and restrictions have evolved. For example, the principal use of funds has been restricted to perishable, nonbasic commodities which do not have in operation a price support program. The major restriction on expenditures is that no more than 25 percent of total available funds may be used for any one commodity.

Also, as Section 32 programs have evolved over time, they have been operated in conjunction with various food distribution programs so that surpluses removed from the market are donated to schools, institutions, and needy persons. Responsibility for the various food distribution programs is delegated to the Food and Nutrition Service (FNS) of the Department. Section 32 funds are being used (1) in partial support for child nutrition programs authorized by the School Lunch Act and the Child Nutrition Act, (2) for financial assistance to enable certain low income counties to operate food distribution programs, and (3) for a food certificate program and special supplementary food packages for expectant mothers, new mothers, and infants (*5*, p. 18).

In terms of the original legislation and its implied objectives, the food distribution activities may be viewed as providing a means for "encouraging domestic consumption of agricultural products." In this light the numerous conditions which must be satisfied can be viewed as restrictions or constraints which have to be met in conjunction with surplus removal through commodity purchases. For example, these constraints include specifications on minimum quantities necessary for national distribution, product form, container size, and nutritional level.

Given the implied objectives, the number of varied activities with their implied constraints, and the number of potential commodities that may be eligible, it becomes evident that operation and coordination of such a program constitute a complex decision process. That is, given these conditions, a decision must be made regarding (1) those commodities eligible for support out of the potential set of commodities, (2) the amount to be spent on each commodity, and (3) the timing of purchases with respect to season, the location of purchase with respect to region, and so on. Add to this the economic interdependence between commodities, so that purchase of any given commodity may affect the prices of many other commodities, and the necessity for a systematic framework to facilitate this decision process is readily apparent.

Development of a Prototype Model

Two important sets of factors must be considered in developing a model to aid in the decision process described above. For expository convenience we might call the first economic considerations and the second administrative considerations.

The two most important economic factors are economic interdependence and the nature of the market mechanism. Theoretically, economic interdependence exists to a greater or lesser extent among the prices of all goods in an economy. Thus, relationships may exist among prices of specific commodities under Section 32, between Section 32 commodities and other commodities, and between various levels in the market from farm to retail. At any given level the interrelations among various commodity prices can be taken into account by a complete set or matrix of demand parameters which show the quantitative relation between commodity prices and quantities. Conceptually, a set of these parameters exists at each level in the system and a relationship between each level and the next is implied. For Section 32 activities this is important because purchases are generally made at several stages removed from the farm level, whereas a major objective relates to benefits accruing at or near the farm level.

Assumptions regarding the nature of the market mechanism are important in designing a prototype model from both the economic and the administrative viewpoint. The administrative issue is one of what the appropriate planning horizon is, while the economic issue is one of specifying the behavioral assumptions most appropriate for the selected period. In this study the planning period was specified to be a year, largely because major planning and budget allocation decisions are made on an annual basis. In conjuction with this, it was assumed that total quantities available for market were given for the period and not subject to change in response to prices or other economic determinants. Thus, it is assumed that quantities are given and the price mechanism makes the necessary adjustments to allocate the fixed quantities among alternative outlets or uses. Consequently, there is implied a complete system of inverse demand functions which express each price as a function of all of the given quantities and income. Thus, from a theoretical viewpoint, the interdependence among the various commodities and prices can be correctly represented by a complete matrix of price flexibilities.[1]

An additional assumption regarding economic behavior in the market is that the existing demand for commodities is independent of Government program activities. Essentially, this says that Government purchase activity largely operates outside the regular market channels, and therefore has a negligible effect on existing demand. While this assumption is consistent with the wording and intent of the legislation, its reality is an open question.

A final economic consideration is the calculation of benefits, or the impact of the various purchases. This includes deciding which beneficial impacts are to be considered, and at what level in the system. Indeed, it raises the more basic question of what constitutes a benefit. In the present study a pragmatic approach was adopted which does not purport to give a definitive answer to this fundamental question. The approach is based primarily on the implied program objective of enhancing price or income to the commodity subsectors. Briefly, given the particular purchase strategy specifying commodities and expenditures, an attempt is made to calculate a measure of dollar benefit and impute an allocation by geographic region and farm income class.

A list of administrative considerations having some relevance in the operation of programs such as Section 32 could probably be extended indefinitely. As in the present study, the delineation can be narrowed substantially by selection of the specified annual time period and by focusing on the plan-selection part of the planning-decision process, as opposed to implementation and evaluation. The list includes the program decisions and constraints mentioned previously, in addition to the following important considerations.

A major consideration is the selection of a decision rule or criterion that can be used as a basis for developing alternative plans among which a choice can be made. A necessary condition in selecting such a rule is that it be directly related to the objective or goal to be achieved. When more than one objective exists, either explicitly or by implication, the selection of a single rule is open to choice. This is the situation in the present problem. That is, it is not clear whether major emphasis should be focused on relative commodity price levels or on returns to producers. Thus, in developing a pilot model two alternative criteria were used. The first focuses on the price level, relating the expected commodity price to a "normal" price, based on a historic moving average of the price of that commodity. The second focuses on the returns to the producer and selects among eligible commodities on the basis of a "farmer's share" concept.

One of the most important considerations in developing a model to aid in this type of administrative decision process is the recognition that a formal model cannot capture all relevant aspects of the decision process. The factors are too numerous, and many of them are either qualitative or lack precise definition, so that they cannot be formally introduced in a model. Such factors would include possible conflict with other programs, agencies, or administrative policies, in addition to adverse political repercussions.

The existence of these factors has important implications for developing a formal system to aid in the decision process. For example, their existence argues strongly against the use of a strict optimizing framework since it purports to come up with a single plan which is "best," even though many factors have not been taken into account. Rather than a framework that attempts to select a single optimum plan, one needs a framework which will generate alternative plans and indicate the tradeoff between them. Selection among these alternatives can then be made in view of the qualitative and other factors not formally included in the model.

A Two-Stage Model

The two-stage model is an annual, deterministic, simulation model which attempts to capture in a mathematical framework the essential quantitative aspects of the planning-decision process undertaken each year by AMS regarding surplus commodity removal under Section 32.[2] It provides a systematic means for developing and evaluating the probable effects of alternative purchase strategies which take into account the program objectives, constraints, and economic considerations. The system is called a two-stage model because it treats the decision process in two sequential stages. A flow chart depicting the basic logic of the model is presented in figure 1.

To facilitate understanding of the model we will first present a brief overview describing what it does and subsequently turn to a more detailed discussion of its structure.

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[1]Following Houck (2), flexibilities are defined as the elements of the inverse of the matrix of demand elasticities.

[2]For a discussion of simulation techniques and definitions, see (4).

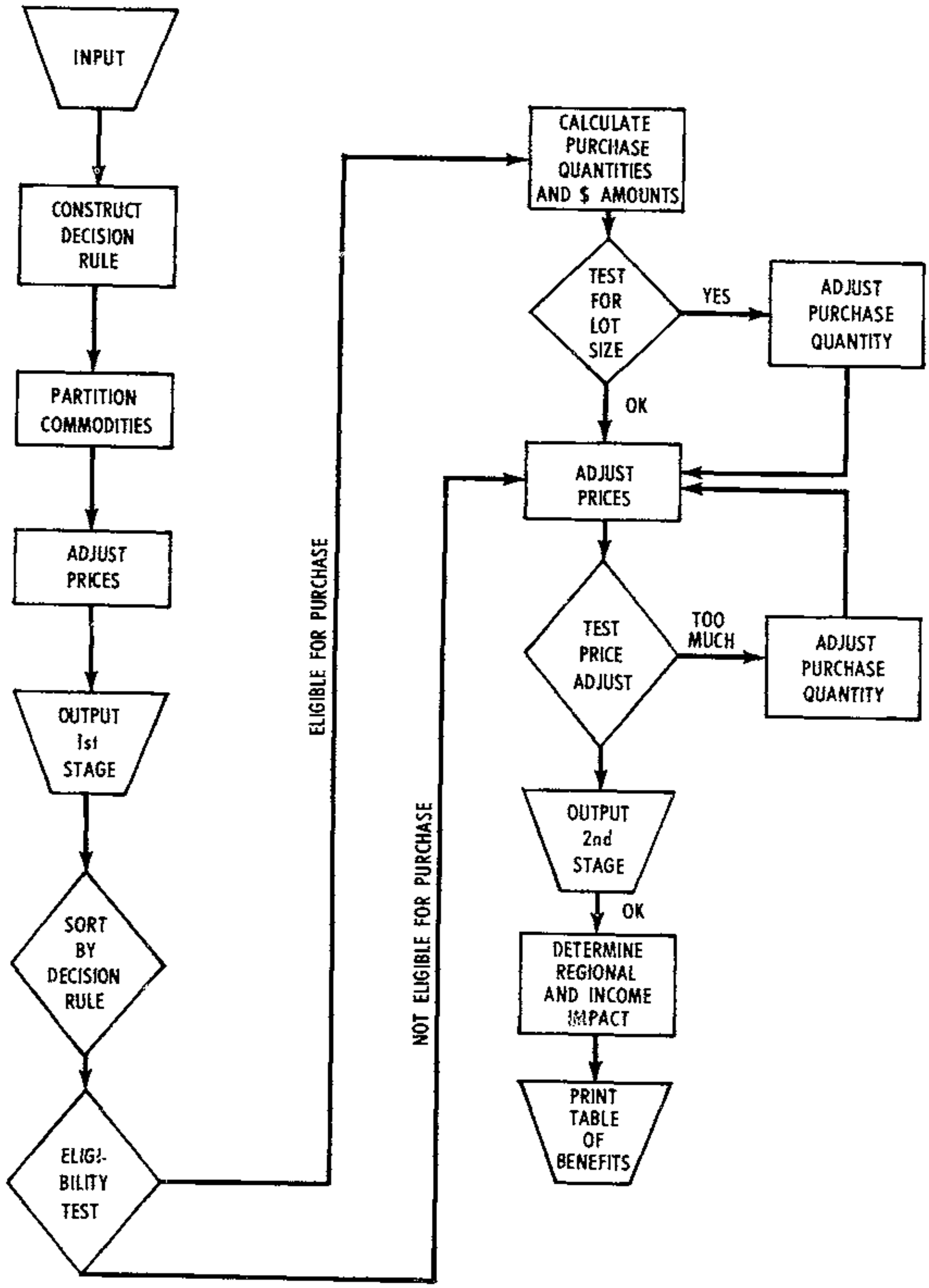

Figure 1. Flowchart of the model.

The set of potentially eligible commodities, the various constraints, and the basic criterion or decision rule for allocating funds to the purchase of specific commodities, are determined outside the model.

Given these specifications, the first stage of the model considers those minimum purchases necessary to meet nutritional and other requirements specified by FNS for the food distribution programs supported by Section 32 funds. These requirements are specified as minimum quantities for groups of similar commodities. For example, a group might be canned vegetables and include corn, peas, green beans, and others. The first operation allocates these minimum group quantities to individual commodity purchases via the specified decision rule used to rank commodities. No fund- or price-oriented constraints are effective in the first stage. Next, all prices at the farm and wholesale levels are adjusted for the effect of purchases of these individual commodities, and the output for the first stage is printed.

In the second stage the commodity group classifications are eliminated and the individual commodities are ranked by the specified values in the decision rule. Given this ranking, purchase eligibility for a given commodity is determined by comparing the adjusted forecast farm price (from the first stage) with the average price. The amount of total funds that can be spent on each eligible commodity and the amount (tons) of each to be purchased are then calculated. Effective constraints at this point are: (1) total funds cannot be exceeded, (2) no more than 25 percent of total funds can be spent on any one commodity, and (3) specified maximum quantities which can be used in food distribution programs cannot be exceeded. A lot-size requirement, effective only for fruits and vegetables, is also checked at this point. It specifies that enough of the given commodity must be purchased to permit national distribution.

Farm prices are then adjusted for the effects of the second-stage purchases and these adjusted prices are again compared with the average farm price. If the ratio of adjusted farm price to average farm price exceeds the specified value, the purchase quantity is reduced until this condition is satisfied. The resulting quantities are then used to adjust all wholesale prices which in turn are used to examine the funds-oriented constraints.

Given the quantities and adjusted prices which satisfy all the constraints, a dollar benefit is calculated and imputed to geographic regions and to farm income classes.

Components of the Model

The set of commodities. As mentioned previously, the set of eligible commodities is prescribed by the authorizing legislation, past experience of AMS, and considerations related to the food distribution programs. The authorizing legislation sets the broad limits, in that funds are to be used principally for perishable, nonbasic commodities which are not price supported. Past purchase history and knowledge about the spectrum of commodities serves to further narrow the list of commodities. Considerations with respect to the food distribution programs have more of an effect on product specifications than the general set of farm commodities per se. Although it is possible, say, through the lot-size restriction, to preclude a minor commodity, the major effect of these considerations is to expand the number of commodities specified at the purchase level over the number of farm level commodities. For example, the farm level commodity might be beef, while at the purchase level there may be alternative product forms such as fresh beef, frozen beef, and canned beef, and each may come in several container sizes.

The objectives. In developing a decision model, the program objectives play a crucial role in determining the criterion on which decisions are made. For example, in the early stages of the present study a linear programming model was developed in which the main objective was to maximize gross returns at the farm level. Thus, the so-called "objective function" which is maximized has a "gross per unit farm return" concept for each commodity as the criterion for choosing among commodities.

In the present simulation model an objective function is not required for maximization purposes, but similar criteria are needed for ranking or weighting as a basis for selecting among commodities in such a way as to enhance the major objectives of the purchase activities. These criteria are referred to as "decision rules." Since the legislation did not specify whether the objective was stabilization and enhancement of farm price or enhancement of farm income, the model was developed using each alternative. These two alternatives are referred to as rule 1 and rule 2.

Rule 1 relates to the price objective, and rule 2 to the income objective. Rule 1 is closely related to the price eligibility criterion discussed in the following section and is treated more fully there. For each commodity an estimate of the farm share of each dollar spent is used as a basis for ranking under rule 2.

Price eligibility. This concept plays an important role in the model. Its introduction in the model rests on the implied program objectives of price stabilization and enhancement and their relationship to surplus removal. The presumption is that a direct relationship exists between a surplus condition for a commodity and the degree to which its price is depressed. The extent to which a given price is depressed is determined by comparing the forecast farm price to a moving average price for that commodity, where the length of the moving average varies from 3 to 5 years depending on the commodity. Specifically, the relationship in the model is:

$$(1)\ PDUD = (PN_i \cdot PFACT) - FP_i$$

where

$PDUD$ = test value

PN_i = moving average farm price for commodity i

$PFACT$ = factor which is used to specify the proportion farm price should be of average price

FP_i = forecast farm price for commodity i.

If the primary objective of surplus commodity removal is specified to be price stabilization and enhancement, then a relationship similar to (1) can be used to determine the weights for the primary decision rule used to rank commodities. In this case, commodities with the most depressed price would be given a higher priority for purchase. The formulation which incorporates this specification is rule 1.

Irrespective of the objective specified, however, the price eligibility relation (1) enters the model as a constraint to which all discretionary purchases (stage 2) are subjected. That is, a commodity is eligible for purchase if *PDUD* is greater than zero, which says that the forecast farm price is less than a specified proportion of its average price in some historic period. On the other hand, if *PDUD* is less than zero, the commodity is not eligible for purchase.

This procedure has some intuitive appeal from the administrative decisionmaker's point of view. First, it relates decisions to actual behavior of a commodity sector. Second, it permits introduction of knowledge the decisionmaker may have about the commodity sector. For example, *PFACT* can be changed in cognizance of long-term price changes that reflect shifts in relative commodity price positions. Later we consider an example in which $PFACT = 1.1$, permitting prices to be greater than their average. If desired, *PFACT* could be defined in terms of parity.

Price adjustments. Incorporation of price adjustments is a central feature of the model in the sense that it constitutes the focal point for capturing the important economic considerations, especially the economic interdependence between commodities and between market levels. The link between market levels is important for the determination of farm price adjustments and of price adjustments at the marketing stage at which commodities are purchased with Section 32 funds. The latter is relevant in the determination of total expenditures which cannot exceed budgeted outlays.

The dependence between commodities is taken into account through the use of a complete matrix of direct and cross price flexibilities for Section 32 commodities. This matrix was derived from a larger matrix of retail demand elasticities developed by George and King (*1*). The specific matrix was derived from the larger matrix by aggregating the elasticity parameters for commodities not explicitly considered in Section 32, using a procedure that maintained the four restrictions on the original set of parameters. The collapsed matrix of elasticities was subsequently inverted to obtain the matrix of direct and cross flexibilities at the retail level. This procedure is adequate as long as the original matrix contains all of the specific commodities of interest. If not, as in the present case, the parameters for the additional commodities must be obtained by some alternative procedure. In developing the present prototype model, a rather arbitrary ad hoc procedure was used in which the missing commodities were assigned magnitudes for flexibilities identical to those for closely similar commodities.

To obtain a conceptually consistent set of parameters at the farm level showing the cross-commodity interdependence, the concept of elasticity of price transmission (*3*, p. 111, and *1*, p. 61) was employed to construct a farm level matrix of price flexibilities from the retail flexibility matrix. The elasticity of price transmission is defined as the ratio of the relative change in retail price to the relative change in farm price. It does not require the assumption of constant percent or constant dollar margins. The relationship of flexibilities is:

$$(2)\ F_{ij} = RF_{ij}(1/N_j)$$

where

F_{ij} = farm level flexibility between the ith price and the jth quantity

RF_{ij} = retail level flexibility between the ith price and the jth quantity

N_j = elasticity of price transmission for the jth commodity.

For the purposes of developing the prototype model it was assumed that the elasticity of price transmission was unity between retail and the level at which purchases are usually made. Thus, the retail price flexibilities are assumed to be applicable at the wholesale or purchase level.

Price adjustments are made in both the first and second stages of the model. These adjustments take account of the effect a given commodity purchase has on the price of that commodity and on all other Section 32 commodities. Specifically, for the wholesale or purchase price adjustment, the relationship is:

$$(3)\ APW_i = PW_i\ (1 + \sum_{j=1}^{n} F_{ij}q_j \cdot C_j/Q_j)$$

where

APW_i = adjusted wholesale price of commodity i
PW_i = wholesale price of commodity i
q_j = farm level of commodity j purchased
C_j = conversion factor from processed to farm weight
Q_j = total quantity of commodity j available for market
F_{ij} = price flexibility between the ith price and the jth quantity
n = number of commodities.

The relationship for price adjustments at the farm level is essentially the same.

Operation of restrictions and constraints. Because of the sequential nature of the model, a certain ordering of constraints exists and some restrictions are only operative in one stage.

The minimum commodity group requirements might be termed mandatory purchases in the sense that AMS must purchase these minimums regardless of the price. These group requirements are partitioned to individual commodities based on weights assigned to commodities by the specification of a given decision rule. Maximum restrictions apply to individual commodities. When the maximum purchase for a given commodity has been reached in the first stage allocation, but the group minimum has not been met, purchase is shifted to the commodity with the next highest rank according to the decision rule used. This continues until the group requirement is met.

Second-stage purchases might be termed discretionary purchases in the sense that there is more latitude of choice between specific commodities and the respective quantities. However, as a result, more considerations become effective as constraints. The focal point of the second stage is the determination of which discretionary commodities to purchase and the level of expenditure on each. This is accomplished through the use of the two funds-oriented constraints and in some cases the lot-size constraint. The first funds constraint restricts total expenditure to be less than or equal to total available funds, while the second states that expenditure on any one commodity cannot exceed 25 percent of total funds. If an individual commodity has a lot-size requirement it is checked at this point and the purchase is adjusted to meet it. Price adjustments are made at this juncture and another constraint is introduced which says that the adjusted farm price cannot exceed a given proportion of the average farm price. Should this restriction be violated, the purchase quantity is reduced by 10 percent and a new adjusted price is calculated. This iterative procedure continues until the adjusted farm price is less than or equal to the specified average price factor, and then the lot-size requirement is checked again.

Calculation and allocation of benefits. Benefits are calculated after a purchase plan has been formulated which conforms to the various constraints and objectives. Given a purchase plan, two measures of dollar benefits are calculated. One measure, called the price impact, is the product of the quantity of a commodity remaining on the market times the price change for that commodity, summed over all commodities. This total calculated benefit is then allocated by both geographic region and farm income class, based on an imputation procedure which uses census data on commodity distribution by region and income classification. Another measure, called return to producers, is based on the estimates of the farmer's share. It is calculated as the product of the farmer's share times the total expenditure for each commodity, summed over all commodities.

Data requirements. Since the data requirements for the model are quite extensive, it may be useful to summarize them at this point. Data requirements are essentially of two types: that which is commodity specific and that which is not. The former category contains the bulk of the data requirements as indicated in the following list:

1. Commodity name and description
2. Forecast farm price
3. Moving average farm price
4. Wholesale price
5. Total quantity available
6. Processed-to-farm-weight conversion factor
7. Farmer's share

8. Lot-size constraint

9. Maximum quantity constraint

10. Percent distribution of sales by region and income class

11. Direct and cross flexibilities at farm and purchase level.

The second category contains the following:

1. Specification of commodity groups

2. Specification of *minimum* quantities for commodity groups

3. Total funds available

4. Specification of values to be used in the decision rule for ranking purposes.

Also, an additional fund variable has been added for use if the model is being run for only a subset of the purchase program, such as the School Lunch Program.

Example of Results

To demonstrate the use of the model, a hypothetical problem was developed around the requirements of Section 32 commodity purchases for the School Lunch Program. Several variations of this problem were executed to illustrate the effect of different decision rules and constraints and also to illustrate the usefulness and flexibility of the model as an aid in the planning-decision process.

It is recognized in this example that the decision model deals explicitly only with one set of objectives of the School Lunch Program, namely that of encouraging the domestic consumption of nutritious agricultural commodities. The broader concerns for safeguarding the health and well-being of the Nation's children could be incorporated into an expanded model, but the complexities of the additional constraints precluded handling the complete matrix of decisions facing this program in one example.

The problem example is formulated for 12 commodities which have been purchased in past years for the School Lunch Program. Data were obtained from the Section 32 program budget for fiscal year (FY) 1972 and from information supplied by individual commodity analysts. The total Section 32 funds for commodity procurement in FY 1972 were approximately $300 million. Of this, about $90 million was allocated to the School Lunch Program. Specified minimum commodity group requirements (in tons) were 18,750 for dry beans, 34,450 for red meat, 17,500 for turkey, and 13,150 for canned fruits and vegetables. These minimum requirements for the 12 commodities appear in table 1 as mandatory purchases in the first stage.

Alternative Specifications

Given the above program specifications, several alternative specifications of the model were employed. In each case two alternatives were used for the major decision rule. They are designated rule 1 and rule 2 in table 1.

Rule 1 employs a ratio of forecast farm price to a moving average price (called "normal price") as a basis for assigning relative weights to commodities for ranking purposes. This criterion is used to reflect the program objective of supporting commodities for which a surplus is indicated by depressed prices. The ratio (DP_i) is defined as

$$(4)\quad DP_i = (PN_i \cdot PFACT)/FP_i$$

where the variables on the right side are as defined in equation (1).

Rule 2 employs a computed value of farmer's share for each commodity as a basis for ranking. This measure was selected to reflect the program objective of enhancing farm income through the purchase of surplus commodities by assigning a higher ranking to those commodities for which the producer received a higher proportion of each dollar spent.

For each of these decision rules, three alternative runs of the model were made in which specific constraints were altered. The first run (RUN 1) had the price eligibility constraint (*PFACT*) set at 1.0, which specified that a commodity's price could not exceed its average or "normal" price. The second run (RUN 2) set the value of *PFACT* = 1.1, permitting a commodity to be eligible for purchase as long as its price did not exceed its average price by 10 percent or more. In the third run (RUN 3) a minimum purchase was specified for potatoes, to demonstrate the effects of specifying the purchase of a commodity that did not enter the solution initially. The value of *PFACT* is kept at 1.1 as in RUN 2.

The following discussion of the numerical results of the three different runs focuses, in turn, on (1) a comparison of the purchase plans and effects of the two alternative primary decision rules, (2) the effect of changes in level of the price eligibility constraint, and (3) the tradeoffs that result from imposing the purchase of a given commodity which was not initially selected for purchase. For each case, the discussion centers on two major effects, namely those for commodity mix and those relating to expenditure impacts or benefits.

Table 1. Two-stage model results for alternative specifications based on School Lunch Program

Item	RUN 1				RUN 2				RUN 3			
	Rule 1		Rule 2		Rule 1		Rule 2		Rule 1		Rule 2	
	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage	1st stage	2nd stage
	Tons	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*	*Tons*
Beef	–	–	34,450	–	–	–	34,450	–	–	–	34,450	–
Pork	34,450	–	–	–	34,450	–	–	11,611	34,450	–	–	8,014
Turkey	17,500	–	17,500	–	17,500	–	17,500	7,500	17,500	–	17,500	7,500
Chicken	–	–	–	–	–	–	–	–	–	–	–	–
Eggs	–	4,000	–	4,000	–	4,000	–	4,000	–	4,000	–	4,000
Peas	–	–	–	–	–	8,857	–	–	–	7,972	–	–
Potatoes	–	–	–	–	–	–	–	–	10,000	–	10,000	–
Dry beans	18,750	–	18,750	–	18,750	–	18,750	–	18,750	–	18,750	–
Pears	–	–	13,150	–	–	10,000	13,150	–	–	2,500	13,150	–
Peaches	–	15,000	–	15,000	–	15,000	–	–	–	15,000	–	–
Apples	13,150	2,500	–	15,000	13,150	2,500	–	–	13,150	2,500	–	–
Tomatoes	–	15,000	–	–	–	15,000	–	–	–	15,000	–	–
	Mil. dol.		*Mil. dol.*		*Mil. dol.*		*Mil. dol.*		*Mil. dol.*		*Mil. dol.*	
Price impact	213.92		151.16		232.16		206.28		232.77		193.80	
Return to producers	33.92		44.23		35.85		50.44		35.74		49.61	
Funds expended	79.48		85.91		88.44		90.06		87.87		90.04	
Benefit-cost ratios:												
Price[1]	2.70		1.76		2.63		2.29		2.65		2.15	
Return[2]	.43		.52		.41		.56		.41		.55	

[1]Ratio of dollar price impact to dollar expenditure.
[2]Ratio of imputed direct returns to producers to total expenditure.

Alternative Decision Criteria: RUN 1

The major effects of using the different decision rules can be seen by examining RUN 1 in table 1 and comparing the results for rule 1 with rule 2.

Commodity mix. In examining the commodity mix under the two rules it is useful to note the effects in both first- and second-stage purchases. For RUN 1, first-stage purchases differ with respect to the allocation within the red meat group and within the canned fruit and vegetable group. In the red meat group under rule 1, which ranks commodities by the extent to which each commodity's price is depressed, the minimum is satisfied by purchasing pork, because its price is low relative to beef. Under rule 2, which ranks commodities by farmer's share, the minimum is filled by purchasing beef, because of its higher farmer's share. For the same reason, under rule 1 apples are purchased, whereas pears are used to satisfy the minimum under rule 2.

With respect to the second-stage discretionary purchases in RUN 1, the commodity mix differs only in the canned fruit and vegetable group. Under rule 1, tomatoes are purchased because of a relatively low price, whereas under rule 2 they are not purchased because they have the lowest farmer's share. Also, an additional 2,500 tons of apples are purchased in the second stage under rule 1 because apples have the most depressed price. This results in the purchase of 650 tons more apples than under rule 2.

Commodity price effects. The proportion of total

Table 2. Price changes for RUN 1

Commodity	Rule 1			Rule 2		
	Quantity removed	Farm level	Retail level	Quantity removed	Farm level	Retail level
	Percent	*Percent*	*Percent*	*Percent*	*Percent*	*Percent*
Beef	0.00	.408	.247	.33	.880	.575
Pork	.59	2.606	1.529	0.00	.224	.151
Turkey	2.06	2.020	1.517	2.06	1.892	1.450
Chicken	0.00	.711	.455	0.00	.459	.324
Eggs	.07	.441	.313	.07	.414	.294
Peas	0.00	.913	.840	0.00	.356	.268
Potatoes	0.00	.002	.026	0.00	.019	.021
Dry beans	.99	4.789	4.393	.99	4.464	4.062
Pears	0.00	−.029	−.015	2.45	5.100	3.224
Peaches	.84	1.714	1.087	.84	1.741	1.101
Apples	.65	1.326	.841	.62	1.293	.818
Tomatoes	.46	3.541	3.680	0.00	.902	.764

quantity removed in RUN 1 and the resulting price changes for each commodity under the two decision rules are shown in table 2. The relative price changes represent the effects of purchases on the initial forecast price for each commodity. These price effects are generated by the price adjustment mechanism discussed earlier which utilizes a matrix of direct and cross price flexibilities. As pointed out there, a procedure which maintains the original restrictions on the parameters is used for aggregating commodities that are not of specific interest. But where specific commodities of interest are not contained explicitly in the original matrix, a somewhat arbitrary, ad hoc procedure was used to obtain flexibilities for the prototype model. Specifically, in the present example, canned pears and apples were assigned values for direct price flexibilities identical to those for canned peaches because the former were not explicitly contained in the original matrix. One difficulty in this procedure is the omission of the cross effects among these three commodities.

Perhaps the most important fact to note is that, irrespective of the decision criteria used, the prices of all commodities are affected whether a commodity is purchased or not. Recognizing the questionable realism of some of the flexibilities, the implications of this interdependence can be illustrated by the results for specific commodities. For example, under rule 1 no pears are purchased, but the effect of other purchases is to decrease the price of pears. In this case the decreased price is a direct result of the purchase of pork. Pork has a positive cross flexibility with pears that is larger than the total effect of other cross flexibilities that are negative. Viewed another way, the tradeoff, or part of the "price" one pays for buying pork, is the reduction in the price of pears.

Another example, which has the contrary effect, is worth noting. The initial forecast price of chicken was approximately 60 percent greater than the "normal" price. Further, under the two rules meat and poultry purchases differ only with respect to pork and beef, the former being purchased under rule 1 and the latter under rule 2. Yet the price of chicken is increased in each case even though no chicken is purchased. However, the effect on the price of chicken is about 50 percent greater under rule 1 than under rule 2. Also, under rule 1 the effect on the price of beef when no beef is purchased is an increase of 0.408 percent, while under rule 2 where beef is purchased, the effect on pork price is an increase of 0.224 percent. Thus, in terms of tradeoffs, one might say that part of the "price" one pays for buying pork or beef is the increase in the price of chicken, the tradeoff being about 40 percent greater for pork than for beef. Moreover, this example shows that if one wants to decrease the impact of purchases with respect to increased prices, rule 2 is a better decision criterion than rule 1.

Overall impacts. The two different decision rules with their corresponding purchase plans lead to some important differences in overall impacts. At the bottom of table 1, three measures of dollar impact are presented. The price impact measure is the product of the change in farm price resulting from purchases, times the total supply of the commodity left on the market, summed over all commodities. Funds expended are the product of quantity purchased times the initial price plus one-half of the price change resulting from purchases, summed over *all* commodities. Imputed returns to producers are calculated by multiplying total expenditure for each commodity by its respective farmer's share and summing over commodities.

Under rule 2, funds expended were about $6.4 million higher than under rule 1, primarily as a result of purchasing beef. The price impact of this larger expenditure under rule 2 is about 30 percent less than that for rule 1, but the imputed returns to producers under rule 2 are about 30 percent larger. Under both decision rules all eligible commodities were purchased without exhausting the total available funds.

As a summary measure for comparison among the various alternatives, the ratio of the dollar price impact to the dollar expenditure might be used as a benefit-cost measure. Another measure is the ratio of imputed direct returns to producers to total expenditure. These ratios appear at the bottom of table 1.

Still another way of looking at the tradeoff is to compute the relative change in impact for a 1 percent change in expenditure as we change from rule 1 to rule 2. For example, in RUN 1, on the average, a 1 percent increase in expenditure in switching from rule 1 to rule 2 results in a 4.4 percent decrease in the dollar price impact and a 3.4 percent increase in the imputed direct returns to producers. Similar comparisons can be made to determine the tradeoff between the purchase plans for a given rule under the different specifications of each RUN.

Distribution of price impact. Program administrators often need some assessment of the relative impact program planning decisions may have on different groups. For illustrative purposes, the dollar price impact generated by the model for each commodity was used in conjunction with distribution data from the 1964 Census of Agriculture to impute a distribution of the price impact by geographic region and farm income class for each of the decision rules in RUN 1. The proportion of the dollar impact is imputed to six geographic regions and five income classes (table 3).

A basic assumption underlying this allocation procedure is that the designated commodities are homogeneous with respect to region and income class. Obviously this is more valid for commodities such as turkey than it is for peaches, since the latter includes more than one variety, each of which may be specific to a given region.

Table 3. Distribution of price impact by region and income class for RUN 1

Item	Rule 1	Rule 2
	Percent	*Percent*
Region:[1]		
West North Central	39.50	31.09
East North Central	23.67	13.77
West	14.75	27.77
South Central	11.28	17.29
South Atlantic	7.61	6.11
Northeast	3.18	3.98
Income Class:		
$40,000 and over	44.71	66.22
$20,000 to $39,999	22.32	15.99
$10,000 to $19,999	18.55	9.73
$5,000 to $9,999	9.50	4.82
0 to $4,999	4.93	3.25

[1]Regions are defined as follows: (1) Minnesota, Iowa, Missouri, North Dakota, South Dakota, Nebraska, Kansas; (2) Ohio, Indiana, Illinois, Michigan, Wisconsin; (3) Montana, Idaho, Wyoming, Colorado, New Mexico, Arizona, Utah, Nevada, Washington, Oregon, California, Alaska, Hawaii; (4) Kentucky, Tennessee. Alabama, Mississippi, Arkansas, Louisiana, Oklahoma, Texas; (5) Delaware, Maryland, Virginia, West Virginia, North Carolina, South Carolina, Georgia, Florida; and (6) New England, New York, New Jersey, Pennsylvania.

Although the distribution data on commodities by region and income class are crude, it is nevertheless instructive to examine the implications of this allocation, since it does provide a reasonably meaningful indication of the distribution of the effects of alternative planning decisions. For example, the figures demonstrate the regional shift in benefits that occur when red meat purchases are switched from beef under rule 2 to pork under rule 1. The percentage allocation of benefits declines in the South Central and West regions, which together account for 47 percent of beef production but only 10 percent of pork production. These alternative purchase strategies also affect the distribution among income classes. The purchase plan under rule 2 skews the distribution of benefits toward the highest income class, whereas the plan under rule 1 distributes benefits more evenly. And, under either alternative, more than 40 percent of the benefit is allocated to the highest income category.

Changes in Price Eligibility: RUN 2

RUN 1 specified PFACT of equation (1) to be equal to unity, which essentially states that a commodity is not eligible for purchase if its price is equal to or greater than its normal price. RUN 2 sets *PFACT* = 1.1, making the price eligibility constraint effective at 10 percent above a commodity's normal price.

Commodity mix. Obviously, first-stage purchases remain the same under both decision rules when the price eligibility constraint is increased. Second-stage purchases, however, are altered in that additional commodities are purchased under both decision rules.

Under rule 1 an additional 8,857 tons of peas and 10,000 tons of pears are purchased. Canned peas were eligible for purchase in RUN 1, but purchase of the minimum lot-size forced the price above normal, and the next most eligible commodity, tomatoes, was purchased. In RUN 2, the model continues to purchase tomatoes and then proceeds to purchase pears, which is the next ranked commodity.

Under rule 2, the commodity mix is altered more drastically in that funds are shifted away from canned fruits and vegetables in favor of red meat and poultry. The second-stage purchases of canned peaches and apples in RUN 1 are dropped in favor of an additional purchase of turkey and pork. For red meat, the first-stage purchase is filled with beef as in RUN 1, because of its higher farmer's share. This purchase forces beef price considerably above the eligibility constraint, precluding additional purchase in stage two. The next ranked commodity is pork, but because its forecast price was slightly above the normal price it was not purchased in RUN 1. However, increasing the price eligibility constraint leads to the purchase of 11,611 tons. Similarly, the increase in price eligibility leads to an additional purchase of turkey.

Overall impact. Comparison of the dollar impact measures for RUN 1 and RUN 2 reveals an increase in each measure, the price impact being rather substantial for rule 2, which also expends the total funds available. Under rule 1 both benefit-cost ratios decline from RUN 1 to RUN 2, while both increase under rule 2. Again, these ratios provide an indication of the tradeoff between the various rules and constraints which can then be used as a basis for program purchase decisions.

Changing Required Purchases: RUN 3

RUN 3 is formulated to illustrate how the model can be used to evaluate the effect of imposing a requirement that a given commodity, which does not appear in the initial plan, be purchased. *PFACT* is set equal to 1.1 for comparison with RUN 2, and a minimum potato purchase of 10,000 tons is imposed for stage one.

Commodity mix. Except for the imposed purchase, first-stage purchases are unchanged. In the second stage, the commodity mix remains unchanged from RUN 2 for either decision rule, but the quantity purchased of some commodities is reduced. Under rule 1 the quantity of peas purchased decreased slightly and the quantity of pears purchased decreased substantially. Under rule 2, the only change was a reduction in the quantity of pork scheduled for purchase. Thus, the effect of the imposed potato purchase was to substitute potatoes for pears and peas under rule 1 and pork under rule 2.

Overall impact. Changes in the magnitudes of the overall impact measures were mostly negligible. The largest change occurred under rule 2, where the price impact decreased by $12 million, but the effect on the corresponding benefit-cost ratio was small. Thus the major effect of the imposed potato purchase was to substitute potatoes for other commodities and under rule 2, to reduce the price impact of a given expenditure.

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