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DYNAMIC MODELS FOR STABILIZING FOOD PRICES

Harold G. Halcrow and Takashi Takayama

Multiyear dynamic spatial models of the U.S. grain, oilseed, and livestock (GOL) economy show how to stabilize prices in this part of the world food economy. The standard GOL model can be operated at modest cost, well within the limits of previous price support and storage programmes operated by the U.S. government. Appropriate application of the model and its derivatives will stabilize the U.S. GOL economy within a relatively narrow price band, and this will help to stabilize prices in other trading countries as well.

Identifying the Problem

The task to be performed by the model was established in this study by identifying the causes and extent of instability inherent in the U.S. GOL economy. The test assumed that from 1976 to 1980 the market would clear at the end of each year with no reserve stocks. The export demand was fixed and perfectly inelastic. Then, eight alternative yield scenarios were selected, each with a unique yield sequence for wheat, maize, and soybeans. These produced yearly model solutions that proved to be infeasible in 1979 and 1980 in the sense that the next year's planted acreage corresponding to the scenario price was negative, or production was not enough to cover the total demand of the United States and the rest of the world.

The instability was attributed to the basic supply-demand structure of the U.S. GOL economy operating under the assumption that the markets must clear at the end of each year. The fact that this assumption does not hold in the real world permits the GOL economy to function. But, since all scenarios became infeasible under this assumption, the findings emphasized that the GOL economy has a tendency to be highly unstable if there is no government reserve stock programme.

Multiyear Stabilizing Programmes

Use of specific forward looking price bands and stocking operations, treated as a primal and dual relationship, transform the structurally unstable U.S. GOL economy into one that is structurally stable, providing that the government of the United States employs a sequence price and reserve stock plan of operations over time consistent with the known dynamics of the GOL economy. An optimum price band width can be established; and there is a least cost, price stabilization, reserve operations policy that can be designed. This proves to be a multiyear spatially coordinated program with specified beginning and ending inventories and designated price band limits.

Simultaneous stocking operations and market prices were developed for 1976 to 1980 for each of the eight alternative yield scenarios. One of the eight is presented as an example, comparing price fluctuations within each of three arbitrarily selected price bands. Price band A is the widest, allowing maximum price fluctuations above and below a price trend line, of \$65 per metric tonne (mt) for wheat, \$55/mt for maize, and \$110/mt for soybeans. Price band B is narrower, allowing maximum price fluctuations above and below the trend line of \$35/mt for wheat, \$15/mt for maize, and \$25/mt for soybeans. This is equivalent to about \$.94/bu for wheat, \$.375/bu for maize, and \$1.34/bu for soybeans. Price band B also includes a trend increase in each price, as consistent with an assumed increase in demand relative to supply. Price band C has no width, allowing no deviation in price above or below the established trend line.

Following the establishment of these price bands, stocking or reserve

operations consistent with each price band were generated for each year by solving a single period, one commodity model within the floor and ceiling price constraints. If the floor price is hit in the solution, its dual withdrawal quantities will be generated in the solution algorithm and will appear in the solution simultaneously. If the ceiling price is hit, then the dual injection quantities will appear in the solution.

Price Band A

Most stock operations under price band A tended to become undesirably large (and some were not feasible). As the required withdrawals and injections escalated, stock operations became incapable of containing prices within the band. In the first four of the eight scenarios, a good maize crop in 1977 suppressed its supply price to the minimum level of \$69/mt, and 5.2 million metric tonnes (mmt) of maize were withdrawn from the market to maintain the minimum market price. This low maize price sharply decreased the acreage for maize, and, at the same time, sharply increased the acreage for soybeans. As a result, the price of maize rose to the maximum level, and an injection was required. This was followed by a withdrawal in 1979 and another injection in 1980.

Soybean operations were correlated with maize. The increased soybean production in 1978 decreased its price to the minimum level and required a withdrawal of 8.5 mmt. Because of this low price, soybean acreage decreased by about 10.7 million acres in 1979 and maize increased almost the same amount. The stock withdrawal in 1978 was followed by an injection of 11.5 mmt in 1979, and a withdrawal of 9.2 mmt in 1980. Wheat was also subject to the withdrawal-injection operation.

In the fifth and sixth scenarios, the withdrawal of maize started in 1978, followed by an injection in 1979, and a withdrawal in 1980. The quantity of withdrawal in 1980 was 45.7 mmt. The seventh and eighth scenarios resulted in a withdrawal of 32.3 mmt in 1979, and an injection of 28.6 mmt in 1980.

Several difficulties were encountered in operating the programmes: (1) in 1979, if scenarios 7 and 8 are realized, the United States cannot meet the quantity of maize to be injected into the market, even though all the carryover stock of maize existing at that time is depleted; (2) the sum of withdrawals and injections is the largest of the three alternative price bands; (3) quantities of withdrawals and injections are larger in the later years than in the earlier years of the projection period, which suggests that there is a tendency for the models to explode; and (4) the soybean sector is exposed to violent year to year fluctuations of prices, production, and consumption.

Price Band B

Stock operations under price band B were more manageable in magnitude, and generally feasible. When price band B is implemented, a withdrawal or an injection is required almost every year for each scenario. Important differences in the operational characteristics of price bands A and B are the following: (1) price band B requires withdrawal-injection operations more often than price band A—in the 5 years, price band B required such operations 79 times, while price band A used them 66 times; (2) the sum of withdrawals and injections in the eight scenario is the smallest among the three price bands, however; (3) quantities of withdrawals and injections required by price band B are more evenly distributed among years than those of price band A; (4) unlike price band A, there are no shortages of stocks of any commodity in any year to meet required injections, and price band B mitigates fluctuations of price and production in the soybean sector rather substantially.

Price Band C

In price band C, a withdrawal or an injection is required every year for each commodity. Prices are completely stabilized, though moving upward along a trend. In terms of quantities of withdrawals and injections, however, this narrowest price band does not produce the highest degree of stability. The sum of withdrawals and injections is not as small as in price band B. In fact, for wheat and maize alone, the sum is close to that of price band A. The price of soybeans is almost completely stabilized, however, which indicates that price stability for a given commodity is possible, providing certain conditions are met.

Alternative Model Costs and Optimality

The price stabilization reserve stock programme has shown that the GOL economy can be stabilized, even though it is structurally unstable without such a policy. The policy alternatives are very large in number and variety, however, and it is important to know whether there is a least cost programme that will provide the desired degree of stability. The exercises with the three alternative price bands show that price band B, which has the intermediate width, resulted in the smallest quantity of withdrawals and injections. This result implies that an optimal price band stocking operation can be found, with optimality defined as the operation that entails the minimum quantities handled by the withdrawal and injection operations of the government. This can be pursued much further, of course, to search for still more optimal results.

The carryover stock operations in the United States must be large enough and timely enough to achieve the desired results. In the case of price band B, the maximum carryover quantities are about 34 mmt for wheat, 51 mmt for maize, and 20 mmt for soybeans. In comparison with historical data, these quantities are well within the capacity of the U.S. GOL economy, but the results generated by the model scenarios indicate clearly that a policy oriented deliberate government program is required. Although private storage firms may be motivated to increase their stocks when there is a drop in price, it is doubtful that they will voluntarily inject their stocks into the market before prices rise above program levels. Owing to this asymmetric tendency, some form of government participation in this operation is necessary to achieve the degree of price stability that is consistent with export goals of the United States, and the desires for price stability as generally expressed by producers and consumers in the United States and the rest of the world.

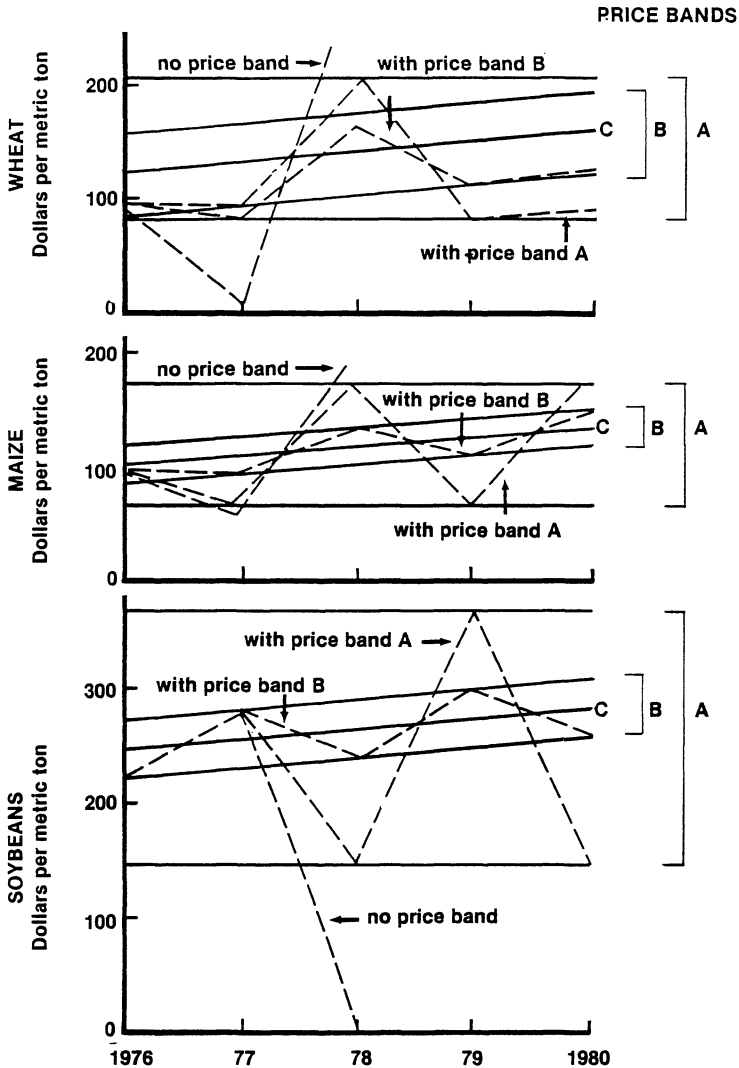
Costs and Benefits of Stabilization Policy

An additional set of models, which allows for some elasticity in export demand, reduces the magnitude but not necessarily the frequency of stock operations required to stabilize prices within a given price band. This would tend to reduce the total costs of the reserve stock programme. Yearly increases and decreases in export demand are an important destabilizing factor in domestic markets, however. If the reserve stock programme is designed to offset these to a significant degree, the required magnitude of the programme would be at least as large as suggested above.

The benefits of an effective stabilization policy can be measured in terms of the ability of the United States to maintain a consistently high level of agricultural exports in poor as well as good crop years, meeting an appropriate share of the import demand of the rest of the world. The argument for government financed reserves is based on the goals of farm and food price stability, a stable export capacity with some potential to meet unusually large export demands, and considerations of national security. From the mid-1950s to the mid-1960s, the grain stocks carried in the United States were generally

adequate for these purposes.

Although some studies have linked low grain prices from the mid-1950s to the late 1960s with large stocks in storage, this study suggests that under an alternate model without such storage, the average grain prices might have been even lower. From 1961 through 1972, grain sales were augmented by the reduction in government held stocks. Prices were not necessarily depressed by holding stocks, but by their release, especially in good crop years, and by insufficient withdrawals of stocks from the market in years of large crops.



Alternative price bands and prices for wheat, maize, and soybeans under a specified multi-year reserve-stock model.

Conclusion

The results of the current study are compatible with the idea that the magnitude of stocks in a government financed grain reserve and the rules for their management must be related to the policy goals that are established. Reserve stocks provide a means of softening the effects of periodic fluctuations in grain supplies by leveling off the peaks of surplus production and filling in the troughs of short crops or large export demands. Limited stocks of grain rise or fall as needed, in lieu of a no-stock policy. The model for stock management must take account of very short run, year to year injections and withdrawals as well as some of the long cyclical swings in crop production. At the present stage of development of science in general and the art of projections in particular, however, making accurate projections covering a long period is hardly possible. Even within the framework of the projection models, the future weather and other economic conditions especially affecting the supply of grains and oilseeds are subject to uncertainty.

A scenario approach is one way of dealing with the future, and this approach is more convincing if the scenario information can be generated on the basis of a consensus by the experts in each specialized field. In order to avoid unnecessary discrepancy between the projections and the evolving market conditions, the projections must be continually updated on the basis of new information. Price ranges and carryover guidelines should also be reviewed and revised at the early stage of each cropyear, to reflect any new situation in the world food economy. If this is done properly, other forms of government interventions, such as acreage set-aside programmes and export controls can be more generally avoided, or at least given less emphasis in national policy. The general benefit can be measured in terms of price stability at a high production level, which also means stability in food consumption in the United States and the rest of the world.

OPENER'S REMARKS—Walton J. Anderson

Further explanation of the concept of structural instability used in the paper would be helpful. What is meant by clearing the market? Does it mean that at some point in the year all that has been produced has been consumed? If so, the appearance of negative prices in certain yield scenarios is understandable. However, clearing the market does not provide a satisfactory basis against which to compare the storage operations resulting from using the selected price bands.

I was not able to find anywhere in the paper how the results of the imposition of the price bands on the acquisition and release of stocks compared with what actually happened during 1977 and 1978. The paper speaks of an optimum price band. How were the bands actually selected and why is the smallest sum of withdrawals and injections into storage a significant criterion for selecting a plan? I am also puzzled as to how the widest price band can result in the largest sum of withdrawals and injections.

Prices in the world grain market are indeed unstable. The chain reaction leads into the livestock industry through changes in the grain-livestock price ratios. The transmittal of grain prices has been experienced time and again, the most dramatic being the grain price increase in the early 1970s which played havoc with the livestock industry. Grain price instability originates primarily from unstable crop yield from one year to another, mainly in the USSR, Canada, and Australia. The United States contributes much less to unstable yields because the large area over which grain is produced has a dampening effect on changes in average yields.

A study of the possibility of one country undertaking to stabilize its own GOL economy with the expectation of spillover effects on world grain stability

presumes that an international stabilization agreement is unlikely to be achieved. Otherwise it would seem that an international agreement would be both cheaper and more likely to be successful than stabilization by one country, even a very large grain producer. Is it possible that the United States could effectively stabilize prices when the real source of instability is outside the country? Can it really be envisioned that the United States would be willing and able to assume an even greater role in price stability than it did in the 1960s? Moreover, would the implementation of such a supply management plan need to be reinforced with a strong set of import restrictions (quotas, tariffs, or both) which would run counter to the U.S. position of greater liberalization of world agricultural trade?

I would like to see some discussion on how trade policy might enter into the achievement of stabilization under the unilateral approach examined in this paper. Would changes to a more liberal trade policy in agricultural commodities by the two giants, the European Community and Japan, lessen the instability of the world grain economy? Can one reasonably expect that exporting countries will cooperate and forego opportunities to benefit from the known policy of the United States of setting price bands and backing it up with a storage programme? Might not the USSR, with its pattern of yield variability, and acting in its own interest, be in and out of the international market in a manner that would introduce an element of uncertainty and cost which the study has not taken into account, and thereby force a much larger acquisition and release of stocks than that shown in the study?

I suggest that there remains a big question of how the private sector would react. Would the introduction of such a plan change the expectations on which production decisions are based and thereby alter the supply response function from the one on which the plan has been based?

The private trade is engaged in storage operations and will presumably continue these operations. Would the price bands under some circumstances not provide an incentive to private traders to speculate against the price bands in the expectation that the government would be forced to allow a breakthrough? In the foreign exchange markets, for example, speculation against the government has made it difficult to maintain an exchange rate within a price band. How would the private sector respond if the firms simply had the information that a study such as this generates? Would their buying and selling be any different than it is under the present circumstances?

RAPPORTEUR'S REPORT--Graham E. Dalton

The results of this study were interesting, although confidence in the conclusions was reduced when it was pointed out that the basic structure of the model seemed to result in explosive behaviour in the GOL markets. Defending this point, the authors referred to the fact that normal behaviour had been simulated when real data were used for the values of the input variables.

The U.S. model treats the variation in world prices caused by climatic changes in the USSR, Canada, and Australia as an exogenous variable. This excludes study in a direct way of the effects of interactions between U.S. policy and that of other countries.

The degree of generalization necessary in these types of models precludes a consideration of the reactions of private traders, including speculators, to the types of price control investigated. The authors do, however, believe that aggregate market behaviour is satisfactorily represented.

Two interesting suggestions for further investigations were that price control might be more effective within asymmetric price bands, and that the effects of autocorrelation between the yields of various crops, if such exist, be tested.