RESEARCH REVIEW

IN THIS ISSUE

The idea of progress had a grip on Western thought during the 18th century. Consequently, people then tended to regard change as leading steadily toward a better world. Malthus, in pointing out that population growth might outrun the food supply, was among the few who saw limits to progress. Nineteenth century technology pushed the limits aside, and the idea of progress remained alive and well as twentieth century agricultural technology advanced.

Consequently, agricultural economists have largely tended to be complacent about U.S. agriculture's capacity to produce food and fiber. In our first article, Spielmann finds this complacency reflected in a sparsity of both theoretical and empirical studies of agricultural capacity. His review of the literature shows the difficulties of defining and measuring capacity. He also reviews some ideas from the nonagricultural sector that could help to remove some of those difficulties.

The burden of innocent citizens who find themselves repeatedly drawn in researchers' random samples forms the topic of Tortora's article. This burden could be shared more equally without destroying the statistical randomness of the sample. A respondent contacted in previous samples could be assigned a lower probability of being drawn than one who had not been queried. Persons whose names appear on lists from which researchers draw repeated samples will welcome the author's suggested procedures.

The third article extends ideas presented in the July 1976 issue of this Journal in which Kost presented a novel, graphic method for analyzing international trade responses to devaluations and revaluations. Authors Bredahl and Gallagher put forth a simplifying refinement of the graphic analysis. In addition, Kost assumed that if domestic demands on two trading countries were inelastic, the net export function would also be inelastic. That conclusion does not necessarily follow, according to arguments presented here. Even though domestic demands are inelastic, the net demand function in the international trade sector can, in principle, be either inelastic or elastic. Consequently, the change in quantity traded in response to small changes in exchange rates can, in principle, be either relatively small or large.

In rereading earlier issues of this Journal, we have found a number of excerpts which may prove interesting to you. Some exhibit lasting value, some complement or contradict current articles, and some are just for fun. The passages reproduced this month come from our first issue, in January 1949.

CLARK EDWARDS

AGRICULTURAL-FOOD POLICY REVIEW

Economic Research Service, U.S. Department of Agriculture. ERS AFPR-1. 138 + ii pages. 1977.

This review reflects the personal assessment of a professional staff member using the information in the congressional process. It does not, however, speak for the Congress, the House Budget Committee, or all congressional staff members. Time and space requirements do not allow a separate review of each article; consequently, I will give a general assessment of the cumulative impact from this report.

Agricultural-Food Policy Review significantly improves analytical information available to us for reviewing agricultural legislation. Members of the Congress or its staff may review, under one cover, analysis of all the major commodity issues facing this session. Further extensions of these studies, however, could fulfill additional needs.

I expect new or junior legislators will read this publication to gain an overview of agricultural-food problems. Agriculture committee members will read specific articles as they address particular problems in their hearings and as they are writing a new bill. Senior members of the agriculture committees may seek familiarity with the publication, but the articles will probably not offer enough new facts to justify the time for a close reading.

Agriculture committee staff and members will use the publication for ideas on questions at hearings. Staff members not trained in agriculture will want to read the *Review* closely to understand the history and complexity of agricultural problems. Experienced staff members will not turn to this publication for answers but for help in framing the questions. The individual articles should suggest expert economists that can be contacted for further help. The charts and tables provide excellent resource material. Staff for the budget committee will find budget and economic implications in some articles.

Articles in the *Review* cover many of the issues expected to be important in the forthcoming farm program debate. The *Review's* authors describe the policy process; project likely political climates; analyze the implication of failure to pass a new bill; consider the concepts of cost of production, support mechanisms, land and grain reserves, and disaster protection. They interpret possible changes in the rice, peanut and extra-long-staple cotton programs; outline the livestock-grain policy connection; and discuss the international implications of U.S. food policy. With the exception of food stamps, the resolution of these issues will likely determine the structure of the farm bill. The magnitude of each issue should, however, depend on the participation of the various interests in a coalition to pass a bill.

Essential questions and basic intra-agricultural relationships are discussed. Review of the 1973 farm bill highlights worldwide developments in the grain and livestock economies. Analysis of the cost of production outlines the differences among the several measurements. The grain reserve article presents a discussion of alternative management mechanisms in the context of economic stability. The current crop disaster program is compared to a possible expansion of the Federal Crop Insurance Program. And the relationship between livestock and grain is explained to show the implications of grain programs on livestock even without direct policy participation by beef and pork producers.

However, several important policy issues are ignored;

such as, changes in dairy, tobacco, and sugar. Changes in these programs could very well emerge as the most controversial or most expensive in the next year. What, for example, is the cost of raising the milk support price from 80 to 85 percent of parity? What is the impact of expanding the transferability of tobacco allotments? What are the economic costs for sugar producers of growing other crops and what are the alternatives to domestically grown sugar? The Congress will be looking to the Department of Agriculture for analysis on these and related issues.

The issue of agricultural finance requirements is not treated. The Congress has incrementally provided a broad array of loan programs to farm producers, rural residents, and others. A guaranteed loan program for livestock farmers or an expansion of farm ownership loans may affect food prices more than any change in target prices, which are analyzed in the report. The growing number of Government lending programs also need further examination.

The budget costs of permanent legislation are not analyzed. Technically, the Budget Act of 1974 requires analysis of the change in budget costs from new legislative bills. Consequently, a cost analysis of proposed bills should reflect not only the total costs of the bill but the difference between costs from the proposal and costs if no new legislation is adopted. The article analyzing a reversion to basic legislation discusses the complexity of an assessment of budget costs, but an actual cost estimate is needed. Economists could meet this requirement by assessing minimum and maximum costs under the basic legislation, making judgements on crop acre slippage and other factors.

The *Review* helps the reader understand implications to producers of agricultural policy, but it fails on implications for consumers. Members of the Congress and their staffs will want to know retail price changes for all food and for specific key commodities. USDA researchers have been reluctant to invest in analytical improvements of farm-to-consumer relationships. Often, horrendous assumptions are necessary to analyze the retail impact of raw farm products. These questions will still be asked, however, and USDA experts are in a better position to make these judgements or assumptions than anyone else.

Some understanding of the mechanics of the policy process is lacking. The articles quite nicely direct attention to important questions, but the Congress may approach the issues from another direction. For example, authors of the first article draw attention to the importance of the appropriations committee; however, they fail to point out that the agriculture programs discussed in the *Review* are entitlements funded outside the appropriations process. The international issues discussed in the last article contain no analysis of the congressional issue of restricting 75 percent of the P.L.-480 program to countries with under $300 average annual income.

Publication of these articles represents a step in the right direction. Economic Research Service economists have prepared a clear and concise analysis in a timely manner. Continuing this effort with more emphasis on answering the questions raised in the articles and the new congressional questions will further facilitate the legislative process.

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WORLD SOYBEAN RESEARCH

Lowell D. Hill, ed. The Interstate Printers and Publishers Inc., Danville, Ill., 1073 pages. 1976. $16.50.

This portly volume contains the proceedings of a 5-day World Soybean Research Conference held in Champaign, Illinois, in 1974. The conference sponsors were the University of Illinois, the Illinois Natural History Survey, USDA, the Agency for International Development, and the National Soybean Crop Improvement Council. The book's editor, Lowell Hill, an agricultural economist at the University of Illinois, performed the remarkable task of wrestling 106 individual manuscripts into a single, well-organized collection of papers displaying a common format and, as far as I can tell, a consistent editorial style.

Five major subject headings divide the papers: production, protection, economics of marketing and production, utilization, and summing up. All but the last are further subdivided into more specific research fields and subject matter areas. As is typical with reference works of this kind, the papers range from highly technical presentations suitable for professional journals to offhand remarks more appropriate for afterdinner speeches. In fairness, the former far outnumber the latter in this collection.

The publisher's blurb declares this to be "an authoritative work that should be in every agricultural library." That is right. It is the latest in a reasonably long line of modern professional monographs cataloging the science, technology, and, more recently, the economics of the soybean (*1* through *4*).[1] The papers in this particular collection are short; they average slightly under 10 pages each, the shortest being 3 pages and the longest, 28 pages. Hence, they tend to be highly specialized summaries of ongoing and completed research, bristling with scientific literature citations, diagrams, and tables. A few selections are overviews, some based on rearrangements of USDA and FAO data.

Anything said in a review of a collection of 106 papers is bound to be general, with few specific comments. But consider the book from the viewpoint of an economist. Unless one has a specific technical interest in some aspects of soybean production or protection, the scientific overviews published in the recent American Society of Agronomy (ASA) monograph (*1*) are probably more helpful. For example, the ASA monograph has a single chapter devoted to insect damage and control in

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

soybeans. *World Soybean Research* features 12 papers on soybean insect problems—a boon to the graduate student in entomology but possibly bewildering to others. The same observation generally applies to the other eight subareas in the production and protection sections, which span some 640 pages. Yet this is not a book of overview articles; it is a compilation of research reports. So the book's value depends on the reader's interest in specific research issues.

What about the 14 papers in the economics of production and marketing and the 19 papers on human and animal utilization of soy products? Of the 19 papers, authors of 11 focus on chemical and nutritional questions somewhat beyond the general interest range of most economists. Consequently, about 22 papers in the book are of obvious general interest to economists.

Three papers by S. C. Schmidt, D. G. Frahm, and A. S. Walter, respectively, deal with world trade and competition. Price and policy relationships are the focus for four papers by J. Vermeer, R. S. Golden, T. A. Hieronymus, and R. A. Hinton, respectively. The Vermeer paper is an especially useful summary of government policies affecting the soybean sector both here and abroad. Seven papers concerning the soybean processing, storage, and transportation sectors are included, by W. J. Free, C. M. Christensen, H. H. Kaufman, H. J. Barre, G. C. Shove, L. D. Hill, C. J. Nichols and W. A. Bailey. Free's paper provides a good, terse overview of the location, type, and size of U.S. soybean processing plants.

In the utilization area, F. E. Horan looks at the use of soy protein for food, W. W. Craven and R. J. Herder discuss uses of soy protein in feed, and G. W. Kromer considers trends in soybean oil use. A paper by O. B. Smith provides a reasonably clear, fairly nontechnical, illustrated discussion of the new textured vegetable proteins and meat analogs.

If your favorite topic in soybean research is not covered in the book, it is probably because it was not included as an invited paper in the conference. However, there is a good chance that such a topic will be among the 52 contributed papers whose titles and authors are listed at the back of the book. Names and addresses of the more than 600 conferees and authors are also given.

If you make decisions for an agricultural library, buy this book. If you collect all things written about soybeans, buy this book. If you have a professional interest in soybeans and related products, borrow this book to see if it contains enough to interest you in purchasing it. There may well be, but surely there is no one alive who will understand everything in it.

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THE POLITICAL ECONOMY OF NATURAL RESOURCES POLICY

As I look back on our natural resource history, I see only plenty. People, with their accumulated knowledge and capital, were the restraints on our advancing welfare, not natural resources. True, there has always been, at each moment in time, an economic margin restraining increased economic use of space, land, timber, forage, water, ores, coal, petroleum, and air. But advances in technology always saved the day so that natural resources never became a restraint.

Technological changes bearing directly on available resources occurred in (1) exploration and discovery and (2) access to and extraction of discovered and known resources. These changes have been overshadowed by technological changes that indirectly increased productivity of labor and capital. It has become an article of faith that technology will always save us.

The socio-politico-economic institutions concerned with natural resources, and the sociocultural system of values and relative preferences we evolved, exploited these natural resources. No harm in that, so long as resources were abundant. But that abundance began to change to scarcity during the first decade or two of this century. The changes broadened slowly and increased gradually between the two great wars and then accelerated markedly. Yet, as recently as 1963, Professors Barnett and Morse, in a trenchant book that greatly influenced me and my students, argued that natural resources were not then and will not for a very long time, if ever, be constraining on growth or welfare (*1*).[1]

Barnett and Morse related their optimism only to the supply of marketable goods and services derived from nature. They argued that the "quality of life" could—and probably would—be affected adversely, particularly by space and energy shortages. As Norgaard (*9*) says:

> We are neither so naive nor confident today. The environmental crisis, the Arab oil embargo, and the subsequent reanalyses of our resources, technologies, and institutions have swept us over an awareness threshold toward the "economics of the coming spaceship earth" (*3*). [W]e have not developed satisfactory methods of adjusting our actions in light of this now widespread consiousness. . . . [O]ur concern over scarcity and growth today is based on the long-standing

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

issue as to whether we are developing technologies as fast as we are depleting high-grade resources.

Within the U.S. economy, increasing scarcity of space, energy, water, and air, ubiquitous in their influence on all production and consumption of material goods and services as well as on the quality of life, is in prospect because of the following:

1. A continuous growth in population numbers together with accelerated change in their distribution among urban, suburban, and rural geographic regions.

2. A rapid and accelerating rise in per capita real incomes, especially among the lower and middle income classes.

3. An accelerating rise in the levels of technology applied to the direct conversions, hence, consumptive use, of natural resources in the production of marketable material goods.

4. An increase in demands for: marketable material goods; services and amenities derived directly from natural resources; energy; and the direct services of land, water, and air as dumps for unwanted endproducts.

5. A relatively slow rate of change in the technologies or relative preferences that save or expand space, that save or increase energy, or that increase the waste recycling or absorptive capacity of air, water, and land.

These changing conditions generate several broadly distinguishable kinds of socioeconomic problems. First, there is an increase in rents (input costs) for space, energy, water, and air. Rents rise because of (1) scarcity, (2) opportunity costs as demands proliferate, and (3) increased domestic dependence on uncertain foreign sources.

Second, accelerating rates of depletions of particular natural resources may, in turn, generate immediate or longrange increases in resource rents through changes in quantity, quality, accessibility, or location.

Third, rising resource rents shift the distribution of real incomes and wealth toward the middle and upper economic classes.

Fourth, existing institutions and the "rules of the game" generally presuppose "free" to "low cost" resources, and they even may be designed to insure that resources will remain free or low cost to their private sector users or managers despite rising social costs.

Fifth, low private (relative to social) costs may (a) cause resources to be exploited too rapidly and too broadly for optimum social gain, and (b) result in sunk investments (fixed costs, frozen assets) that will hinder conversion to resource conserving systems.

Sixth, after hundreds of years of gradual change (Webb refers to it as the "four hundred year boom," *10*, pp. 13-28), we have suddenly crossed Norgaard's "threshold of awareness." Problems are emerging faster than the system is able to adjust. We resist the problem of natural resource development by ignoring it, by refusing to see even when shown, by praying for deliverance, and by awaiting a crisis too severe to ignore with its attendant *ad hoc*, crash responses.

It would be typical for us to undertake economic analysis of emerging natural resource problems by applying conventional economic wisdom. That wisdom presupposes:

- An infinite supply of whatever resource may be in question, or an infinite supply of perfectly substitutable other resources;
- Today's structure of socio-politico-economic institutional environments—or worse, perfect competition and perfect markets;
- The current relative preferences for resource products and services among consumers;
- A projected rate of technological change;
- A projected rate of population growth;
- An objective function designed to maximize a unidimensional welfare goal.

From such a conventional model, analysts can, given adequate data, project the growth of GNP (sometimes accompanied by observations about the related growth of amenity services), the growth of GNP per capita, and possibly the distribution of GNP (and possibly of amenities) among socioeconomic classes. Doesn't that sound splendid?

But its splendor is a mirage, for we will be of little help to resource policymakers. We will have assumed away the problem. We will imply that whatever is, is both good and right, subject only to consideration as to the adequacy of knowledge. We will be saying to policymakers—all you need do is ensure that the channels of communication to resource managers and consumers are functioning adequately in order to "fine tune" natural resource use and consumer products. Using the model, the economist cannot predict exact outcomes, quantify objectives, or weigh uncertainties.

Most economists know of the all-pervading presence of externalities; neither the resource manager nor the product consumer maximizes social good, even though both may be individually and collectively seeking the most productive combinations. The problem's source lies in (1) the institutions that are involved in resource decisionmaking and (2) the goals and preferences of society. The answer to the problem lies not in conventional economic wisdom, but in political economy, law, government, social psychology, and ethics.

The fact that the problem needs solution within a wide context does not mean that economists should be replaced as analysts of natural resource problems. The economic content of the problem dominates. But economists engaged in natural resource policy analyses must become political economists, or institutional economic analysts, or, at the very least, must be flanked with political scientists, lawyers, and social psychologists. We need to purposively engineer changes in our institutions and our goals and preferences. It seems we must always be dragged kicking and screaming into such a process.

Boulding asserts that policymakers do not take as their objective the maximization of some "idealized social goal" or unidimensional goal. Rather,

> [policymaking] tries . . . to proceed from day to day in a direction it perceives as "up"—"up", for some strange reason, meaning "better" . . . . It brings us closer to realism when we abandon the "social goals" concept and concentrate simply on what might be called a "dynamic evaluation function", which is simply a way of trying to describe

"which way is up". To those eagle-eyed soaring souls who want to base every action on some splendid glimpse of a distant glorious future, this may seem like chickening out. The awful truth is that most of us are chickens, not eagles (*4*, pp. 141, 142).

Boulding stands four-square with Professor Lindblom and "marginal incrementalism" (*8*) and Professor Wantrup and "safe minimum standard" in resource conservation policy (*5*). Boulding concludes:

> Fortunately for us, we have to leave most of these problems to our descendants. All we can really do is to wish them well, to leave them a little elbow room, and to guide our current evaluation functions somewhere toward the minimax of being on the safe side (*4*, p. 151).

We must shun policies that claim to lead our society over the one true path and substitute Boulding's concept of a "dynamic evaluation function," or what I would call an "up-function," the strategy of "upmanship."

Marginalism can lead us into perverse processes in which society becomes progressively worse off. "... we must look beyond incrementalism to some kind of long-range vision that can penetrate the fog to permit us to view more distant summits" (*2*, ch. 3, p. 67). We must hold some vision—or hope—of which route we think is up—even if we can't see it very clearly.

The institutions which guide economic change must incorporate "feedback" loops so that the system can learn from mistakes and adjust to change. The system can then make incremental corrections at those moments when the fog lifts enough to reveal error, or in which experience reveals that our course is actually downward.

This approach requires flexibility and reversibility. Preference must be given to institutions and policies that "leave future options open." Incrementalism together with built-in flexibility and reversibility in resource policies and institutions really represent pleas to grant freedom of choice to future generations—freedom curbed by the responsibility of each succeeding generation of analysts and decisionmakers.

Krutilla and others have considered the conceptual and methodological issues in analyses involving irreversibilities and uncertainties in natural environments (*6*; *7*). Krutilla and Fisher explore the following question:

> When a pristine natural environment has two alternative uses, one extractive and the other amenity yielding, each alternative being destructive of the other, which use should be assigned to the site, when in time should it be assigned, and by what analytical methodologies can guidance to the decision be given?

Choosing one alternative can close the option for the other. If you build a dam for water and power, you sacrifice amenity. If you open an ore body to gain minerals, you destroy a pristine wilderness. Krutilla-Fisher find the following issues crucial:

1. Asymmetric influence of technological change between commodity outputs and amenity services;
2. Impact of congestion on amenity services of pristine natural environments;
3. Differing economic costs of irreversibilities under uncertainty.

Their concept applies to any natural environment yielding an amenity service that (1) can be used only at the site, (2) can be destroyed by human beings if the site is used for commodity outputs, and (3) cannot be produced or, once destroyed, be reproduced by us.

The Krutilla-Fisher model, applied by them to a half-dozen real-world cases, revealed that the amenity alternative overvalued the commodity alternative in every case. Two flexibility costs vastly different in their impact on commodity compared with amenity production brought about this result. These costs are (1) the differing impact of technological change and (2) the differing costliness of reversibility. Reversibility will be cheap when shifting from the amenity to the commodity alternative. But it will be very dear, even infinitely costly, in attempts to shift from the commodity to the amenity alternative.

The Krutilla-Fisher analysis gives only passing and perfunctory attention to the changes in policy and administrative institutions that would ensure the amenity alternative would be evaluated in terms of the opportunity costs it imposes on commodities.

Resource policy analyses consist primarily of descriptions of alternative sets of institutions whose function is to guide, as by an "invisible hand," choices which will determine the content, purpose, rate, "where," and "for whom" of economic activity. Resource policy analyses examine which institutions to leave unchanged, which ones to modify and in what way, and what new ones to create. Institutions in resource policy analyses cannot be silent. They must be explicitly in, even at the center of, the analytic system. That is why Professor Wantrup has referred to resource policy analysis as "applied institutional economics."

This note summarizes the ERS Bicentennial Lecture delivered by M. M. Kelso on November 9, 1976. Dr. Kelso is Professor Emeritus at the University of Arizona.

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AGRICULTURAL PRODUCTION ECONOMICS IN THE FUTURE

Agricultural production economics is not a scientific or academic field which comes and goes with the "fads". It is and will remain a major field of graduate study, research, and extension. It provides a basis for defining problems, information, and relationships which need continuous re-estimation as markets, technology, and institutions change.

Most of the State universities retain agricultural production economics and farm management as a major field. It is not listed by name in the organizational chart of the Economic Research Service (ERS), which emphasizes problem areas. This problem emphasis is needed in an applied field wherein society has invested in the solution of problems. Strong demand for production economists is expected as the highly commercial farm strata continue to strengthen. While this potential is an intellectually exciting opportunity, it has its dangers.

Perhaps a study could be made of the impacts of economic research on groups other than the target group to which results are directed. Speakers at the 1976 AAEA meetings suggested that those conducting micro studies should follow through on the expected macro outcomes. Concentration on highly capitalized farms not only accelerates their development but it also causes disadvantages to fall on smaller farms and rural communities.

The production economists' interest in highly commercial farms has helped animal scientists, agronomists, and other technical scientists to understand and apply what they term systems analysis. This method provides a widening opportunity for cooperative efforts between economists and other scientists. Unfortunately, the physical separation of economists and technical scientists, or even other social scientists, serves somewhat as an obstacle for ERS personnel in engaging in joint activities.

At the firm and subfirm level, micro models developed and applied to guide managerial decisions should be kept current. So should macro or aggregative models. In earlier times, a single publication represented the end of the research activity. Now, many models developed will be continuously updated to provide a stream of solutions. This activity is already underway in several States; it is partly represented by the Federal Enterprise Data System (FEDS) budget generator of ERS.

However, this question can be raised: Does continued application of the model with additional data represent research? My inclination is to classify it as a useful activity which might best be carried on by the extension services or private firms. There is much greater need today for joint appointments of personnel to extension and research. The research portion might be used for the updating and extension of developed models, and the extension portion, for continued applications. This is a more pressing problem in land-grant universities than in ERS.

The overwhelming majority of models developed to aid farmer decisions have been static and deterministic. Recent developments have greatly increased price volatility and the uncertainty surrounding agriculture. The corn blight in 1971 and variable demand and weather conditions in the seventies illustrate this uncertainty. There is need for stochastic models.

The production potential of the Nation's agriculture has two important research facets. If concerns over the world food situation continue, one problem is how to better estimate our food supply capacity under various conditions of technology and land and water use. We need to know the investment required to bring land into production, and the supply price for food produced on each strata of the land. If growth in exportable surpluses mainly translates into livestock feed for rich countries, the basis for concern perhaps need not be great. If the goal is more food to the world's hungry and poor, and if extramarket institutions can be developed and implemented to accomplish this task, then we need to be concerned.

The second research facet relates to the policy means by which the hunger of the world's poor can be translated into effective demand, with prices at levels stable enough for U.S. farmers to profitably produce at the maximum. Both extramarket demands to feed 500 million hungry people and commercial market demands are highly uncertain. U.S. supply capacity likely is sufficient to meet export demands expressed through commercial markets. Prices can even be depressed in relation to the high-cost structure which has now been capitalized into agriculture. Stochastic microlevel decision models can be useful in treating price volatility and uncertainty to improve decisions and encourage greater output. Mostly, however, reduction of this uncertainty must come through grain reserve policies. Research to establish optimal grain reserve policies is a potentially more powerful alternative in reducing the uncertainty than is research on farmers' decisions.

Capital demand and farm financial and estate management need more research. The research momentum may be toward concentration on models, legal alternatives, and information about family corporations which leads to even larger and fewer farms. We have little parallel activity on the behalf of younger and smaller farmers. While the nonfarm corporation is posed as an evil giant standing over agriculture ready to snatch control away, the more exact threat is the very large scale family farm.

A study in ERS by Pat Madden a few years back suggested that the major scale economies were attained by farm sizes falling far short of the level to which the largest of commercial farms now seem headed. Research in this realm could help revive rural development, especially in light of recent information on "backward migration" from urban to rural areas. Our initial study at Iowa State University showed larger and fewer farms to be associated with lower aggregate farm income, smaller input usage, and reduced nonfarm employment in rural areas. Of course, income per large farm is much higher and supply prices for agricultural commodities are lower.

Two elections back, it seemed that every presidential and congressional candidate had rural development as a major platform plank. Farmers, too, plugged for rural development programs—more or less equating them with higher support prices and greater farm income. With the recent upward burst in farm income, commercial farmers have fairly well abandoned interest in the unsolved problems of rural community welfare. "Front burner" problems have become those of energy, land prices, environmental controls, and urban encroachment on farmland.

Public programs affecting resources tend to involve either situations where there is strong competition among alternative users for land and water, or where there are externalities. More studies need to be initiated which measure fully the economic impacts of such programs. For example, the Environmental Protection Agency can specify the types of inputs and farming systems which can be used. We need to know the costs of these programs and to be able to identify those for which society should compensate farmers who are adversely affected. For farming practices long in use, where the resulting income stream has been capitalized into resource values, compensation from the public seems entirely appropriate if the input is condemned. However, development of a new input could promise increased yields but have a potential negative impact on the environment. Compensation is not required here if the input is condemned because the farmer would not have realized a sacrifice.

Public programs redistribute income and resource values within agriculture. For example, a program which limits soil loss to 5 tons per acre annually can reduce output and income in areas of the Southeast, where rain is abundant and soils are erosive. Such a program would not limit output in the Corn Belt and Great Plains, where land is level, rainfall is limited, and there is not an erosion hazard. In addition, because the supply of the first region is restrained, the latter regions gain through improved market prices.

At an earlier time, ERS kept data on a fairly complete set of "typical farms." These indicated the input, expense, and income by type of farm in different regions. These efforts have been in abeyance. A reinstitution would be highly complementary with the ongoing FEDS project, which provides production costs for a wide range of enterprises and locations, and with other types of farming data which ERS is again starting to collect.

Because of the high commodity price now capitalized into agricultural resources, I expect to see periods of pressure for price supports even with continued high exports. I see no reason why society should capitalize speculative prices into land values. In addition to payment limits, there is considerable consensus that income rather than price should be supported. The level and amount of these payments would best be based on results from studies of typical farms.

Production economics historically has involved macro studies. Early examples were represented by delineation of farming regions in terms of comparative advantage or supply response. Later, a massive supply response and comparative advantage study was made for milk over the Lake States and New England. It was inspired by Sherman Johnson and J. D. Black. It included farm response estimates which were aggregated into regional supply functions. Some three decades later, ERS cooperated with the North Central and New England States in somewhat parallel studies emphasizing dairy, pork, beef, and closely competitive products. Farm estimates were aggregated into State or regional responses. Later, ERS launched a fairly large-scale national model project, but this effort seems to have faded away. Similarly, the methodological and quantitative interest in econometric supply response estimates in the fifties and sixties has also faded away.

The basic world food problem renews the need for supply response estimation. Models need to consider supply prices on lands not now cropped if production is carried to successive levels. Though often implied, it is not true that the world's ability to produce food follows a supply function which is horizontal at the outset, but vertical at some posed capacity. Rather, the quantity supplied depends on the price that consumers or some world institution can pay for food. With wheat and corn at $10-$12 per bushel for an extended period of time, we could have much more food available for human consumption.

There is need to review our supply capacity and response in relation to two areas:

- Export capability under normal commercial markets and somewhat volatile export demands;
- Potential contributions to world food supplies.

At Iowa State we have been developing and applying models which provide supply estimates on an aggregative regional basis. We, in fact, started this as a cooperative project with ERS—which withdrew from it in a fairly early stage. However, we are again engaged in a large-scale cooperative effort with ERS and the Water Resources Council in analysis for the National Water Assessment Study. These longrun models assess production potentials and supply prices based on regional, rather than farm, restraints. They reflect regional comparative advantage and resource capabilities.

A considerable number of national "econometric" and simulation models have been developed. It would be convenient if these models could be disaggregated to provide results at least by the major producing regions. ERS is close to the data base and is the appropriate place to locate such models. Regional disaggregation and partitioning of national simulation models is a needed counterpart to the call for extension of micro models so that their macro implications can be better understood.

Agricultural production economics is a broad field encompassing all aspects of production and resource use related to agriculture. Some 25 years ago I titled one of my books *The Economics of Agricultural Production and Resource Use*. I made this choice because a common set of economic concepts and quantitative methodologies surround the analysis, which can be applied to various subsets of phenomena, such as farm optimization, estimation of commodity supply functions, or resource economics. Specialization in agricultural economics is now largely disappearing as graduate training becomes more generalized in the application of basic economic principles and quantitative methods. The task ahead is to amass sufficient labor and skills around a particular problem, as reflected in the organization of ERS, so that the problem's many facets and particular data needs can be examined. Large-scale quantitative undertakings can link the various levels of aggregation and sets of economic relationships. Team research will be needed if analysts are to exploit possibilities in linking commodities and resource sectors, micro and macro relationships, or regional and national aggregations. Many economic philosophers and model builders will continue to be concerned the most with individual research activities. However, for some problems, a team approach will be necessary, just to complete all facets of model quantification. It also may be necessary for incorporating all of the relevant disciplines and subdisciplines.

In the early years of farm management and commodity marketing, a new study completed in one State resulted in a repetition in other States. While the local conditions were different, the methodology and general findings were often the same. For current-day problems, solutions are so urgently needed we perhaps require a greater degree than now exists of specialization and cooperation in the Nation's agricultural economics research effort. Thus, rather than a half-dozen econometrically based simulation models at six institutions, we would be better served by one or two models which develop and use other models and make them available.

Regional research projects of the State agricultural experiment stations generally do not provide the mechanism for such a pooling of resources because these projects have a short financing and planning horizon. Groups of universities do not have the flexibility in use of State funds to concentrate such efforts.

ERS perhaps is the single institution with a sufficient pool of professionals to accomplish this degree of specialization and concentration. This pool might also be used to aid specialized concentration on major problems and quantitative models in individual States. Such a goal could be accomplished if the ERS field staff were spread somewhat less thinly over many States and were instead concentrated more at centers of specialization. The Economic Research Service is large enough to have important influences on the quality, trends, and methods of agricultural economics research. Hopefully, ERS might evaluate the greater impact it could have on the agricultural economics profession. The opportunity to lead the profession is, I believe, greater than is being realized.

This note summarizes the ERS Bicentennial Lecture delivered by Earl O. Heady on December 1, 1976. Dr. Heady is Professor of Economics, Curtis Distinguished Professor of Agriculture, and Director of the Center for Agricultural and Economic Development at Iowa State University.

TESTING A THEORETICAL MODEL FOR WORLD TRADE SHARES

Alternative methods to link models developed through the forecasting and market studies projects being conducted in ERS by the Foreign Demand and Competition Division have been presented in a review paper by Schwartz (*13*).[1] Among models discussed are those that predict both the total volume of world trade and the flows of trade among regions. Schwartz downplayed the role of transportation costs as allocators of market shares, yet economic theory suggests these costs may be an important consideration. The focus here is on predicting the matrix of trade flows according to the hypothesis that the transport cost[2] of satisfying the regional demands is minimized. It will be shown that ERS regional trade models could benefit by incorporating this transportation cost hypothesis. In ERS, we have the theory, data, and computer routines, and this analysis suggests use of the hypothesis could improve our explanatory capability.

DATA REQUIREMENTS

The most essential data required are those for the transportation cost matrix. The amounts traded may be specified alternatively as (1) price-insensitive amounts imported or exported, (2) price-sensitive equations for net trade flows, or (3) individual regional demand and supply relations. Here, 1963-65 trade data for wheat, rice, and coarse grains in the form of method (1) were used.

The transportation cost matrix comes from (*10*, p. 128). Several changes were made to insure comparability between the rows of the transportation cost matrix and

[1] These included simple equilibrium models (*8*), optimizing spatial equilibrium models (*4, 12, 14, 15*), state transition dynamics (*1*), linkage by systems of demand equations (*2, 3, 5*), transportation models (*11*), and methods involving "desired distribution matrices" (*9*).

Note: Italicized numbers in parentheses refer to items in References at the end of this note.

[2] This hypothesis underlies the trade flows in spatial equilibrium models (for example, Takayama and Judge (*15*), Schmitz and Bawden (*12*)), which simultaneously determine the regional totals and the matrix of trade flows. The Abel-Waugh state transition dynamics approach to trade flows (*1*) makes no *a priori* assumption regarding the origin of the base period trade flow matrix. The Loubal-McBride "desired distribution matrix" approach (*9*) needs some external (or policy) specification of the "desired" matrix of trade flows. The transportation cost hypothesis could be used to form either this matrix or the initial matrix in the Abel-Waugh methodology.

those of the trade flow matrix.[3] An economic relationship to update the transportation costs would probably include port-to-port mileage, fuel prices, the size of the world tanker fleet, and a measure of congestion—in both the importing and exporting facilities. If the structural model is not feasible, a minimal effort would be to index the table to the costs along one or two major shipping routes; any cost changes would determine the current cost estimates. Such an approach is very similar to that of Takayama and Hashimoto (*14*).

ADEQUACY OF PREDICTED TRADE FLOWS

The predicted pattern of trade will be found through solution of a linear program. The number of basis activities (nonzero trade flows) is much less than the total number of activities (potential trade flows); most of the predicted trade flows are zero. If the cost-minimizing assumption adequately describes the trade flow, the major observed flows will correspond to the predicted nonzero flows and the observed minor flows will correspond to the nonbasic (zero) flows. Thus, the correlation between the predicted and actual flows will be high.

For the analysis presented here, a description which explains less than 50 percent of the variation ($r < 0.707$) in actual trade flows was considered inadequate. Table 1 contains the results of a statistical test of this hypothesis, based on Fisher's transformation of the correlation coefficient to an asymptotically normal random variable.[4] The conclusions of the statistical test are that the transport cost-minimizing hypothesis adequately explains the market shares for rice and coarse grains, but not wheat.

Country-by-country comparisons of the market share distributions appear in table 2. The first column is the correlation of a region's predicted exports by destination with its actual distribution of exports. The second column is the correlation of the predicted imports by source with the actual distribution of imports into that region. The third column is the net trade position of that region for the commodity; negative numbers imply that imports exceed exports. The prediction errors for each region are typically larger than the errors in predicting the overall world trade distribution.

The rice trade among the less developed countries (LDC's) and the feed grain trade among the developed countries are particularly well explained. For rice, both import and export correlations in the regions from Latin America to the Far East are all 0.5 or better. For coarse grains, the same is true for the correlations in the direction of the trade flows in the regions listed from the United States to Australia (excepting other Western Europe). For wheat, distributions seem better explained for imports than for exports. Argentina is the only major wheat exporter whose shipments are well explained by the transportation hypothesis. South Asia, the USSR, and Africa are the only wheat importers whose supplies are not explained by the transportation cost hypothesis.

The predicted distribution of U.S. exports of both wheat and rice differed from their actual pattern. In each case, actual shipments were more to South Asia and less to Eastern Europe and the USSR. Both these aberrations reflect forces other than that of the market impacting on the system. The politics of trade with the Communist bloc[5] and the forces motivating food aid to

[3] An example of such a change is that the Latin American rate is the simple average of the rates to Central America, Eastern South America (Rio), and Western South America (Callao). Further, the rate to and from the regions of Australia and New Zealand (and sometimes the Union of South Africa) was taken to be the rate for Australia and New Zealand (Melbourne). The Far East and Oceania region was taken to have the transportation rates for East Asia and Pacific (Singapore). For other East Asia, the rates to and from Japan (Yokohama) were used.

[4] If r and ρ are the sample and population correlations, consider the transformations below:

$$z = \tfrac{1}{2} \ln (1 + r) / (1 - r) \text{ and } \zeta = \tfrac{1}{2} \ln (1 + \rho) / (1 - \rho)$$

It can be shown that z is distributed asymptotically Normal with mean ζ and variance $(n - 3)^{-1}$. Although there are 400 possible flows in a 20 x 20 region world, the constraints imposed by the regional totals reduce the freely assignable flows to 361. In analysis presented here, the sample size (361) is large enough to neglect the small sample biases. For more detail, see Yule and Kendall (*17*, p. 451), Hays and Winkler (*7*, p. 610), or a number of other statistics texts.

[5] See Hadwiger (*6*, p. 78).

Table 1.—Statistical test of trade flow correlation coefficients

Commodity	Correlation	Statistical test[1]			
		z^2	Decision	Error probability	
				Type I error[3]	Type II error[4]
Rice	0.8922	10.35	Accept H_O	N/A	0.0
Coarse grains	.7890	3.53	Accept H_O	N/A	.00025
Wheat	.4054	-8.48	Reject H_O	[5] 0.0	N/A

[1] Null hypothesis: population correlation is greater than or equal to 0.707, versus the one-sided alternative that the correlation is less than 0.707. [2] Defined in footnote 4 in text. [3] Reject a true null hypothesis. [4] Accept null hypothesis when the alternative is true. [5] Probability less than 10^{-6}. Note: N/A means not applicable.

Table 2.—Net trade and market share correlations, by region and commodity

Region	Rice			Coarse grains			Wheat		
	Correlations		Net trade	Correlations		Net trade	Correlations		Net trade
	Exports	Imports		Exports	Imports		Exports	Imports	
			Thous. metric tons			*Thous. metric tons*			*Thous. metric tons*
United States	0.15	-0.09	1,327	0.92	-0.07	15,966	0.24	-0.05	20,436
Canada	.95	.97	-35	.69	-.05	1,016	.45	1.00	13,221
Japan	1.00	.38	-534	1.00	.84	-4,658	.24	.77	-3,452
European Community	.51	.56	-144	.80	.91	-10,474	.23	.23	927
United Kingdom	-.06	.70	-79	-.08	.47	-3,961	-.08	.92	-4,254
Other Western Europe	.01	.14	-93	.38	.03	-4,268	-.08	.48	-1,578
Australia and New Zealand	[1] -.00	.53	-27	.50	1.00	2,101	.05	.82	5,901
Eastern Europe	1.00	-.03	-318	.47	.17	-1,707	.91	.51	-6,191
Soviet Union	-.08	.48	-243	-.06	1.00	2,044	-.08	.14	-3,064
Communist Asia	.28	.27	747	-.05	-.12	-216	-.05	.46	-5,274
Argentina	-.10	1.00	10	.05	-.05	3,919	.72	1.00	3,967
Other Latin America	.93	.64	-242	.03	.04	107	.90	.81	-5,302
North Africa	.65	.47	215	.02	[1] -.00	8	.11	.95	-2,898
West Africa	1.00	.68	-369	[2] .00	-.02	-13	-.07	-.09	-469
East Africa	.73	.99	-178	.42	.32	-17	.69	[1] -.00	-231
West Asia	.89	.65	-295	.69	.29	-214	.88	.95	-1,797
South Asia	.46	.91	-1,156	-.05	-.06	-64	1.00	-.01	-7,629
Southeast Asia	.96	.68	3,656	.45	-.05	948	-.05	.16	-211
Other East Asia	.99	.88	-717	1.00	1.00	-350	.20	.98	-1,558
Far East and Oceania	.96	.99	-1,525	.69	1.00	-167	1.00	.89	-544
World total	.8922		7,153	.7890		34,739	.4054		52,929

[1] -.00 indicates correlation whose value lies between 0.0 and -.005. [2] .00 indicates correlation whose value lies between 0.0 and .005.

the Indian subcontinent[6] disrupt the (more nearly) free market equilibrium pattern of trade which minimizes transport costs. The shift to a more "market-oriented" agriculture in the seventies has resulted in more trade with the Soviets and less with India—much as the model presented here would predict.

To capture the effects of these nonmarket forces, the following adjustments to the programmed solution were made. Diverting the entire predicted U.S. trade flow to Eastern Europe (318,000 metric tons) into South Asia would increase the correlation for the U.S. export distribution of rice from 0.15 to 0.70.[7] Similarly, diverting the 2.505 million metric tons predicted as U.S. exports of wheat from the USSR to South Asia would increase the correlation for the U.S. wheat export distribution from 0.24 to 0.55.[8]

CONCLUSIONS

Minimizing the transportation costs is a good analytical method to use to allocate regional market shares. It explained a significant portion of the market shares of rice and coarse grains. But food aid and other policy considerations seem to supplement the cost-minimizing hypothesis in the market for wheat. The transportation model allows for changing market shares in response to differing export supplies and import demands. Moreover, it remains valid even if a proportional increase of all transportation costs occurs.

Transportation cost minimization is not inconsistent with any of the share mechanisms being considered by FDCD, and economic theory says that such minimization should underlie any allocating mechanism. Algorithms for solution are available and inexpensive, and the basic transportation cost matrix for one point in time is also available. If FDCD's market studies projects will be concerned with who exports to whom, any allocating device should start with this mechanism. To bring the model on-line, only the transportation cost matrix needs

[6] See (*16* , pp. 150-151 and 170-171). Refers to U.S. agricultural exports under P. L. 480.

[7] This change required adjustment of the export flows of Southeast Asia, raising the overall correlation from 0.8922 to 0.9127.

[8] In this case, predicted Australian exports to South Asia would be diverted to Communist Asia, and Canadian exports to Communist Asia would be diverted to the Soviet Union. This adjustment increased the overall correlation of wheat market shares from 0.4054 to 0.6329, which differs from 0.707 by a Normal deviate of -2.10 (type I error probability is 0.0179).

to be updated, because other efforts of FDCD involve estimating total imports and exports by region.

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WHEAT FARMERS' DEMAND FOR COMMODITY LOANS, 1950-75

By law, the Commodity Credit Corporation (CCC) must make wheat loans to farmers using the crop as collateral, or it must purchase wheat from farmers at the announced loan rate. Farmers can voluntarily place any amount of their crop under loan at this rate. To forecast farmers' use of this wheat loan program, the Agricultural Stabilization and Conservation Service (ASCS) needs a simple model. ASCS analysts use such forecasts to estimate CCC capital outlays and to plan work loads in State and county ASCS offices. We present here results of an analysis made to improve such loan forecasting by identifying relevant variables.

We expect that the demand curve for wheat under loan is downward sloping. The supply is considered perfectly elastic, because at any given ratio of the market price to the support price of wheat, any quantity of wheat not exceeding total production in a given year can be used as collateral for loans. Therefore, a simultaneous equation model for supply and demand was not needed. A single equation with four independent variables was found to explain most of the annual variation in loans. The price variable is the ratio of wheat's market price to its support price (loan rate). We hypothesized that variables other than this ratio influence the quantity of wheat placed under loan.

The following equation was used:

$$WLV = B_0 (WC)^{B1} (WCOS)^{B2} (WP)^{B3} (WFSH)^{B4} (WMSPR)^{B5} (WCPR)^{B6} (WSRPR)^{B7} (IR)^{B8}$$

Where

WLV	=	Volume of wheat under the loan program
WC	=	Domestic consumption of wheat
WCOS	=	Carryover stocks of wheat in the preceding year
WP	=	Production of wheat
WFSH	=	Total foreign shipments of wheat
WMSPR	=	Ratio of market price to support price of wheat
WCPR	=	Ratio of the price of wheat to the price of corn
WSRPR	=	Ratio of the price of wheat to the price of sorghum
IR	=	Interest rate charged by production credit associations

The model estimates a positive loan volume of wheat unless one of the independent variables takes a value equal to zero, which is most unlikely. The model is easily estimable because it becomes linear when logarithms are taken. Elasticities of loan volume of wheat are directly provided. The model also provides zero volume of wheat under loan, when the price support program is withdrawn, if the estimated coefficient of the ratio of market price to the support price of wheat (B5) is negative, as logically expected.

Data for 1950-75 were taken from *Agricultural Statistics*, published by the U.S. Department of Agriculture (table 1). The loan volume fluctuated highly, recording

Table 1.—Time series data on variables included in analysis of wheat loan volume under price support program, 1950-75

Year	WLV	WC	WCOS	WP	WFSH	WMSPR	WCPR	WSRPR	IR
	- - - - - - - - - -	- - - - - - - *Million bushels*	- - - - - - - - - -	- - - - - - - - -					
1950	197.0	680.0	307.3	1019.4	365.9	1.0050	1.3158	1.9048	6.01
1951	213.0	689.8	424.7	988.2	475.0	.9679	1.2711	1.5985	6.08
1952	460.0	688.6	399.9	1306.4	317.5	.9500	1.3750	1.3228	6.33
1953	553.0	661.0	256.0	1173.1	216.7	.9231	1.3784	1.5455	6.35
1954	430.0	633.9	605.5	983.9	274.0	.9464	1.4825	1.6825	6.36
1955	318.0	611.4	933.5	935.1	346.0	.9519	1.4667	2.0204	5.92
1956	252.0	603.7	1036.2	1005.4	549.1	.9850	1.5271	1.7130	6.20
1957	256.0	588.7	1033.5	955.7	402.3	.9650	1.7387	1.9897	6.66
1958	609.0	591.7	908.8	1457.4	442.8	.9615	1.5625	1.7500	6.72
1959	317.0	608.6	881.4	1117.7	509.8	.9724	1.6762	2.0465	6.50
1960	424.0	596.9	1295.1	1354.7	661.5	.9775	1.7400	2.0714	7.25
1961	271.0	603.4	1313.4	1232.4	719.4	1.0223	1.6636	1.8119	6.61
1962	300.0	608.0	1411.3	1092.0	643.8	1.0200	1.8214	2.0000	6.36
1963	172.0	580.3	1322.0	1146.8	856.1	.9113	1.6667	1.8878	6.30
1964	206.0	588.5	1195.2	1283.4	752.0	.7697	1.1709	1.3048	6.47
1965	173.0	643.6	901.4	1315.6	867.4	.7849	1.1638	1.3500	6.58
1966	133.0	731.2	817.3	1311.7	744.3	.8579	1.3145	1.5825	6.87
1967	282.0	673.1	535.2	1522.4	761.1	.7514	1.3495	1.4040	7.29
1968	453.0	633.3	425.0	1576.3	544.2	.6776	1.1481	1.3053	7.34
1969	408.0	735.4	539.4	1460.2	606.1	.6443	1.0783	1.1589	7.34
1970	254.0	771.6	818.6	1370.2	737.5	.6650	1.0000	1.1667	8.98
1971	438.0	768.6	884.7	1639.5	632.5	.7486	1.2407	1.2762	7.28
1972	143.0	854.7	731.5	1544.9	1190.3	1.0233	1.1210	1.2847	7.02
1973	60.0	784.6	863.1	1705.2	1148.5	2.7055	1.5490	1.8453	8.09
1974	36.0	751.3	438.4	1796.2	1040.0	1.9951	1.3498	1.4712	9.43
1975	50.0	751.3	247.4	2133.8	1168.0	1.7171	1.4309	1.4915	8.91

Source is *Agricultural Statistics*, 1950-75.

its highest level of 609 million bushels in 1958 and its lowest level of 36 million bushels in 1974. The volume of wheat under loan has been substantially lower in the last few years mainly because the wheat market price has been much higher than the wheat loan rate, and foreign shipments of wheat, substantially higher than earlier.

Multicollinearity does not appear to be a serious problem (table 2). The correlation between the logarithms of any two variables is very low, except in two cases: correlation between wheat production and interest rate charged by production credit associations is 0.815; between the wheat-sorghum price ratio and the wheat-corn price ratio, 0.90. One variable from each pair could be deleted from the forecasting equation.

The regression coefficients, T values, and R^2 values appear in table 3. Variables are listed in the order in which they entered a stepwise regression program. These four variables are statistically significant at the 1-percent level: carryover stocks (+), wheat production (+), foreign shipments (-), and ratio of wheat to loan price (-). The signs are as expected.

Coefficients for domestic consumption, interest rate charged by production credit associations, wheat-corn price ratio, and wheat-sorghum price ratio are not statistically significantly different from zero, even at the 10-percent level of significance.

The regression equation with all the included independent variables explained about 92 percent of the year-to-year variation in the volume of wheat under loan during 1950-75.

The chart compares the actual volume c´ wheat under loan for the period studied with estimates from equation number 8. The difference between the actual and the estimated volume of wheat in the last few years appears to be very narrow. Thus, the model appears to be fairly reliable for projecting the volume of wheat under loan.

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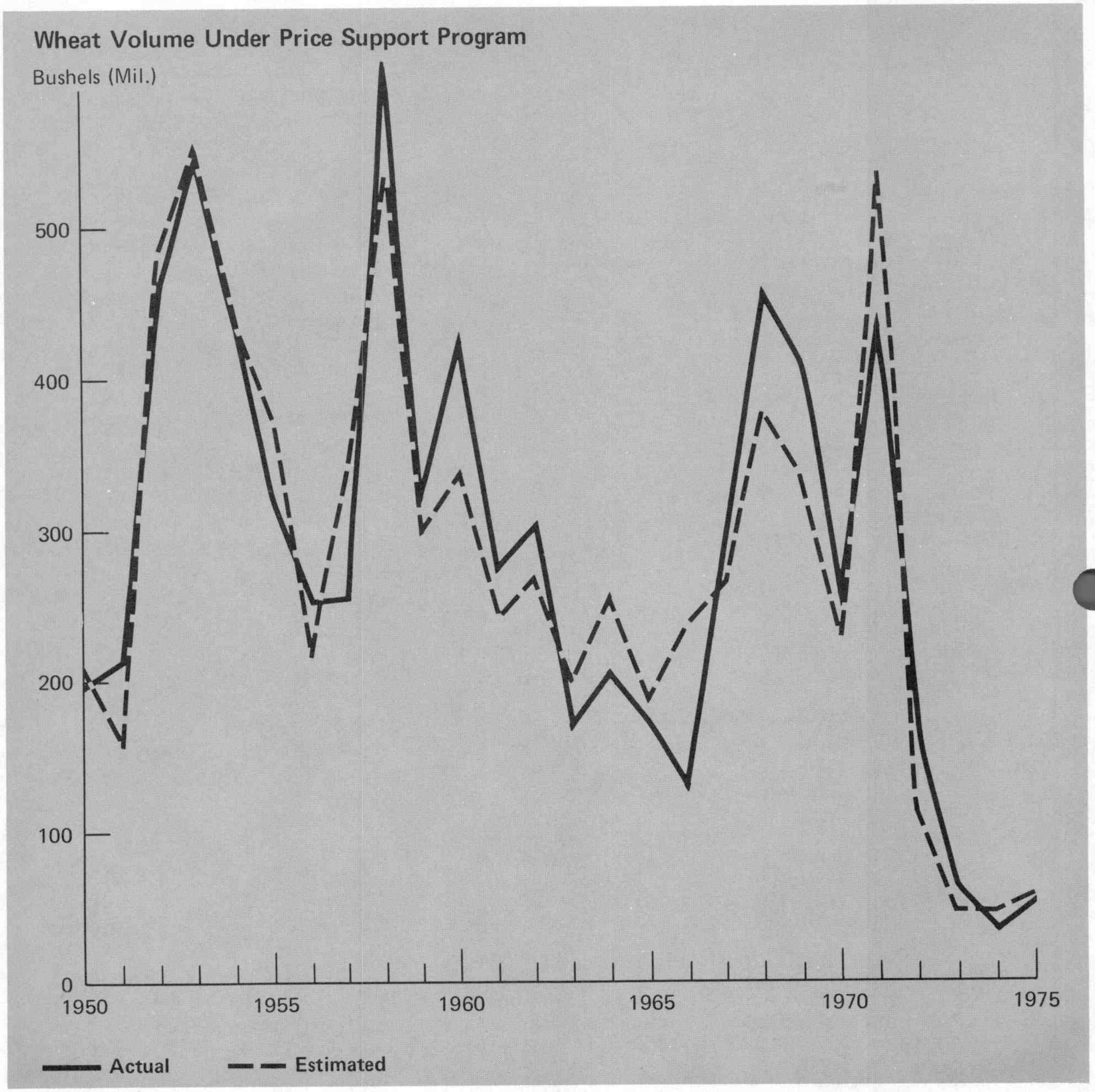
Table 2.—Correlations among variables in wheat loan volume analysis*

Variable	WCL	WCOSL	WPL	WFSHL	WMSPRL	WCPRL	WSRPRL	IRL	WLVL
WCL	1.000								
WCOSL	-0.045	1.000							
WPL	0.602	-0.272	1.000						
WFSHL	0.428	0.254	0.661	1.000					
WMSPRL	0.273	-0.147	0.327	0.353	1.000				
WCPRL	-0.588	0.385	-0.333	-0.159	0.398	1.000			
WSRPRL	-0.572	0.353	-0.521	-0.230	0.367	0.900	1.000		
IRL	0.605	-0.220	0.815	0.613	0.357	-0.321	-0.438	1.000	
WLVL	-0.462	0.146	-0.443	-0.709	-0.734	0.045	0.010	-0.535	1.000

*The final "L" in an acronym indicates a logarithm to the base 10.

Table 3.—Regression coefficients, *t* values, and $\bar{R}^2$ in wheat volume under loan regression analysis

Equation	BO constant	B5 WMSPR	B4 WFSH	B6 WCPR	B3 WP	B2 WCOS	B8 IR	B1 WC	B7 WSRPR	$\bar{R}^2$
1.	2.3532	-1.63217								
		(-5.3013)								0.5394
2.	4.6224	-1.2296	-0.81635							
		(-5.1845)	(-4.8151)							0.7706
3.	4.0889	-1.51589	-0.681633	1.09434						
		(-6.08255)	(-4.11835)	(2.33736)						0.8163
4.	1.36134	-1.73393	-0.937791	1.63166	1.07932					
		(-7.4169)	(-5.3985)	(3.5662)	(2.71197)					0.8639
5.	-0.27251	-1.33940	-1.39528	0.769344	1.61355	0.380483				
		(-5.7036)	(-6.6999)	(1.61594)	(4.27489)	(3.08983)				0.9079
6.	-0.632593	-1.27141	-1.37702	0.642234	1.94682	0.488940	-0.871521			
		(-5.3551)	(-6.69728)	(1.33958)	(4.28079)	(3.18945)	(-1.27213)			0.9151
7.	-3.01399	-1.39805	-1.39608	1.02813	1.91418	0.508995	-0.962817	0.884925		
		(-5.39356)	(-6.83094)	(1.77475)	(4.23987)	(3.32972)	(-1.40906)	(1.16376)		0.9211
8.	-3.29384	-1.42245	-1.40649	0.858393	1.99259	0.512306	-0.961062	0.897098	0.216285	
		(-5.0904)	(-6.60526)	(1.02148)	(3.70009)	(3.25592)	(-1.37009)	(1.14758)	(0.285879)	0.9214



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