USE OF SCENARIOS
IN ERS'S
ECONOMIC PROJECTIONS PROGRAM

by

Leroy Quance

Agricultural Economist, U.S. ERS

Contributed Paper

1976 Summer AAEA Meetings

Pennsylvania State University

August 15-18, 1976

USE OF SCENARIOS IN ERS's

ECONOMIC PROJECTIONS PROGRAM 1/

Originally a theatrical term setting forth the sequence of action as well as describing characters and scenes, Herman Kahn introduced the term "scenario" into the public dialogue about the future in his The Year 2000, published in 1969 (Kahn). Kahn defines scenario as a hypothetical sequence of events constructed to focus attention on causal processes and decision points. Thus, a scenario is a consistent, well researched and detailed set of events permitting the reader to understand the situation, conditions, and strategies that prevail (Carr).

In ERS's Economic Projections Program, we give scenarios a similar but probably somewhat more restricted meaning. We define scenario as a precise statement of assumptions and/or projections about the future required to define the environment in which the food and fiber system will function. Scenarios provide information necessary to prime the econometric components of the National-Interregional Agricultural Projections (NIRAP) system. Scenario statements, assumptions and/or projections are essential parts of the Economic Projections Program's total information system but they are inputs into econometric components of the NIRAP system rather than output from them.

Thus, in their use for "priming" our current operational NIRAP system, the scenarios are static; that is, once a scenario is specified, no new "shocks" occur. This limiting characteristic of our use of scenarios will be transformed into a much more dynamic application of scenarios in an "interactive mode" as analytical capability of the NIRAP system is expanded. 2/

General World Food Scenarios

Scenarios can become so restrictive that they predetermine the future. For example, we've had a feast or famine attitude about the world food situation. With the regularity of a pendulum, we swing from the position that the U.S. food and agricultural sector has an inherent and chronic capacity for overproduction to the other extreme of viewing scarcity as a permanent characteristic of food production. For convincing evidence supporting the chronic overproduction hypothesis, see The Roots of the Farm Problem (Heady et. al.) and The Overproduction Trap in U.S. Agriculture (Johnson and Quance, editors). For the scarcity theme, read almost any current literature on global food production, for the pendulum is at that extreme; but especially see Lester Brown's By Bread Alone. And for a near complete swing of the pendulum from feast to famine, read Brown's Seeds of Change before you read his By Bread Alone.

The feast or famine pendulum scenarios, although acknowledging demand for food in the form of population and income growth, emphasize supply as the positive or negative force in the world food balance. To more fully complete the broad scenario possibilities, we must give demand equal weight in a kind of four quandrant supply-demand scenario plane, as illustrated in Figure 1. 3/

Depending on the quadrant in Figure 1, supply and demand are positive or negative forces in the world food balance.

Malthus was the originator of the quadrant III doomsday scenario in which only starvation is effective in holding population in check and balancing food supplies with needs. In An Inquiry Into the Human Prospect, Heilbroner is a modern day Malthus. He laments the human prospect: horrifying population growth without sufficient food results in catastrophic starvation and disease

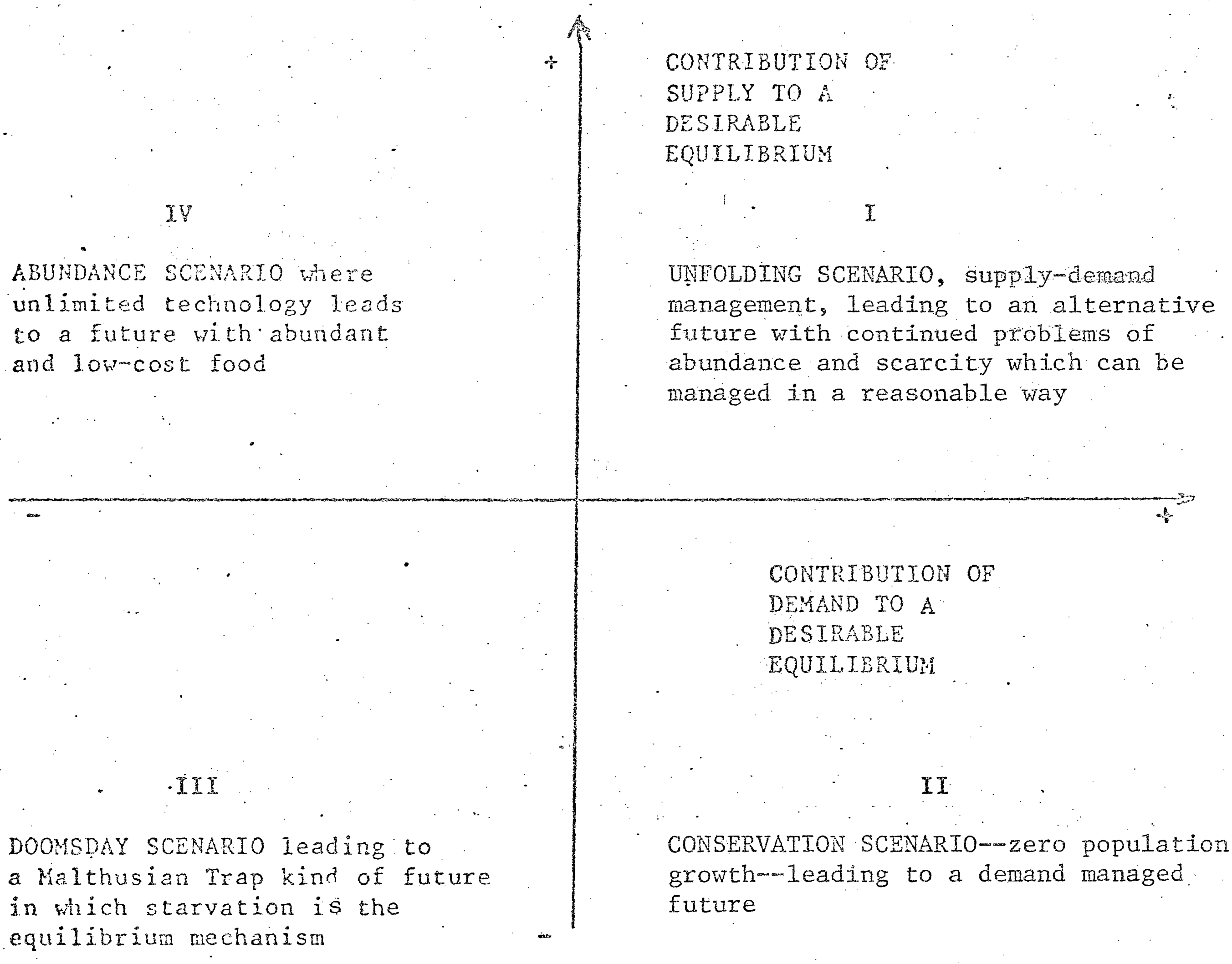

Figure 1.--The world food situation supply-demand scenario plane

throughout a large portion of the developing world. Unrestricted industrial growth eventually brings about a serious threat of environmental collapse.

Advocates of the technology induced abundance scenario of quadrant IV view unchecked population growth and other negative aspects of demand as an alarm calling for greater technical research in food and agriculture. In the U.S., Michigan State University's Sylvan Wittwer, the whirling coordinator of the National Academy of Science's World Food and Nutrition Study: Enhancement of Food Production for the United States, advocates a "Manhattan project" in food that would rival the atomic bomb effort. Through an impressive government commitment of agricultural research funds, technological breakthroughs of increased photosynthetic efficiency, genetic engineering and controlled environment, land grant experiment stations could remove production constraints and create an abundant food supply to meet demand.

Hans Linneman, the Dutch economist and Leader of the Club of Rome's project on feeding a doubled world population by year 2000, is apparently also convinced that food constraints need not limit population growth in the foreseeable future.

The conservation scenario futurists in quadrant II ignore the possibilities of increasing conventional food supplies, placing emphasis on regulating population growth. These advocates believe that population growth combined with continually rising affluence will unbearably pressure the earth's resources and ecosystem. Lester Brown's In the Human Interest advocates a population control strategy leading to a stable world population of 5.8 billion by year 2015. This compares with uncontrolled world population projections ranging from 10 to 16 billion in the same time horizon. Teamed with the population control advocates are those emphasizing conservation of our limited resources. For Mumford's Pentagon of Power--The Myth of the Machine, energy is one ingredient forcing us to adapt civilization to the machine. He advocates that we all "plant, work and eat." In the Cornbelt, Barry Commoner is investigating the output of organic farms. And in urban neighborhoods, Karl Hess is experimenting with basement trout fisheries and rooftop gardens as alternative food sources.

The supply-demand management or unfolding scenario of quadrant I sees man in control of himself and his environment, a world in which both technologies and human values change. Rather than concentrating on either technological change to increase food supplies or population and resource use control and conservation to decrease food needs, a balanced future is sought in which both the quantity and quality of human existence is valued. Rather than accept Mumford's rejection of the machine, Wittwer's worship of the machine, or Heilbroner's hopelessness, those of us in quadrant I have reasoned faith in a future where the machine and man are adaptive to a common rhythm in tune with our environment.

Actually, only the unfolding scenario provides for a real opportunity to project and analyze alternative futures for the U.S. and world food and agricultural system. For those futurists basing their analysis on the doomsday, abundance, or conservation scenarios, the future is largely predetermined by their single dimensional and unyielding scenario.

The unfolding scenario calls for bracketing the determinants of food supply and demand such as technological change, inflation, environmental conditions, population and income growth and world trade in likely ranges. Probabilities of each reasonable combination of sub-ranges are estimated and the resulting alternative futures simulated through a planning horizon.

If the projections and analysis indicate a high probability of something like a doomsday, society is not constrained to accept the results. Rather, we can stop the simulation as it advances through time, rewrite the "second act" of the scenario, making new policy decisions in reaction to undesirable events, should they appear likely, and continue our journey through time in reasonable control of our destiny but subject to the stochastic elements of our natural and human environment.

The unfolding scenario seems to be a reasonable one. It has held for about 4000 years and Genesis records: "As long as the earth remains, there will be springtime and harvest, cold and heat, winter and summer, day and night", and "man--the master of all life upon the earth and in the skies and in the seas."

Scenario Development Procedure

Although ERS and USDA has had important economic projection activities as far back as records are available (Porter), it was only with the 1973 reorganization that ERS developed our present organization for, and approach to, long-range projections (Quance). And our use of scenarios in a systems approach to simulating and analyzing alternative futures for U.S. agriculture is still being developed, tested, and modified. But the scenario development process as we now see it involves three basic activities: issue identification, information collection and classification, and information analysis (figure 2).

Issue Identification

Although perhaps the greatest analytical task in the Economic Projections Program is to simulate the basic structure of all subsectors of U.S. food and agriculture via the NIRAP System, we want to use the NIRAP system to analyze major recurring and emerging long-range issues with respect to food and agriculture. Thus, the first major activity in the scenario development process is to update our "information package" concerning these issues. And we find that almost all such issues relate to shifts in agricultural supply or demand functions over time.

We examine the NIRAP system for a capability to simulate a reasonable range of uncertainty with respect to the issue by accepting exogenously calculated or generating calculated shifts in the appropriate supply or demand function representing the likely range of uncertainty. If appropriate supply-demand components of the NIRAP system do not have such a capability, that attribute is considered for future system development along with other research priorities. If the needed capability exists, the issue information package is stored as a candidate for a scenario dimension. Our current scenario dimension capability includes population and GNP growth domestically and world agricultural trade as commodity demand attributes and public expenditures for agricultural research and extension programs, input price inflation and environmental controls as supply dimensions. We are also working on alternative energy conservation practices as an additional supply attribute. See Agriculture The Third Century: Commodity Production and Utilization Projections to 1985 (Number 2, Smith) for our first application of demand attributes in scenario development.

Information Collection and Classification

The above issue identification process is designed to identify the major uncertainties with respect to the future supply and demand for agricultural output and how these might change over time. But there is an increasingly large amount of information available about projected events that could impact on the

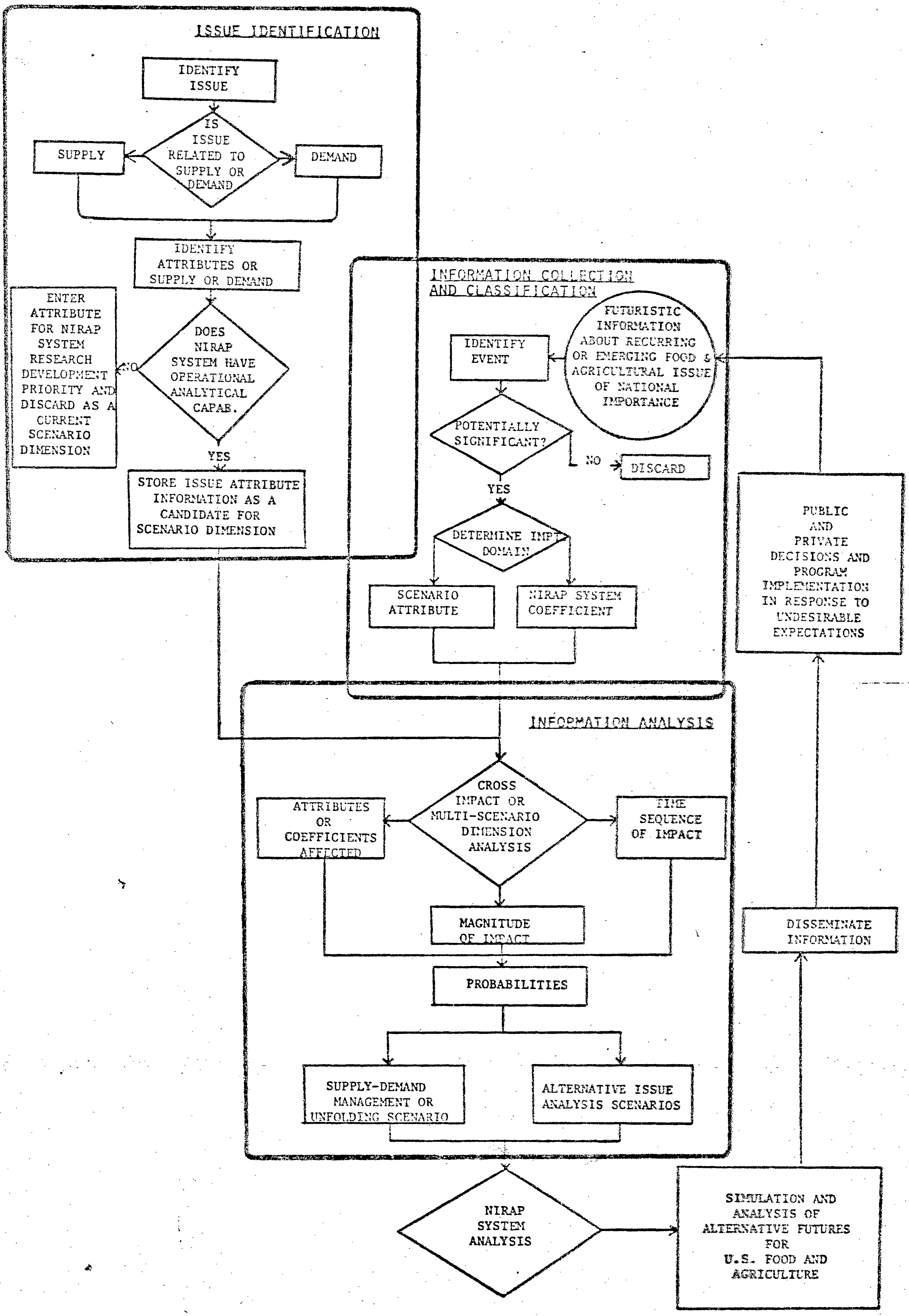

FIGURE 2. FLOW DIAGRAM OF THE SCENARIO DEVELOPMENT PROCESS IN ERS'S ECONOMIC PROJECTIONS PROGRAM.

supply and/or demand attribute representing the uncertainty. The Futures Group's Scout Index and the Foundation For The Futrure's Future Report are examples of major organized sources of information about possible future events. We routinely collect, evaluate and sort such forecasts as potentially impacting a scenario dimension or NIRAP system coefficient. This information is also stored for periodic scenario development.

Information Analysis

Information from both of the above activities is brought together in a scenario development workshop for analysis.

Most technical and economic components of the NIRAP System depend basically on "hard" time series and cross sectional data and thus on "hard" econometric analytical techniques. But the scenario development component depends mainly on "soft" or judgmental data. Here some of the emerging "soft" analytical techniques such as Delphi processes and cross-impact models are more appropriate because they lend themselves to professional interaction, consensus derivation, and indexing of judgmental information (Mitchell et. al.).

Scenario development workshop participants are selected for their knowledge of proposed scenario dimensions and the uncertainties surrounding their future growth. Background papers are provided to participants summarizing information generated in the issue identification and information collection and classification phases. With the use of Delphi and other professional judgment consensus generating techniques, coefficients of a cross impact model are developed and the model is used to derive composite scenarios. Information generated in this phase includes supply and demand attributes or "shifters" and NIRAP system coefficients affected, time sequence of impact, magnitude of impact and associated probabilities or likelihood that the forecasted events and adjustment ranges comprising the resulting scenarios will in fact occur.

The combination of "most likely" adjustment ranges comprises the "unfolding" or supply-demand management scenario while other adjustment ranges permit issue analysis and estimates of the likelihood that our food future could fall within various ranges depicted by the stereotyped scenarios of Figure 1. Scenario detail provides adjusted coefficients for, and "primes" econometric supply-demand oriented components of, the NIRAP system. Resulting projections and analysis of alternative food and agricultural futures are disseminated to public and private decisionmakers and one round of a general interactive research, planning and policy making cyclic process is complete.

A Food Future Hypothesis

The supply-demand scenario plane concept presented in Figure 1 may be useful for more than stereotyping people who propose of various alternative futures for food and agriculture. The axes of Figure 3 measure the annual percentage "shifts" or nonprice increases in the supply and demand for U.S. farm output In the context of Figure 1, it is thus necessary to index the axes of Figure 3 such that combinations of long-run normalized annual shifts in the supply and demand for U.S. farm output falling within each quadrant would constitute a food future dominated by a unfolding or supply-demand management situation, conservation, doomsday, or technology induced abundance.

With respect to demand, I have labeled the origin of Figure 3 as 4 percent because a recent preliminary appraisal of U.S. agricultural production capacity indicates that our feasible supply capacity could accommodate an annual increase in demand of up to 4 percent per year. Greater annual increases in output would be so costly as to cause prices received by farmers to increase sharply and thus perhaps unreasonable food price increases (yeh, et. al.).

U.S. agriculture has generally been blessed with technological advances and increasing agricultural productivity. And although input price inflation and cost increasing environmental controls cause a "real" negative shift in the supply function for farm output, we include these as real price supply responses in the NIRAP system. Thus, technology induced productivity growth is the primary farm output supply shifter. And since any long run decrease in productivity would be an alarming development, the vertical axis in Figure 3 representing the annual shift in the supply function for U.S. farm output is indexed with zero at the origin.

According to Figure 3 then, a long run food future with positive productivity growth and less than 4 percent annual growth in demand would constitute a manageable supply-demand or <u>unfolding</u> food future. Food <u>abundance</u> with long-run demand growth in excess of 4 percent per year could be sustained only with technology induced productivity growth. Long-run negative productivity growth would necessitate a population controlled <u>conservation</u> food future where growth in demand was constrained to less than 4 percent per year. And negative productivity growth accompanied by long-run demand growth in excess of 4 percent per year could constitute a <u>doomsday</u> food future. These generalities hold only within reasonable ranges of annual shifts in supply and demand. For example, a 1 percent per year productivity gain accompanied by a 7 percent per year increase in demand would not represent a food future of abundance. This raises the question of probability or estimates of the likelihood that agriculture will adjust within various areas of Figure 3.

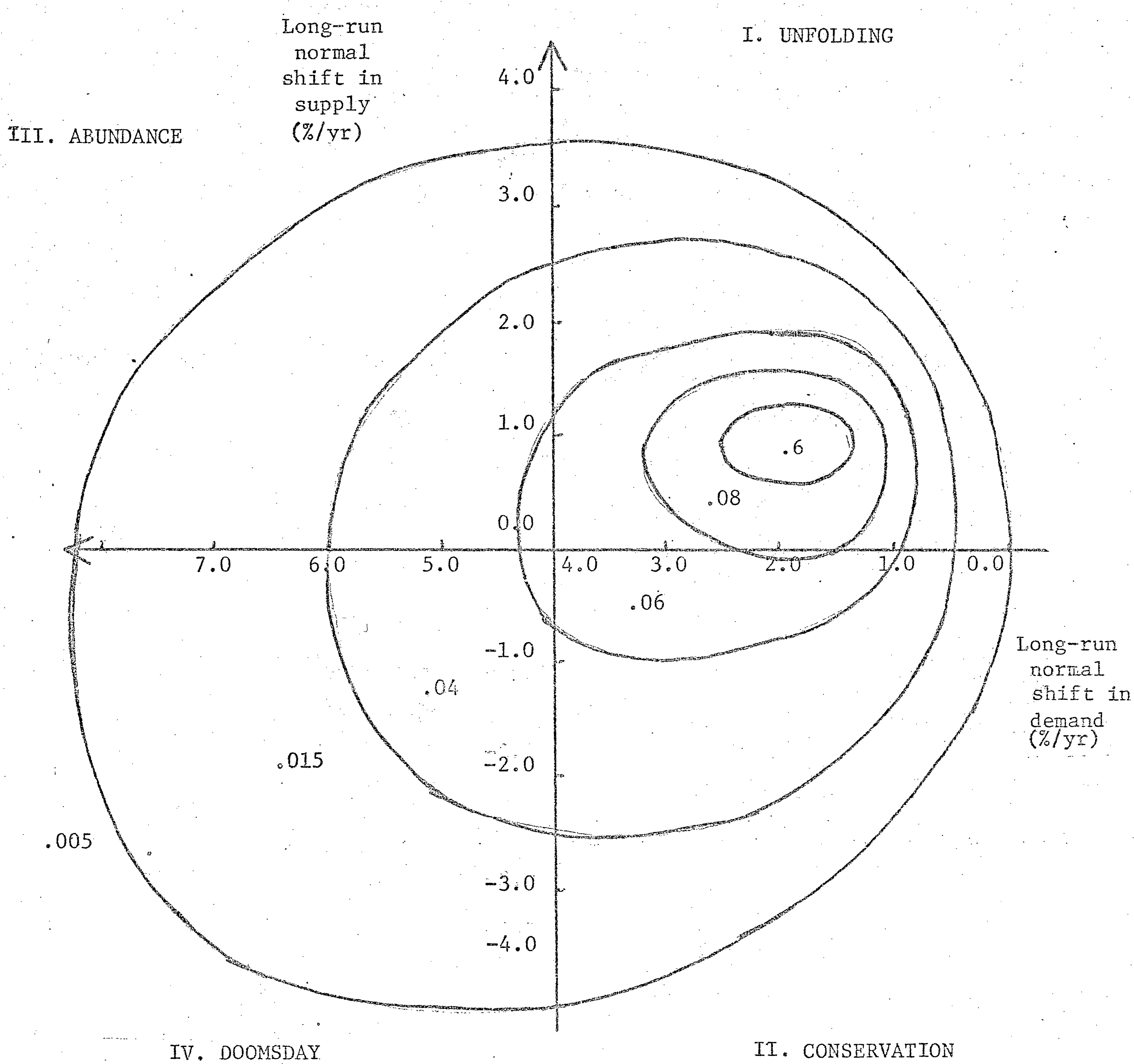

Figure 3.--A probabilistic alternative future hypothesis.

We have developed projections of several alternative futures for U.S. agriculture based on major uncertainties with respect to possible shifts in the supply and demand for U.S. farm output. In all such cases, the resulting annual shift in supply was centered around 1 percent per year and the annual shift in demand generally ranged from 1 to 2 percent per year. This leads to the hypothesis represented by the probability contours imposed on Figure 3. This hypothesis is that there is about an 80 percent likelihood that we will experience a long-range food future bounded by a 1.5 to 2.5 percent annual shift in demand and a .5 to 1.5 annual shift in supply. As the food future possibilities extend from this central tendency, the probabilities of our food future falling within the various areas of Figure 3 decrease rapidly. And the likelihood that our food future will have the doomsday characteristics of quadrant III is only a fraction of .12 since that propability area (.06 + .04 + .015 + .005) is shared by almost all of quadrants II and IV plus the outlying areas of quadrant I.

We will be repeatedly testing this food future hypothesis in the ERS Economic Projections Program. Through careful specification and quantification of scenario attributes, we can make a direct linkage between the general world food scenario possibilities and our projections and analysis of alternative food futures. Each alternative future will have quantified dimensions related to emerging or recurring long-run food issues, can be plotted in Figure 3 when reduced to an annual percentage shift in the supply and demand for farm output, and will provide an early warning for long-range food and agricultural policy considerations if its location approaches quadrants II, III, or IV.

But much work remains to be done. I don't know if the axes of Figure 3 are indexed to accurately represent the four general types of food and agricultural futures. The probability dimension of Figure 3 needs to be mapped out more completely through repeated simulation of alternative futures for food and agriculture where scenarios are purposely compiled to push agriculture toward a doomsday, conservation, or technology induced abundant food future. And we need to develop auxilary indicators of the quality of our food future such as percent of per capita real disposable income spent on food, the number of people dependent on welfare for their food diets, the nutritional quality of our future food diet, the incidence and magnitude of world food shortfalls, environmental quality, food safety, etc.

Developing long-range projections is by nature a risky business. We often find ourselves in a "box" of trying to predict a future that has not yet been invented. We want to avoid this dilemma. Private and public decisions and actions will combine with stochastic natural forces to invent our food future. We want to develop a comprehensive information system to aid this process. Our system must rely on both professional judgment and formal modeling capabilities combined in optional combinations. Scenario development, while relying mainly on professional judgment, can be a very detailed and rigorous process and can contribute much toward making our food future manageable.

FOOTNOTES

1/ This report is a product of ERS's Economic Projections Program. As such, it is an integration and analysis of pertinent data and professional judgment contributed by many economists, program managers, and support personnel in several program areas and divisions of ERS and sister agencies of the U.S. Department of Agriculture. Because so many persons supply materials for the program, it is not feasible to name all in each report. Also, it is necessary to include some analysis and interpretations of projections that should be attributed only to the author. Agricultural projections presented herein are preliminary working materials and not official U.S. Department of Agriculture projections.

2/ See (Quance) Agriculture The Third Century: Introduction to the Economic Projections Program for a fuller explanation of how the NIRAP system fits into the overall ERS Economic Projections Program.

3/ I am indebted to Jean Johnson, National Science Foundation, for the original supply-demand scenario plane concept used in this paper. Johnson originally developed this idea with respect to energy scenarios while she was with Forecasting International, Ltd, Arlington, Va., in Societal and Political Implications of the Energy Crisis, April 1974 and has since extended it to the resource development field.

REFERENCES

Brown, Lester R. Seeds of Change: The Green Revolution and Development in the 1970's. Praeger Publishers, New York, 1970.

__________. In the Human Interest. W. W. Norton & Company, Inc., New York, 1974.

__________. with Erik P. Eckholm. By Bread Alone. Praeger Publishers, New York, 1974.

Carr, Barry A. "Use of Scenario Writing in Assessing Technology." Paper presented at ERS workshop on technology assessment, April 22, 1976.

Heady, Earl O., et. al. Roots of the Farm Problem. The Iowa State University Press, Ames, 1965.

Johnson, Glenn L. and C. Leroy Quance, eds. The Overproduction Trap in U.S. Agriculture: Resource Allocation From WWI to the Late 1960's.

Kahn, Herman and Anthony Wiener. The Year 2000, McMillan, New York, 1967.

Linneman, H., et. al., "Food for a Doubling World Population," Prepatory paper for the Club of Rome Conference, Alpback, Tyrol, June 25-27, 1975, Institute for Economic and Social Research, The University of Amsterdam (May 14, 1975)

Mitchell, A., et. al., Handbook of Forecasting Techniques, prepared for Institute for Water Resources, IWR Contract Report 75-7, Policy Research Report 10, SRI Project URS - 3738, Stanford Research Institute, Menlo Park, California (December, 1975).

National Academy of Sceinces. World Food and Nutrition Study: Enhancement of Food Production for the United States, Report of the Board on Agriculture and Renewable Resources., Washington, D.C., 1975.

Porter, Jane M. Agriculture the Third Century: Historical Perspective on Demand and Supply Projections in the USDA (number 3), Economic Researech Service U.S. Department of Agriculture, September, 1976.

Quance, Leroy. Agriculture The Third Century: Introduction to the Economic Projections Program (number 1), Economic Research Service, U.S. Department of Agriculture, May 1976.

Smith, Allen G. Agriculture The Third Century: Commodity Production and Utilization Projections to 1985 (number 2), Economic Research Service, U.S. Depart-

Yeh, Chung, J., Luther G. Tweeten and L. Quance, "United States Agricultural Production Capacity" AJAE, February 1977.

The Futures Group. The Scout Index: The First Comprehensive Monthly Reference Guide For Libraries, Oriented only to the Future V 124 Hebron Avenue, Glastonbury, Conn. (Monthly issues).

Foundation For the Future, Inc., Future Report: A News-Letter on the Future - For Planners, Educators, and Others (Published twice a month) Inn Street, Mall Market Square, Box 2001, Newburyport, Massachusetts, 01950.