CONFERENCE ON HUMAN NUTRITION AND THE AMERICAN FOOD SYSTEM: A REVIEW

Increasingly loud voices are being raised by participants in the public policy process regarding the adequacy of the American diet. Consumer groups, social scientists, nutritionists, and participants in the food marketing process are forming alliances and they are forcing the development of an integrated domestic food policy. Adoption of such a policy framework will likely bring an increased demand for human nutrition research and food policy analysis.

Some important research questions, as well as the political realities accompanying development of a "food policy", received attention at a conference on "Nutrition and the American Food System: A New Focus" held in July 1977. The sponsors, the Community Nutrition Institute in cooperation with the Food Marketing Institute and Family Circle Magazine, brought together representatives from government, industry, consumer groups, and academia. The objective was to improve the information flow among food system participants so that priority research needs could be identified, so that present nutrition-related practices could be more completely understood, and areas of agreement on an integrated focus for national nutrition policy could be isolated. Invited paper presentations in four major areas were followed with discussions by response panels. The format generated shared ideas which were developed further in organized discussion work groups.

Senator Robert Dole (Rep.-Kans.), in the keynote address, stressed the need to integrate farm policy considerations with the national concern for improved nutrition. He emphasized a need for recognition of the linkage between producers and consumers, and noted the alliances required for passage of the 1977 "omnibus" agriculture bill.

The theme was carried further by Representative Fred Richmond (D-N.Y.). "Nutrition Policy Structure: Is It There?" underscored his belief that Government must provide leadership in seeing that American diets improve. His conclusion, one shared by most conference participants, was that no unified policy relates food and nutrition with other Federal programs. Richmond announced the initiation of a five-part investigation on the role of the Federal Government in nutrition education. The study will be undertaken in 1978 by the House of Representatives' Domestic Marketing, Consumer Relations, and Nutrition Subcommittee.

Of the eight major issue papers, four had particular relevance because of their potential impact on the ERS nutrition-related research program. William Gahr, Assistant Director of the Food Staff in the U.S. General Accounting Office, spoke on "Nutrition Planning as a Community Process." His thesis, that we are now thinking more in terms of world systems, highlighted the need for an integrated social science approach to the nutrition research issue. ". . . The active groups interested in nutrition policy in recent years have expanded and, as a result, nutrition planning has become more complicated in the process." The community, he said, now involves all those interested in the food system—consumers, retailers, processors, and producers. Food and nutrition research must therefore involve more than the technical composition of foods. It must focus attention on the social consequences of poor diets and inadequate nutrition, allow for a changing environment, and encourage a simultaneous consideration of interdependent political systems, partially conflicting national goals, and changing cultures.

Mark Hegsted, professor of nutrition at Harvard University, discussed the development of a common language for nutrition education and public policy. A major question he raises: What will be the likely social value of accomplishing current dietary goals versus the costs of not achieving them. He cited a need for better data and more thorough analyses: "Much of the presumed malnutrition in the United States is due to errors in data collection and analysis." Yet Hegsted also urged initiation of a nutrition reform program based on available data.

In a set of questions, Sheldon Margen, professor of human nutrition, University of California-Berkeley, suggested research needed for a new focus on the nutrition question. Most of them involved the technical aspects of nutrition research, such as determining which elements are necessary for an adequate diet. However, his plea to determine more clearly the relationship among nutrition, health, social productivity, and disease implies the need for a sizable input by economists and other social scientists. So also did his request to broaden the research definition for food and nutrition to include considerations within the social setting. Certainly, he said, food is "the carrier of nutrients, but it is much more than that." Food consumption and nutritional adequacy have cultural as well as biological aspects. It may therefore be ineffective to use legislative decree to alter dietary intake—even if it is clear that certain purchase patterns are unhealthy. Given that we can rely on a relatively free market economy to allocate resources and on free-choice human behavior for purchase decisions, we must learn much more about the determinants of choice if public nutrition intervention programs are to succeed.

Otto Doering, associate professor of agricultural economics at Purdue University, discussed what conference planners called "the first problem for the new focus on nutrition"—the energy situation. Doering emphasized "end product use" rather than simple energy accounting as crucial to the development of an energy policy which recognizes the relationship between nutrition and food. Though advocating continued reliance on prices to allocate energy inputs in the food system, Doering stressed that, "to be effective in allocating energy inputs, energy prices must be allowed to rise *relative* to other inputs." Such a policy would, he said, undoubtedly influence nutrition as food price relationships—and even the availability of some foods—would be affected.

The conference highlighted fertile areas for economic research in food policy. Clearly, food and agricultural programs of the Department of Agriculture affect the amount and kinds of food consumed, and, thus, the nutritional adequacy of the American diet. Before new public policy measures are adopted, it is crucial, then, that we better understand those now operating. Much more needs to be known about the factors affecting food choices. Retail level demand and the household expenditure process need greater study. Further, conference speakers underscored the immediate need to identify and document the implied nutritional consequences of changes in food industry technology and market structure. Such an undertaking would be reasonably familiar territory for most marketing economists. More also needs to be known about the linkages between food and farm programs. Finally, we need to better understand the relationships among nutrition, energy use in the food system, and food industry regulatory programs. Such issues are the key to better nutrition in the future.

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A NOTE ON THE ACCURACY OF COMPUTER ALGORITHMS FOR LEAST SQUARES

Numerous investigators have reported on the accuracy of computer algorithms used for least squares since Longley's article in 1967 (*9*). The most recent, an article by Boehm, Menkhaus, and Penn (*4*) prompted the testing of computer software currently used by ERS researchers.[1] The intent here is to present results collected from tests of program packages listed below. The computer used in all cases was an IBM 370, Model 168.

ERS researchers have access to a variety of software:

BMD—*BioMeDical* Computer Program package acquired from the University of California at Berkely. ERS has access to both the 1973 BMD version and the 1975 BMDP version.

DAMSEL—*Data Management System and Econometric Language* is the property of Boeing Computer Services, Inc., and was used extensively in early 1977 by the Forecast Support Group in the Commodity Economic Division, ERS.

ECONA—A generalized program for multiple regression originating at the University of Pennsylvania but modified at Cornell University.

ECONPAK—A generalized multivariate analysis package developed at Pennsylvania State University.

ERSBLS—A generalized program for multiple linear regression developed at the Bureau of Labor Statistics, U.S. Department of Labor.

OSIRIS—*Organized Set of Integrated Routines for Investigations with Statistics* (Release III.2) acquired from the Institute of Social Research at the University of Michigan.

SAS—*Statistical Analysis System* developed at North Carolina State. ERS has access to both the 1972 and 1976 versions.

SPEAKEASY—A high-level, user-oriented computing language developed at the Argonne National Laboratory, Argonne, Illinois.

SPSS—*Statistical Package for the Social Sciences* (Release 6.02) acquired from the National Opinion Research Center at the University of Chicago.

TSP—*Time Series Processor* (Version 2.7) developed at the Harvard Institute of Economic Research, Harvard University.

Data Services Center staff tested the multiple regression procedures in these software using a technique employed originally by Wampler (*11*) and most recently by Boehm and others (*4*). In this experiment, two equations were processed; both were fifth degree polynomials. The X-variable was a consecutive series of integers 0, 1, 2, . . . , 20. Observations for Y1 and Y2, the respective dependent variables, were calculated as follows:

$$Y^1 = 1 + X + X^2 + X^3 + X^4 + X^5$$

and

$$Y^2 = 1 + .1X + .01X^2 + .001X^3 + .0001X^4 + .00001X^5$$

If least squares solutions were derived with no rounding error, the expected parameter values would be those used to calculate the Y's. Thus, for the first equation, one would expect the constant and each regression coefficient to be 1. Similarly, coefficients in the second equation would be .1, .01, .001, .0001, and .00001 for the successive powers. Since there is no error term, the standard error of estimate is zero, the standard errors on the

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

In Earlier Issues

"My personal preference is for individual papers. At best a committee report is a compromise that covers up real differences in judgment about important issues. This is all right if the reader wants an authoritative statement of areas of agreement among the most competent experts. But the subject of policy really gets interesting when we go beyond these areas of agreement, or when some economist is bold enough to attack principles that have been accepted by most other students.

Frederick V. Waugh
Vol. II, No. 1, Jan. 1950

regression coefficients are zero, and the multiple coefficient of determination is 1.

Wampler (*11*) adds:

> The two test problems, Y1 and Y2, were chosen because they are so highly ill-conditioned that some programs fail to obtain correct solutions while other programs succeed in obtaining reasonably accurate solutions. Polynomial problems were chosen because polynomial fitting is an important type of linear least squares problem which occurs frequently in practice.

Boehm and others then observed ". . . that if computer routines successfully handle these test problems, computational accuracy should not be a serious issue for less ill-conditioned cases" (*4*). When we used a power transformation to create our test variables in two of the packages (DAMSEL and OSIRIS), additional error was introduced. Therefore to maintain consistency for the test, all data were constructed by taking successive products of X. For example, we multiplied X·X·X to generate X^3.

The resulting matrix of highly intercorrelated correlation coefficients appear below:

Power of X	X	X^2	X^3	X^4	X^5
X	1.0				
X^2	.965	1.0			
X^3	.912	.986	1.0		
X^4	.861	.958	.992	1.0	
X^5	.816	.927	.975	.995	1.0

Results for the regression on Y1 are shown in table 1. Numbers in the table were rounded to five deci-

Table 1—Summary of statistics with Y1 as dependent variable

Computer package	Constant	X	X^2	X^3	X^4	X^5	R^2	S
BMD (03R)	([1])	-1792.00000 (0.0)	1616.00000 (0.0)	-96.00000 (0.0)	7.00000 (0.0)	0.83203 (0.0)	1.0815	0.0
BMDP (P1R)	-188.0625 (NA)	390.924 (857.148)	-139.437 (156.728)	19.368 (8.779)	NA (NA)	1.019 (.008)	1.0000	1573.8774
BMDP (P5R)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	NA	NA
DAMSEL[2]	1.00000 (.00000)	1.00000 (.00003)	1.00000 (.00010)	1.00000 (.00014)	1.00000 (.00008)	1.00000 (.00002)	1.000	0.0
ECONA	1.00000 (.02081)	1.00000 (.02285)	1.00000 (.00754)	1.00000 (.00098)	1.00000 (.00005)	1.00000 (.00000)	1.00000	.02282
ECONPAK	1.00000 (2.02641)	1.00000 (2.22267)	1.00000 (.73289)	1.00000 (.09543)	1.00000 (.00531)	1.00000 (.00011)	1.00000	2.21947
ERSBLS	1.00000 (NA)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000	.00000
OSIRIS	1.0000 (.0000)	1.0000 (.0000)	1.0000 (.0000)	1.0000 (.0000)	1.0000 (.0000)	1.0000 (.0000)	1.00000	.0000
SAS72	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000	.00000
SAS76	1.00000 (0.0)	1.00000 (0.0)	1.00000 (0.0)	1.00000 (0.0)	1.00000 (0.0)	1.00000 (0.0)	1.00000	0.0
SPEAKEASY	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.00000 (.00000)	1.0000	.00000
SPSS	1.00000 (NA)	1.00000 (.01032)	1.00000 (.00340)	1.00000 (.00044)	1.00000 (.00002)	1.00000 (.00000)	1.00000	.01030
TSP	.61738 (1.24977)	1.13655 (1.37241)	.98624 (.45253)	.99981 (.05393)	1.00007 (.00328)	1.00000 (.00006)	1.00000	1.37044

[1] Number exceeded allotted print format. [2] Standard errors on regression coefficients not printed; derived from *t*-values that were displayed.

NA=Not available from computer printout. S=Standard error of estimate. R^2=Multiple coefficient of determination.

Note: Numbers in parentheses are standard errors on coefficients.

Table 2—Summary of statistics with Y2 as dependent variable

Computer package	Constant	X	X^2	X^3	X^4	X^5	R^2	S
BMD (03R)	−.46927 (NA)	.11719 (0.0)	.01563 (0.0)	.00195 (0.0)	.00008 (0.0)	.00001 (0.0)	1.0541	0.0
BMDP (P1R)	.9839 (NA)	.135 (.009)	−.003 (.002)	.003 (.000)	NA (NA)	.000 (.000)	1.0000	.0174
BMDP (P5R)	1.00000 (0.0)	.10000 (0.0)	.01000 (0.0)	.00100 (0.0)	.00010 (0.0)	.00001 (0.0)	NA	NA
DAMSEL[1]	1.00000 (.00000)	.10000 (.00000)	.01000 (.00000)	.00100 (.00000)	.00010 (.00000)	.00001 (.00000)	1.0000	0.0
ECONA	1.00000 (0.0)	.10000 (0.0)	.01000 (0.0)	.00100 (0.0)	.00010 (0.0)	.00001 (0.0)	1.00000	0.0
ECONPAK	.99997 (.00195)	.10002 (.00214)	.01000 (.00071)	.00100 (.00009)	.00010 (.00001)	.00001 (.00000)	1.00000	.00214
ERSBLS	1.00000 (0.0)	.10000 (0.0)	.01000 (0.0)	.00100 (0.0)	.00010 (0.0)	.00001 (0.0)	1.00000	0.0
OSIRIS	1.0000 (0.0)	.1000 (0.0)	.0100 (0.0)	.0010 (0.0)	.0001 (0.0)	.0000 (0.0)	1.00000	0.0
SAS72	1.00000 (0.0)	.10000 (0.0)	.01000 (0.0)	.00100 (0.0)	.00010 (0.0)	.00001 (0.0)	1.00000	0.0
SAS76	1.00000 (0.0)	.10000 (0.0)	.01000 (0.0)	.00100 (0.0)	.00010 (0.0)	.00001 (0.0)	1.00000	0.0
SPEAKEASY	1.00000 (0.0)	.10000 (0.0)	.01000 (0.0)	.00100 (0.0)	.00010 (0.0)	.00001 (0.0)	1.0000	0.0
SPSS	1.00000 (NA)	.10000 (0.0)	.01000 (0.0)	.00100 (0.0)	.00010 (0.0)	.00001 (0.0)	1.00000	0.0
TSP	1.00000 (.00002)	.10000 (.00002)	.01000 (.00001)	.00100 (.00000)	.00010 (.00000)	.00001 (.00000)	1.0000	.00002

[1] Standard errors on regression coefficients not printed; derived from *t*-values that were displayed.
NA=Not available from computer printout. S=Standard error of estimate. R^2=Multiple coefficient of determination.
Note: Numbers in parentheses are standard errors on coefficients.

mal positions when the printout presented greater detail.

Results from BMD multiple regression programs were poor and misleading compared with most other packages. BMD programs 03R and P1R produced unacceptable results. On the other hand, BMD's polynomial regression program (P5R), specially designed to fit a power series, gave the expected regression coefficients but the R^2 and the standard error of estimate were not part of the printed output.

The least squares algorithm in Harvard's TSP package also gave undesirable test results. Other packages—DAMSEL, ECONA, ECONPAK, and SPSS although producing the expected coefficients calculated standard errors that differed from zero by varying amounts. Tests of the remaining packages produced the results that we sought.

Results for the regression on Y2 are shown in table 2.

These numbers raise questions about the validity of the algorithm used for BMD programs 03R and P1R. The calculation of the standard errors in ECONPAK also is somewhat suspect. All other procedures produced acceptable results. The results in table 2 are generally better than those in table 1, apparently benefiting from the scaling used in creating the observations for Y2.

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PLANNING NOW?

Planning has recently been getting more attention in the Congress, the Executive Branch, universities, industry, and elsewhere. In USDA, the Secretary has emphasized the need for more effective planning and for strengthening the planning role of the Department. Yet there is no clear trend. As in the past, confusion continues to accompany increased attention to planning. Some of the confusion stems from different political views of our economy and society, and some of it arises from different definitions and concepts of planning.

I do not attempt to untangle that confusion. I will simply try to offer some views on the need for a more effective long-term planning activity in the Department of Agriculture.

So long as we had fairly well agreed upon national and international goals and we and the rest of the world were making steady progress toward them, there was little need for or thought given to long-term planning in the United States. This seems to have been the situation in the post World War II period—during the fifties, sixties, and perhaps very early in the seventies. With agreed-upon economic goals, steady growth, and reasonably stable social systems, uncertainty about the future was at a low level. Simple projections based on past trends and agreed-upon values seemed to serve our purposes. We were a wealthy Nation with abundant and growing resources and certain of the future. Both our planning and budgeting activities were incremental. They focused more strongly on tactics than strategies.

Beginning in the sixties and continuing strongly into the seventies, our social and institutional stability began to break up. Not everybody was sharing equally in the economic growth. Economic growth in itself was not a fully satisfactory social goal for the less affluent. For the more affluent, environmental values began to take precedence over economic values. As our disagreements about national values and goals grew, they were suddenly aggravated by the energy crisis, more variable weather and food prices, questionable leadership, and, more recently, by unexpected levels of unemployment and inflation.

It has become apparent that we can no longer control or predict major events impacting on our economic and social condition. With the loss of agreement on goals and values, we lost the "steering wheel" to direct our future. With the loss of control or predictability of future events, we also lost the "compass" to tell whether we were headed in the right direction. In this state of national uncertainty, planning becomes an attempt to redefine alternative directions and to recover the compass. Given the state of the planning art, it is a hand compass with a very unstable needle.

The objects of planning are these: (a) to provide better information about the sources and extent of uncertainty and their potential impacts, (b) to evaluate the probability of events that would increase or reduce those uncertainties, and (c) to define strategies that can effectively help us cope with the uncertainties and achieve the type of future our society desires. I exclude establishment of national goals and values as an object of planning. The results of planning can be informative for goal and value choices. However, in our type of society, they are generally arrived at through democratic debate and social interaction in peaceful, stable times. They can, of course, also be forged by war, or by economic, social, or environmental catastrophe.

The planning process starts with identification of major uncertainties, or sources of concern and with estimates of the probability of events that would increase or reduce those uncertainties. This information takes the place of assumptions in traditional projections. Planners start with the future, as best they can, and they develop potentially credible scenarios by moving back to the present.

Planners identify strategies to cope with the uncertainties. This aspect of the process corresponds to the definition of policy alternatives in traditional projections. But, because strategic planning focuses on how to deal with future issues rather than estimating the outcome of a given policy, this part of planning requires a dynamic approach to policy over time as well as effective analysis of interactions among factors impacting on the sources of uncertainty, policy responses, and the future itself. Some people would define this aspect of the process as futures research. I call it strategic or long-term planning. It moves from the future to the present as it identifies alternative strategies for coping with future uncertainties.

To be effective, planning needs to address issues of high interest and concern among policy officials. The planning results and their presentation must be credible and understandable to policy officials without the complexities of the analytic methods and procedures. The alternatives for addressing the future must include avenues of action that could succeed in the political arena. The policy officials must be willing to use information developed through the analytic process.

A number of relevant issues confront us which suggest the need for increased planning and research in agricultural economics. Among these are: an overriding uncertainty about the long-term outlook for the amount and mix of export demand; an increasing pessimism about world food supplies; and, incomplete information about our domestic agricultural capacity and projected levels of production. These and other critical issues are too important to our future to take the chance of letting them work themselves out when planning now can increase the probability that they will work out satisfactorily.

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CURRENCY ADJUSTMENTS UNDER TRADE RESTRICTIONS

The impact of an exchange rate change on equilibrium price and quantity under free trade was determined by Bredahl and Gallagher in this journal.[1] We extend that analysis here by incorporating trade restrictions similar to those employed by the European Economic Community (EEC). The impacts of an exchange rate change given free trade are reviewed, impacts under restricted trade determined, and the impacts in the two cases compared.

The impact of an exchange rate change under restricted trade is not symmetrical. The impact of a devaluation by the exporting country is different from that of a revaluation by the importing country. The impact of an exchange rate change may be greater under restricted trade than under free trade.

EXCHANGE RATE CHANGES AND FREE TRADE

The effect of an exchange rate change on equilibrium prices and quantitites is illustrated through the traditional two-country one-commodity closed system used in many international trade textbooks. The model assumes zero transportation cost; competitive, unrestricted markets; and a homogeneous commodity.

The net or reduced-form elasticity of the equilibrium price with respect to the exchange rate was shown to be in the earlier Journal article to be:

$$E_{\$P,\gamma} = -\frac{1}{1-\frac{\eta_{es}}{\eta_{ed}}} \qquad \text{(E.1)}$$

where η_{ed} is the own-price elasticity of the excess demand and η_{es} is the own-price elasticity of the excess supply. The percentage change in the equilibrium price is bounded by 0 and −1. Therefore, the percent change in equilibrium price will be, at most, equal to the percentage change in the exchange rate.

The excess supply curve (measured in dollars) does not shift because of the exchange rate change. Therefore, the elasticity of the equilibrium quantity with respect to the exchange rate was shown in the earlier Journal article to be:

$$E_{q,\gamma} = \frac{\eta_{es}\eta_{ed}}{\eta_{es}+\eta_{ed}} \qquad \text{(E.2)}$$

The multiplication of the net elasticity of the equilibrium price with respect to the exchange rate and the own price elasticity of the excess supply function yields the elasticity of the equilibrium quantity with respect to the exchange rate. Logically, this elasticity, which is negative, is bounded on the upper end by zero, *but it has no lower bound*. Depending on the elasticities of the excess supply and demand relationships, this net elasticity may be less than a minus one; the percentage change in equilibrium quantity may exceed the percentage change in the exchange rate.

EXCHANGE RATE CHANGES AND EEC POLICIES

Initially, the effect of EEC trade policies assuming stable exchange rates is developed. The effects of exchange rate changes are determined and the effects of exchange rate changes given EEC-type policies are compared with those of the free trade model.

The EEC trade policies are explicitly intended to restrict imports by the application of variable levies to most imported agricultural products. The minimum import price is termed the *threshold price*. The *variable levy* is calculated as the *residual* between the threshold price and the c.i.f.price of imported grains delivered to Rotterdam.

Consider a simple trade model:

[1] Bredahl, Maury, and Paul Gallagher. "Comment on 'Effects of an Exchange Rate Change on Agricultural Trade.' " *Agr. Econ. Res.* 29, No. 2: 45-48, Apr. 1977.

The excess demand equation 2 of the importing country is treated as a function of predetermined policy price ($\overline{PP}$) rather than \$P which would be used in the free trade model.

$$Q_{es} = \alpha_1 + b_1\$P \quad (b_1 > 0)$$

(Excess supply) (1)

$$Q_{ed} = \alpha_2 + b_2\overline{PP} \quad (b_2 < 0)$$

(Excess demand) (2)

$$Q_{ed} = Q_{es}$$

(Equilibrium) (3)

Since equation (2) is based on exogenous variables (other equations are the same as the free trade model), trade is not affected by price (\$P) changes unless the world market price exceeds the threshold price.

The effect of currency adjustments given a threshold price depends on the source of the currency adjustment. *The effect of a devaluation by the exporting nonmember country may be different from the effect of a revaluation by an importing member country.*

The mechanism establishing EEC-wide threshold prices must be explained briefly to illustrate the effect of a currency adjustment by non-EEC countries. These prices are quoted in *units of account* (U.A.); the U.A. is defined in terms of gold. The threshold prices are translated into the currency of member countries by fixed exchange rates.

The devaluation of the exporting country's currency will not affect equilibrium values. Assume a devaluation of the dollar from equality with the unit of account to 1.25\$ = U.A. Assume one unit of the commodity is offered by the United States at \$50; initially, 50 U.A., and after devaluation, 40 U.A. If the threshold price is 100 U.A., the variable levy will increase from 50 to 60 U.A. Assume that a member country's currency (MCC) is valued at 4 MCC units to one unit of account. Before devaluation, an importer would pay 200 MCC units for one unit of the commodity plus a levy of 200 MCC units. After devaluation, one unit of the commodity would cost 160 MCC units plus a levy of 240 MCC units. Therefore, the devaluation would not reduce the cost (effective price) to the importer.

The excess demand function can be rewritten

$$Q_{ed} = \alpha_2 + \gamma b_2\left(\frac{\overline{MCP}}{\gamma}\right) \quad (2a)$$

to illustrate the offsetting effects ($\overline{MCP}$) is the member country's threshold price). The exchange rates (γ) cancel; the exchange rate between the importing and exporting countries' currencies has no effect on equilibrium prices and quantities.

There are two cases to be considered. First, the MCC will be revalued against the dollar and the unit of account. Second, the MCC will be revalued against the dollar but not against the unit of account.

To determine the reduced-form effects in Case I, the revaluation of the MCC against the dollar and the unit of account, the excess demand relationship will be rewritten to reflect the fixed import price quoted in units of account (UAP) and the MCC-UA exchange rate (δ).

$$Q_{ed} = a_2 + b_2\gamma\left(\frac{UAP \cdot \delta}{\gamma}\right)$$

$$(b_2 \leqslant 0). \quad (2b)$$

The excess supply function does not determine equilibrium quantity. The differential of the excess demand equation determines the change in the equilibrium quantity, which may be expressed as a net elasticity:

$$E_{q,\delta} = \eta_{ed} \quad (E.3)$$

Therefore, the net elasticity of the equilibrium quantity with respect to the exchange rate equals the elasticity of the excess demand relationship. This elasticity (E.3) is greater than that under free trade (E.1).

The change in the equilibrium dollar price may subsequently be determined from the differential of the excess supply function and expressed as a net elasticity:

$$E_{\$P,\gamma} = \frac{\eta_{ed}}{\eta_{es}} \quad (E.4)$$

The net elasticity of the equilibrium price with respect to the exchange rate equals the ratio of the excess demand function elasticity to the elasticity of the excess supply function. Comparing the elasticity under free trade (E.2) and that under restricted trade (E.4) indicates that if the sum of the absolute elasticities of the excess demand and supply curves is less than one, the restricted trade elasticity will be greater than the free trade elasticity.

Case II, revaluation of the MCC against the dollar, is numerically illustrated and reduced from effects determined. Assume one unit of the commodity is offered at \$50, a threshold price of 100 U.A. and a unity exchange rate between the dollar and the unit of account. The \$-MCC exchange rate will decrease from 4 to 3; the MCC-U.A. exchange rate will be 4. The offer price is converted into units of account and the variable levy determined. In this case, the variable levy will be 50 U.A. The tabulation below indicates the MCC effective import price (cost) before and after the revaluation:

	Threshold price	Commodity price	Variable levy	Import price
	Units of account			
Before	400	200	200	400
After	400	150	200	350

After revaluation, the effective import price declines and is less than the official threshold price.

The excess demand relationship must be rewritten to reflect the fixed variable levy:

$$Q_{ed} = \alpha_2 + b_2\gamma\left[\$P + \frac{VL_{ua} \cdot \delta}{\gamma}\right]$$

$$(b_2 \leqslant 0) \quad (2c)$$

Totally differentiating the equations (1) and (2c) yields:

$$dQ_{ed} = b_2\gamma d\$P + b_2\$Pd\gamma$$

$$dQ_{es} = b_1\, d\$P$$

which is exactly the same result derived if trade were not restricted.

The devaluation of the exporting country currency (dollar) has no impact on equilibrium values. However, in the absence of counter measures by the EEC, the impact of a revaluation by a member country dramatically affects equilibrium prices and quantities. In the first case (revaluation against the dollar), impacts are identical to those of free trade. In the second case (revaluation against the dollar and the unit of account), impacts are greater than those of free trade.

Any analysis of the impact of currency value changes on U.S. exports must consider these theoretical results. The exports of U.S. commodities to the European Community cannot be considered independent of changes in the value of member countries' currencies relative to the dollar and the unit of account. Any research effort, seeking to quantify the demand of the European Community must consider exchange rate impacts.

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GROWTH AS A DIFFERENTIAL EQUATION

Growth can be described by the level of a variable and the change in that level with respect to time. Hence, the economist needs two measures to describe growth. These two measures are functionally related and, according to Allen, "the conditions of a dynamic model reduce to . . . a differential equation" (*3*, p. 5).[1]

Say we are interested in the growth of variable Y at time t, where the rate of change in Y with respect to time is dY/dt. Then the first-order differential equation which describes the growth process is:

$$aY + \frac{1}{b}\frac{dY}{dt} = c \qquad (1)$$

where a, b, and c are parameters. If we ignore terms of second order and higher, this differential equation underlies all growth processes both in and outside of economics. The differential equation has the solution:

$$Y_t = \frac{c}{a} + \left(Y_0 - \frac{c}{a}\right)e^{-abt} \qquad (2)$$

The usual exponential growth curve is implicit in equation (1). To make it explicit, note that we can set $a = -1$ without loss of generality, and take the special case where $c = 0$. Then solve equation (1) for dY/dt:

$$\frac{dY}{dt} = bY \qquad (3)$$

which says the rate of change in Y over time is a constant proportion of Y. Equation (3) has the solution:

$$Y_t = e^{bt}Y_0 \qquad (4)$$

which is the usual exponential growth curve with a rate of growth equal to b. A graph of this solution is shown in figure 1.

When c is not zero, a number of interesting applications of the growth equation arise. For example, define Y as aggregate income of an economy and the parameter a as the labor requirement per unit of income. These definitions imply a definition of aggregate employment (E):

$$E = aY \qquad (5)$$

The parameter c limits the level to which income (Y) can grow. We can interpret c as the labor force from which employment is drawn:

$$LF = c \qquad (6)$$

Substituting (5) and (6) into (1) gives:

$$E + \frac{1}{b}\frac{dY}{dt} = LF \qquad (7)$$

This can be solved for the rate of change in income with respect to time:

$$\frac{dY}{dt} = b(LF - E) \qquad (8)$$

which shows growth to be a product of two factors. One can be interpreted to be a supply factor, and the other a demand factor. A graph of the solution to equation (8) is shown in figure 2.

The supply factor limiting growth is the degree of unemployment in the economy. If the term (LF − E) is positive, there are idle workers and the economy can continue to grow. It will grow more slowly as unemployment decreases. At full employment (LF − E = 0), growth in income will cease.

The demand factor is b, which can be interpreted as the ability of the economy to absorb idle labor through job creation. This factor b might be increased, for example, through an investment tax credit. If b increases, idle labor is more rapidly absorbed. If b is zero, growth ceases and the economy can experience persistent unemployment.

The differential growth equation suggests, in this application, that two factors affect the growth of an economy: its ability to absorb idle labor through job creation, and the presence of unemployed labor. If either factor goes to zero, growth stops.

The parameter a affects the rate of and the limit to growth. It was in-

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

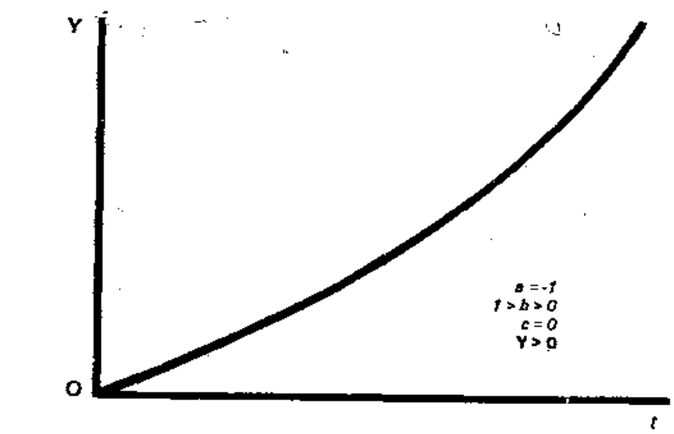

FIGURE 1
GROWTH WITHOUT LIMIT

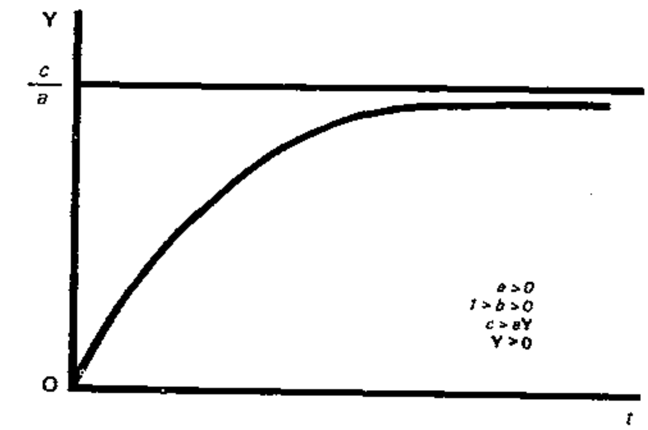

FIGURE 2
GROWTH TOWARD A FIXED LIMIT

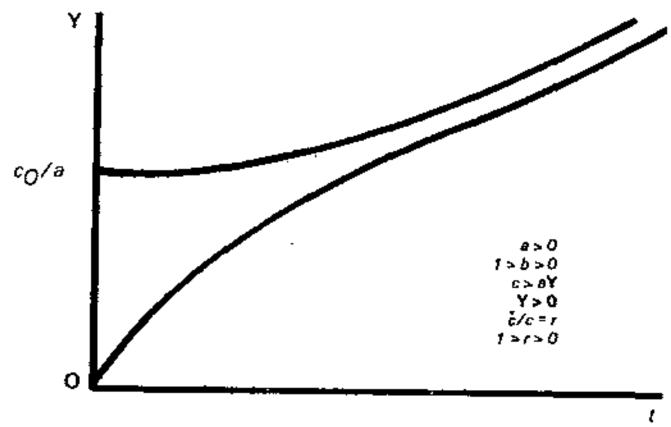

FIGURE 3
GROWTH TOWARD A GROWING LIMIT

terpreted in equation (5) as the labor requirement per unit of income. The reciprocal of a is the productivity of labor. An increase in labor productivity reduces the labor requirement at a given level of income and increases the idle labor supply at that level. The larger idle labor supply results in an increase in the rate of growth at a given level of income, and it increases the limit toward which income can grow.

There are many ways to interpret equation (1) within economics, in addition to the examples above. Allen associates it with distributed lags (*1*, *2*). He demonstrates use of the equation in tracing the path price will follow in closing a gap between demand and supply, and also in tracing the path quantity will follow in closing a gap between bid and ask prices. Alternatively, Allen interprets Y as national income, c as investment, and a as the propensity to save (*2*, *3*). The model traces the path income will follow in closing a gap between planned saving and actual investment. Allen variously sets the coefficient b equal to one, calls it a speed-of-response coefficient, and associates it with the power of the investment accelerator.

Outside of economics, parameter b might be associated with the metabolism of penicillin cells growing in sugar or of trees growing in a forest. Parameter c in these examples could be defined as the limit to growth of penicillin represented by the sugar supply, or as the space required by the roots of a mature tree. As another example, if Y is interpreted as velocity and the reciprocal of b as mass, then c is a measure of force and a is a coefficient of friction. Velocity increases with either a smaller mass or with an increase in net force after allowing for friction.

It is frequently more convenient to use difference equations instead of differential equations. That is, to study growth in discrete intervals of time instead of over a continuous duration. The difference equation which replaces equation (1) is:

$$aY_{t-1} + \frac{1}{b}(Y_t - Y_{t-1}) = c \quad (9)$$

which has the solution:

$$Y_t = \frac{c}{a} + (Y_0 - \frac{c}{a})(1 - ab)^t \quad (10)$$

Now if $a = 0$, and (9) is solved for Y_t:

$$Y_t = Y_{t-1} + bc \quad (11)$$

and the growth increment is an additive constant. Let $a = -1$ and $c = 0$, and solve (9) for Y_t:

$$Y_t = (1 + b) Y_{t-1} \quad (12)$$

which has the solution:

$$Y_t = (1 + b)^t Y_0 \quad (13)$$

and b can again be interpreted as a compound rate of interest, as in equation (4) (see fig. 1). Solving (9) for Y_t gives:

$$Y_t = Y_{t-1} + b(c - aY_{t-1}) \quad (14)$$

which is the difference equation counterpart to the differential equation (8) (see fig. 2). It again shows the increment of growth to be the product of what can be interpreted as a supply factor and demand factor. The supply factor $(c - aY_{t-1})$ represents idle capacity and the demand factor b represents the propensity to absorb idle capacity.

Equation (14) is the form which may be found by economists to be most convenient for use in economic models which simulate growth processes. See (*4*) for an illustration of its use in analyzing rural development problems. There, the limit to growth, parameter c, was considered itself to be a function of time as it was in (2, pp. 50, 66).

Consider, for example, that the limit to growth is a function of time:

$$c_t = (1 + r)c_{t-1} \quad (15)$$

and that Y grows as in equation (14). A graph showing the growth of Y toward a growing limit over time for this two-equation system is shown in figure 3. In this model, Y grows rapidly when there is a high level of excess capacity, as before. The interesting new result is that the economy approaches an equilibrium rate of idle capacity as a limit and can never reach full employment.

To illustrate, interpret c as the labor force as before, then equation (15) becomes:

$$LF_t = (1 + r)LF_{t-1} \quad (16)$$

Let Y grow as in equation (14) with employment defined as in equation (5). Then, in the long run, the economy will approach an equilibrium rate of utilization of the labor force.

$$\frac{E_t}{LF_t} = \frac{b(1 + r)}{b + r} \quad (17)$$

where the equilibrium rate of unemployment is a constant.

The longrun equilibrium rate of growth in income in this example equals the rate of growth in the labor force. That is:

$$Y_t = (1 + r)Y_{t-1} \quad (18)$$

By way of illustration, suppose that the economy is able to absorb a third of its idle labor force each year ($b = 0.33$), where the idle labor force is defined as this year's new entrants to the labor force plus last year's unemployment; and that the labor force grows at 2 percent per year ($r = 0.02$). Then:

$$\frac{E_t}{LF_t} = \frac{0.33(1.02)}{0.33 + 0.02} = 0.96 \quad (19)$$

resulting in an economy which, in longrun equilibrium, will grow at the rate of 2 percent per year and have an unemployment rate of 4 percent.

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In Earlier Issues

The fight against tuberculosis and the drives of the Red Cross which reached rural areas almost as early as they reached urban areas, and the development of health services, form a good example of a steady development that is taking place and the principles upon which the welfare movement has developed in rural areas. From the time 40 or 50 years ago, when practically nothing more was done than to care for those in the almshouses and on outdoor relief, to 1946 when 1,842 counties had full-time professional services, development of rural services has moved forward.

The evidence is that farm people thoroughly approve these advances in welfare programs and there is some indication that the traditional aversion to becoming recipients of social-welfare services has not been so deeply set in the minds of farm people as many have assumed.

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