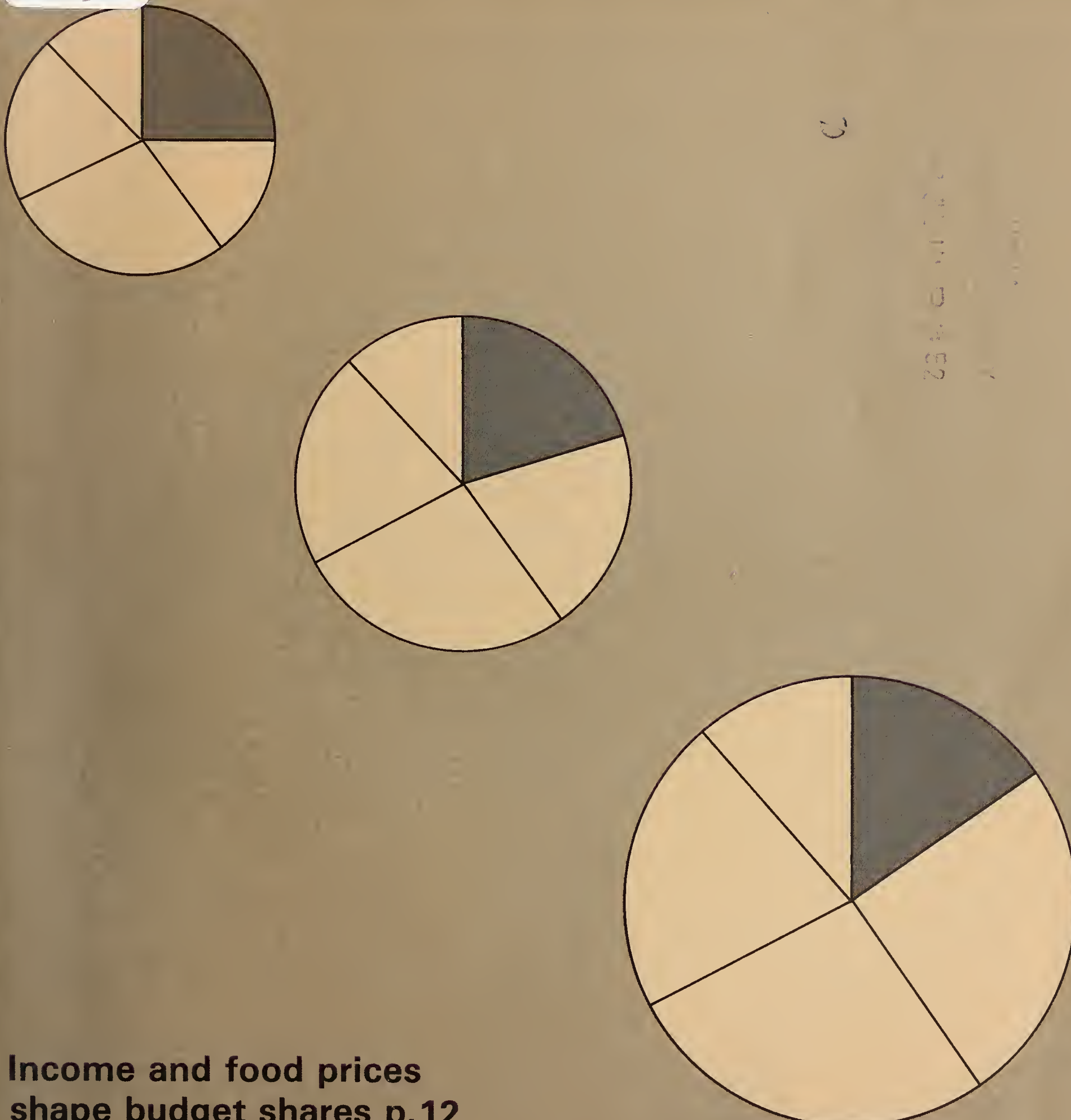
AGRICULTURAL ECONOMICS RESEARCH

JANUARY 1980 VOL. 32 NO. 1



Income and food prices shape budget shares p.12

Agricultural Economics Research

A Journal of the U.S. Department of Agriculture • Economics, Statistics, and Cooperatives Service

Macroeconomics is sometimes characterized simply as "looking at the big picture." The higher the level of aggregation of the variables in a study, the more macro the analysis. This description is popular in agricultural economics, a profession whose members tend to be especially well grounded in neoclassical microeconomic theory. By this description, the four articles in this issue treat macroeconomics topics.

However, there are other ways to distinguish a macroeconomics topic from a microeconomics one. The distinction can be made according to the problems addressed, the data sources used, or the theoretical concepts applied. If we classify the four articles in this issue by these finer distinctions, some of the articles are better characterized as aggregate microeconomics and others as macroeconomics.

In the first article, Huang and others address the impacts of a change in resource allocation on prices and quantities. This is a typically microeconomic issue. The authors examine two kinds of aggregative models used to evaluate national and regional effects of agricultural policy. An econometric model of commodity supply and demand is used to estimate equilibrium prices and quantities. A linear programming model is used to examine the allocation of resources among alternative uses. The authors reach the interesting conclusion that a hybrid of these two kinds of models can be useful for evaluating aggregative agricultural policies.

Mann, in the second article, uses a typically macroeconomic data base—the national income and product accounts. But he asks a typically microeconomic question about the price and income elasticities for aggregate personal consumption expenditures. He uses the so-called Rotterdam Model to develop the elasticity estimates. This model is rooted in neoclassical microeconomic theory—a theory which answers questions about individual prices and quantities while assuming answers about full employment and the general price level.

In the third article, Meyers and others look at commodity prices and quantities—variables explained by microeconomic theory—in terms of world trade. The authors evaluate the effects of a change in the exchange rate on aggregate international trade when explicit allowance is made for price-insulating policies and for domestic demand elasticities. The impacts of exchange rates are found to vary by commodity as well as by country.

The final article addresses the macroeconomic problem of simultaneous unemployment and inflation. Using data from the national income and product accounts and Keynesian theory, the author concludes that monetary and fiscal activities of the past decade may have contributed to the problem rather than helped to solve it.

CLARK EDWARDS

Contents

The Secretary of Agriculture has determined that the publication of this periodical
is necessary in the transaction of the public business required by law of this Department.
Use of funds for printing this periodical has been approved by the Director,
Office of Management and Budget, through February 28, 1980.

For sale by the Superintendent of Documents, U.S. Government Printing Office,
Washington, D.C. 20402. $6.50 a year domestic; $8.25, foreign.

THE RECURSIVE ADAPTIVE PROGRAMMING HYBRID MODEL: A TOOL FOR ANALYZING AGRICULTURAL POLICIES

By Wen-yuan Huang, Reuben N. Weisz, Kenneth H. Baum, Earl O. Heady, and Lloyd Teigen*

A comprehensive model of U.S. agriculture incorporates the spatial pattern of supply, resource use, and the technical structure of agricultural production that is generated by a linear programming component, and it utilizes detailed information on market structure, processes, and prices that is provided by an econometric component. The methodology for the hybrid model is explained, and a summary of lessons learned from a recent test of this model is presented.

Keywords

Policy
Simulation
Forecasting
Models
Systems

INTRODUCTION

Many agricultural policies have been region specific or have had different regional impacts. Policies for cotton, public irrigation programs, and others have been region specific. In the supply control programs of the fifties, for example, the Southeast could shift land from cotton to feedgrains and wheat. Thus, the region partially escaped the rigors of supply control in a way that other regions could not.

Because of the different impacts of agricultural policies among regions, we need models that reflect price, income, resource use, and related items over space and time. Econometric models and mathematical programming models can be used independently, or in combination with each other, depending on the needs of the analysis.

Econometric models can be *positive* or predictive, forecasting the response that farmers and regions will take (*13*, *14*, *24*, *25*).[1] These models predict future response based on past experience as reflected in time series data.

Programming models can be *normative*, suggesting the response that farmers and regions ought to take. Such models indicate, for example, whether natural resources or environmental possibilities are sufficient (*9*, *11*, *12*, *17*, *21*, *38*).

In some instances, we want to examine production potential or resource capability and to learn the market outcome if these potentials were realized. Here, we need to link a normative model with a positive model. Sonka and Heady's study (*32*) is typical.

In some instances, we combine an econometric component and a programming component to generate predictive estimates; for example, Day's (*6*), Schaller and Dean's (*29*), and Sahi's (*28*) recursive linear programming tableaus linked yearly by econometrical flexibility constraints. Positive and normative aspects have been combined in quadratic programming models (*19*, *23*, *35*). Although these solutions are simultaneous, they utilize econometrical demand functions in the objective functions and conventional linear programming constraints. Generally, the recursive linear programming models are used for shortrun analyses, while the simultaneous models are used for longrun analyses.

We present a Recursive Adaptive Programming (RAP) hybrid model in this article which combines a large-scale econometric model with a large-scale programming model. Ideally, such a hybrid model would provide the best features of both types of models, while eliminating problems associated with each. The ideal hybrid would incorporate information on the spatial pattern of supply, resource use, and the technical structure of production generated by the programming model. And it would use detailed information on market structure, processes, and prices provided by the econometric model. Such a hybrid can simulate a dynamic sequence of interrelated events over space and through time and provide a consistent set of economic performance indicators. Our model achieves these objectives.

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Journal Paper No. J-9735, Project No. 2105, Iowa Agricultural and Home Economics Experiment Station, Ames, Iowa.

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

Generally, the recursive linear programming models are used for shortrun analyses, while the simultaneous models are used for longrun analyses.

FOUR METHODS OF COMBINING AN ECONOMETRIC MODEL AND A PROGRAMMING MODEL

Before presenting our hybrid model, we discuss four alternative hybrid approaches for linking econometric and mathematical programming models.

The One-Way Communication Model

In the One-Way Communication Model, output from one type of model becomes input for the other. For example, information can flow from the econometric model to the programming model. This hybrid is best characterized by a single-period and interregional programming model with fixed demands determined by a set of econometric equations.

The National Water Assessment conducted by the U.S. Water Resources Council used a One-Way Communication Model to analyze alternative future potentials for U.S. agriculture (*18*). The quantities of agricultural products demanded were projected by an econometric model for 1985 and 2000 (*24*). These demand projections became constraints in a linear interregional programming model (*18*). That model then projected the least-cost (competitive equilibrium) spatial pattern of agricultural production and resource use subject to these minimum fixed demands.

This One-Way Communication Model has worked well for long-range analysis. However, its ability to simulate the shortrun behavior of the agricultural sector (not its original purpose) is limited by the lack of feedback from the programming to the econometric model within or between time periods. This model obtains nonfeasible solutions when the econometrically estimated values of the linkage variables fall outside the feasible region defined by restraints in the programming model.

The Simultaneous Solution Model

The Simultaneous Solution Model uses equations from an econometric model as identities (rather than inequality constraints) within the programming model (*19*, *23*, *35*). Its conceptual appeal is that the solution will simultaneously satisfy the assumptions of both parent models.

Penn and others (*22*) used this approach to evaluate the shortrun impacts of energy shortages on the U.S. economy. Their Simultaneous Solution Model incorporated input-output data developed by the U.S. Department of Commerce for 85 sectors into a linear programming model that contained two energy constraint equations (*37*).

Problems will arise in applications of a Simultaneous Solution Model when any of the following three conditions occur:

1. The feasibility region defined by the equations derived from the positive model is smaller than the computational errors inherent in the linear programming software package.
2. A static equilibrium solution is imposed on a dynamic disequilibrium system (*2*).
3. Nonlinear equations derived from the econometric component result in prohibitive computational costs or cannot be solved when cast within a mathematical programming framework.

A Simultaneous Solution Model constructed from large scale ESCS econometric and programming models would contain thousands of equations and tens of thousands of variables. A Simultaneous Solution Model of this size would be computationally impossible and/or prohibitively costly (particularly if bounding procedures were used).

Recursive Interactive Programming (RIP) Models

Unlike the static hybrid models described earlier, RIP models (*1*, *30*, *31*) simulate the evolutionary structure of the economy over space and through time. A RIP model can be characterized as an intertemporal sequence of One-Way Communication Models that has the following basic features:

- Within each stage of time, the individual (econometric and programming) components are solved once in a prespecified sequence.
- Within each stage of time, the state of the model is defined by historical information derived from preceding stages of simulation and by exogenous events (that is, input data) not brought about by the previous history of the simulation.

The RIP Models have many advantages over those described earlier. For example:

The RAP model uses an econometric model (26) as the first component of the hybrid and a linear programming model (15) as the second component.

1. They allow for a flow of communication within each stage and between stages.
2. They present fewer computational problems than the Simultaneous Solution Models because the feasibility set is not restricted to equality solutions of the econometric model.
3. They dynamically simulate a sequence of events over space and through time in a nonsimultaneous, or cobweb, framework.
4. They allow evaluation of potential supply capacities for the future in contrast to being based on time series data.

The RIP approach also has limitations. For example:

1. If the first component within each stage of time is a linear programming model, the RIP hybrid tends to overestimate total production and, therefore, to underestimate prices because the linear programming component produces an economically efficient use of resources.
2. The RIP hybrid begun by being run with an econometric model may encounter an infeasible solution. The econometric component may give an estimated production that exceeds capacity.
3. If either of the components has been specified incorrectly, the model's recursive nature may result in propagation of errors over time.

The first problem has been ameliorated by introducing pseudo-behavioral constraints into the programming component. The RIP models cited earlier had a procedure for adjusting upper and lower bounds on regional acreage limitations to respond to the price impacts produced by the econometric component; this is appropriate.

The second and third problems presented by the RIP model can be partly addressed by incorporating a two-way flow of communication between the econometric and programming components within each stage of the analysis. This feedback concept resembles a self-adaptive control system (7). It is a model able to change values of variables that link components through an internal process of estimation, evaluation, and adjustment according to a predetermined rule. It forms the basis of our RAP model which is described below.

THE HYBRID MODEL

Recursive Adaptive Programming (RAP) Model

The RAP model uses an econometric model (*26*) as the first component of the hybrid and a linear programming model (*15*) as the second component. It is constructed from the RIP model by including a feedback structure in each stage.

The Cross Commodity (CED-CC) Model

The econometric component (*36*) descends from the Commodity Economics Division (CED) Commodity Forecast System (*4*). Commonly referred to as the CED Cross Commodity (CED-CC) Model, it includes both crop and livestock sectors.

The model has 127 exogenous variables and 164 endogenous variables represented by 164 regression and identity equations. These equations are divided into 10 groups: retail demand, retail product supply relations in the dairy sector, farm demand for the livestock sector, capital stocks, livestock supply, crop demand, product stocks, planted acreage relations, supply and utilization identity, and index definitions. The crop sector includes corn, sorghum, barley, oats, wheat, and soybeans. The CED-CC model can be expressed as:

$$Y_{it} = a_{it} + \sum_{n=1}^{164} (b_{0in} Y_{nt}) + \sum_{n=1}^{164} \sum_{k=1}^{5} (b_{kin} Y_{n,t-k}) + \sum_{m=1}^{127} (c_{im} z_{mt}) + e_{it} \qquad (1)$$

where i=1, . . . , 164; Y_{nt} and z_{mt} denote endogenous and exogenous variables, respectively; the diagonals of b_0 are zero; the b_k matrices are increasingly sparse; and e_{it} is an error term.

The Linear Programming Model

The linear programming component (*15*) updates the National Water Assessment Model (*18*) described earlier. To reduce the cost of

To evaluate shortrun impacts of agricultural policies, one would use the econometric model for the principal component in the hybrid model and the linear programming (LP) model for . . . subordinate and complimentary roles.

testing this hybrid model, the programming component has only one land class and it uses only land as the resource restraint. There are 13 commodities ($i = 1 \ldots 13$) in the model. For computational purposes, these are divided into two groups:
$i = 1 \ldots 6$ includes corn, sorghum, oats, barley, wheat, and oilmeals;
$i = 7 \ldots 13$ includes corn silage, sorghum silage, nonlegume hay, legume hay, cotton, summer fallow, and sugar beets.

The programming component can be expressed as:

Maximize:

$$\sum_{i=1}^{6}\sum_{j=1}^{105}\Big[\sum_{k=1}^{k_j}(XD_{ijkt} + XI_{ijkt})P_{ijt} - \sum_{k=1}^{k_j} XD_{ijkt}\,CD_{ijkt} - \sum_{k=1}^{k_j} XI_{ijkt}\,CI_{ijkt}\Big] - M\sum_{i=1}^{6}(V_i^+ + V_i^-) \qquad (2)$$

Subject to:

National production balance restraints

$$\sum_{j=1}^{105}\sum_{k=1}^{k_j}(XD_{ijkt} + XI_{ijkt}) + V_i^+ - V_i^- = Q_{it} \qquad (3)$$

$i=1, \ldots, 6$; k_j varies from region to region; and

regional production response restraints

$$\sum_{k=1}^{k_j}(XD_{ijkt} + XI_{ijkt}) \leqslant [\overline{\beta}_{ijt}]\Big[\sum_{k=1}^{k_j}(XD_{ijkt-1} + XI_{ijkt-1})\Big]$$

$$\sum_{k=1}^{k_j}(XD_{ijkt} + XI_{ijkt}) \geqslant [\underline{\beta}_{ijt}]\Big[\sum_{k=1}^{k_j}(XD_{ijkt-1} + XI_{ijkt-1})\Big]; \qquad (4)$$

land restraints,

$$\sum_{i=1}^{13}\sum_{k=1}^{k_j} VD_{ijkt}\,XD_{ijkt} \leqslant LD_{jt}$$

$$\sum_{i=1}^{13}\sum_{k=1}^{k_j} VI_{ijkt}\,XI_{ijkt} \leqslant LI_{jt}$$

$j=1, \ldots, 105;$ (5)

where XD_{ijkt} (or XI_{ijkt}) is defined as the quantity of production of crop i using rotation and tillage practice k on dry (or irrigated) land in producing area j in time period t. CD_{ijkt} or CI_{ijkt} is the cost of producing one unit of XD_{ijkt} or XI_{ijkt}, respectively. VD_{ijkt} or VI_{ijkt} is acres of land used to produce one unit of XD_{ijkt} or XI_{ijkt}, respectively. LD_{jt} or LI_{jt} is total dry or irrigation land available in producing area j in time period t. P_{ijt} is the farm level price for crop i in producing region j in the time period t. M is an arbitrarily large penalty cost that is associated with the deviational variables, V_i^+ and V_i^-. $\overline{\beta}_{ijt}$ and $\underline{\beta}_{ijt}$ are, respectively, the maximum and minimum proportionate increases or decreases of production of crop i in producing area j from year $t-1$ to year t; the price elasticities are used to determine their values.

Linkages Between Components

To evaluate shortrun impacts of agricultural policies, one would use the econometric model for the principal component in the hybrid model and the linear programming (LP) model for the following subordinate and complimentary roles:

- Three sets of endogenous variables are selected as linkage variables to transfer information from the econometric component to the programming component. These three sets (expressed as Y_{it} in the econometric component) are regional crop price P_{ijt}, cost of production CD_{ijkt} (and CI_{ijkt}), and national aggregate crop production Q_{it}. At time period t, the values of P_{ijkt} and CD_{ijkt} are used to revise the coefficients in the objective function, the values of P_{ijt} are used in the regional production response restraints; the value of Q_{it} is used as the value of the right-hand side of the national aggregate production balance restraints.
- For each commodity, the LP model contains an accounting row that measures the deviation (V_i) between aggregate produc-

tion as forecast by the econometric component and the aggregate contained in the LP solution. Large penalty costs are assigned to the deviational variables in the profit maximizing objective function to force the LP solution to approach the econometric solution as nearly as possible.

- If all the deviational (production) variables in the LP solution vector are equal to zero, the solutions produced by the two components are assumed consistent: the econometric estimates are within the feasible region. In this case, the RAP model initiates computations for the next stage in time.

- However, if any deviational variables in the LP solution vector are not equal to zero, the production forecast by the econometric component lies outside the production possibilities region defined by the feasibility constraints in the LP component. Here, the predetermined adaptive feedback mechanism is invoked. The production variables in the econometric component become linkage variables from the programming component to the econometric component; they are set equal to the LP solution values. The econometric component is resolved producing a new set of endogenous variables such as prices. These newly adjusted values are used subsequently in the simulation; they comprise the historical information that defines the state of the model in the next stage of time.

Test Methods

The hybrid model's performance in estimating agricultural production, prices, and levels of other agricultural activities was tested with static and dynamic simulation. Both test methods were applied to the hybrid model and to the CED-CC Model. Estimated values from these two models are compared with actual observations.

In the static simulation, actual observed data are used for all predetermined variables (including lagged and exogenous) for each time period. In the dynamic simulation, the lagged endogenous variables are estimated recursively and used as input in the next time period.

Results from the static test provide information on how well the model can perform when errors from input data are removed or kept at a minimum. Results from the dynamic test provide information on how well the model can be used for multiperiod simulation—for example, how seriously the error accumulated in previous time periods will affect the performance of the model in later time periods.

The years 1969 and 1972 were selected arbitrarily for the static simulation of the hybrid model.[2] The years 1969 through 1973 and the years 1972 through 1976 were selected for the dynamic test. However, only results for 1969-73 are presented here. The regression coefficients of the econometric component (CED-CC model) were established in 1977 from historical data for 1950-77. Endogenous and exogenous data for 1960-77 were updated.

The data set in the programming component was derived from the 1975 LP data base at the Center for Agricultural and Rural Development (CARD) at Iowa State University. Initial data (1968 and 1971) were derived from this data base. The production costs were adjusted according to cost indices for production, interest, taxes, and wage rates. Projected production costs were adjusted by a constant rate from test periods 1969 and 1971. Constant yield was assumed during the test period. The derived regional to national price ratio (1972-74) was assumed unchanged. The values of elasticities are from Richardson and Ray (*27*).

Test Results

Each year's simulation of the econometric component determines 164 values for endogenous variables—livestock and crop production, utilization, and marketing activities. The programming component gives spatial distributions of thousands of crop production activities and land use patterns in 105 producing areas. Empirical results are available from the authors for the 48 contiguous States. Key data from a selected State are presented in the following table. (Iowa was selected because two of the authors are currently working there.)

[2] In conducting a static simulation, one must use actual values for all predetermined variables as input data. Although this requirement poses no difficulty in the econometric component, it does pose difficulty in the programming component. The LP component uses extensively synthesized data that do not have observed values; therefore, it only approximates a static simulation.

The static simulation results indicate that the hybrid model does well estimating production of major crops (that is, corn and soybeans) at both State or national levels but performs poorly in estimating output of minor crops (for example, oats).

Static simulation results of hybrid model, 1969 and 1972

Area and crop	Results		Error
	Actual	Estimated	
1969 national production:			
	Million bushels		*Percent*
Corn	4,687	4,487	0.27
Soybeans	1,133	1,116	1.50
Oats	965	959	.62
Wheat	1,442	1,453	.76
1969 Iowa production:			
	Thousand bushels		
Corn	1,012,563	1,001,146	1.13
Soybeans	179,850	182,530	1.49
Oats	93,840	108,720	13.69
Wheat	1,320	1,755	32.95
1972 national production:			
	Million bushels		
Corn	5,570	5,444	0.24
Soybeans	1,270	1,312	3.31
Oats	690	784	13.62
Wheat	1,546	1,601	3.56
1972 Iowa production:			
	Thousand bushels		
Corn	1,212,200	1,154,493	4.76
Soybeans	217,800	215,161	2.92
Oats	70,000	81,362	16.23
Wheat	1,238	1,360	9.90

The static simulation results indicate that the hybrid model does well estimating production of major crops (that is, corn and soybeans) at both State or national levels but performs poorly in estimating output of minor crops (for example, oats). At the State and national levels for both years (1969 and 1972), there was less than a 5-percent error in estimation for the major crops. However, at the State and national level for a minor crop (oats), there was a more than 13-percent error in estimation.

In the dynamic simulation test, most of the national crop production generated by the econometric component was adjusted by the programming component. This caused a significant discrepancy between the hybrid model and the CED-CC model in their estimates of national crop production and prices.

Figures 1 through 4, grouped at the end of this article, illustrate the following significant features of the hybrid model:

- When using regional restraints, the hybrid model does not yield better estimates for aggregate national production and price than those generated by the CED-CC model alone. This failure occurs because the restraints caused by using national price elasticities do not represent the regional responses adequately.
- The adjustment mechanism in the hybrid model assumes that national aggregate production can be estimated better by summing the individual regional production estimates than by using the national aggregate figure from the CED-CC econometric model. This assumption is true only if a set of accurate regional response functions can be formulated. To improve the performance of the hybrid model, we should estimate and use region specific elasticities of production with respect to price instead of the national (β) elasticities that were available for use in this study.
- The time recursive structure used by the hybrid model will accumulate error and pass it on to the next time period. (The estimates illustrate this point.) This error might be reduced by formulating regional restraints as a function of the endogenous

The Recursive Adaptive Programming (RAP) hybrid model is the most sophisticated method of linking econometric and programming components.

variable in the econometric component rather than depending heavily on the previous year's production, as in (*4*).

Therefore, we suggest that whenever accurate regional response restraints are not available, the One-Way Communication Model will probably perform better between time periods than will any model with a recursive structure.

In a second dynamic simulation run, we did not include the previously described regional restraints but used instead four regression equations representing corn, soybean, oat, and wheat production responses to generate the right-hand side values of the regional restraints for Iowa. The hybrid model gave the same estimation of national production as the CED-CC model. Furthermore, we made significant improvement in simulating regional (Iowa) crop production, as judged by the values of the root mean square error (RMSE). This outcome demonstrates that if we use a regional response function that is better estimated econometrically, the hybrid model will yield better estimates of national and regional production and price.

CONCLUSION

The need for a policy model with space and time characteristics of price, production, and resource use has led to the development of hybrid models combining econometric and programming components. The Recursive Adaptive Programming (RAP) hybrid model is the most sophisticated method of linking econometric and programming components. It uses a programming component to validate the estimates by the econometric component and adjusts the estimates when they fall outside the feasible production region.

The static simulation tests of RAP show it performs well in estimating corn and soybean production at both national and regional (Iowa) levels, but they show inconsistencies in estimating production of oats and wheat. The dynamic simulation tests show that both national and regional (Iowa) estimates follow the general movement of the observations but have cumulative error. The model could be used as a national model if the bounds of regional restraints were relaxed. The regional restraints need to be improved considerably, before a high degree of confidence can be attached to the region specific results of the RAP model.

Figure 1

Corn: Performance of Hybrid and CED-CC Models Compared with Actual Observations

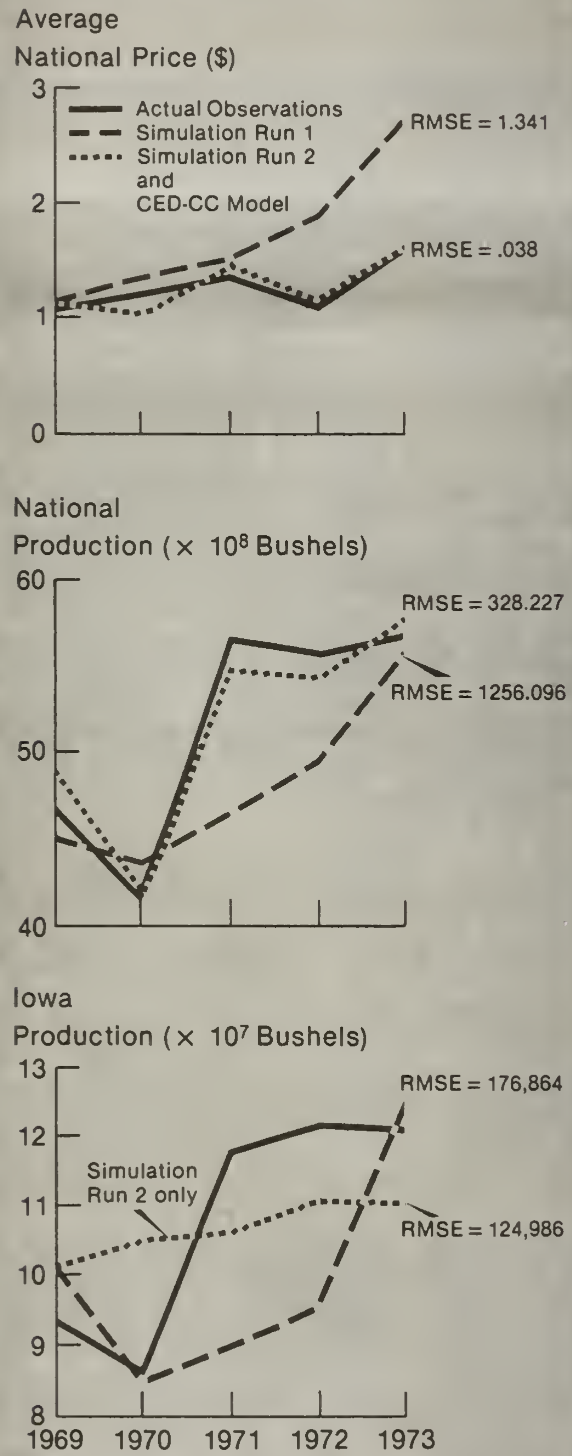


Figure 2

Soybeans: Performance of Hybrid and CED-CC Models Compared with Actual Observations

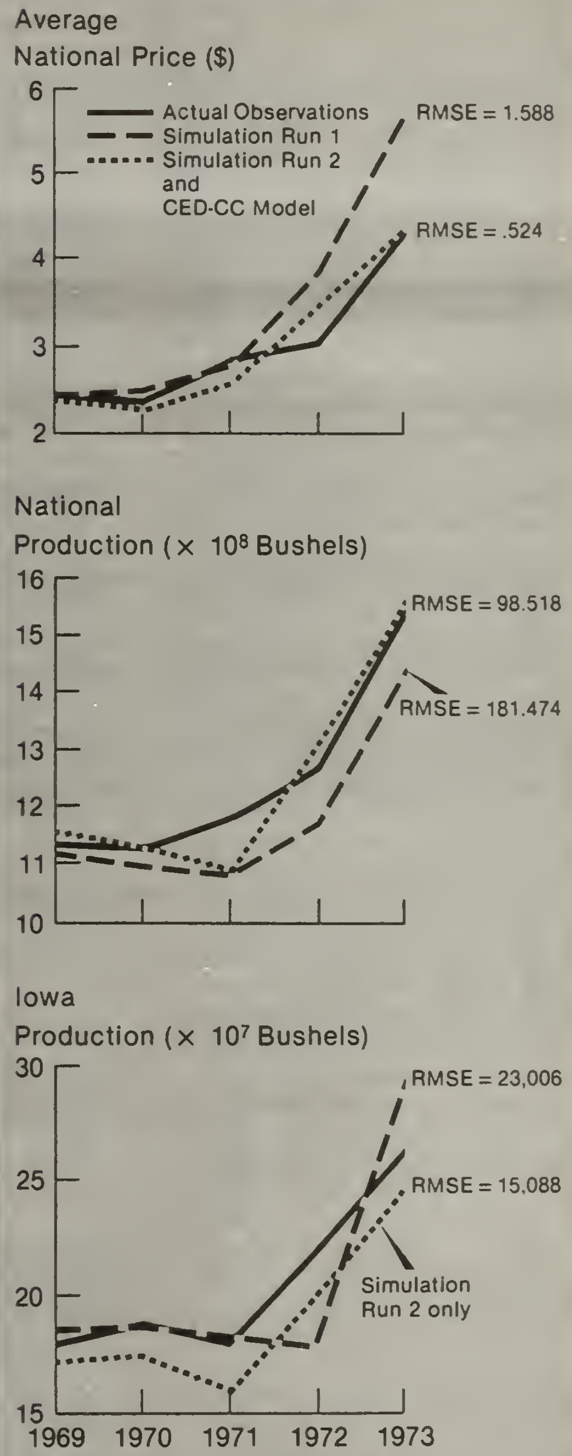


Figure 3

Oats: Performance of Hybrid and CED-CC Models Compared with Actual Observations

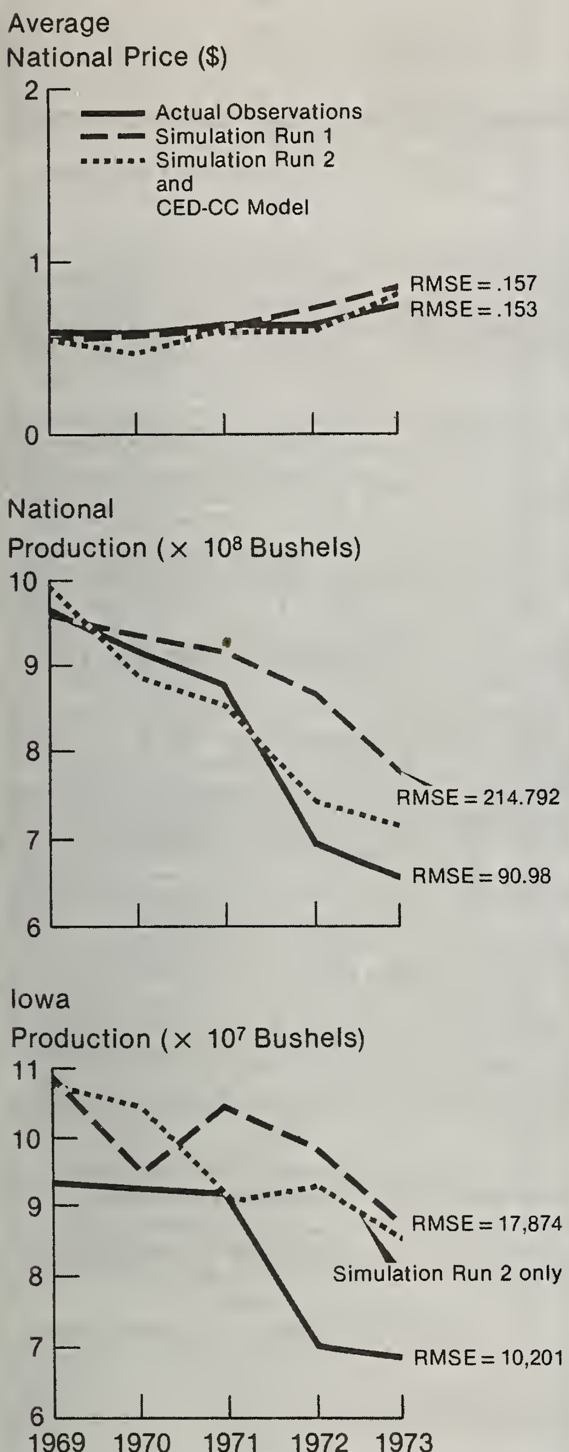
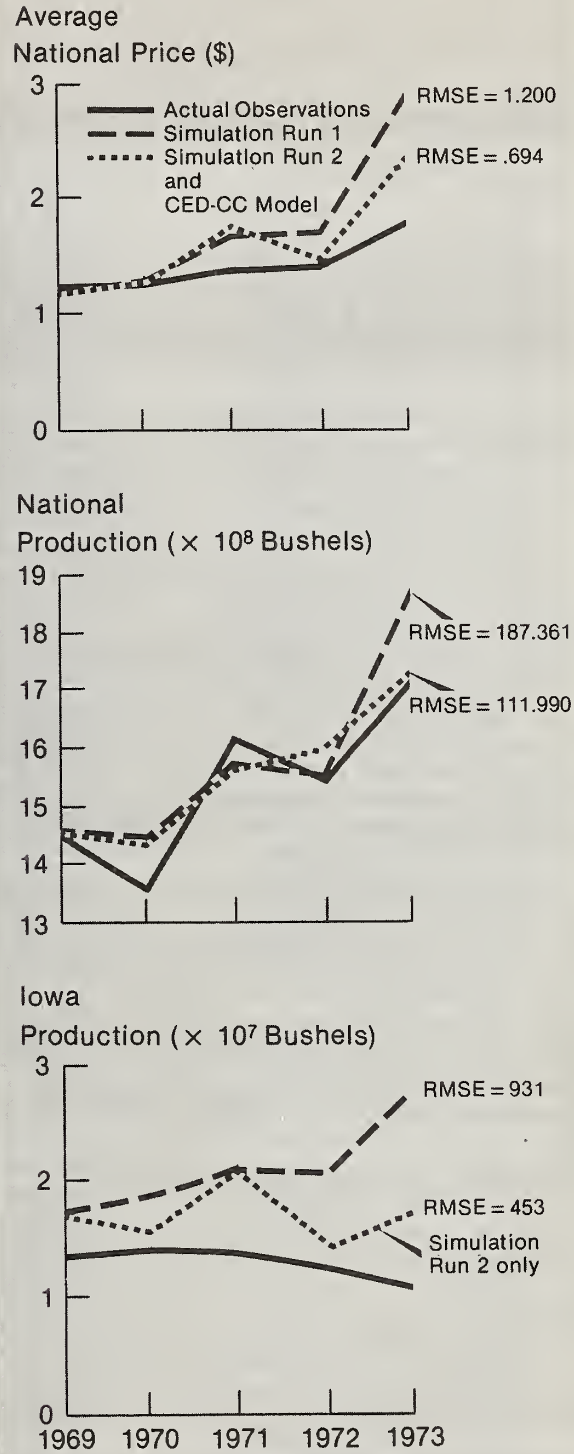


Figure 4

Wheat: Performance of Hybrid and CED-CC Models Compared with Actual Observations



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AN ALLOCATION MODEL FOR CONSUMER EXPENDITURES

By Jitendar S. Mann*

INTRODUCTION

The consumer's basic problem, as defined by economists, is how to allocate expenditures among different commodities, given their prices and the consumer's income. When income and prices change, the consumer changes the income shares spent on different commodities. For example, U.S. food expenditures as a percentage of personal consumption expenditure declined from 21 percent in 1960 to about 18 percent in 1977. The share of expenditure on food purchased for use at home also fell, from 17 to about 13 percent.

The objective here is to describe, analyze, and explain the behavior of budget shares (amount spent) for major commodity groups, with emphasis on food expenditures. A complete system of demand equations for consumer expenditures is estimated, and a full matrix of direct and cross price elasticities and income elasticities is presented.

In studying expenditure allocation, the analyst must specify a complete system, which should allocate consumer expenditures among all categories. The Rotterdam model used here (developed by Theil and his associates—(*1-3; 11-13*)) explains the quantity component of the variation in budget shares.[1]

The Rotterdam model, a complete consumer demand system, was fitted to personal consumption expenditure data for 1949-77 to study the interaction of consumer expenditures. A full matrix of direct and cross price elasticities and income elasticities was estimated. The 12 categories of expenditures were: food at home, food away from home, alcohol and tobacco, clothing, housing, utilities, transportation, medical, durables, other nondurables, services, and miscellaneous.

Keywords

Consumer expenditures
Consumer demand
Rotterdam model
Price elasticities
Income elasticities

BUDGET SHARES

The budget shares are defined as:

$$w_i = p_i q_i / m,$$

where w_i is the budget share of the i^{th} commodity; p_i, its price; q_i, the quantity purchased; and m, the total expenditure. The shares are non-negative and add up to one for all commodities. The consumer expenditure data analyzed are Personal Consumption Expenditures (PCE), published by the U.S. Department of Commerce. The data are combined into 12 major commodity groups: food at home, food away from home, alcohol and tobacco, clothing, housing, utilities, transportation, medical services, durables, other nondurables, services, and miscellaneous. The details of expenditure items included in each category appear in an appendix.

In this article, total expenditure is per capita personal expenditure. Saving is assumed exogenous and the terms "total expenditure" and "income" are used synonymously. Quantities are represented by per capita constant dollar PCE. Because these data are in constant dollars, variation in the time series is due to variation in quantities purchased only. Prices are the implicit prices obtained by dividing current dollar expenditure by constant dollar expenditure. The use of the implicit price deflator (instead of the Consumer Price Index) assures that price times quantity equals expenditure.

The budget shares of the 12 expenditure categories for 1949-77 appear in table 1. The share of food consumed at home declined from about 19 percent in 1949 to about 13 percent in 1977. The share of food consumed away from home has remained almost unchanged. The share of alcohol and tobacco used has fallen steadily. Clothing expenditure went from about 13 percent in 1949 to about 8 percent in 1977. While the share spent on housing increased, that for utilities remained steady. Transportation increased slightly. The share spent on medical services more than doubled. The shares of durables and other nondurables did not change. Services rose a bit during the period. The miscellaneous category includes items which do not pass through the marketing system but are included in PCE to account for the output of certain sectors.

The partial elasticities of budget share with respect to price, quantity,

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

Table 1—Budget shares of personal consumption expenditures

Year	Food at home	Food away from home	Alcohol and tobacco	Clothing	Housing	Utilities	Transportation	Medical	Durables	Other nondurables	Other services	Miscellaneous
						Percent						
1949	18.86	4.57	6.63	12.98	9.93	3.35	6.98	4.49	12.39	4.93	9.22	5.67
1950	18.07	4.33	6.32	12.21	10.24	3.49	6.90	4.49	14.28	5.02	9.20	5.46
1951	18.82	4.52	6.17	12.11	10.65	3.49	6.94	4.49	12.72	5.11	9.08	5.90
1952	18.89	4.52	6.29	12.05	11.30	3.48	7.15	4.63	11.71	4.90	9.05	6.03
1953	18.25	4.36	6.10	11.54	11.89	3.46	7.27	4.80	12.57	4.80	9.13	5.83
1954	18.38	4.25	5.86	11.32	12.59	3.61	7.24	5.05	12.00	4.70	9.37	5.64
1955	17.67	4.09	5.58	10.01	12.50	3.66	7.23	4.97	13.68	4.69	9.59	5.32
1956	17.62	4.10	5.55	10.96	12.77	3.74	7.42	5.14	12.66	4.74	9.94	5.35
1957	17.80	4.06	5.47	10.51	12.98	3.77	7.55	5.36	12.44	4.77	10.00	5.30
1958	18.13	3.97	5.43	10.30	13.47	3.88	7.59	5.64	11.13	4.79	10.25	5.41
1959	17.39	3.94	5.45	10.13	13.44	3.75	7.64	5.73	12.02	4.80	10.33	5.36
1960	16.96	4.01	5.39	9.90	13.77	3.74	7.76	5.92	11.68	4.88	10.67	5.31
1961	16.80	4.11	5.38	9.81	14.21	3.75	7.68	6.14	10.85	5.01	10.96	5.31
1962	16.01	4.15	5.28	9.67	14.35	3.71	7.64	6.32	11.52	5.20	10.84	5.31
1963	15.46	4.17	5.22	9.43	14.41	3.70	7.50	6.46	12.09	5.27	10.96	5.30
1964	15.33	4.14	5.02	9.54	14.28	3.63	7.35	6.77	12.43	5.31	10.94	5.24
1965	15.35	4.07	4.93	9.35	14.17	3.55	7.35	6.72	12.96	5.35	10.94	5.25
1966	15.41	3.97	4.84	9.45	13.93	3.48	7.39	6.73	12.87	5.56	11.06	5.32
1967	14.94	3.89	4.81	9.37	14.05	3.47	7.50	6.91	12.54	5.54	11.45	5.53
1968	14.70	3.96	4.68	9.34	13.87	3.37	7.42	6.99	13.26	5.58	11.40	5.43
1969	14.49	3.93	4.53	9.29	13.92	3.34	7.51	7.47	13.00	5.59	11.44	5.41
1970	14.72	3.99	4.61	8.96	14.14	3.37	7.71	7.85	12.11	5.61	11.46	5.47
1971	14.00	3.86	4.48	8.90	14.40	3.38	7.82	8.00	12.94	5.55	11.38	5.29
1972	13.61	3.83	4.36	8.83	14.33	3.43	7.72	8.17	13.58	5.58	11.29	5.29
1973	13.80	3.92	4.25	8.86	14.20	3.49	7.66	8.25	13.64	5.67	11.13	5.11
1974	14.29	4.03	4.14	8.57	14.30	3.78	8.32	8.46	12.10	5.72	11.17	5.11
1975	14.27	4.17	4.05	8.36	14.26	4.03	8.13	8.93	11.96	5.49	11.25	5.11
1976	13.60	4.24	3.93	8.13	14.15	4.15	8.15	9.40	12.79	5.35	11.12	4.99
1977	13.28	4.29	3.71	7.91	14.16	4.26	8.30	9.61	13.20	5.24	11.05	4.99
Average	16.10	4.12	5.12	9.96	13.33	3.63	7.55	6.55	12.53	5.20	10.54	5.38

The share of food consumed at home declined from about 19 percent in 1949 to about 13 percent in 1977. The share of food consumed away from home has remained almost unchanged.

and income are 1, 1, and −1, respectively. To see this, take the total differential of the definition of w_i:

$$dw_i = \frac{q_i}{m} dp_i + \frac{p_i}{m} dq_i - \frac{p_i q_i}{m^2} dm$$

$$= w_i d \log p_i + w_i d \log q_i$$

$$- w_i d \log m.$$

This equation states that the change in the i^{th} budget share is a weighted sum of logarithmic (relative) changes in price, quantity, and income; the weights being the budget share of the i^{th} commodity. Dividing by w_i, we obtain these elasticities:

$$\frac{\partial \log w_i}{\partial \log p_i} = 1$$

$$\frac{\partial \log w_i}{\partial \log q_i} = 1$$

$$\frac{\partial \log w_i}{\partial \log m} = -1$$

The relative importance of the variation in prices and quantities gives us an idea of the variation of relative shares. These changes in prices and quantities appear in tables 2 and 3.

Prices of these categories increased throughout 1949-77: food away from home, housing, transportation, medical services, and other services. Demand for housing and medical services also rose steadily during the period. The largest average annual price increase was for medical services—4.45 percent.

The average price increase for food at home was 3.32 percent; for food away from home, 4.13 percent. Large price increases in utilities (22.56 percent) and transportation services (16.95 percent) during 1973-74 should be noted.

The share spent on housing increased the most annually—3.87 percent. During 1949-77, food at home rose 0.93 percent and food away from home, 1.16 percent.

The components of change in the share of food consumed at home appear in table 4. Income (total PCE) went up each year from 1949, to 197 percent. The price of food at home increased at an average annual rate of 3.32 percent, the quantities consumed increased 0.93 percent, and per capita income rose 5.49 percent. Expenditures on food during this period averaged 16.1 percent and declined about 0.2 percentage point annually.

We want to know the relationship between income and price elasticity and the change in budget shares during the period. First, assume that p_i is constant, and write the above differential as:

$$dw_i = w_i d \log q_i - w_i d \log m$$

$$= w_i \left[\frac{d \log q_i}{d \log m} - 1\right] d \log m$$

From this we get the following expression:

$$\frac{d \log w_i}{d \log m} \quad p_i = \text{constant} = E_i - 1$$

where E_i is the income elasticity.

For it to be positive, for w_i to go up when m increases, we need:

$$E_i > 1.$$

Now assume that m is unchanged, and:

$$\frac{d \log w_i}{d \log p_i} \quad m = \text{constant}$$

$$= \epsilon_{ii} + 1,$$

where ϵ_{ii} is the price elasticity.

For the share w_i to go down when p_i increases, we need:

$$\epsilon_{ii} > -1.$$

A luxury is defined as a commodity with an income elasticity greater than 1. If a good is a luxury, its budget share goes up as income goes up with the price assumed constant. This occurs because when $E_i > 1$, a given proportionate increase in income has a larger proportionate effect on $p_i q_i$, the numerator of w_i.

THE MODEL

I now present a derivation of the absolute prices version of the allocation model for consumer expenditures. A more detailed derivation of the general model appears in (*12*).

The demand function for a commodity can be formulated in income and prices:

$$q_i = q_i (m, p_1, ..., p_n)$$

$$i = 1, 2, ..., n,$$

Table 2—Relative changes in implicit price deflators, 1949-50 through 1976-77*

Year	Food at home	Food away from home	Alcohol and tobacco	Cloth-ing	Hous-ing	Util-ities	Trans-porta-tion	Medical	Dur-ables	Other nondur-ables	Ser-vices	Miscel-laneous
1949-50	1.48	2.29	−0.54	−0.63	3.44	1.66	4.68	1.11	2.89	0.63	1.51	0.93
1950-51	10.52	7.16	2.70	8.46	3.98	2.21	5.38	2.63	4.86	7.56	6.30	10.22
1951-52	1.75	.57	6.19	−.73	3.98	1.59	4.76	4.64	0	−1.91	6.37	.33
1952-53	−1.75	0	.83	.15	5.32	2.55	5.20	4.83	1.35	.44	5.36	−.67
1953-54	0	1.89	1.80	.29	3.35	.70	3.37	3.29	−3.26	−.44	2.47	−2.04
1954-55	−1.93	.93	0	−.29	1.42	1.79	1.57	2.63	1.37	1.76	3.80	−.86
1955-56	.75	1.84	1.29	2.16	1.82	1.76	1.85	2.02	2.82	1.88	5.16	1.89
1956-57	3.22	3.75	2.06	1.56	1.79	2.52	4.04	3.92	4.53	3.51	5.08	2.68
1957-58	4.23	2.94	.94	.56	1.89	1.30	2.75	3.43	.25	2.59	3.48	2.61
1958-59	−1.39	2.85	3.51	.97	1.33	1.92	2.81	2.83	3.60	1.07	3.03	3.17
1959-60	.97	2.45	2.67	1.51	1.57	1.76	2.47	3.07	.49	1.59	4.38	2.01
1960-61	.96	2.24	.87	.81	1.29	1.85	.94	2.51	.97	1.43	.79	1.37
1961-62	.68	2.65	1.30	.40	1.15	0	.93	2.00	1.55	.77	2.95	1.94
1962-63	1.35	2.28	1.70	1.07	1.01	.61	.13	1.36	.94	1.53	3.46	2.19
1963-64	1.73	1.64	1.54	1.19	1.00	−.85	.13	2.08	1.05	1.75	2.05	1.86
1964-65	2.35	2.34	2.06	.92	.99	.49	3.51	2.61	−.46	.49	2.43	2.66
1965-66	5.16	4.67	2.81	2.57	1.34	.97	2.77	4.20	.23	.98	4.15	3.53
1966-67	−.49	4.98	4.01	4.11	1.80	1.32	2.70	5.73	1.84	2.53	3.20	3.15
1967-68	3.51	4.99	4.95	5.11	2.36	1.42	2.39	4.93	3.69	3.86	5.99	4.06
1968-69	4.76	5.94	4.94	5.52	3.21	1.98	4.28	6.21	2.39	3.71	5.76	5.56
1969-70	5.19	7.15	6.12	3.98	4.09	3.84	5.51	4.86	2.54	3.90	5.12	4.59
1970-71	1.92	5.02	4.64	3.11	4.55	6.44	5.02	5.16	3.49	3.96	5.61	5.67
1971-72	5.45	4.08	3.05	2.12	3.36	3.87	1.92	4.71	1.01	2.12	4.71	5.87
1972-73	14.41	8.16	.40	3.44	4.21	7.23	4.40	4.97	1.78	2.37	4.40	8.71
1973-74	16.04	11.56	6.18	6.73	4.96	22.56	16.95	8.55	6.56	11.34	8.00	13.52
1974-75	7.39	8.12	7.31	3.81	4.98	11.95	6.34	12.92	8.21	12.37	6.99	9.32
1975-76	.95	6.45	4.68	3.42	5.32	9.12	7.80	9.08	5.60	5.62	4.04	5.74
1976-77	3.79	6.59	3.67	3.79	5.77	9.84	7.56	8.20	4.16	5.25	4.56	8.51
Average	3.32	4.13	2.92	2.36	2.90	3.66	4.01	4.45	2.30	2.95	4.33	3.88

*Changes in logs multiplied by 100.

Table 3—Relative changes in quantities, 1949-50 through 1976-77*

Year	Food at home	Food away from home	Alcohol and tobacco	Cloth- ing	Hous- ing	Util- ities	Trans- porta- tion	Medical	Dur- ables	Other nondur- ables	Ser- vices	Miscel- laneous
1949-50	-0.07	-1.80	1.79	0.40	5.40	8.12	-0.08	4.66	16.99	6.80	3.97	0.95
1950-51	-.24	3.30	.83	-3.21	6.13	4.15	1.46	3.71	-10.19	.37	-1.31	3.95
1951-52	1.87	2.68	-.91	3.54	5.02	1.31	1.29	1.62	-5.25	1.01	-3.52	5.04
1952-53	2.32	.31	-.02	-.53	3.91	.67	.47	2.68	9.93	1.60	-.50	1.32
1953-54	1.46	-3.51	-4.97	-1.36	3.07	4.39	-2.77	2.63	-.65	-1.02	.81	-.65
1954-55	3.34	.64	.58	-2.77	3.25	4.94	3.52	1.24	17.14	3.50	3.99	.31
1955-56	1.97	1.04	1.11	.39	3.25	3.40	3.70	4.26	-7.65	2.08	1.29	1.79
1956-57	1.17	-1.17	-.15	-2.42	3.27	1.59	1.13	3.54	-2.85	.60	-.91	-.28
1957-58	-.85	-3.67	-.17	-.98	3.34	3.07	-.72	3.34	-9.92	-.75	.45	.90
1958-59	2.69	1.86	2.17	2.76	3.78	.22	3.18	4.03	9.50	4.46	3.15	1.22
1959-60	-.69	1.98	-.97	-1.01	3.75	.82	1.91	3.11	-.43	2.92	1.74	.14
1960-61	-.54	1.66	.34	-.28	3.28	-.19	-.43	2.45	-6.93	2.55	3.22	-.14
1961-62	-1.19	2.78	1.37	2.47	4.14	3.23	2.76	5.26	8.71	7.39	.27	2.44
1962-63	-.94	2.02	.97	.27	3.22	3.08	1.96	4.57	7.71	3.71	1.72	1.55
1963-64	2.68	2.98	-.12	5.32	3.37	3.96	3.09	8.08	6.98	4.38	2.86	2.33
1964-65	3.70	1.75	1.88	2.88	4.20	3.43	2.45	2.49	10.60	6.03	3.52	3.45
1965-66	1.91	-.48	2.17	5.23	3.56	3.50	4.44	2.52	5.77	9.62	3.61	4.40
1966-67	1.76	-2.70	-.31	-.51	3.49	2.95	3.14	1.42	-.05	1.45	4.65	5.17
1967-68	2.80	4.78	.14	2.47	4.30	3.62	4.45	4.06	9.81	4.80	1.54	1.97
1968-69	.73	.15	-1.27	.69	3.96	3.91	3.81	7.33	3.16	3.28	1.44	.93
1969-70	1.73	-.09	.93	-2.15	2.89	2.34	2.39	5.52	-4.97	1.84	.36	1.73
1970-71	-.49	-1.94	-1.03	2.05	3.75	.43	3.03	3.16	9.56	1.39	.18	-2.39
1971-72	.02	3.34	2.72	5.31	4.42	5.81	4.97	5.67	12.19	6.72	2.75	2.25
1972-73	-3.78	3.56	6.17	6.05	4.10	3.90	4.14	5.26	7.84	8.54	3.45	-2.90
1973-74	-3.90	-.32	-.32	-1.34	4.44	-6.00	-.13	2.53	-9.82	-1.91	.94	-4.72
1974-75	1.22	4.03	-.68	2.48	3.48	3.30	.12	1.19	-.61	-7.60	2.55	-.73
1975-76	4.24	5.30	2.51	3.74	3.98	3.67	2.52	6.13	11.10	1.72	4.79	1.90
1976-77	3.16	4.06	-.25	2.94	3.57	2.22	3.53	3.35	8.38	2.08	4.21	.85
Average	.93	1.16	.52	1.38	3.87	2.71	2.12	3.78	3.43	2.77	1.83	1.17

*Changes in logs multiplied by 100.

Table 4—Components of change in share of food consumed at home, 1949-50 through 1976-77

Year	Change in share	Relative change (percent)		
		Price	Quantity	Income
	Number		*- - - Percent - - -*	
1949-50	−0.7936	1.48	−0.07	5.77
1950-51	.7564	10.52	− .24	5.89
1951-52	.0713	1.75	1.87	3.18
1952-53	− .6462	−1.75	2.32	4.00
1953-54	.1361	0	1.46	.83
1954-55	− .7090	−1.93	3.34	5.34
1955-56	− .0569	.75	1.97	2.93
1956-57	.1797	3.22	1.17	3.45
1957-58	.3358	4.23	− .85	1.46
1958-59	− .7393	−1.39	2.69	5.40
1959-60	− .4316	.96	− .69	2.86
1960-61	− .1631	.96	− .54	1.40
1961-62	− .7858	.68	−1.19	4.35
1962-63	− .5505	1.35	− .94	3.86
1963-64	− .1307	1.73	2.68	5.26
1964-65	.0156	2.35	3.70	5.93
1965-66	.0581	5.16	1.91	6.69
1966-67	− .0467	− .49	1.76	4.40
1967-68	− .0241	3.51	2.80	7.81
1968-69	− .0203	4.76	.73	6.85
1969-70	.0231	5.19	1.73	5.36
1970-71	− .7247	1.92	− .49	6.50
1971-72	− .3908	5.45	.02	8.28
1972-73	.1941	14.41	−3.78	9.19
1973-74	.4941	16.04	−3.90	8.66
1974-75	− .0275	7.39	1.22	8.77
1975-76	− .6722	.95	4.24	10.03
1976-77	− .3201	3.79	3.16	9.36
Average	− .1993	3.32	.93	5.49

where q_i is the quantity of the i^{th} commodity demanded; p_i, its price; and m, consumer income (equal to total expenditure). Taking the differential of the logarithm of the above demand function, we obtain:

$$d(\log q_i) = \frac{\partial(\log q_i)}{\partial(\log m)} \, d\,(\log m)$$

$$+ \sum_{j=1}^{n} \frac{\partial(\log q_i)}{\partial(\log p_j)} \, d(\log p_j)$$

$$i = 1, 2, ..., n.$$

Derivations on the right-hand side of this equation are the elasticities. The price elasticities are not symmetric. To obtain symmetry of the coefficients, multiply both sides of the equation by the budget share of the i^{th} commodity:

$$w_i = \frac{p_i q_i}{m} :$$

$$w_i \, d\,(\log q_i) = \left(\frac{p_i q_i}{m} \, \frac{\partial q_i}{\partial m} \, \frac{m}{q_i}\right) d\,(\log m),$$

$$+ \sum_{j=1}^{n} \left(\frac{p_i q_i}{m} \, \frac{\partial q_i}{\partial p_j} \, \frac{p_i}{q_i}\right) d\,(\log p_j)$$

$$= p_i \frac{\partial q_i}{\partial m} \, d\,(\log m)$$

$$+ \sum_{j=1}^{n} \frac{p_i q_j}{m} \, \frac{\partial q_i}{\partial p_j} \, d\,(\log p_j)$$

The coefficients of $d(\log p_j)$ are now symmetric. The left-hand side of this equation is the quantity component (endogenous) of a change in the consumer's budget shares. In the microeconomic theory of consumer behavior, prices and income are considered given and the quantities are the endogenous variables. Therefore, $w_i d(\log q_i)$ is the endogenous component of variations in budget shares.

Let us define:

$$\mu_i = p_i \frac{\partial q_i}{\partial m}$$

$$\pi_{ij} = \frac{p_i q_j}{m} \, \frac{\partial q_i}{\partial p_j}$$

so that

$$w_i d(\log q_i) = \mu_i\, d(\log m)$$

$$+ \sum_{j=1}^{n} \pi_{ij}\, d(\log p_j)\ i = 1, 2, ..., \text{n}.$$

The coefficient μ_i is called the marginal budget share of the i^{th} commodity. It represents the additional amount spent on the commodity when income (total expenditure) increases by 1 dollar. It is also called the marginal propensity to spend, and it is the income elasticity weighted by the value share. These coefficients satisfy the restriction:

$$\sum_{i=1}^{n} \mu_i = 1.$$

This is the adding up property of the demand system. The μ's do not have to be positive. For an inferior commodity, the marginal propensity to spend is negative. However, for broad commodity groups, the μ's are expected to be positive. Multiplying both sides of the definition of μ_i by $\frac{m}{q_i}$, we obtain:

$$\frac{m}{q_i}\mu_i = p_i \frac{\partial q_i}{\partial m}\frac{m}{q_i},$$

or

$$\frac{m\mu_i}{p_i q_i} = \frac{\partial q_i}{\partial m}\frac{m}{q_i},$$

or

$$E_i = \frac{\mu_i}{w_i},$$

where E_i is the income elasticity of demand for the i^{th} commodity.

The parameters π_{ij} are the compensated price elasticity (Slutsky) weighted by the budget shares. Dividing both sides of the definition of π_{ij} by q_i, we get:

$$\frac{\pi_{ij}}{q_i} = \frac{p_i p_j}{m}\frac{\partial q_i}{\partial p_j}\frac{1}{q_i}$$

or

$$\frac{\partial q_i}{\partial p_j}\frac{p_j}{q_i} = \frac{\pi_{ij}}{q_i p_i} m$$

or

$$\eta_{ij} = \frac{\pi_{ij}}{w_i},$$

where η_{ij} is the price elasticity of demand of commodity i for the j^{th} price. The coefficients π_{ij} are called the Slutsky coefficients, and the elasticities η_{ij} are the pure substitution elasticities under a compensating income change to keep utility constant.

The price coefficients, π_{ij}, form a symmetric, negative, semidefinite matrix of order n. Also:

$$\sum_{j=1}^{n} \pi_{ij} = 0 \quad i = 1, 2, ..., n.$$

The sum of these coefficients for each commodity is zero. This equation represents the homogeneity condition for the demand equations.

Substitutes and complements can be defined simply in terms of the sign of π_{ij} (6). If π_{ij} is positive, goods i and j are substitutes; if π_{ij} is negative, they are complements.

The Slutsky coefficients are defined as:

$$\pi_{ij} = \frac{p_i p_j}{m}\frac{\partial q_i}{\partial p_j}$$

where $\frac{\partial q_i}{\partial p_j}$ are the quantity price slopes with utility unchanging:

$$\left(\frac{\partial q_i}{\partial p_j}\right) u = \text{constant}.$$

The traditional formulation of the Slutsky equation is:

$$\frac{\partial q_i}{\partial p_j} = \left(\frac{\partial q_i}{\partial p_j}\right) u = \text{constant}$$

$$- q_j \frac{\partial q_i}{\partial m}$$

from which we get:

$$\left(\frac{\partial q_i}{\partial p_j}\right) u = \text{constant}$$

$$= \frac{\partial q_i}{\partial p_j} + q_j \frac{\partial q_i}{\partial m}.$$

Substitute this in the above definition,

$$\pi_{ij} = \frac{p_i p_j}{m}\left[\frac{\partial q_i}{\partial p_j} + q_j \frac{\partial q_i}{\partial m}\right].$$

The commonly estimated elasticities are generally uncompensated. The uncompensated cross price elasticities, however, do not tell us whether the goods are substitutes or complements.

Change to elasticities:

$$\eta_{ij} = \frac{\pi_{ij}}{w_i} = \frac{m}{p_i q_i} \frac{p_i p_j}{m} [\frac{\partial q_i}{\partial p_j} \cdot$$

$$+ q_j \frac{\partial q_i}{\partial m}] = [\frac{p_j}{q_i} \frac{\partial q_i}{\partial p_j}$$

$$+ \frac{p_j q_j}{m} \frac{\partial q_i}{\partial m} \frac{m}{q_i}] = [\epsilon_{ij} + w_j E_i],$$

where ϵ_{ij} are the uncompensated price elasticities. This equation gives the relationship between the uncompensated and compensated elasticities. The commonly estimated elasticities are generally uncompensated (*2*, *3*, *5*, *10*). The uncompensated cross price elasticities, however, do not tell us whether the goods are substitutes or complements.

ESTIMATION

To apply the model, we take changes in logs, and use the symbol (D) as the log-change operation:

$$D p_t = \log p_t - \log p_{t-1}$$

The demand model is thus:

$$w^*_{it} \, Dq_{it} = \mu_i \, Dq_t + \sum_{j=1}^{n} \pi_{ij} \, Dp_{jt}$$

$$+ U_{it} \quad i=1, ..., n$$

where:

$$w^*_{it} = \frac{w_{it-1} + w_{it}}{2}, \; Dq_t$$

$$= \sum_{i=1}^{n} w^*_{it} \, Dq_{it}$$

and U_{it} is a random error term with the following properties:

$$E(U_{it}) = 0$$

$$E(U_{it} U_{js}) = \begin{matrix} \omega & \text{if } s = t \\ o & \text{if } s \neq t \end{matrix}$$

The random errors do not correlate over time but do correlate across demand equations for each observation. It can be shown that the sum of n disturbances U_{it} equals zero for each time period, and that the matrix ω_{ij} is of rank n-1.

The variable Dq_t is a weighted sum of the logarithm of quantities demanded. It is the sum of the left-hand side of all the demand equations. Dq_t measures relative change in total consumption and can be used to measure the relative change in real income. Formally, we have 12 demand equations:

$$w^*_{it} \, Dq_{it} = \mu_i Dq_t + \sum_{j=1}^{12} \pi_{ij} \, Dp_{jt}$$

$$+ U_{it} \quad i=1, 2, ..., 12.$$

However, it can be shown that only 11 equations are independent. Summing the first 11, we get:

$$\sum_{i=1}^{11} w^*_{it} \, Dq_{it} = (\sum_{i=1}^{11} \mu_i) Dq_t$$

$$+ \sum_{j=1}^{12} (\sum_{i=i}^{11} \pi_{ij}) Dp_{jt} + \sum_{i=1}^{11} U_{it}$$

The left-hand side is $Dq_t - w^*_{12} Dq_{12t}$ because

$$Dq_t = \sum_{i=1}^{12} w^*_{ij} Dq_{it}.$$

The first term on the right-hand side is $(1 - \mu_{12})Dq_t$, because

$$\sum_{i=1}^{12} \mu i = 1.$$

From

$$\sum_{i=1}^{12} \pi_{ij} = \sum_{j=1}^{12} \pi_{jt} = 0$$

and symmetry, we have

$$\sum_{j=1}^{11} \pi_{ij} = - \pi_{j12} = - \pi_{12j}.$$

Because the sum of U_{it} is zero for each t,

$$\sum_{i=1}^{11} U_{it} = - U_{12}.$$

Using these values we obtain:

$$Dq_t - w^*_{12} Dq_{11t} = (1 - \mu_{12})$$

$$Dq_t - \sum_{j=1}^{12} \pi_{12j} \, Dp_{jt} - U_{12t}$$

which is the 12th equation. In other words, we can leave out the 12th equation because all the information is contained in the other 11. Also, Barten has shown that it makes no difference which equation is left out; the estimates of the coefficients will be the same (*3*).

Here, the equation for the miscellaneous category was omitted, being of little interest because the

As utility prices rise, food consumption goes up, while that of alcohol and tobacco, clothing, other nondurables, and services declines. Low income elasticity of food consumed at home explains the fall in the budget share of this category from 1949 to 1977.

items are included in the PCE for accounting purposes only.

We can impose homogeneity on the model by using the miscellaneous price as a deflator for the other 11 prices. Estimates of the coefficients were obtained in several stages. First, the model was fitted without symmetry restrictions and with and without the intercepts. The model without the intercepts gave positive price elasticities for the clothing, medical services, and durables categories. The model with intercepts also gave a positive price elasticity for clothing. Estimates of price elasticities for medical and durables were negative, however, while the income elasticity estimate for durables was high.

Second, the model was fitted with the symmetry constraint; estimates of price coefficients were required to be symmetric. Again, positive estimates were obtained for price elasticities for the medical services and durables categories. So this problem could be overcome, the negative price elasticities from an unconstrained system with intercepts were included as prior estimates in a symmetric system. The model also includes the theoretical restriction implied by the homogeneity, adding-up, and symmetry conditions.

RESULTS

As discussed above, the demand system was fitted by including prior own-price coefficients for medical services (−0.01176) and durables (−0.10426) (table 5). Because the Slutsky matrix is symmetric, only the upper triangle of the price coefficient matrix appears. Values in parentheses under the coefficients in table 5 are the *t* values. All the income coefficients have high *t* values, as do the own-price coefficients (except for *a priori* medical services and durables). Estimates of all the price and income elasticities appear in table 6.

All the income elasticities are positive in table 6, which means that all goods are normal. One expects this behavior at this level of aggregation. The following categories have income elasticity estimates greater than one, which shows they are luxuries: food away from home (1.16), medical services (1.289), durables (2.459), nondurables (1.275), and services (1.009).

The positive sign of cross elasticity means substitutability; the negative sign indicates complementarity between two goods. Food consumed at home substitutes for food away from home, alcohol and tobacco, clothing, housing, utilities, medical, other nondurables, and services. Food at home shows complementarity with transportation and durables. Food away from home substitutes for food at home, alcohol and tobacco, clothing, housing, utilities, and other nondurables. Food away from home shows complementarity with the transportation, medical, and services categories. The estimates of income and price elasticities for food at home are 0.364 and −0.463, respectively. The elasticity estimates for food consumed away from home are 1.16 (income) and −0.917 (price). The income elasticity of demand for food consumed at home is, not surprisingly, the smallest of all the expenditure categories.

The cross elasticities in table 6 show that utilities substitute for food consumed at home and food away from home. As utility prices rise, food consumption goes up, while that of alcohol and tobacco, clothing, other nondurables, and services declines. Higher priced transportation services, a major part of which is oil and gasoline, are associated with lower use of food at home, food away from home, housing, medical, durables, and other nondurables. A rise in the prices of medical services is associated with a decline in consumption of food away from home, alcohol and tobacco, transportation, and nondurables.

Low income elasticity of food consumed at home explains the fall in the budget share of this category from 1949 to 1977. The income elasticity of food consumed away from home is close to one, which agrees with the almost constant budget share.

LIMITATIONS

The analysis and results presented here have three drawbacks: limitations of the general approach, the specific model, and the data.

The general approach, based on classical consumer demand theory, explains variations in consumption in terms of consumer income and prices. Although the model is a "complete system," it does not account for all the possible variables. Thus, specification error could occur in, for example, the equation for durables. The demand for durables, which is complex, depends on many

Table 5—Estimates of the coefficients of a demand system for consumer expenditures

Item	Marginal shares	Slutsky coefficients										
		Food at home	Food away from home	Alcohol and tobacco	Clothing	Housing	Utilities	Trans-portation	Medical	Durables	Other non-durables	Services
Food at home	0.05863	−0.07456	0.01013	0.00848	0.01304	0.01820	0.01175	−0.00890	0.01052	−0.01106	0.02019	0.00543
	(3.91508)	(6.62960)	(1.31471)	(1.67941)	(1.47319)	(1.94207)	(2.72088)	(1.95838)	(1.07927)	(.66704)	(3.14762)	(.62554)
Food away from home	0.4780		−.03777	.00650	.00824	.00161	.01856	−.01523	−.00839	.01599	.01439	−.00487
	(5.50558)		(2.35581)	(.86211)	(.63824)	(.14739)	(3.04852)	(2.05569)	(.75708)	(1.50829)	(1.55846)	(.49808)
Alcohol and tobacco	.01911			−.01594	−.01215	.00005	−.00622	.00526	−.00674	.03769	−.01799	−.00807
	(3.56263)			(2.24856)	(1.44359)	(.00713)	(1.52223)	(1.13153)	(.96656)	(5.10675)	(2.88649)	(1.22929)
Clothing	.06616				−.03933	−.01373	−.00688	.00122	.00826	.03721	−.00083	.00300
	(6.52404)				(2.15044)	(1.10681)	(1.03315)	(.16839)	(.66061)	(2.74923)	(.08521)	(.26591)
Housing	.12540					−.03169	.01014	−.00873	.00741	−.02250	.00878	.03809
	(10.83640)					(1.98882)	(1.75852)	(1.28231)	(.60499)	(1.64094)	(.99544)	(3.48907)
Utilities	.03496						−.01843	.00965	.00976	.00853	−.00031	−.00985
	(7.41158)						(4.04832)	(2.30511)	(1.65818)	(1.34284)	(.05964)	(1.77126)
Transportation	.05615							−.02075	−.01383	−.01226	−.00389	.03135
	(11.16300)							(3.38544)	(2.20837)	(1.84286)	(.67674)	(5.29064)
Medical	.08444								−.01176	.01569	−.02901	.01346
	(6.69910)								(a priori)	(.97996)	(3.28437)	(1.31675)
Durables	.30808									−.10426	.01963	−.00073
	(9.72334)									(a priori)	(1.96979)	(.05275)
Nondurables	.06626										−.03552	.02858
	(9.51261)										(3.32586)	(3.55683)
Services	.10626											−.08789
	(10.23920)											(5.94478)

Table 6—Estimates of income and price elasticities

Item	Income elasticities	Price elasticities										
		Food at home	Food away from home	Alcohol and tobacco	Clothing	Housing	Utilities	Trans-portation	Medical	Durables	Other non-durables	Services
Food at home	0.364	−0.463	0.063	0.053	0.081	0.113	0.073	−0.055	.093	−0.069	0.125	0.034
Food away from home	1.160	.246	−.917	.158	.200	.391	.450	−.370	−.204	.388	.349	−.118
Alcohol and tobacco	.373	.166	.127	−.311	−.237	.001	−.121	.103	−.132	.736	−.351	−.158
Clothing	.665	.131	.083	−.122	−.395	−.138	−.069	.013	.083	.374	−.008	.030
Housing	.941	.137	.012	.000	−.103	−.283	.076	−.065	.056	−.169	.066	.286
Utilities	.964	.324	.511	−.171	−.190	.279	−.507	.266	.269	.235	−.009	−.271
Transportation	.743	−.118	−.202	.070	.016	−.116	.128	−.275	-183	−.162	−.052	.415
Medical	1.289	.161	−.128	−.103	.126	.113	.149	−.211	−.180	.240	−.443	.205
Durables	2.459	−.088	.128	.301	.297	−.180	.068	−.098	.125	−.832	.157	−.006
Nondurables	1.275	.388	.277	−.346	−.016	.169	−.006	−.075	−.558	.378	−.683	.550
Services	1.009	.052	−.046	−.077	.028	.361	−.093	.288	.128	−.007	.271	−.834

Earlier studies have usually treated food demand in isolation from consumers' other allocation decisions.

other variables besides prices and income. An elaborate model for durables would include credit availability, interest rate, average life of the equipment, and so on.

The specific model used here, the Rotterdam Model, is based on the principle of maximization of utility without restriction on the functional form. Therefore, it is more realistic and general than other complete systems, such as the linear expenditure system or the indirect addilog model. However, the Rotterdam Model assumes that marginal budget shares (μ_{ie}) and the Slutsky coefficients (π_{ij}) are constant; that is, they are independent of prices and income. The rapid rise in prices since 1972 makes this a restrictive assumption. A model encompassing variable parameters for these two elements must await further developments in the theory of consumer demand.

The third category of limitations is inherent in the Personal Consumption Expenditure data used here. The PCE represents the most comprehensive series available on consumer expenditure, but it has many limitations when considered for use in demand analysis. Developed as a part of the national income accounts, the PCE must fit into these accounts' requirements and definitions.

For example, the PCE on durables is obtained by multiplying the number of pieces of equipment sold by an average price and allocating the expenditure between personal consumption and producer durable equipment. What consumers actually pay during any given year is the installment payment. Any difference between the PCE and the amount of equipment sold is a source of error.

PCE expenditure on medical service measures the expenditure by the private sector. In recent years, the proportion of health expenditure financed by the Government has increased considerably. According to U.S. Department of Health, Education and Welfare estimates, public expenditure on health services increased from 20 percent in 1950 to 42 percent in 1976 (*6*). See (*8*) for a critique of personal consumption expenditure data for food.

The study reported on here represents, despite these limitations, a major step in studying food demand as part of an interrelated system of consumer demand equations. Earlier studies have usually treated food demand in isolation from consumers' other allocation decisions. Hassan and others made the only other application of the Rotterdam model to U.S. data known to this author (7). They fitted the relative prices versions of the model to PCE data for 1929-65, and, to estimate the coefficients, they incorporated the separability hypothesis. Recent revisions of the U.S. national income accounts (*15*) provided additional motivation for the present work.

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APPENDIX: THE DATA

Data used here are per capita U.S. personal consumption expenditures for 1949-77, divided into 12 commodity groups:

(1) Food at home includes food purchased for off-premise consumption excluding alcohol.

(2) Food away from home includes purchased meals and beverages.

(3) Alcohol and tobacco.

(4) Clothing includes shoes, and other footwear; shoe cleaning and repair; clothing and accessories except footwear; cleaning, laundering, dyeing, pressing, alteration, storage, and repair of garments; and jewelry and watches.

(5) Housing includes owner-occupied nonfarm dwellings and tenant-occupied nonfarm dwellings.

(6) Utility includes electricity, gas, fuel oil, and coal.

(7) Transportation includes tires, tubes, accessories, and other parts; repair, greasing, washing, parking, storage and rental, gasoline and oil; bridge, tunnel, ferry, and toll roads, insurance premiums less claims paid, purchased local transportation; and purchased intercity transportation.

(8) Medical care expenses include drug preparations and sundries; physician, dentist, and other professional services, and privately controlled hospitals and sanitariums; medical care and hospitalization insurance; income loss insurance; and workmen's compensation insurance.

(9) Durable goods include furniture, mattresses, and bedsprings; kitchen and other household appliances; china, glassware, tableware, and utensils; other durable house furnishings; books and maps; wheel goods, durable toys, sports equipment, boats, and pleasure aircraft; radio and television receivers; new autos; net purchases of used autos; and other motor vehicles.

(*10*) Other nondurable goods include toilet articles and preparations; semidurable household furnishings; cleaning and polishing preparations; miscellaneous household supplies and paper products; stationery and writing supplies; magazines, newspapers, and sheet music; nondurable toys and sport supplies; and flowers, seeds, and potted plants.

(11) Other services include personal business expenditures; barber shops, beauty shops, and baths; water and other sanitary services; telephone and telegraph; domestic service; other household operations; radio and television repair; admissions to spectator amusements; clubs and fraternal organizations; parimutual net receipts; other recreation; and commercial participant amusements.

(12) Miscellaneous includes private education and research; religious and welfare activities; net foreign travel; food furnished employees; food produced and consumed on farms; clothing furnished military; rental value of farm dwellings; other housing; and ophthalmic products and orthopedic appliances.

Detailed expenditures from the Commerce Department public use tapes were aggregated into these 12 categories. Dividing the current dollar expenditure by the constant dollar expenditure produced implicit price deflators.

THE EFFECT OF PRICE-INSULATING POLL POLICIES ON EXCHANGE RATE ANALYSIS

By William H. Meyers, Elizabeth J. Gerber, and Maury E. Bredahl*

A model derived to compute exchange rate effects on trade uses foreign internal demand elasticities and price transmission elasticities which account for government price-insulating policies. Appreciation of the Japanese yen relative to the dollar is analyzed for impacts on Japanese imports of U.S. wheat, feed grains, and soybeans.

Keywords

Exchange rate
Government price policies

The relationship between exchange rate fluctuations and U.S. agricultural exports has been a topic of considerable interest to policymakers and economists since the currency adjustments of the early seventies. The recent weakening of the U.S. dollar has intensified the debate on the nature and magnitude of exchange rate impacts. Schuh postulated that the currency realignment of the early seventies had a major effect on subsequent crop price increases (*7*).[1] Kost proposed some theoretical reasons why the impact should be small (*6*). Bredahl and Gallagher extended Kost's analysis by developing conditions under which export impacts could be large or small in a free trade model (*3*). Bredahl and Womack compared free trade and restricted trade cases in the context of the European Economic Community (EC) trade policies for grains (*1*). Johnson, Grennes, and Thursby tested Schuh's hypothesis for wheat, using derived price elasticities, and concluded that foreign government policies were more important than exchange rates in explaining the wheat price surge in 1973/74 (*5*). Yandle, using a commodity equilibrium approach to analyze exchange rate effects on the wheat market for the 1971 to 1974 period, found that exchange rates were a minor factor in explaining the price and export changes (*10*).

The size of the U.S. export demand elasticities colors much of the debate over the magnitude of exchange rate impacts. Schuh (*8*) pointed to foreign demand elasticity computations by Tweeten (*9*), which were large. Bredahl, Meyers, and Collins later showed that omitting the effects of price-insulating policies in trading countries leads to serious overstatements of U.S. export demand elasticities (*2*). These internal price policies are therefore an important factor in the analysis of exchange rate effects.

We develop a model of shortrun exchange rate effects which uses price transmission elasticities to account for price-insulating policies. The model derives the commodity equilibrium impacts on U.S. price and exports as a weighted summation of effects in individual countries. We demonstrate the price transmission effects by a partial equilibrium application to Japan.

THE ANALYTICAL MODEL

The impact of the exchange rate on U.S. agricultural exports can be divided into two components (see figure). A devaluation of U.S. currency rotates import demand (ID) to the right.[2] Exports increase from M_0 to M_1 at the initial export price P_0 — this is the maximum impact on exports. Equilibrium price rises to P_2 if export supply is not perfectly elastic, and the net increase in exports is reduced to M_2-M_0. Given the elasticities of export supply (η_{es}) and import demand (η_{ed}) and the relative shift in import demand at $P_0(\hat{M})$,[3] the relative changes in equilibrium price ($\hat{P}$) and exports ($\hat{X}$) can be determined by:

$$\hat{P} = \frac{1}{\eta_{es} - \eta_{ed}} (\hat{M}) \qquad (1)$$

$$\hat{X} = \frac{\eta_{es}}{\eta_{es} - \eta_{ed}} (\hat{M}) \qquad (2)$$

Countries must be treated individually, because exchange rates behave differently in each country. The shift in the import demand at $P_0(dM)$ can be separated into shifts in demand (dD) and supply (dS) by country:

$$dM = \sum_i (dD_i - dS_i) \qquad (3)$$

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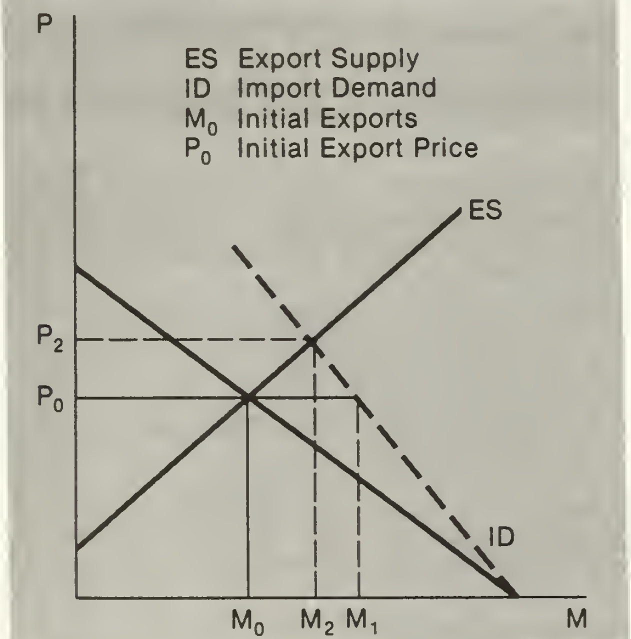
[1] Italicized numbers in parentheses refer to items in References at the end of this article.

[2] See (*3*) for a more detailed treatment.

[3] For the relative shift (such as dM/M), we use the notation $\hat{M}$.

Countries must be treated individually, because exchange rates behave differently in each country.

Illustration of the Components of An Exchange Rate Impact



Shifts in exchange rates would not affect current supply in the short run, because of production lags. Thus, separation of the relative shift in import demand by country becomes:

$$\hat{M} = \sum_i \hat{D}_i \frac{D_i}{M} \qquad (4)$$

where:

$\hat{D}_i$ = the relative shift in the i^{th} country's demand resulting from an exchange rate change.

A revaluation of an importer's currency relative to the dollar reduces the importer's cost of purchasing a given quantity of U.S. commodities. Whether such revaluation influences the level of imports depends on whether the resulting cost reduction is passed along as lower domestic commodity prices. In some cases, internal prices are clearly insulated from world market influences; for example, feed grains and wheat in the EC, where variable levies protect internal prices. The extent of price insulation is an empirical question needing research. We specify price linkage relationships in this model to measure the amount of price transmission. In situations where internal prices respond to world price fluctuations, the response in import levels to changes in exchange rates depends on the internal price elasticity of demand.

As exchange rates are assumed to affect demand through the price mechanism, we abstract from other demand factors and specify demand as a function of own-price (P) and the price of other commodities (PO):

$$D_i = f_i(P_i, PO_i) \qquad (5)$$

We further specify relationships to link the domestic prices of the i^{th} country to U.S. prices (P and PO) and to incorporate explicity the exchange rate (r_i):

$$P_i = g_i(r_i P) \qquad (6)$$

$$PO_i = h_i(r_i PO) \qquad (7)$$

We derive the shift in demand due to an exchange rate adjustment by substituting equations (6) and (7) into (5) and taking the partial derivative of D_i with respect to r_i. The result can be expressed more conveniently as the exchange rate elasticity of demand (E_{dri}).[4]

$$E_{dri} = E_{d1i}E_{P1i} + E_{d2i}E_{P2i} \qquad (8)$$

[4] This result is easily extended to demand specifications with more than two prices by simply adding to the summations on the right-hand side of equation (8).

... in situations where internal prices respond to world price fluctuations, the response in import levels to changes in exchange rates depends on the internal price elasticity of demand.

where:

E_{d1i} = Elasticity of demand with respect to P_i,
E_{d2i} = Elasticity of demand with respect to PO_i,
E_{P1i} = Price transmission elasticity of P_i,
E_{P2i} = Price transmission elasticity of PO_i.

Noting that

$$\hat{D}_i = E_{dri}\hat{r}_i, \qquad (9)$$

we combine equations (2), (4), and (9) to obtain:

$$\hat{X} = \frac{\eta_{es}}{\eta_{es} - \eta_{ed}} \sum_i \left(E_{dri}\hat{r}_i \frac{D_i}{M} \right) \qquad (10)$$

We determine the impact of changes in exchange rates on U.S. exports by the elasticities of export supply (η_{es}) and aggregate import demand[5] (η_{ed}) and the demand shift in each country ($E_{dri}\hat{r}_i$) weighted by the size of the country's domestic market relative to U.S. exports (D_i/M).[6]

The model represented by equations (8) and (10) has interesting features. First, we would not expect exchange rates to have impact in countries which insulate all relevant internal prices from world market prices. Regardless of what the demand elasticities (E_{d1i}, E_{d2i}) may be, the price transmission elasticities would all be zero and import demand would not change ($E_{dri} = 0$).

Second, if a derived demand curve is homogeneous of degree zero in prices, an exchange rate adjustment would have no impact if all the price transmission elasticities are equal in magnitude. However, if the transmission elasticities differ due to price policies or nontraded goods, there could be an impact. For example, if the own-price of the commodity is insulated but at least one other price is not, some exchange rate effect is expected. Whether imports increase or decrease depends on the sign of the cross-price elasticity. If the market determines a substitute price (E_{d2i} $E_{P2i} > 0$), a currency revaluation would decrease rather than increase imports of that commodity ($E_{dri} > 0$). This may well be true for EC imports of corn, as the import price is fixed for corn but not for soybeans or soymeal.

Finally, a weighted exchange rate computed conventionally (without regard to price insulation policies) will be of little value in estimating exchange rate impacts. For example, it is clear from equation (10) that countries with complete price insulation should not be included in such a computation.

THE MODEL APPLIED

Country-by-country analysis implied by equation (10) lies beyond the scope of this article. The major unknown variables in equation (10) are the exchange rate elasticities (E_{dri}). We estimate these below for major grains and feeds imported by Japan, and use the results for a partial equilibrium analysis.

We chose Japan because of the large appreciation of the yen against the dollar, and because Japan is an important customer for U.S. corn, sorghum, soybeans, and wheat. The Japanese yen has appreciated nearly 40 percent relative to the U.S. dollar since 1970. Japan has strict price-insulating policies only for wheat.

We analyze impacts on feed grains and soybeans by estimating demand functions for these commodities and price linkage equations for the appropriate prices. Wheat is analyzed more simply, as fixed resale prices exist for wheat and rice (the major substitute for wheat) in Japan, set by the Government well above world market prices. The price transmission elasticities therefore become zero for both commodities. This means that exchange rate changes will not affect domestic prices in Japan for wheat or rice. As a result, no matter what the internal demand elasticities for wheat in Japan might be, exchange rate fluctuations would not be expected to influence Japanese wheat demand and imports.[7]

Demand for Feed Grains

Corn and sorghum are combined into a single feed grain demand with the following specification:

[5] The import demand elasticity must also account for the price transmission elasticities of trading countries, as in (*2*). In terms of the shortrun model, equation (10), it can be shown that $\eta_{ed} = \sum_i (E_{dri}D_i/M)$.

[6] Note that if exchange rate changes were equal across countries ($\hat{r}_i = \hat{r}$), equation (10) would simplify to $\hat{X} = \frac{\eta_{es}\eta_{ed}}{\eta_{es} - \eta_{ed}}\hat{r}$ which is equivalent to the formula derived in (*3*).

[7] The price transmission effect was apparently overlooked in a previous study (*4*) which imputed an exchange rate effect to Japanese wheat imports.

Conventional weighted exchange rates and other analyses which ignore government price-insulating policies will not measure exchange rate effects reliably.

$$QFG_t = a_0 + a_1 PC_t + a_2 PSM_t + a_3 LP_t + a_4 RF_t + u_t \quad (11)$$

where:

- QFG = Total demand for corn and sorghum (1,000 metric tons),
- PC = Corn, wholesale price index, Japan (1970 = 100),
- PSM = Soymeal, wholesale price index, Japan (1970 = 100),
- LP = Pork and poultry, production index, Japan (1970 = 100),
- RF = Rice fed to livestock in Japan (1,000 metric tons).

Ordinary least squares estimates of these demand coefficients are equations (1) and (2) in table 1. The coefficient on rice fed (RF) indicates that the program in Japan to divert surplus rice to feeding in the early seventies displaced corn and sorghum at a rate of about 0.8 to 1.0. Livestock production (LP), the major demand shift variable, has an elasticity of approximately 1.0. In equation (1) the soymeal price coefficient has a high standard error. It was omitted in equation (2), and the corn direct price elasticity changed only slightly.

Demand for Soybeans

Japan's demand for soybeans is also specified as a feed demand equation:

$$QSB_t = b_0 + b_1 PS_t + b_2 PC_t + b_3 LP_t + u_t \quad (12)$$

where:

- QSB = Total soybean demand (1,000 metric tons),
- PS = Soybeans, wholesale price index, Japan (1970 = 100),
- PC = Corn, wholesale price index, Japan (1970 = 100),
- LP = Pork and poultry, production index, Japan (1970 = 100).

The OLS estimates of these demand coefficients are equations (3) and (4) in table 1. A dummy variable for 1972/73 (DV72) accounts for effects of the U.S. soybean embargo in those years. Its coefficient reflects the unusually high Japanese soybean imports in 1972/73.[8] Livestock production is again the major cause of growth in demand; its elasticity is 0.68 at the means. In equation (3), elasticities at mean levels are −0.37 and 0.02 for soybean and corn prices, respectively. The corn price, however, is not significant. In equation (4) it is omitted, which reduces the direct price elasticity for soybeans to −0.35.

Price Linkage Equations

The price linkages for each commodity are specified as follows:

$$JP_t = c_0 + c_1 (USP_t \cdot r_t) + u_t \quad (13)$$

where:

- JP = Japanese wholesale price index (1970 = 100).[9]
- USP = U.S. price (dollars per bushel).
- r = Japanese exchange rate (yen per U.S. dollar).

[8] Some analysts believe this resulted from Japanese overreaction to the embargo scare.

[9] Although the Japanese price is in index form, the only effect is to change the coefficients on the right-hand side by a constant multiple.

The estimated price transmission elasticities computed at means range from 0.99 for soybeans to 0.77 for soybean meal (equations (6) and (7) in table 1). The estimate for corn price (5) is 0.85.

Exchange Rate Impact

We compute the price elasticities of demand and the price transmission elasticities from the estimated relations using the mean of the last 4 years in the estimation period (1973/74 to 1976/77). These are used in table 2 to compute exchange rate elasticities. The computed elasticities of demand for the exchange rate are −0.21 and −0.42 for feed grains and soybeans, respectively. Recall that these shifts in demand (with U.S. commodity prices constant) give the maximum exchange rate impact. Thus, a 10-percent appreciation of the yen would at most increase Japanese feed grain demand 2.1 percent and soybean demand 4.2 percent. At 1977 levels, Japanese demand and U.S. exports would increase 300,000 metric tons (12 million bushels) for corn and 155,000 metric tons (5.7 million bushels) for soybeans.

IMPLICATIONS

Conventional weighted exchange rates and other analyses which ignore government price-insulating policies will not measure exchange

Table 1—Ordinary least squares estimates of demand coefficients and price linkages for feed grains and soybeans, Japan (1960-76)

Corn and sorghum	C	PC	PSM	LP	RF		$\bar{R}^2$	Standard error	Durbin Watson statistic
(1) Coefficient	1804.	−19.41	5.893	2.334	−0.7934		0.97	663	1.27
(*t*)	(2.2)	(−1.9)	(0.62)	(9.7)	(−1.4)				
Elasticity		−0.26	0.08	0.96	−0.02				
(2) Coefficient	2082.	−18.53		2.426	−0.8594		0.97	647	1.43
(*t*)	(3.1)	(−1.9)		(13.2)	(−1.6)				
Elasticity		−0.25		1.00	−0.02				
Soybeans	**C**	**PC**	**PS**	**LP**		**DV72**	**$\bar{R}^2$**	**Standard error**	**Durbin Watson statistic**
(3) Coefficient	1729.	0.3745	−8.238	0.5671		569.9	0.97	131	3.26
(*t*)	(14.1)	(0.13)	(−3.3)	(15.8)		(3.9)			
Elasticity		0.01	−0.37	0.68					
(4) Coefficient	1737.		−7.965	0.5666		564.5	0.97	126	3.26
(*t*)	(17.1)		(−5.7)	(16.5)		(4.2)			
Elasticity			−0.35	0.68					
Dependent variable	**C**	**(USP)**					**$\bar{R}^2$**	**Standard error**	**Durbin Watson statistic**
Corn price:									
(5) Coefficient	15.59	0.1805					0.94	7.13	1.57
(*t*)	(2.8)	(16.3)							
Elasticity		0.85							
Soybean price:									
(6) Coefficient	0.8150	0.0966					0.94	9.47	1.95
(*t*)	(0.11)	(16.6)							
Elasticity		0.99							
Soybean meal:									
(7) Coefficient	25.00	0.0026					0.84	13.2	2.52
(*t*)	(2.6)	(9.4)							
Elasticity		0.77							

Note: Elasticities are computed at means of variables.

Table 2—Demand and price transmission elasticities and computation of Japanese exchange rate elasticity

Price	Commodity	
	Feed grains[1]	Soybeans[2]
Demand elasticity	–0.23	–0.44
Transmission elasticity	0.90	0.96
Exchange rate elasticity	–0.21	–0.42

Note: All elasticities are the mean of 1973/74 to 1976/77. The computations are based on equation (8) in the text.

[1] Equation 2, table 1.
[2] Equation 4, table 1.

rate effects reliably. The measurement error will be greater for commodities whose prices are more highly protected by trading countries.

The commodity equilibrium model we presented incorporates the effect of price-insulating policies. It requires the weighting and summing of exchange rate effects within individual countries to obtain the impact on equilibrium price and export levels. The procedure, although not complex, requires large amounts of data. The elasticities of demand and price transmission used in the model could be assumed or obtained from previous studies to reduce the computational requirements. The model was discussed in the context of analyzing U.S. exports but can be applied to any exporting country. The same procedure could be used to derive a model for import analysis.

The model could be enhanced by adding a supply response component for each country. The data requirements would increase but it would be possible to analyze longer run impacts of exchange rate changes. The individual country components of the model can also be used for partial equilibrium analysis (with U.S. prices constant). This simple procedure, as applied to Japan above, provides useful estimates of the maximum exchange rate impacts.

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INFLATION AND UNEMPLOYMENT: ARE THEY COMPLEMENTS OR SUBSTITUTES?

By Clark Edwards*

Unemployment and inflation used to be seen as bipolar events. They were considered to be at opposite ends of a continuum and, therefore, could not both happen at the same time. Since 1970, events have taught many of us to see them as possibly correlated or independent rather than as substitutes.

The older belief was well grounded empirically. During the last 31 years (1948-78), the United States experienced 12 years of relatively high unemployment (over 4 percent) and low inflation (less than 2.5 percent) (table 1 and fig. 1). Economists following Keynes identified insufficient aggregate demand as the cause of the unemployment and recommended expansionary monetary and fiscal policies. During years of high unemployment and low inflation, expanding money supplies and increased government deficits were expected to deal with the problem.

During 6 of the years since 1948, the United States experienced relatively high inflation (over 2.5 percent) and low unemployment (less than 4 percent) (table 1 and fig. 1). These were characterized as years of excess aggregate demand. Tight monetary and fiscal policies were expected to cope with inflation withou exacerbating unemployment.

Only 2 of these 31 years—1952 and 1953--were characterized by both low price rises (less than 2.5 percent) and low unemployment (less than 4 percent) (table 1 and fig. 1). The national goals adopted by the Congress in 1946 of stable prices and full employment have yet to be realized.

Inflation and unemployment plagued the U. S. economy during the decade of the seventies. Some economic models suggest that inflation and unemployment are bipolar events—they cannot occur at the same time. This article reviews two models that have been in the economics literature since the thirties and that explain inflation and unemployment as complements, not substitutes. One is the well-known IS/LM framework; the other is sometimes called the structural unemployment framework. A third model which helps to explain the complementarity between inflation and unemployment—one which focuses on the international balances of payments and trade—is not discussed.

Keywords

Inflation Unemployment
Montary policy
Fiscal policy
Economic theory

The recent experience of simultaneous inflation and unemployment initially came as a surprise to many. But by now this phenomenon has occurred in 11 of the past 31 years. The first time it happened, in 1956 and 1957, the phrase "structural unemployment" was introduced. The concept was that one had to examine the detailed structure of the economy, not just the aggregate, to locate which sectors had unemployment and which had inflation. Persistent inflation and relatively high unemployment have occurred in each year since 1970.

Broad monetary and fiscal policies worked reasonably well during the 12 years of relatively high unemployment and low inflation and during the 6 years of inflation and relatively low unemployment. This gave the public a sense of confidence in the economics profession. But the policies seemed to fail during the 11 years of simultaneous inflation and high unemployment. This failure, and the apparent inability of economists to explain to the public and to policymakers what was happening, has understandably weakened public confidence in the advice of economists.

Yet the textbooks are not without explanations. This article examines two ideas introduced into the economics literature since the midthirties but does not review the extensive literature defending and attacking them. These ideas help to explain how the problem arises and they point to ameliorative policies. The first of these ideas comes from J. M. Keynes' theory of interest as modified and improved upon by J. R. Hicks. The Keynes-Hicks formulation of the midthirties helps to clarify why broad monetary and fiscal policies began to fail during the late sixties. The second idea, directly from Keynes, teaches us to look at the economic structure beneath the broad aggregates to understand and explain how inflation and unemployment can be simultaneous. A third idea, of more recent origin and not dealt with in

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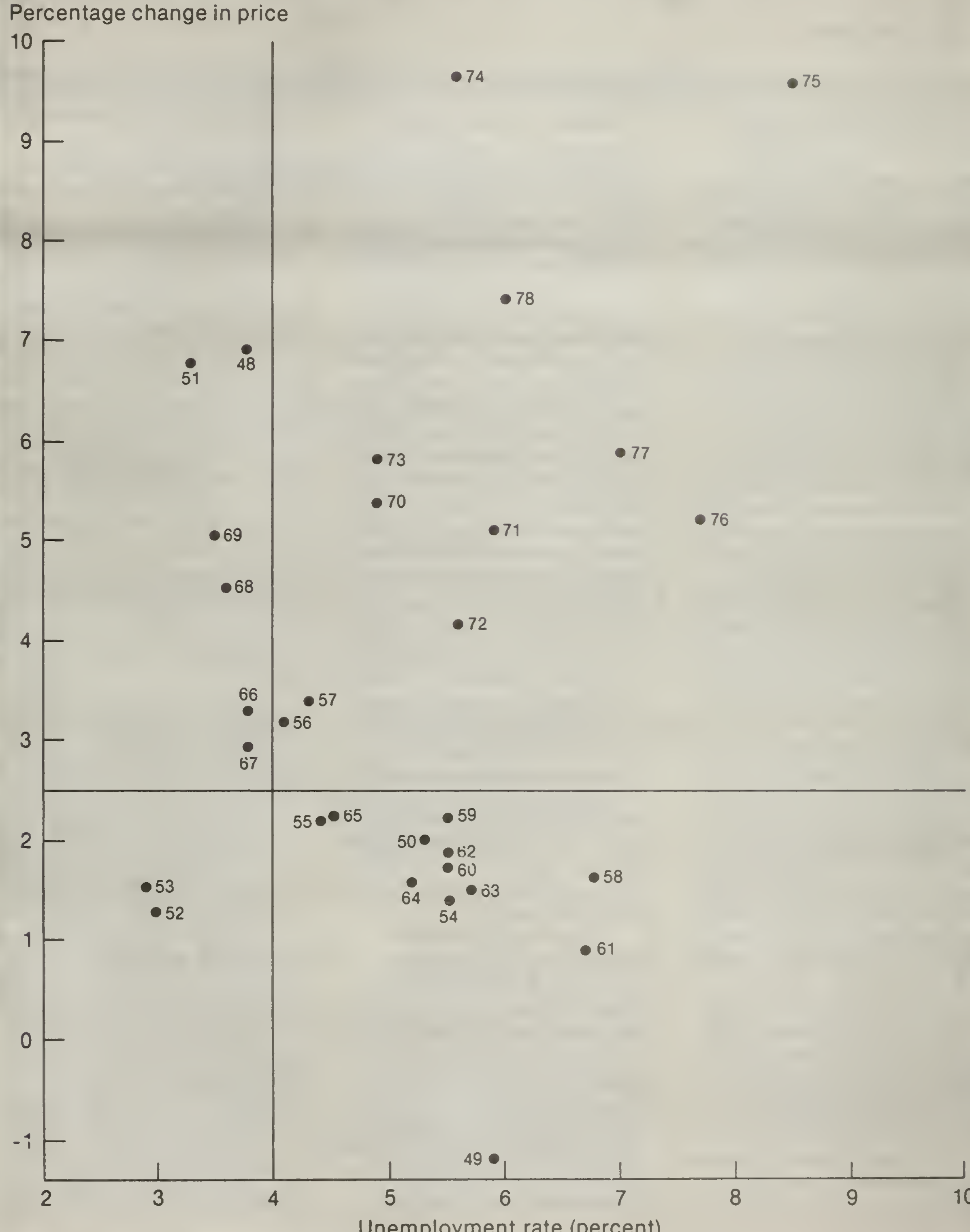
Figure 1

Inflation and the Unemployment Rate, 1948-78



Note: Numbers in field of chart are years, 1948, 1949 and so on.

Unemployment and inflation used to be seen as bipolar events. Since 1970, events have taught many of us to see them as possibly correlated or independent rather than as substitutes.

this article, pertains to international linkages: policies which alleviate a domestic problem may aggravate a foreign one.

INTEREST RATES AND AGGREGATE ECONOMIC POLICY

Keynes' theory of interest, published in 1936 in his *General Theory*, deviated sharply from the classical explanation which depended on the supply and demand for loanable funds in a smoothly functioning competitive market for real goods and services (*2*).[1] Keynes thought the supply of loanable funds depends not on the interest rate but on the level of income and the propensity to save. The interest rate depends on the supply and demand for money in a smoothly functioning portfolio market apart from and in addition to the supply and demand for real goods and services. The demand for money reflects liquidity preference—the desire to remove money from the circular flow of spending and hold it idle. The supply of money can be controlled, at least to an extent, by the central monetary authority. With this formulation, the quantity of money could play an active part in public policies dealing with inflation and unemployment. For example, an increase in the money supply could result in a lower rate of interest which would, in turn, induce investment and lead to an increase in income, output, and employment.

Hicks, in an effort to show that Keynes' ideas were not inconsistent with what Keynes called the classical formulation, developed a generalized version of Keynes' general theory. Hicks' version, published in 1937 in his "Mr. Keynes and the Classics," allowed for feedback between the real and monetary sectors (*1*). He showed that the interest rate provided a close link between two markets—the supply and demand for money in the portfolio market which was emphasized by Keynes, and also the supply and demand for real goods and services which was emphasized in the classical system. Hicks saw Keynes'

Table 1—Inflation, the unemployment rate, and the interest rate, 1948-78

Year	Inflation rate[1]	Unemployment rate	Interest rate[2]
1948	6.90	3.80	3.24
1949	−1.02	5.90	3.47
1950	2.00	5.30	3.42
1951	6.77	3.30	3.24
1952	1.27	3.00	3.41
1953	1.52	2.90	3.52
1954	1.38	5.50	3.74
1955	2.16	4.40	3.51
1956	3.15	4.10	3.53
1957	3.37	4.30	3.88
1958	1.60	6.80	4.71
1959	2.21	5.50	4.73
1960	1.70	5.50	5.05
1961	.89	6.70	5.19
1962	1.83	5.50	5.08
1963	1.47	5.70	5.02
1964	1.56	5.20	4.86
1965	2.21	4.50	4.83
1966	3.28	3.80	4.87
1967	2.94	3.80	5.67
1968	4.49	3.60	6.23
1969	5.03	3.50	6.94
1970	5.35	4.90	7.81
1971	5.10	5.90	9.10
1972	4.14	5.60	8.56
1973	5.80	4.90	8.15
1974	9.66	5.60	8.24
1975	9.59	8.50	9.50
1976	5.20	7.70	10.61
1977	5.87	7.00	9.75
1978	7.40	6.00	8.97

[1] Annual percentage change in Implicit Price Deflator.
[2] Moody's Corporate Baa Bond Yield.

Source: *Survey of Current Business.*

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

The critical point is that monetary and fiscal policies are not symmetrical. In general, one cannot offset easy fiscal policies with tight monetary policies.

published view and the classical view as special cases of his own more general system.

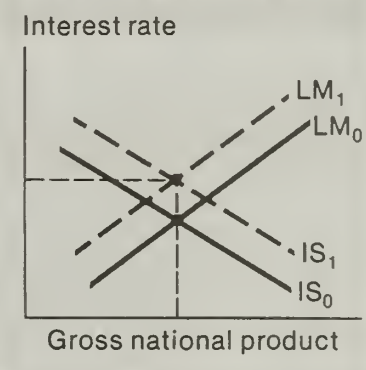
Hicks said his improvements in Keynes' version were suggested by "mathematical elegance" (*1*, p. 156). Keynes must have objected to this method because he had said, when presenting his theory, that:

> Too large a proportion of recent 'mathematical' economics are mere concoctions, as imprecise as the initial assumptions they rest on, which allow the author to lose sight of the complexities and interdependencies of the real world in a maze of pretentious and unhelpful symbols (*2*, p. 298).

Hicks' symbols have proved exceedingly helpful in explaining the interactions among Keynesian variables and his generalizations have been supported by empirical evidence accumulated later. The Keynes-Hicks idea is referred to as the IS-LM framework (fig. 2).This framework suggests that real flows of goods and services can be described by an equation relating the interest rate to the level of aggregate income (the IS curve), and that monetary flows can be described by another equation involving the same two variables (the LM curve (Hicks called it the LL curve.)).

The critical point is that monetary and fiscal policies are not symmetrical. In general, one cannot offset easy fiscal policies with tight monetary policies. Consider an economy initially in equilibrium as indicated by the intersection of IS_0 and LM_0 in figure 2. According to the Keynes-Hicks theory, if a fiscal policy of deficit spending is embarked upon to fight unemployment, output and employment will increase. (In the figure, this is shown by a shift from IS_0 to IS_1.) If the total money supply is held constant as aggregate business activity rises, then as more money is used to support the increase in transactions, less money is free to satisfy liquidity preferences. As money disappears from idle balances, efforts to maintain liquidity will cause interest rates to rise.

Figure 2
The IS-LM Framework



On the other hand, expansionary monetary policies used to fight unemployment would increase output and employment but would decrease interest rates. This is because more idle monetary balances would be available. Both policies create jobs, but they have opposite effects on the interest rate. Because of this asymmetry, an expansion resulting from fiscal policy cannot be cancelled by tight monetary policy. The initial level of aggregate demand is restored but the interest rate is higher. (In the figure, this is shown by a shift from LM_0 to LM_1.)

Now apply this framework to the monetary and fiscal activities in the United States since late 1965. The economy then was close to full employment and inflation was moderate (table 1 and fig. 1). Deficit spending was incurred to pay for the Vietnam War; fiscal policy was political, not economic, in purpose. But the policy had economic consequences: It spurred inflation by pushing aggregate demand beyond existing production capacity. Some economists at the time suggested that one way to fight the coming inflation was to raise taxes. This policy would have held aggregate demand at noninflationary levels. Once the economy reallocated resources to produce less butter and more guns, inflationary pressures would ease, full employment would be sustained, and interest rates could be maintained at accustomed levels.

A tax increase was not forthcoming, however. Neither was a curtailment of government spending. Tight monetary policy became the only remaining recourse. Such a policy could reduce aggregate demand to noninflationary levels and maintain full employment. But, as explained by the IS-LM framework, it would raise interest rates further. High interest rates, according to the

Keynes-Hicks theory, limit aggregate demand by discouraging investment; thus they can ease inflationary pressures.

However, a counter force fanned the inflation. Higher interest rates increased the cost of production and pressed up the very prices they were intended to limit. Demand-pull inflation from deficit spending was eliminated, but cost-push inflation from high interest rates was introduced. Each of the 11 years of relatively high interest rates since 1968 was also a year of relatively high price increases. Figure 3 suggests a correlation between interest rates and the price level, but correlations are silent about cause and effect.

The consequence of the attempt to offset fiscal policy with monetary policy was to pay for the Vietnam War with inflation. In the subsequent decade, monetary and fiscal activities continued to be reflected in larger deficits and higher interest rates. The net result was to hold aggregate demand below productive capacity, allow more unemployment than was considered acceptable, hold interest rates at historic highs, and maintain inflationary pressures. Most policy debates on how to cope with these problems overlooked the Keynes-Hicks explanatory model.

The theory, however, does have an important weakness. This weakness helps to explain why monetary policies which maintain relatively high interest rates were useful, after all, for the past decade. Hicks' theory assumes a closed economy—one with no exchange among nations of goods, capital, people, and ideas—whereas we live in an open economy.

The closed economy version of the IS-LM framework suggests that, since 1966, we should have had policies of reduced government spending, higher taxes, and easier money to maintain full employment with lower interest rates and stable prices. An open economy version might prescribe tight money and high interest rates on the grounds that interest rates lower domestically than abroad would induce capital outflows and induce a balance of payments problem. Slow real growth resulting from high interest rates also would ease the international monetary imbalance by limiting our propensity to import.

A domestic equilibrium of full employment and stable prices need not be one of balanced international payments. As it has turned out, policies which would have ameliorated domestic problems would also have exacerbated international ones. If we have had the correct policies after all for limiting the capital drain, it is small comfort to know that we have had them for the wrong reasons. Worse, had we understood the reasons, we might have found alternative policies. For example, a reinstatement of the tax on the flow of capital out of the country could have limited the tendency to a capital drain.

Relatively tight money and relatively large Federal deficits for the past decade have increased domestic inflation and unemployment, limited the size of the private sector by inhibiting private investment, and expanded the size of the government sector by deficit spending. Domestic and international imbalances associated with these monetary and fiscal activities have spread the costs of the problem deeper—into the structure of the economy. This brings us to the second of Keynes' ideas which can help us to understand the economic problems of the economy over the past decade.

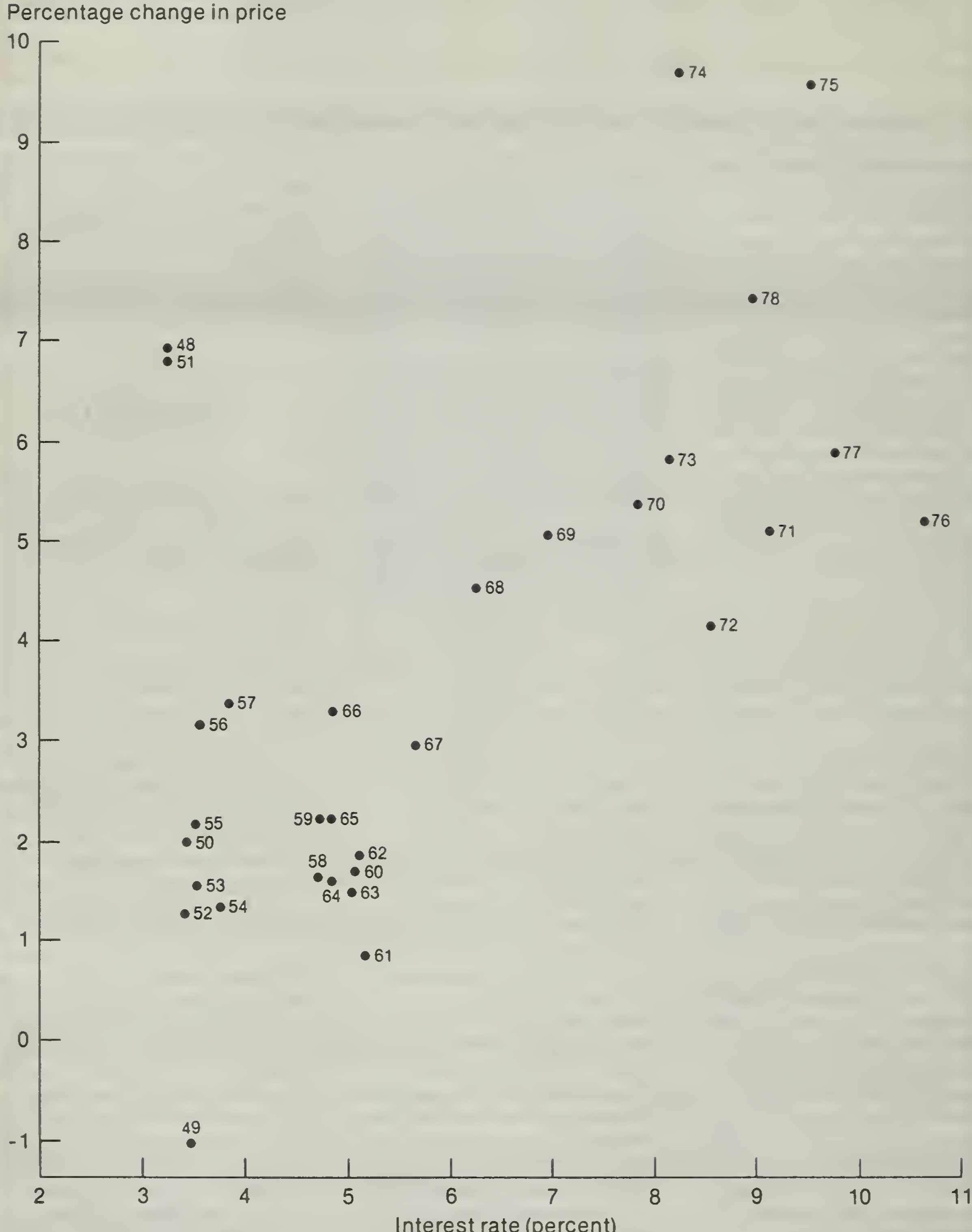
STRUCTURAL BOTTLENECKS

It is common in macroeconomics to use simplified aggregate models which explain either (1) unemployment assuming stable prices or (2) inflation assuming full employment. Keynes, in his *General Theory*, never intended that we accept such extreme assumptions. Every chapter recognizes that prices can be rising in an economy experiencing unemployment. But chapter 21, "The Theory of Prices," contains the material of prime importance to explain the 11 years of simultaneous inflation and unemployment we have experienced since World War II.

In this chapter, Keynes seeks to remove what he calls "a haze where nothing is clear and everything is possible" (*2*, p. 292). Removal of the haze follows from his distinction between what we now call microeconomics, "the theory of the individual industry or firm," and macroeconomics, "the theory of output and employment *as a whole*" (*2*, p. 293). He also distinguishes statics from dynamics. He defines his subject as what we would now call dynamic macroeconomics, although his dynamics concentrate on the role of money, expectations, and aggregate demand. We would today characterize his theory as

Figure 3

Inflation and the Interest Rate, 1948-78



Note: Numbers in field of chart are years, 1948, 1949 and so on.

Keynes' goal was not tradeoffs, but elimination of both offensive events. Keynes did not consider inflation and unemployment as bipolar in the sense that to move toward one is to move away from from the other.

static with respect to plant capacity, technology, and aggregate supply.

Keynes begins by making the simplifying assumptions required to provide models which would have been adequate to explain 20 of the past 31 years of inflation and unemployment:

> If there is perfectly elastic supply so long as there is unemployment, and perfectly inelastic supply as soon as full employment is reached . . . [it follows that]: So long as there is unemployment, *employment* will change in the same proportion as the quantity of money; and when there is full employment, prices will change in the same proportion as the quantity of money (*2*, p. 295).

We could substitute the phrase "aggregate demand" for "quantity of money" to make his meaning clearer for modern readers.

Immediately after reaching this conclusion, Keynes relaxes the simplifying assumptions on which it depends. He considers five possible complications which will, in fact, influence events (*2*, p. 296). Having experienced simultaneous inflation and unemployment, he knew that these complications needed to be understood. The U.S. economy had two such periods about which Keynes must have known—one just before World War I and another near its close. His five factors which help to explain rising prices when there is unemployment included diminishing returns and rising pressure on wage rates as the capacity of plants and of the labor force are approached. The complexity of concern in this article is number three.

The third of his five complicating factors is the one to which the phrase "structural unemployment" refers:

> Since resources are not interchangeable, some commodities will reach a condition of inelastic supply whilst there are still unemployed resources available for the production of other commodities (*2*, p. 296).

From this and the other complicating factors, Keynes concludes that we have, in fact, a condition of rising prices, not stable ones, as unemployment continues:

> The increase in effective demand will, generally speaking, spend itself partly in increasing the quantity of employment and partly in raising the level of prices (*2*, p. 296).

Some readers of Keynes may interpret this to imply a Phillips Curve, but it does not—for two reasons. First, the Phillips Curve focuses on tradeoffs; its purpose is to estimate how much inflation must be endured to reduce unemployment. Keynes' goal was not tradeoffs, but elimination of both offensive events. Keynes did not consider inflation and unemployment as bipolar in the sense that to move toward one is to move away from the other. He recognized explicitly that they can occur simultaneously and he aimed to avoid both.

Second, the Phillips Curve is an empirical formulation which describes the history of price changes and unemployment rates. One can see from the pre-1970 data in figure 1 how the empirical idea of the Phillips curve caught on. Keynes' formulation, however, is a theoretical one which can help to explain history with the intent of finding economic policies to avoid repeating the past.

The remainder of chapter 21 considers each of the five complicating factors in turn. The next section presents an empirical test of factor three.

An Empirical Test of Keynes' Structural Hypothesis

Keynes expanded on his structure hypothesis as follows:

> In general, the demand for some services and commodities will reach a level beyond which their supply is, for the time being, perfectly inelastic, whilst in other directions there is still a substantial surplus of resources without employment. Thus as output increases, a series of 'bottle-necks' will be successively reached, where the supply of particular commodities ceases to be elastic and their prices have to rise to whatever level is necessary to divert demand into other directions (2, p. 300).

Keynes' hypothesis that simultaneous inflation and unemployment for the aggregate economy reflects a weighted average of inflation in some sectors and unemployment in others is tested below through the use of data on price, quantity, employment, and wages by industry. These data, from the *Survey of Current Business* (3), are shown as annual percentage changes for 1978 from a year earlier in table 2. Comparable data examined from the same source annually from 1966 are not shown, but analysis of them is included.

The correlation between employment and price changes by industry is moderate. The correlation between quantity and price changes was negative in every year examined.

Pairwise Analysis

To test the hypothesis directly, we should compare changes in industry price with the extent to which idle resources are available to an industry. Unemployment is not available by the industries in table 2, so we will try other tests. First, we can compare price changes with changes in employment.

The correlation between employment and price changes by industry is moderate. The R^2 was less than 0.30 each year since 1966-67, and was often close to zero. For about half the years, the regression coefficient was positive, and half negative. For most years the slope was not significantly different from zero. Only the change from 1976 to 1977 significantly agrees with Keynes' statement that "... we have in fact a condition of prices rising gradually as employment increases" (p. 296). That is, industries which were creating jobs during 1976-77 tended to be raising prices; those with stable prices tended not to be creating jobs.

The correlation between quantity and price changes was negative in every year examined. The R^2 ranged from close to zero up to more than 0.50. A regression line explaining change in price as a function of change in quantity had a slope significantly less than zero for more than half the observations. This result agrees with Keynes' idea that the supply of some commodities, those with idle resources, is elastic and responds to an increasing demand by an increase in quantity but has little effect on prices, while the supply of other commodities "... ceases to be elastic and their prices have to rise to whatever level is necessary" (*2*, p. 300). That is to say: "A series of 'bottlenecks' will be successively reached" (*2*, p. 300). Some industries are seen to respond to an increase in aggregate demand with increases in output, while others respond with higher prices, as suggested by the structural unemployment hypothesis.

The correlation between changes in wage rates and changes in price ranged from zero up to 0.34 for the 12 observations. The slope of a regression line explaining change in wage rates was positive for 8 of the years, but significantly positive only for 3 of the years. Keynes hypothesized the relation would be positive: "A proportion of any increase in effective demand is likely to be absorbed in satisfying the upward tendency of the wage-unit" (*2*, p. 301). He called this a position of "semi-inflation" (*2*, p. 301), determined in part by the psychology of workers and by policies of employees and trade unions. His "semi-inflation" involves some of what we would call today a cost-push inflation, or a wage-price spiral. He distinguished this from "absolute inflation" (*2*, p. 301) or "true inflation" (*2*, p. 303) when "... a further increase in the quantity of effective demand produces no further increase in output and entirely spends itself on an increase in the cost unit" (*2*, p. 303).

Table 2—Change in price, wage, employment, and quantity by industry, 1977-78

Industry	Price of output	Quantity of output	Wage	Employment
		Percent		
Farms	21.64	−0.58	7.98	−2.99
Forestry and fisheries	4.29	15.38	7.22	15.13
Mining	9.37	4.52	9.54	6.72
Construction	9.12	4.59	5.60	10.75
Nondurable goods	4.50	3.38	8.21	1.91
Durable goods	7.72	5.87	7.95	5.84
Railroad	6.94	4.95	9.14	−1.90
Trucking	5.80	9.13	8.99	6.23
Airline	10.27	9.38	8.52	5.21
Other transportation	15.49	0.00	8.27	4.94
Telephone and telegraph	0.54	12.12	11.04	3.39
Radio	7.23	7.14	8.91	5.92
Electricity and gas	7.13	3.19	8.19	3.95
Wholesale	4.71	6.12	8.00	5.23
Retail	7.56	4.05	6.29	5.97
Finance and insurance	7.49	5.46	8.31	5.28
Real estate	5.79	4.85	11.65	5.81
Service	7.94	6.02	8.47	5.58
Government	7.03	1.94	7.30	1.73

Keynes' pairwise statements were not confirmed in the three simple tests above. But neither were they denied. He did not explicitly venture a hypothesis in chapter 21 about multivariate relationships. We look at two such relationships below. One examines the role of technology. The other supports the three hypotheses which were tested separately above and, at the same time, adds further insight into the interplay of wages, employment, and quantity of output. The multivariate analysis shows that the failure of the two-variable analysis just described to find a significant relationship results from a problem of interaction among the data and not a lack of validity in Keynes' hypotheses.

Technology

The ratio of change in output to change in employment indicates change in technology, or in labor productivity. This measure is negatively correlated with the change in price. The R^2 ranged up to 0.65 for the years examined. A regression line explaining change in price as a function of change in productivity of labor has a slope less than zero in every case, significantly so in two-thirds of the cases. Keynes took "technique as given" (*3*, p. 294) and did not discuss in chapter 21 the dynamics of changes in technique. The result is implicit, however, in his hypothesis of a negative correlation of price with quantity (which is in the numerator of the measure of technical change) and of a positive correlation with employment (which is in the denominator). The result supports the conviction that industries which are adopting more efficient techniques reduce inflationary pressures. Industries which adopt output-increasing technologies tend to have stable prices; those with no advance in technology tend to have rising prices.

Multivariate Analysis

The four data series we have studied—price, quantity, wage, and earnings—have been related empirically to one another in various studies by means of an equation containing a single parameter. Consider the equation:

$$k = \frac{WE}{PQ} \qquad (1)$$

where W is wages, E is employment, P is the price level, and Q is the level of output. One interpretation is that the earnings of workers are a constant share of the total value of output; k is a measure of the share. Another interpreation is that the aggregate production function is a Cobb-Douglas equation; k is a measure of the elasticity of production of labor, and the above equation is a necessary condition for competitive equilibrium.

A regression line was fit to the industry earnings and value of output for the 13 years from 1966 to 1978. These were absolute levels of earnings and value from the *Survey* (*3*), not annual percentage changes such as shown in table 2. The equation was:

$$(WE) = a + k(PQ) \qquad (2)$$

The value of the constant term a was not significantly different from zero in any year. This result makes equation (2) identical in informational content to equation (1). When a was set equal to zero, the resulting value for k ranged from 0.62 to 0.67 and the t-ratio was greater than 10.00 in each year. The R^2 ranged from 0.85 to 0.87 after adjustment to reflect the absence of a constant term. This suggests the assumption of a constant value for k is tenable for the cross-sectional data under consideration.

Let us rewrite equation (1) a third way:

$$P = \frac{WE}{kQ} \qquad (3)$$

Using the notation $\dot{P}$ for the derivative with respect to time, we can derive from equation (3):

$$\frac{\dot{P}}{P} = \frac{\dot{E}}{E} + \frac{\dot{W}}{W} - \frac{\dot{Q}}{Q} \qquad (4)$$

This equation says the percentage change in price equals the percentage change in employment plus the percentage change in wages less the percentage change in output under the assumption that k is a constant. Were k not constant, an additional (negative) term showing the percentage change in k would appear in the equation.

A regression line was fit to the change data such as in table 2 for each of the 12 years for the following version of equation (4):

$$(\%\Delta P) = a + b_1 (\%\Delta E) + b_2(\%\Delta W) + b_3(\%\Delta Q) \qquad (5)$$

This analysis supports Keynes' hypothesis of structural bottlenecks as an explanation of simultaneous inflation and unemployment.

where (%ΔP) means the annual percentage change in price. The regression constant (*a*) differed significantly from zero in only 2 of the 12 regressions. It was significantly positive for 1971-72 and again for 1977-78. The constant term was set equal to zero and the equation was fit again. If *k* is constant, then we anticipate from equation (4) that $b_1 = 1, b_2 = 1$ and $b_3 = -1$.

Table 3 shows regression results for fitting equation (5) to data such as those in table 2 for annual percentage changes in price, wages, employment, and quantity since 1966. With the constant at zero, the annual regressions explained from 49 to 91 percent of the variation in price, according to the R^2's listed in table 3. These R^2's are adjusted as is appropriate when there is no constant term. They are, therefore, slightly higher than the unadjusted R^2's.

Table 3 shows that the relation between wages and prices was significantly greater than zero for each of the 12 observations, and the relation between employment and prices for 5. The relation between quantity and prices was significantly less than zero for nine of the observations. These statistics tend to support Keynes' three hypotheses that were not supported in the pairwise analysis.

The wage coefficient was significantly different from 1.0 in the multivariate analysis in only 2 of the 12 years since 1966. A coefficient close to 1.0 helps to support the assumption that *k* in equation (1) is a constant which, in turn, supports equation (4) as a description of the relation among changes in the four variables.

The employment coefficient was significantly different from 1.0 only 3 times. The quantity coefficient was significantly different from a minus 1.0 only 2 times.

These tests tend to support equation (4) as a descriptor of the relationship between changes in price, wages, employment, and quantity. The 19 industries tend to behave differently from one another in any given year in accordance with the pattern suggested by Keynes. This analysis supports Keynes' hypothesis of structural bottlenecks as an explanation of simultaneous inflation and unemployment.

MONITORING INFLATION BY INDUSTRY

Equation (4) can be of assistance in monitoring industry behavior. Using equation (4), for which the coefficients are 1, 1, and −1, the estimated price changes are within 3 index points of the actual price

Table 3—Coefficients for regressions of changes in wages, employment, and quantity on price changes, with comparisons, 1966-78

Year	Coefficient			Standard error			Standard errors from 0.00 (T-statistic)			Standard errors from 1.00			R^2
	Wage	Employment	Quantity	Wage	Employment	Quantity	Wage	Employment	Quantity	Wage	Employment	Quantity	
67-66	0.5976	0.7247	−0.7782	0.1711	1.8360	1.8460	3.49	3.95	4.21	2.35	1.50	1.20	0.62
68-67	0.8810	0.6972	−0.8608	.1069	.1958	.1490	8.24	3.56	5.78	1.11	1.55	0.93	0.85
69-68	0.9094	0.5729	−1.0072	.0907	.1966	.1339	10.02	2.91	7.52	1.00	2.17	0.05	0.90
70-69	0.7284	0.4826	−0.7711	.0591	.2852	.1825	12.31	1.69	4.23	4.60	1.81	1.25	0.91
71-70	0.8986	0.2807	−0.5448	.0802	.2344	.1606	11.20	1.20	3.39	1.26	3.07	2.83	0.89
72-71	1.0781	0.6506	−0.8759	.2221	.3604	.2525	4.85	1.81	3.47	0.35	0.97	0.49	0.72
73-72	1.3955	1.1916	−1.7728	.5255	.5251	.7453	2.66	2.27	2.38	0.75	0.36	1.04	0.49
74-73	1.0070	1.0435	−0.6859	.3637	.6832	.5740	2.77	1.53	1.19	0.02	0.06	0.55	0.62
75-74	0.9539	0.5019	−0.4456	.1186	.3013	.2812	8.04	1.67	1.58	0.39	1.65	1.97	0.82
76-75	0.8999	0.2087	−0.2061	.2214	.4135	.3042	4.06	0.50	0.68	0.45	1.91	2.61	0.70
77-76	0.8526	1.2586	−0.9357	.1720	.2172	.2952	4.96	5.79	3.17	0.86	1.19	0.22	0.88
78-77	1.3225	0.3812	−0.9509	.2140	.3077	.3437	6.18	1.24	2.77	1.51	2.01	0.14	0.81

Keynesian economics includes two elements which help to explain why the United States experienced simultaneous inflation and unemployment during the seventies. The first element is that monetary and fiscal policies are not symmetrical.

changes for 15 of the 19 industries during 1977-78. For example, in the services industry, the percentage change in employment (5.58) plus the change in wage (8.47) minus the change in quantity (6.02) misses the actual change in price (7.94) by only 0.09 (table 2).

While the use of equation (4) works reasonably well, it is probably more accurate to use the regression estimate for equation (5) instead. Equation (5) is formulated to explain price in terms of least squares. In this form it is useful for monitoring inflation. An alternative formulation might be used if the focus were on unemployment. The equation explains most, but not all, variation in price by industry. Something can be learned by identifying those industries which the equation fails to explain.

For 1977-78, the equation in the bottom row of table 3 explained 81 percent of the variation in prices. In that year, inflation rates among the 19 industries in table 2 ranged from a fraction of 1 percent up to about 21 percent. The standard error of the regression was 3.7 index points. For the 15 industries whose estimates were within 1 standard error of the regression (that is, for which the estimate was less than 3.7 points away from the observed value), the price change reported is consistent with changes in wages, employment, and quantity of production.

Take the "other transportation" as an example: The reported price change in table 2 was 15.49 percent and the change predicted by the equation was within 1 standard error of the regression. This was one of the more rapidly inflating industries, yet the rate of change in price was explained adequately by changes in wages, employment, and quantity. Efforts to limit the price rise in that industry could have focused on: (1) increasing the quantity of output which, in fact, had remained about the same as the year-earlier level, (2) limiting the wage increase which was 8.27 percent compared with the industry average of 7.80 percent, and (3) creating new jobs, which had grown only 4.94 percent, about in line with the all-industry average. Each of these three strategies was suggested by Keynes in chapter 21 of his *General Theory* as a way to cope with structural inflation.

Agriculture and the air transportation industry had relatively large price rises during 1977-78—21.64 and 10.27 percent, respectively. Further, these gains exceeded the rise predicted by the equation by more than one standard error. This result would occur for an industry for which the coefficient k in equation (1) is not constant, but is decreasing. If the wage share is decreasing over time, equation (4) will have a (negative) term relating to the percentage change in k. Were a term with decreasing k included in the estimating equation, a higher price rise, closer to the actual price rise, would have been predicted. Consequently, one can infer that these price increases exceeded what was warranted by changes in wages, employment, and quantity. This may be interpreted to mean that the wage share (coefficient k in equation (1)) was declining in these industries and the share of returns to interest, rent, or profits was rising.

The nondurable manufacturing industry and the government had relatively moderate price rises during 1977-78—4.50 and 7.03 percent, respectively. Further, these rises fell short of the rise predicted by the equation by more than one standard error. Were a term with increasing k included in the estimating equation, a smaller price rise, closer to the actual price rise, would have been predicted. Consequently, one can infer that these price changes were less than warranted by changes in wages, employment, and quantity. This may be interpreted to mean that the wage share (coefficient k in equation (1)) was increasing in these industries and the share of returns to interest, rent, and profits was declining.

When the equation predicts closely the price change in an inflationary industry, it points to which explanatory variable—wage or employment or quantity—is critical. And when the equation fails to predict the price change, it tells us even more; it tells us whether the factor payment changes were favoring labor or management.

CONCLUSION

Keynesian economics includes two elements which help to explain why the United States experienced simultaneous inflation and unemployment during the seventies. These elements first appeared in the economics literature during the thirties.

The first element is that monetary and fiscal policies are not symmetrical. Expansionary fiscal policy tends to raise interest rates while expan-

The second element follows from the fact that not all industries, occupations, and regions share equally in national business activity.

sionary monetary policy tends to lower them. Hence, if an economy is overheated by fiscal deficits, tight monetary policies can not correct the situation. Aggregate demand can be restored to the equilibrium level, but the equilibrium level of interest rates will be higher; perhaps sufficiently high to create a disequilibrating, cost-push inflation. Further tightening of the money supply will result in limited private investment, more unemployment, rising interest rates, and accelerated inflation. The economy can be come unstable, with simultaneous inflation and unemployment. Through deficit spending, the government will have an increasing share of the total economy; through the inhibiting effect of high interest rates on investment, the private sector will have a decreasing share. This persistently unstable situation may put industries out of balance relative to one another and set the stage for the second element from Keynesian economics.

The second element follows from the fact that not all industries, occupations, and regions share equally in national business activity. Some industries, those with access to idle resources and advancing technology for example, tend to respond to an increase in aggregate demand with an increase in output and with stable prices. Meanwhile, other industries, already at capacity, tend to respond with higher prices instead. A weighted average of both types of industries will show higher prices (from one set of industries) and continued unemployment (from the other set).

Policy implications of these two elements called for higher taxes, reduced government spending, easy money, and policies which treat certain industries, occupations, and regions differently than others during a decade characterized by tax cuts, government deficits, tight money, and broad-brush policies. Of course, the actual world is more complicated than the IS-LM model and the structural model assume. In addition to demand-pull, cost-push, and structural inflation discussed here, there are other problems:

- Inertia, where expectations of more inflation continue to be realized;
- Ratchets, where prices tend to move up, not down, and one price increase tends to induce others;
- Institutional breakdowns, where timing is off, decisions do not get made, and inefficiencies arise;
- International linkages where inflation is imported and where a negative balance of payments contributes to the international monetary crisis; and
- Monopoly, where prices are managed.

The problems are complicated and the two models discussed here oversimplify. Yet, they point to economic policies quite different from those used during the past decade. There has been a tendency to run up government deficits and then to fight the ensuing inflation with monetary policies which raise interest rates and which can exacerbate the inflation while creating unemployment. And there has been a tendency to overlook structural problems and treat all sectors of the economy with the same broad-brush policies. It is time to think the matter through again.

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RESEARCH REVIEW

INFLATION AND THE MONEY SUPPLY

By Alan R. Bird*

To stop inflation, cut the money supply. That is a traditional remedy. Yet the persistence of inflation throughout the seventies implies the need for novel remedies that would discourage nonproductive speculation and encourage resource productivity. Complementary efforts to remedy structural deficiencies in markets would also seem called for.

Cutting the money supply through such traditional means as a higher discount rate (the interest rate the Federal Reserve System charges its member banks), higher reserve ratios (the percentage of deposits that member banks cannot loan or invest), or increased purchase of bonds on the open market will likely intensify inflation. Why?

Chronic inflation has created a climate of expectation that inflation will continue. The conventional definition of money supply thus no longer applies. This definition includes currency and demand deposits, and several other variants, among them, successively less liquid assets, such as deposits at savings and loan institutions and certificates of deposit.

The relevant definition of money supply when inflation is expected to continue will be termed the "operative money supply." It includes the conventionally defined money supply plus bank borrowings of foreign funds and an increasing array of commodities and other goods that serve as near-money and can substitute for conventional money as inflation intensifies.

Obtaining goods which serve as operative money typically involves borrowing which, in turn, creates more conventional money. These actions inflate prices further, creating more demand for operative money. As the process continues, more goods function as near-money and goods already in that category become more liquid and more acceptable as a store of value for deferred payments. They also displace conventional money as a unit of account so that nominal money values have less and less meaning unless converted to real terms. In other words, goods, increasingly displacing conventional money, function as money while fulfilling their conventional functions. These goods include diamonds and other precious stones and metals and many agricultural and other commodities. As inflation progresses, residential housing and other real estate begin to perform as money. So do automobiles, refrigerators, and other consumer durables.

As inflation intensifies, the effects of the snowballing supply of operative money are reinforced by its increasing velocity of circulation. Goods and conventional money both change hands an increasing number of times each year.

Higher interest rates encourage those with the most assets to seek ownership of more assets. They expect continuing inflation to reduce the financial burden of outstanding loans and to increase their equity in owned assets, which increases their ability to borrow. They thus increase inflation through the increased prices of goods and services and increased nominal value of assets ranging from gold to real estate. Those with the most assets and the most debt stand to gain most from this behavior. And their potential for borrowing is the greatest.

Business will boost prices and hire more labor. Why? Because the nominal value of their current plant and equipment is now greater and the cost of replacement greater still, they have a greater incentive to use this plant and equipment to full capacity. They may also extend the life of plant and equipment through increased servicing, repair, renovation, and hiring of labor and services to perform these functions. They may postpone replacement even beyond the point of prudence. They may increase raw material inventories both to expand production and to profit from further price hikes. They will also tend to mark up prices as much and as often as possible, to help cover the increasing costs of labor, credit, and materials, and the anticipated snowballing costs of plant and equipment. Moreover, such businesses will have both increased ability and incentive to borrow to purchase further assets also expected to appreciate.

When inflation is expected to continue, higher interest rates will encourage businesses to borrow more from one another and from the public by overbilling, as with utilities, which further expands the operative money supply. This kind of borrowing, reportedly quadrupled in the last decade, now amounts to an estimated $90 billion annually. An accurate estimate is difficult because new ways of borrowing surface more frequently as inflation intensifies.

Higher interest rates and reserve ratios encourage more banks to leave the Federal Reserve System so that they may loan and borrow more. Banks are encouraged to increase the operative money supply by issuing credit cards with liberal limits and hedging their risks by wider geographic dispersion of accounts.

Because the U.S. economy is open-ended and because the number and size of multinational corpora-

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Thus, expected continuing inflation in an open-ended economy such as ours means that intense application of such traditional measures as higher interest rates and higher discount rates to slow the money supply can, instead, exacerbate inflation.

tions are growing, higher interest rates attract greater quantities of foreign money, including Euro- and petro-dollars. This money expands the operative money supply further as foreigners buy money market bills, real estate, commodities, and other assets. It also increases bank deposits and bank borrowing, which adds to domestic inflation because of increased dividend and interest payments to foreigners, and it inflates commodity prices, real estate, and other asset values.

Such foreign investment tends to "stengthen the dollar" in a cosmetic sense. Increased foreign ownership of U.S. assets slows the relative outflow of U.S. dollars just as such outflow would be slowed from increased net exports due to greater productivity and the containment of inflation. This factor does not show up in the usual Federal Reserve statistics of the domestic money supply.

Higher interest rates also encourage more Government lending and spending on housing. When inflation is not expected to continue, the slowing of housing construction in response to mild increases in interest rates is a major signal of slowing inflation. However, when inflation is expected to continue, governments will loan low-income and young families the downpayment to buy a home as an inflation hedge. Thus, the money supply increases still more.

Thus, expected continuing inflation in an open-ended economy such as ours means that intense application of such traditional measures as higher interest rates and higher discount rates to slow the money supply can, instead, exacerbate inflation. The relevant money supply becomes open-ended. Asset owners and debtors are encouraged to borrow and buy more assets rather than investing in activities and processes that enhance resource productivity. These asset values increasingly become part of the operative money supply. This operative money supply increasingly fans further inflation since asset values generally appreciate faster than the rate of increase in wages and prices.

In such a situation, individuals and businesses with the least assets and the least expertise in money management will become bankrupt. Layoffs will occur. Higher interest rates and related tighter conventional controls on money supply may hasten this "cosmetic" recession. It can be termed cosmetic because it simply signifies a widening of income and asset distribution whereby those with the most assets become richer and those with the least become poorer. There is no reason to suppose that such a recession would induce fundamental changes in the composition of investment and other economic activities to enhance resource productivity. An example of such a change would be the development and marketing of lower-priced substitutes for items with an inelastic demand. Meanwhile, individuals and businesses contributing most to the increase in inflation through asset purchase and negotiated wage increases gain the most and can continue to fuel inflation.

Thus, as stated, new approaches are needed to encourage a more productive pattern of investment and related economic activity. These measures will likely extend far beyond ways to control the money supply, although its control remains a priority. What can be done to control the supply? Since increasing the interest rate accelerates the increase in the money supply, a somewhat lower set of rates seems called for, such as lower spot and forward exchange rates for the U.S. dollar. However, because the United States is an open economy, further interim provisions would be needed to prevent a flight of funds to foreign countries with greater inflation rates. The need for these provisions would diminish when both U.S. and foreign investors perceived a lesser risk to investment for comparable rates of return in the United States. This lesser risk would result from the successful application of basic anti-inflation measures such as those to enhance resource productivity and modulate monopoly power. Lower interest rates could enable increased investment for these purposes. Other, more specific provisions would be needed to trim the overall money supply. Examples would be limiting foreign ownership in real estate and other assets, and imposing tighter credit controls.

Measures to control the money supply alone, however, are unlikely to be enough to enhance resource productivity and the functioning of various economic institutions to ensure only mild continuing inflation. But that is another story.

In Earlier Issues

Self-appraisal—serious-appraisal—is often recommended, rarely practiced.

O. V. Wells
AER, Vol. IV, No. 3, p. 65
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AN ANALYSIS OF THE 1979 FEED GRAIN SET-ASIDE PROGRAM*

By Lloyd D. Teigen, Thomas M. Bell, and Joseph M. Roop*

INTRODUCTION

In this note we describe a shortcut method for evaluating the impact of alternative set-aside and diversion decisions for the 1979 feed grains program that draws on existing models and data systems and that provides needed policy information quickly, to meet demands within USDA. The models used are (1) commodity acreage equations; (2) impact multipliers from the USDA Cross-Commodity Forecasting System (CCFS), which are maintained by the Food and Agriculture Policy Branch of the National Economics Division (NED) ESCS; (3) the farm income and Consumer Price Index (CPI) processors developed by the Aggregate Forecasting Project of the National Economics Analysis Division, (NEAD) (now part of the Economic Indicators and Statistic Branch, NED), and (4) the Outlook and Situation Information System (OASIS), (*1*,*2*)[1] (now in the World Analysis Branch, International Economics Division (IED).

We measure impacts on Government costs, consumers, and the agricultural commodity and financial sectors. We also analyze cash receipts for commodities, aggregate U.S. net farm income (and changes of relative incomes between the crop and livestock sectors), and the CPI for food.

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

Assumption

The first of the five scenarios, referred to as the base solution, assumes a zero set-aside for feed grains and cotton with a 20-percent set-aside for wheat. The other four alternatives analyzed were:

A 10-percent set-aside on all feed grains (except oats).

A 10-percent set-aside on all feed grains (except oats) and an optional 10 percent paid diversion of acreage with payments of $2 per bushel on corn and $1.20 per bushel on barley and sorghum grain.

A 15-percent set-aside on all feed grains (except oats).

A 15-percent set-aside on all feed grains (except oats) and an optional 15-percent paid diversion of acreage with payments of $2.50 per bushel on corn and $1.50 per bushel on barley and sorghum grain.

ACREAGE ANALYSIS

To analyze supply response, we use the regional cotton equations of Evans and Bell (*3*) and the corn equation of Gallagher (*5*). The feed grain equations revise and modify the original work by Houck, and others (*7*). The wheat equation is original with this analysis.[2]

As the equations used here were not estimated with either constrained estimation or a consistent set of variables (particularly variables representing the current program), our solutions provide only one interpretation. For example, a set-aside program can be viewed as reducing the price facing farmers, increasing the diversion payment, increasing the opportunity cost of the crop, or any combination of the three. In our analysis, the expected effective support price overrode lagged farm prices. We did not adjust the diversion payment to account for inflation as we used the nominal variable in each equation. Nor did we constrain the acreage estimates to equal a fixed land base.

The effective support prices for grains[3] were factored by the appropriate percentages to represent the set-aside scenarios (for example, the effective support price for sorghum for the 10-percent set-aside is 90 percent of the zero set-aside price but is not allowed to fall below the loan rate). Effects on the competing crops were estimated either by reducing farm prices facing the grower or by increasing opportunity costs or diversion payments. For the scenarios with set-aside and diversion payments, the diversion payment variable (if present) or a modification of the producer price induced the acreage response. The effective diversion payment is the per bushel rate times the ratio of diverted to total (planted, set-aside, and diverted) acreage.

[2] The variables in the wheat equation are loan rate, diversion payment, wheat/sorghum price ratio, oat-plus-barley acreage, and cotton acreage.

[3] The effective support price is the loan rate plus the allocation factor estimate times the difference between target and loan. The allocation factor is the ratio of national program acreage to the estimated harvested acreage, and affects the level of deficiency payments received by farmers.

The presence of a set-aside program alone is not enough to affect planted acreage substantially. A paid diversion program is needed to appreciably reduce supply.

Table 1 presents the acreage estimates for 1979 under the five policy scenarios. For all feed grains plus wheat, the equation estimate for 1979 was given an additive adjustment equal to the difference between the model solution for 1978 and the actual 1978 acreage. The most significant of these adjustments were -7 million acres for wheat, -4 million acres for corn, and 1.7 million acres for barley.

The presence of a set-aside program alone is not enough to affect planted acreage substantially. A paid diversion program is needed to appreciably reduce supply. The actual 1979 program was a 10-percent set-aside/10-percent diversion program. Actual 1979 planted feed grain acreage was within 3 percent of the 10/10 scenario's estimate. The overestimation of minor grains (due to an unexpected increase in sunflower acreage) slightly exceeded the underestimation of corn acreage. The record soybean acreage was not forecast by the equations and its error exceeds that for all seven crops. ESCS Cross-Commodity Forecasting System (CCFS), which links together

CROSS-COMMODITY IMPACTS

This analysis used multipliers from the four-sector model of the the livestock, feed grain, wheat, and soybean sectors.[4] This 165-equation model links the U.S. consumer demand for meats and export demands for grains to U.S. production of crops. We calculated multi-

[4] The basic equations for all except the soybean sectors are those reported in (*11*). The soybean sector results from current research in ESCS that has used the work of Houck, Ryan, and Subotnik (*8*); the specific estimates of coefficients are available from the authors. The cotton model was developed by Bell and Evans, whose detailed supply side is presented in (*3*), and the impact multipliers were presented by Evans, Bell, and Remmele (*4*).

Table 1—Acreage response for 1979 to five policy scenarios

Crop	0 pct. set aside 0 pct. diversion	10 pct. set aside	10 pct. set aside 10 diversion	15 pct.	15 pct. set aside 15 pct. diversion	Actual
	Million acres					
Corn	85.3	82.82	78.3	82.1	76.28	80.0
Sorghum	18.2	17.3	16.5	16.9	15.9	15.4
Barley	9.9	9.3	8.9	8.9	8.5	8.1
Oats	17.4	17.3*	17.2	17.2*	17.1	14.1
Total	130.8	126.72	120.9	126.1	117.7	117.6
Wheat[1]	70.7[2]	70.4*	70.1[2]	70.1[2]	70.1[2]	71.2
Soybeans	68.0	68.0	65.5	68.0	65.4	71.5
Cotton	13.5[1]	13.5[3]	13.5[3]	13.5[3]	13.3[3]	14.1
Total	283.9	278.57	269.5	277.55	266.5	274.4

[1] Assumes a constant participation rate.
[2] 20 percent wheat set-aside.
[3] 10 percent set-aside; 10 percent paid diversion.
* Interpolated solution.

The acreage response equations suggest the set-aside without a paid diversion program induces little response to reduce acreage.

pliers (*12*) of corn, soybean, wheat, sorghum, and cotton production on both the crop and the livestock sectors using the CCFS.[5]

For the livestock sector, ESCS analysts tabulated the impacts on production, the market price of live animals, and the index of retail meat prices. They also calculated crop sector impacts on farm price, domestic use, exports, and stock levels. To capture the dynamic response of these changes, they tabulated both the immediate and induced impact on subsequent production, consumption, and price. The cotton sector is virtually independent of the food sectors.

We estimated the overall free market effects of each of the set-aside options on commodity production, consumption, and prices using the CCFS impact multipliers. The crop acreage equations with corresponding yield estimates determined supply.[6] The difference between these estimates and the supply under the zero set-aside option, together with the CCFS multipliers, determined free market results. We integrated these results with minimum commodity prices (the loan rates) and maximum commodity prices[7] and inserted these results into the CCFS, with commodity prices simultaneously exogenized, to determine the results shown in table 2.

AGGREGATE INDICATORS

These set-aside programs influence retail meat prices. Concentration in the cereal, baking, and other grain-processing industries, together with the large fraction of nonagricultural value added, has caused retail prices for these products to be relatively independent of farm grain prices. The 1979 set-aside plus diversion scenarios will increase retail meat prices between 2 and 3 percent in 1980 and 1981, while the set-aside-only scenarios would have a smaller impact on meat prices. Meat prices represent about half of total food costs, which make up about one-fifth (18 percent) of the consumer's total budget.

We translated the above prices and quantities into effects on cash receipts and farm sector income using algorithms developed by NEAD and documented in (*1*) and (*2*).

Table 3 estimates the effect of different programs relative to the zero-set-aside baseline (the 10- and 15-percent set-aside-only scenarios only fractionally affected farm income). Expense reductions almost offset reduced receipts both from marketings and Government payments. When paid diversion is considered with set-aside, the income effects are substantial—$1 billion to $5 billion on a base of $28 billion.

RESULTS

We selected five scenarios to indicate the wide range of options open to decisionmakers. The acreage response equations suggest the set-aside without a paid diversion program induces little response to reduce acreage. For example, a 10-percent feed grain set-aside decreases total acreage by about 5 million acres, and the 15-percent set-aside idles slightly less than 8 million acres of land. Consequently, aggregate impacts on farm income and retail prices (table 3) are negligible. This results from: (1) the narrow spread between the target and loan (or market prices) that induces the acreage response; (2) the stock action generally required to maintain the

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Economic forecasting has always been a hazardous pursuit. . . . we employ a combination of qualitative judgment and statistical estimation, which doubtless involves too much intuition to satisfy the econometricians and too much statistical manipulation for those who believe that predominantly judgmental appraisals are likely to yield the best predictions.

James P. Cavin
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[5] The following reservations regarding the specific estimates of the multipliers should be noted. The corn and soybean demand equations may be slightly too inelastic (*13*). Pork supply and beef demand may also be too inelastic (*6*) while pork demand seems too elastic (*6*). The cross-commodity price impacts on the wheat sector may be too "hot," overestimating the wheat price effect of nonwheat-sector changes.

[6] Actually the acreage is converted to production by harvested acreage and yield equations.

[7] After looking at stock impacts and consulting with commodity specialists, the authors reached the conclusion that the maximum commodity price is generally less than commodity release prices under reserve programs and sometimes less than the free market price plus the change from free market levels using impact multipliers.

price at loan, or higher, and (3) the requirement of participation in Government programs for program benefits, which decreases U.S. Treasury outlays due to relatively low program participation.

However, the 10-percent set-aside plus 10-percent paid diversion removes enough acreage from production (16.4 million acres) to maintain aggregate U.S. farm income near 1978 levels.[8] Treasury outlays are increased less than $500 million, and the consumer pays approximately 1 percent more money for 1 percent less meat. The total CPI increases less than 0.1 percent. Crop producers gain income increases, averaging more than $1 billion, in 1979, 1980, and 1981. Total cash receipts for crops, which decrease negligibly are more than offset by decreased production expenses of approximately $1 billion. The livestock sector suffers small losses as increased cash receipts of approximately $1 billion in 1980 and 1981 are more than offset by the $1.3 billion cost increase in feed.

Relative to the 10/10 scenario, the 15-percent set-aside, plus 15-percent paid diversion, increases farm income about $2 billion and $5 billion for 1979 and 1980. This increase results from: slightly increasing crop cash receipts (over the base) rather than the no change or slight decrease in total cash receipts for the 10/10 scenario. U.S. Treasury outlays are approximately $400 million over the 10/10 scenario, and feed costs increase about $300 million. Farm production expenses decline approximately $300 million, and little change occurs in aggregate cash receipts for livestock. There is a slight increase in consumer purchases and prices over the 10/10 scenario.

[8] The current estimate of 1979 net farm income is about $31.7 billion.

Table 2—Final impacts of set-aside/diversion scenarios

Commodity	Unit	Calendar year							
		10 percent set aside		10/10 diversion		15 percent set aside		15/15 diversion	
		1980	1981	1980	1981	1980	1981	1980	1981
CPI, meats	1967=100	+0.19	-0.65	+3.75	+5.30	+0.29	-0.36	+4.07	+5.82
Beef:									
Production	Mil. lbs.	-.3	+24	-106	-138	-12	+14	-119	-157
Price, Omaha, slaughter steer	$/cwt.	+.03	-.27	+1.09	+1.17	+.12	-.20	1.22	+1.33
Price, Kansas City feeder steer	$/cwt.	-.03	+.54	-.62	-.25	-.05	+.57	-.72	-.31
Retail price index	1967=100	+.009	-.095	+3.26	4.07	.36	-.68	6.59	2.84
Pork:									
Production	Mil. lbs.	+0	+32	-69	-101	+1	+28	-68	-107
Price 7-market borrows and gilts	$/cwt.	+.01	-.52	1.16	1.39	.04	-.47	1.20	1.51
Retail price index	1967=100		-1.65	3.66	4.63	.16	-1.44	3.85	5.05
Broilers:									
Production	Mil. lbs.	+0	+37	-69	-22	4	38	-63	-16
Price, 9-city wholesale	¢/lb.	+.02	-88	1.88	1.96	.09	-.79	1.98	2.15
Retail price index, broilers	1967=100	.07	-2.94	6.33	6.85	.34	-2.64	6.75	7.56
Milk:									
Production	bil. lbs.	-.07	1.11	-2.28	-1.78	-.23	1.04	-2.51	-2.02
Farm price	$/cwt.	+.022	-.036	0.73	.057	.007	-.033	0.80	.065
Retail price index, dairy	1967=100	+.02	-.34	.71	.55	.07	-.32	.78	.63

Table 2—Final impacts of set-aside diversion scenarios

Crop	Unit	10 pct. set aside		10/10 diversion		15 pct. set aside		15/15 diversion	
		Crop year							
		1979	1980	1979	1980	1979	1980	1979	1980
		Number							
Corn:									
Price	$/bu.	0	-0.10	+0.20	$0.10	0	-0.10	+0.20	+0.20
Feed use	Mil. bu.	-2	-37	36	84	+10	-32	49	112
Commercial exports	Mil. bu.	0	-51	1.02	6	15	-44	122	154
Sorghum:									
Price	$/bu.	0	.05	0	+.17	0	-.05	.07	+.17
Feed use	Mil. bu.	0	+6	-2	-17	-1	+7	-20	-16
Commercial exports	Mil. bu.	-0	-9	22	14	2	-8	20	18
Barley:									
Price	$/bu.	.12	+.17	.20	.25	.20	.25	.28	.33
Feed use	Mil. bu.	-18	-28	-45	-42	-31	-37	-53	-68
Total exports	Mil. bu.	0	0	0	0	0	0	0	0
Oats:									
Price	$/bu.	.01	.01	.01	.01	.01	.01	.02	.02
Feed use	Mil. bu.	-4	-11	+14	+6	-4	-11	+10	+3
Total exports	Mil. bu.	0	0	0	0	0	0	0	0
Wheat:									
Price	$/bu.	0	0	0	0	0	0	0	0
Feed use	Mil. bu.	-0	-4	-1	+12	-0	-4	+4	+12
Commercial exports	Mil. bu.	6	-13	46	43	10	-11	+60	+49
Soybeans:									
Price	$/bu.	.06	.10	1.00	1.55	0.09	.14	1.22	1.72
Commercial exports	Mil. bu.	-0	+20	-37	-41	-4	+18	-42	-49
Soybean meal:									
Price	$/bu.	-.033	-.910	+1.883	+1.708	+.165	-.841	+2.107	2.015
Feed use	Thous. S.T.	-6	+501	-859	-9.55	-79	+457	-955	-1.114
Commercial exports	Thous. S.T.	+1	+285	-594	-579	-61	+260	-676	-692

Set-aside-only options have little impact unless the set-aside and paid diversion scenarios maintain or increase farm income over 1978 levels. Increased livestock receipts fail to offset increased feed costs. The consumer eats slightly less meat at slightly higher prices.

CONCLUSION

For farm income to be maintained at approximately 1978 levels, some form of acreage diversion program would have been required for the feed grains for 1979. Set-aside-only options have little impact unless the set-aside percentages are higher than those analyzed here. Combination set-aside and paid diversion scenarios maintain or increase farm income over 1978 levels. The increase occurring entirely in the crop sector results from slightly higher Government payments and decreased crop production expenses. Increased livestock receipts fail to offset increased feed costs. The consumer eats slightly less meat at slightly higher prices.

The models were shown to be an efficient means of obtaining a comprehensive quick-response evaluation of a major policy question. In concert with the judgments of economists with both institutional and analytical backgrounds, the models provide a consistent framework for analysis. The analyst's judgments are still needed because not all of our economic knowledge is precise enough to express in explicit mathematical language.

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In Earlier Issues

Economic forecasting is still exceedingly unsatisfactory, and some economists regard it as a vice from which the virtuous should resolutely abstain. But so long as individuals, commercial enterprises, and governments must make decisions on the basis of judgment as to the course of economic events in the future, economic forecasts must necessarily be made and acted upon.

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U.S. AGRICULTURE IN AN INTERDEPENDENT WORLD: CLOSING THE GAP BETWEEN ANALYTICAL SYSTEMS AND ECONOMIC REALITY

Leroy Quance and Mihajlo Mesarovic*

Institutions that provide information about food and agriculture to private and public decisionmakers are developing more realistic analytical systems. Their models are becoming globally oriented and more interdisciplinary. They are directed more at longrun planning, better balanced in terms of man/machine components, more explicit as to policy and management decision options, and thereby more useful.

We can no longer analyze significant issues in U.S. food and agriculture apart from the global system to which they are related. Comprehensive, computerized simulation models together with professional subject-matter expertise are essential.

CURRENT USDA MODELS

For the past 6 to 10 years, most long-range projection activities in ESCS and its predecessor, the Economic Research Service (ERS), have depended on formal models. Projections of U.S. agricultural exports and analyses of the world food situation depend heavily on the Grains, Oilseeds, and Livestock (GOL) world trade model (*4*).[1] For long-range analyses of U.S. domestic food and agricultural issues, we use the National-Interregional Agricultural Projections (NIRAP) system (*3*).

GOL, a longrun equilibrium model of world grains, oilseeds, and livestock production, consumption, and trade, relates grain-oriented food economics of developing regions to livestock-oriented economies of developed regions.

NIRAP, an annual supply-demand equilibrium model of U.S. farm production, provides linkages to the general economy, farm inputs, natural resource use, the environment, food prices, total and per capita food consumption and expenditures, and world agricultural trade. It relates equilibrium production and prices to scenario-determined shifts in commodity and aggregate demand and supply functions.

Collaboration between the groups responsible for GOL and NIRAP has generally resulted in consistent projections of U.S. agricultural exports. However, such consistency is achieved offline and is time-consuming; furthermore, the real-world feedback loops or the interactions between world demands for U.S. agricultural exports, as represented in GOL and U.S. domestic demand and supply representations in NIRAP, have been dealt with inadequately.

Largely due to increasing exports, the demand for U.S. farm output is projected to increase faster than supply, resulting in real commodity price increases. U.S. supply and demand details in the GOL model are inadequate to realistically project the real price increases. Agricultural exports derived from the GOL model are generally higher than projections generated by NIRAP. In NIRAP, real price increases generally lower quantities demanded for export more than the GOL model. Such phenomena generally occur when two sectors or markets are simulated independently. The lack of adequate feedback loops causes projections to approach simple trend projections and rates of change to be projected too high.

Our recent experience with the Global 2000 Study, directed by the U.S. Council on Environmental Quality (CEQ), provides an excellent example of the problem of inadequate feedback loops. The CEQ study, requested in President Carter's 1977 environmental message, assesses worldwide trends in population, environment, and resources. In coordinating the study, CEQ analysts asked several U.S. Government agencies to provide projections in their respective areas of important variables under three scenarios differing in U.S. Bureau of the Census population projections and in World Bank GNP projections. Projections were also generated for food, fisheries, energy, water, and minerals.

The CEQ staff discovered that, although most projections and analyses had been made with great care and considerable subject-matter expertise, they were not consistent. This inconsistency resulted from considering each major sector independently of other sectors. Impacts of other variables, such as population, energy, and agriculture, had been inadequately treated. For example, an assumption of high economic growth for a specific region may not have been consistent with high oil imports and high balance of payment deficits.

WORLD INTEGRATED MODEL

To assess the importance of these inconsistencies, the Global 2000

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

The GOL and NIRAP models need linkages not only between agricultural export demand and domestic supply and demand but also to general economic growth, energy, and population.

Study director asked Case Western Reserve University and Systems Applications, Incorporated, to analyze the impact of closing such feedback loops using their World Integrated Model (WIM). WIM has 7 sectors and 13 geographic regions with 27 possible subsectors. It is supported by five submodels: population, food, energy, raw materials, and international trade. WIM analysts initially cut the feedback loops to validate the Global 2000 projections. To assess the impact, they closed the loops linking the various sectors. They analyzed some important feedback loops: (1) balance of payment restrictions on imports, (2) the impact of energy deficits on economic growth, (3) fertility as a function of income, and (4) the impact of calorie and protein availability on mortality (*1*).

In the WIM open-loop analysis, the global economy grows from $6.1 trillion in 1975 to $14.8 trillion in 2000—a 3.5-percent growth rate; that is, slightly below the average for the sixties but almost identical to the Global 2000 Study projection of $14.7 trillion for 2000 (generated by the World Bank's SIMLINK model). This compares with an $11.7 trillion world economy in 2000 under the WIM closed-loop analysis—a difference of 21 percent. The lower economic growth projected by the open-loop analysis occurs primarily because energy shortages materialize by the late eighties and early nineties and because high levels of foreign debt occur, particularly in the less developed countries. In the closed-loop analysis, the lack of adequate new capital leads to reduced imports, including energy and capital goods, and to slower economic growth.

World grain production increases 107 percent from 1975 to 2000 in the WIM open-loop analysis, compared with a 96-percent growth in the median Global 2000 projections generated by the GOL model. This difference is caused largely by differences between the initial values of grain production for GOL and WIM. The calculations of the U.N. Food and Agriculture Organization (FAO) for 1975 production used in the WIM analysis involve a slightly different accounting system than those used by USDA. In the WIM closed-loop analysis, there is less capital for agricultural investments and production inputs as indicated by the WIM closed-loop scenario's lower fertilizer projections. This causes world grain production to fall considerably short of the growth rate projected in either the WIM open-loop scenario or the Global 2000 median projection (an 85-percent increase by 2000).

The Global 2000 Study projects a 40-percent increase in real grain prices by 2000, compared with a 100-percent increase in the WIM open-loop projections. WIM accounts for the impact of increasing input prices whereas the Global 2000 Study does not. However, the WIM closed-loop scenario does not result in higher food prices than the open-loop scenario because, in the former, less income is spent on food and fewer people buy it.

This comparison makes a strong case for an integrated global analytical system for studying food and agricultural issues. The GOL and NIRAP models need linkages not only between agricultural export demand and domestic supply and demand but also to general economic growth, energy, and population.

AGRICULTURE IN THE WORLD INTEGRATED MODEL (AGWIM)

While ESCS analysts were initially discussing integration of GOL and NIRAP, Mesarovic approached ESCS about the possibility of integrating GOL, NIRAP, and WIM. Whereas GOL and NIRAP lack WIM's general economic and nonagricultural world detail, WIM lacks the agricultural detail of GOL and NIRAP to analyze emerging U.S. and world food and agricultural issues fully.

The cooperative project that followed has resulted in a first-generation combined GOL, NIRAP, and WIM model — Agriculture in the World Integrated Model (AGWIM). Linkages have been effected among the three major submodels for population and GNP growth and for agricultural production and trade. That is, WIM provides population and GNP projections for GOL and NIRAP. GOL and NIRAP then project U.S. and world agricultural production, prices, trade, and utilization.

These agricultural projections provide the value added for agriculture in the economic submodel and food availability for the population submodel in the next WIM iteration. The WIM food submodel provides world agricultural production and trade projections for some commodities, such as tubers, coffee, and sugar, which GOL lacks. Thus, the agricultural projections capability originating in GOL and NIRAP is internally consistent and has linkages with, and feedback loops to, the population and GNP projections generated in WIM. Furthermore, *We cannot expect any modeling system to analyze effectively all issues regarding food and agriculture. But we think AGWIM points in the direction of future modeling developments that will help in analyzing complex issues.*

AGWIM provides a global analytical framework with emphasis on food and agriculture in which future developments can simulate interactions between emerging agricultural issues and population growth, economic development, energy, and the environment.

To test AGWIM, we developed two extreme U.S. energy policy scenarios. First, we assumed a successful energy policy combining conservation, additional investment in domestic energy production, and substitution of other energy sources for oil imports. Then we simulated a pessimistic scenario in which we assumed that the United States does not develop an energy conservation policy and relies as much as possible on oil imports. We then analyzed the implications of these two energy scenarios for U.S. agricultural exports. In particular, assuming a vigorous agricultural export policy in both cases, what portion of the U.S. oil import bill will be covered by agricultural exports?

The results suggest that the AGWIM model performs well. The tentative answer to the policy question posed is that, under the successful energy scenario, agricultural exports will cover 40 percent of the U.S. bill for oil imports in the year 2000. Under the second scenario in which the United States does not develop a successful energy conservation program and past trends continue, U.S. agricultural exports will offset only 14 percent of the bill for oil imports.

The AGWIM model is new. Only basic linkages are operational as opposed to the complete integration of its three component models. We cannot expect any modeling system to analyze effectively all issues regarding food and agriculture. But we think AGWIM points in the direction of future modeling developments that will help in analyzing complex issues. Such models can be used to develop and test new theories about food and agriculture in an interdependent world.

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In Earlier Issues

. . . farmers were indoctrinated in antimonopolism, in the physiocratic faith that agriculture was the basic industry in the economy, and in the belief that they had not been receiving a fair share of the national income. They were devoted, moreover, to the use of government power to protect their interests. Farmers were pictured as small capitalists, determined to protect their investments and anxious to have a fair return from their labor.

Everett E. Edwards
AER, Vol. IV, No. 3, p. 96
July 1952

SCARCITY AND GROWTH RECONSIDERED

V. Kerry Smith, Editor. Published for Resources for the Future, Inc. by the Johns Hopkins University Press, 1979, $18.95 hardcover, $6.95 paperback.

*Reviewed by Karl Gertel**

The stated objective of this volume of conference papers is to "reconsider the long-run importance and availability of natural resources for economic growth and material well-being." The focus is on nonrenewable extractive resources, although some data are presented for agriculture, forestry, and fisheries. The interrelationship between resource extraction and quality of environment is emphasized. The title derives from the influential book by Barnett and Morse who found that economic growth need not be restrained by resource shortages.[1]

Scarcity and Growth Reconsidered covers three areas: (1) the role of natural resources in economic modeling, or to be more accurate, the role of natural resources in the economy, (2) the availability of natural resources as viewed by physical scientists, and (3) empirical measures of the economic scarcity of resources. V. K. Smith and J. V. Krutilla provide an interpretive introduction and a summary and discussion of research issues. They integrate the papers within the relevant literature and suggest areas for further inquiry. However, they are perhaps too wide ranging to delineate sharply the issues and priorities, nor could any overview substitute for the background and detail developed in the papers.

J. E. Stiglitz in the lead paper, "A Neo-classical Analysis of the Economics of Natural Resources," briefly, but systematically, explores the significance of natural resources in an aggregate production function and makes a series of judgments on such issues as the effects of monopoly, government policies and interventions, and a drastic oversimplification of optimal intertemporal use rates of exhaustible resources. One need not be comfortable with all of Stiglitz's conclusions to find this a perceptive and stimulating paper.

"Entropy, Growth, and the Political Economy of Scarcity" by H.E. Daly eloquently presents the moral perspective of "the continuation of life, the survival of the biosphere and its evolving processes." Daly proceeds from the concept of entropy, which, as I understand it, derives from the laws of thermodynamics and the ultimate state of degradation of matter and energy in the universe, a state to be avoided by a "steady state economy." Daly proposes depletion quotas sold at auction as the principal means to achieve the steady state. The steady state would also include a constant population and maximum use of renewable resources. Whereas Stiglitz states that his paper addresses "the more immediate future," Daly's spectrum seems timeless.

N. Georgescu-Roegen, who is in sympathy with Daly, discusses both papers. Nonetheless, Georgescu-Roegen points out that a steady state economy may not be achievable, and Daly himself recognizes that ecological and full employment equilibria may not coincide. S. V. Ciriacy-Wantrup's "A Safe Minimum Standard as an Objective of Conservation Policy," may be relevant.[2] Recognizing uncertainty, he calls for modest or minimal standards of conservation. Although developed for renewable resources with a "critical zone" of rate of use, this principle might be adaptable to nonrenewable resources policy.

The papers on availability of natural resources by D. A. Brobst and H. E. Goeller will most help readers with limited background in areas such as the distribution of depletable resources over the earth and the meaning of "reserves." The two papers and the discussion by B. M. Hannon evaluate future adequacy. Brobst and Goeller both conclude that the next few decades are critical. Ample supplies and low-cost energy to process the relatively plentiful materials with very low concentrations of metals and minerals represent the key to future abundance. Brobst and Goeller's differences in outlook stem largely from estimates of the amount of energy required to process low-grade sources. They agree substantially on appropriate public policies and the important role of the political economy.

The final section on empirical measures of resource scarcity is introduced by H. J. Barnett who recapitulates the findings of *Scarcity and Growth* and supplements them with more recent statistics for the United States and selected countries. The principal measures of resource scarcity are output per unit of input of extractive industries, agriculture, forestry, and fishing and trends in

*The reviewer is an agricultural economist with the Natural Resource Economics Division, ESCS.

[1] Barnett, Harold J., and Chandler Morse. "Scarcity and Growth, the Economics of Natural Resource Availability." Published for Resources for the Future, Inc., by the Johns Hopkins University Press, 1963.

[2] Ciriacy-Wantrup, S. V. "Resource Conservation, Economics, and Policies," University of California Press, 1952.

Economic growth need not be restrained by resource shortages.

productivity. Barnett concludes that most of the more recent tests confirm his earlier conclusion for 1870-1957, which rejected the hypothesis of general resource scarcity. He considers monetary costs for mitigating environmental degradation as tolerable.

Two papers complete the third section: G. M. Brown, Jr., and B. Field's "The Adequacy of Measures for Signaling the Scarcity of Natural Resources" and A. C. Fisher's "Measures of Natural Resource Scarcity." Both offer penetrating analysis of conventional measures: unit cost of extraction, price of extracted resources, and rent; the cost of discovery of new resources as a proxy for rent; and elasticity of substitution among resources, capital, and labor. They generally prefer price to extraction cost and rent, although all measures can be misleading under certain specified conditions. The logical next step, in this reviewer's opinion, is to move from theoretical analysis to the more difficult task of deciding empirically how prevalent conditions are under which measures of resource scarcity give wrong signals.

These conference papers rate high in technical quality and clarity. The authors discuss mathematical formulations in a way that makes them meaningful to most nonmathematical readers. Optimists and pessimists can find evidence to support their positions. The book accomplishes its stated purpose of summarizing the state of knowledge in three areas—the role of resources in the economy, availability of resources, and measures of resource scarcity. It brings to the reader's attention gaps in existing knowledge and makes recommendations for further research. Although the priorities of an integrated research program do not fall easily into place, *Scarcity and Growth Revisited* is a good source for developing such a program.

In Earlier Issues

Policy sciences draw upon all the sciences that can be useful in policy development. In this context, knowledge is for practical application to policy needs at a given period. During the war we needed to know, for example, the harbor installations at Casablanca, or the attitudes of the population of Pacific Islanders toward the Japanese, or the maximum range of a fixed artillery piece. These were questions for geographers, anthropologists, or physicists. . . . economists . . . were extensively used during World War II to estimate the facilities, manpower, and resources necessary to produce the munitions required by the armed forces and to supply men and materiel where needed. The economic scientists who made the greatest direct contribution . . . employed mathematics and statistics.

Charles E. Rogers
AER, Vol. IV, No. 3, p. 99-100
July 1952

AGRARIAN STRUCTURE AND PRODUCTIVITY IN DEVELOPING COUNTRIES

Albert R. Berry and William R. Cline,
The Johns Hopkins University Press,
Baltimore, 248 pp.

*Reviewed by Donald Baron**

Berry and Cline present a refreshingly staightforward criterion for determining the need for land reform programs in developing countries. They propose that if output per unit of constant-quality land is substantially higher on small than on large farms, redistributing land from large to small farms will increase both aggregate agricultural output and employment opportunities. Berry and Cline offer several hypotheses for why such an inverse relationship can be expected in most labor-surplus developing countries. They support these hypotheses by establishing the existence of this inverse relationship derived from an analysis of input-output ratios and the intensity of land use characterizing farms in Latin American and Asian countries.

Chapter two presents the main theoretical framework for their hypotheses. Land productivity declines as farm size increases, primarily because labor-market dualism creates an effective price of labor that is substantially lower on small than on large farms. Both the rate of land cultivation and the amount of labor employed per acre of cultivated land are, therefore, higher on small farms. Land and capital market imperfections make the effective price of these factors lower on large farms than on small ones. Land price differences "reinforce the difference in effective labor costs in leading to higher labor/land ratios on small farms than on large and, as a result, higher output per hectare available on the small farms" (p. 10). Lower capital costs induce greater capital use on larger farms. However, in most developing countries, lower capital costs also encourage replacement of labor with machinery in existing production. Therefore, any increase in output/land ratios is likely to be small, while differences between small and large farm labor/land ratios are certainly greatly exacerbated.

Chapter three reviews 1960 U.N. Food and Agriculture Organization (FAO) agricultural census data from 30 developing countries.

> In practically all of these countries, the large farm sector (with the top 40 percent of land area) uses its land less intensively than the small farm sector (with the bottom 20 percent of area), based on the percent of farm area under cultivation (pp. 41-43).

The clear implication is that output/land ratios are also much smaller in the large farm sector.

This chapter also presents statistical tests suggesting that differences between small-farm and large-farm sector output/land ratios should generally decline slightly as land endowment per population declines across countries. The inverse relationship between land productivity and farm size should therefore be less pronounced in land-scarce countries than in land-abundant countries.

Chapter four presents much more detailed analyses of productivity/farm size relationships in six countries: Brazil, Colombia, the Philippines, Pakistan, India, and Malaysia. Data sources include sample farm surveys conducted during the mid-sixties to early seventies, and, for some countries, 1960 or 1970 FAO agricultural censuses. The following hypotheses are tested:

(1) Output per unit of constant-quality land declines as farm size increases.
(2) Between the early sixties and early seventies, this inverse relationship between land productivity and farm size weakened slightly, if at all.
(3) Total social factor productivity, defined as the ratio of value added to total factor costs measured at social prices, also declines as farm size increases.
(4) For any given farm size, land productivity is generally the same on land cultivated under sharecropping arrangements as on land cultivated by owners.

Data from all six countries confirm the first hypothesis. Tests of the second hypothesis are less conclusive. Differences between small-farm and large-farm output/land ratios appear to have remained fairly constant during the sixties in Brazil (at least in the northeast). In India and Pakistan, the differences appear to have lessened somewhat, apparently because large farms have benefited more from green revolution technology than have small farms. However, the productivity differences were still substantial as of the early seventies. Estimates of total social factor productivity for Brazil, Colombia, India, and Malaysia confirm the third hypothesis while estimates of land productivity on sharecropped and owner-cultivated land in Brazil, India, and the Philippines confirm the fourth hypothesis.

Chapter five presents the obvious policy implications. Redistribution of land from large farms to small

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If output per unit of constant-quality land is substantially higher on small than on large farms, redistributing land from large to small farms will increase both aggregate agricultural output and employment opportunities.

family farms is clearly justified, not only in land-abundant countries such as Brazil and Colombia, but also in land-scarce countries such as India, Pakistan, Malaysia, and the Philippines. However, where redistribution is not feasible politically, governments should consider alternative measures to assist small farms. Facilities providing small farmers with "improved seeds, fertilizer, and other modern inputs" plus agricultural credit could be expanded. Governments could also expand credit for land purchases by small farmers, or implement progressive land taxation to encourage voluntary land redistribution (p. 137). However, the absence of any evidence that sharecroppers are less productive than owner-cultivators argues against laws limiting or prohibiting sharecropping.

The apparent strong support given to land redistribution policies by Berry and Cline's statistical tests is weakened somewhat by the age of the productivity data. The census data are now at least 10 years old, and even the latest sample surveys—conducted in 1973—are becoming outdated. The possibility exists that the estimates of small-farm/large-farm productivity differences may no longer be valid today, especially for countries such as India and Pakistan where a trend towards reduction of these differences began as early as the midsixties. If greater rates of adoption of green revolution technology by large farmers during the seventies have reduced these differences further, they may now be so small that land redistribution will have little effect on aggregate agricultural output.

Berry and Cline's analysis is, therefore, most valuable to policymakers today not as direct input in policymaking but as a guide to the types of data that must be collected and the productivity/farm size relationships that must be estimated if correct decisions on land reform are to be made. Policymakers who read this book should recognize that the most difficult land reform issue today is not that of analyzing land-related data but that of obtaining the data in the first place. Berry and Cline underscore the need for much more effort to be directed toward solving the data gathering problem.

In the past, data requirements for land reform studies have been met by farm surveys and by the much less frequent agricultural censuses. Data bases usually vary considerably, which make intertemporal data comparisons and trend analyzes often difficult, as Berry and Cline point out. Moreover, productivity statistics soon become outdated unless surveys and censuses are repeated more frequently than cost constraints generally allow. Part of the cost problem is that sample farm surveys, such as the ones cited by Berry and Cline, usually generate data relevant only to a limited range of land-related issues. Data relevant to other issues must come from additional surveys.

In Earlier Issues

Too many agricultural economists are frightened by the word econometrics. . . . An unfortunate and erroneous impression appears to be current that econometrics is a particularly abstract branch of mathematics, and that only a chosen few can understand it.

Frederick V. Waugh
AER, Vol. IV, No. 3, pp. 100-101
July 1952

The obvious method of reducing the costs of data collection is, therefore, the implementation of a single comprehensive land data system, or cadastre, which will maintain all land-related data needed for policymakers to formulate and administer the entire range of government-sponsored economic development programs, not just land reform. For a given planning region, this data system could maintain separate records for all private ownership units. For each record, data on location, size, ownership, and economic characteristics (land values, existing and potential uses, soil quality, and water availability) could then be maintained. Thus, information relevant to productivity/farm size questions would be one of a variety of data items that would be routinely available. Simple estimates of relative land productivity could be derived through a determination of the percentage of available farmland actually cultivated on each farm which contains land recorded in the land data system.

With the assistance of the U.S. Agency for International Development, a number of developing countries—most notably the Dominican Republic and Honduras—have recently instituted cadastral programs to support land reform efforts. These programs should be monitored closely to ensure that they provide sufficient data for policymakers to determine if output/land ratios actually are significantly lower on large farms than on small farms, the location of areas where productivity differences are most severe, and the location of large ownership units which have the lowest output/land ratios and which are, therefore, prime candidates for land redistribution.

ECONOMICS AND DESIGN OF SMALL-FARMER TECHNOLOGY

Alberto Valdes, Grant M. Scolie, and John L. Dillion, editors. The Iowa State University Press, Ames, 1979, 211 pp., $15.00.

*Reviewed by Donald K. Larson**

A message to the research community comes through clearly in this collection of papers by a distinguished group of scientists. For new technology to be an attractive improvement on current technology, the subjective, ecological, and institutional constraints confronting the small farmer must be incorporated into an evaluation of such technology rather than recognized afterward. This view is reflected throughout 10 papers presented at an International Conference on Economic Analysis in the Design of New Technology for Small Farmers held at the Centro Internacional De Agricultura Tropical (CIAT), November 26-28, 1975. The authors focused on the role of technological design at the farm level and the role of technology change in a context of small-farmer welfare and rural development.

The foreword and introductory chapter set the stage for why prior evaluation needs attention. The small farmer is an important client for new technology, which can increase food production and improve human well-being in the less developed countries of the world. However, technological benefits have not been shared equitably among agricultural producers, and new technologies have not always been readily accepted by small farmers. New technologies must take into account the economic, social, and physical realities faced by small farmers. These realities, interrelated and complex, have often been isolated for study by each appropriate discipline. CIAT has recognized that multidisciplinary teams, involving biological and social scientists, are needed to develop technology that fits these realities.

Authors of these papers examine alternative approaches to technology design and appraisal for small farmers and expose gaps in the existing concepts and techniques. Culture, tradition, and environment, plus mechanisms of choice and available choices, introduce considerable heterogeneity that greatly complicates this task.

The heterogeneity of small farmers is a widely recognized phenomenon that many researchers have faced while attempting to define and focus on the many issues important to small farmers. Unless we have a full quantitative understanding of how small farmers react to and behave in the face of uncertainty, "it is most unlikely that ex ante appraisal can adequately reflect small-farmer reasoning on technology choice."

This book is well written and a valuable reference for economists and other professionals concerned with technology design in agriculture. The papers are a refreshing mixture of economic theory and applied case studies along with some policy implications. Although 9 of the 10 papers focus on Latin America, the analytical approaches can apply wherever technological design involving small farmers is considered. Valuable comments by conference participants follow each article. In addition, the book has a good reference section.

However, this book goes beyond being useful only as a reference. For full benefit, it must be read carefully and its many ideas compared. The editors, in chapter 1, review the problems identified by the papers and discussions and pose a series of related questions that they feel need further, indepth study. Chief among these are: questions on priority of technology research and the welfare gain of consumers (including small farmers), the role of agricultural policy if small farmers are to capture benefits of new technology, changes needed in existing institutional structures before improved technology can benefit small farmers, and the lack of information about resources and psychological attributes of small farmers. If these issues can stimulate the world research community, understanding the technology problems faced by small farmers will be advanced appreciably.

In Earlier Issues

. . . the subject of experimental design has grown to impressive, not to say formidable, proportions. The average agricultural scientist must sometimes long for the good days, not too long past, when conducting an experiment was a simpler matter than it is today. Whatever his feelings may be, he has come to accept the fact that he must learn to live with this thing that has beset him. He should not be blamed too severely for seeking to make the process as painless as possible.

Walter A. Hendricks
AER, Vol. IV, No. 3, p. 101
July 1952

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*U.S. GOVERNMENT PRINTING OFFICE : 1980 0-310-945/ESCS-54

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