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Research Review

Statistical Estimation of Firm-Level Demand Functions: A Case Study in an Oligopolistic Industry

By S. Shapouri, R. J. Folwell, and J. L. Baritelle*

Demand theory has occupied a prime place in economic literature The statistical estimation of demand relationships has usually focused on industry or aggregate market levels, and researchers have used time series data and have assumed perfect competition However, the lack of data from secondary sources and the cost of assembling data from primary sources have precluded analysis of demand at the firm level in a market with imperfect competition

A recent marketing survey by the Economics and Statistics Service and Washington State University yielded a data set which enabled researchers to estimate firm-level demand function in an imperfect, competitive market The principal objective of this research was to gain information on the marketing and consumption of U S wines The results of this study lend credibility to the postulates of the theory of the firm under imperfect, competitive market structures

Microeconomic Considerations

Price-quantity decisions of competitive firms are deterministic because of the atomistic character of the demand market, the firm is a price taker and, therefore, the demand function it faces is perfectly elastic

The behavior of the firm in making price-quantity decisions is usually indeterminate in an imperfect, competitive market structure. In an oligopoly, this indeterminancy arises from the varying degrees of interdependence among the participants Each oligopolist is aware (to varying degrees) that specific actions will lead to, or will stimulate, responses by rivals

The individual firm in an oligopolistic market faces its own distinct demand curve (see *4*) [1] Thus, the quantity the ℓth firm sells depends on the pricing decisions of all firms (n) in the industry

$$\overline{Q}_\ell = F_\ell(p_1, p_2, \quad , p_n) \qquad \ell = 1, 2, \quad , n \tag{1}$$

The profit function (Π) of the ℓth oligopolist is

$$\Pi_\ell = q_\ell f_\ell(p_1, p_2, \quad , p_n) - C_\ell(q_\ell) \tag{2}$$

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

The economist's efforts to analyze and predict firm behavior can appear confused when the oligopolist competes with rivals For example, one way for the economist to ensure a deterministic solution would be to incorporate reaction functions for competing, rival firms' pricing decisions (equation (2)) It may also be necessary to make behavioral assumptions concerning the market share and the degree of product differentiation Prices, product (quantities), quality and promotion (advertising) could all be major elements of a firm's demand curve

In examining the theory of the firm under an imperfect, competitive market structure, we restricted our research to the price dimension as presented in equation (1), as information on product and promotion decisions of specific firms was not available We anticipated that (1) most firms face a demand function with approximately the same price elasticity as at the aggregate market level or at a slightly more price-elastic one, (2) some firms face demand functions with significantly greater price elasticity, and these firms charge lower prices, and (3) some firms face less price-elastic demand functions, and these firms charge higher prices We expected that the prices of rival firms would be statistically significant in cases (1) and (2), where a firm faced a demand function that was at least as price elastic as the industry level

We specified and estimated aggregate market-level or industry-level demand functions for various types of American wines These functions generated information on the nature and elasticities of the aggregate market-level demand functions by wine type Then, we specified and estimated demand functions by wine type for each major U S wine firm We compared the firm-level demand functions with industry-level demand functions to confirm the oligopolistic structure of the market

Method

We estimated the demand functions using cross-sectional, wine purchase data The purchase data were reported monthly by a panel of 7,000 households We used cross-sectional data from February 1975 through January 1976 to estimate industry-level demand functions We used data from August 1975 to January 1976 to estimate the firm-level demand functions Costs of compilation precluded recording brand data for the entire period We estimated the functions using ordinary least-squares regression

We specified the aggregate market or industry-level demand functions for each U S wine type This specification was of a double-logarithmic functional form

$$lnQ_{ijk} = B_0 + B_1 lnY_{jk} + B_2 lnP_{ijk} + U_{ijk} \qquad (3)$$

where *ln* denotes the natural log value of the following variables Q_{ijk} = quantity of the ith type of wine purchased in the jth month by the kth household per adult member (ounce/adult), Y_{jk} = the deflated income per adult in the kth household in the jth month ($1,000/adult), P_{ijk} = the deflated price paid per ounce for the ith wine type purchased in the jth month by the kth household (cents/ounce), U_{ijk} = random disturbance term, and B_0, B_1, and B_2 = ordinary least-squares estimated parameters We deflated the income and price variables by the monthly Consumer Price Index for all items The double logarithmic functional form provided the best statistical results over other functional forms—for example, the linear, inverse logarithmic, and semilogarithmic

We estimated demand functions at the industry level for the major wine types (1) varietal red, white, and pink table wines, (2) nonvarietal red, white, and pink table wines, (3) sherry, port, and other dessert wines, (4) champagne and other sparkling wines, (5) apple, berry, citrus, and other flavored wines, and (6) vermouth, flavored and natural brandies [2] We included other wine types in earlier specifications of the demand functions as substitutes (equation (3)), but the prices of such substitutes were not statistically significant

[2] Varietal table wine is made of at least 51 percent of the kind of grape after which the wine is named, and nonvarietal table wine is a blend of various varieties of grapes

We specified the demand functions for individual firms (brands) by wine type as

$$lnQ_{ijk\ell} = B_0 + B_1 lnP_{ijk\ell} + B_2 lnY_{jk} + B_3 ln\overline{P}_{ij} + V_{ijk\ell} \qquad (4)$$

where ℓ = ℓth brand of the ith type of wines, $\overline{P}_{ij}$ = the deflated, weighted-average price paid by all households for all other brands of the ith type of wine during the jth month, and $v_{ijk\ell}$ = the random disturbance term We defined all the other variables as before. We estimated firm-level demand functions only for those nine firms that had a relative market share of at least 1 percent (table 1)

We treated each purchase by an individual household as an observation If a household purchased some other brand of wine and not the brand considered, we did not treat as a zero purchase for that brand, but entered it as an observation in the data set we used to estimate the demand function for the alternative brand. Thus, the estimated functions are demand functions for purchases of a given brand.

The substitute prices we used in the firm-level demand functions were the average prices of all other brands in a region during a given month ($\overline{P}_{ij}$) The regions we used were the nine U S census regions (see 2) In earlier specifications, we used as separate explanatory variables the prices of other brands for the wine type which each specific household purchased rather than the average price for all competing brands We dropped this specification because a singularity ($X'X$) matrix made the estimation of the parameters using ordinary least-squares ($\beta = (X'X)^{-1}X'Y$)) impossible

Table 1—Market shares and average prices, by U S wine company, August 1975 through January 1976

Wine type	Gallo	United Vintners	Franzia	Mogen David	Almaden	Guild	Taylor	Paul Masson	Christian Brothers	All firm average
Market shares					*Percent*					
Varietal table	6 1	26 1	2 4	15 9	3 8	1 3	0 5	1 5	0 9	N A
Nonvarietal table	32 7	11 9	2 3	1	5 5	4 7	2 3	2 0	1 6	N A
Dessert	39 4	8 7	7	1	4 4	3 5	15 2	3 8	3 3	N A
Flavored	50 4	13 6	1	10 0	2 0	6	2 1	1 0	1	N A
All wine	32 9	12 9	2 0	2 8	4 5	3 8	3 6	2 0	1 5	N A
Average price					*Cents per ounce*					
Varietal table	6 0	4 5	3 7	6 0	7 5	4 4	8 6	9 6	11 5	6 1
Nonvarietal table	4 1	4 6	3 8	5 1	5 6	3 6	7 3	7 3	6 6	4 3
Dessert	4 5	4 6	5 0	5 3	6 9	4 8	7 2	9 1	8 2	5 6
Flavored	4 5	4 9	9 6	5 9	5 0	4 4	7 8	7 6	8 4	5 2

N A = not applicable

Industry-Level Demand Functions

Table 2 shows the estimated industry-level or the aggregate market-level demand functions for the major wine types It presents the slope coefficients and their *t*-values The slope coefficients associated with the price variables are negative, statistically significant, and between zero and −1 We retained explanatory variables with signs (in agreement with economic theory if the value of the standard error of the slope coefficient was less than the value of the slope coefficient The results of our study show that the demand functions for each wine type at the U.S industry level are inelastic with respect to price The slope coefficients in the estimated demand functions are elasticity coefficients for the double-log functional form

Firm-Level Demand Functions

Tables 3, 4, and 5 report the estimated demand functions for each wine type at the firm level The signs of the slope coefficients conform to *a priori* economic theory, that is, the signs associated with the price of the wine type considered are negative, and those related to prices of substitute wines and to income are positive We report only those slope coefficients or those cross elasticities for substitute wines that are statistically significant

In the case of varietal table wines (table 3), only the price elasticity of the firm-level demand function for pink varietal table wines differ significantly[3] from that of the industry-level demand function (see footnote 3 of table 3) All the other firm-level demand functions have price elasticities which do not differ significantly from the aggregate market-level elasticity United Vintners has the dominant market share for varietal table wines and has lowest prices (table 1) [4] Thus, we expected a more price-elastic demand function

[3] To test for significant differences between pairs of slope coefficients, we used a *t* test of the following form

$$t = \frac{\beta_i - \beta_j}{V(\beta_i) + V(\beta_j) - 2\,\mathrm{Cov}\,\beta_i\,\beta_j}$$

The value of the covariances (Cov $i\,j$) was assumed to be zero

[4] Use of brand names in this article is for identification only and does not imply endorsement by the U S Department of Agriculture

The lower part of table 4 shows the estimated firm-level demand functions for nonvarietal table wines Comparisons of the price elasticities at the firm level with those at the industry level (table 1) reveal that if a firm-level demand function differs from the aggregate, market-level demand function with respect to price elasticity, the direction of difference is always toward greater elasticity The other price elasticities are almost identical with those at the industry level In four out of five cases, when the firm-level demand function was more price elastic, the prices of substitutes were significant

The only firm-level demand function which was significantly less price elastic than the aggregate market-level demand function was that for Christian Brothers' nonvarietal, pink table wines The average price Christian Brothers charged for nonvarietal table wines was among the highest in that product category

Table 4 shows the estimated firm level demand functions for sherry and port dessert wines Only for Gallo sherry was the firm-level demand function less elastic than that at the industry level, however, the difference was not statistically significant For all other firm-level demand functions for sherry, the price elasticities were greater than, or the same as, those for the industry level Prices of substitutes were significant for two of the eight firms

Comparisons of firm-level demand functions for flavored wines (table 5) with those at the industry level (table 1) indicate two groups in which the firm price elasticity was significantly greater than the industry price elasticity Gallo and Mogen David berry wines

Thus, our statistical estimation of firm-level demand functions in an oligopolistic market substantiate the anticipated theoretical results, which are based on the behavioral assumptions underlying conjectural variations for such a market situation The nine firms studied faced demand functions that were not significantly different from those for the aggregate market When an individual firm-level demand function differed from the aggregate market-level demand function, it tended to be more price elastic and the prices of substitutes (rival firms) were significant

Table 2—Market demand functions for U S wine types

Type	Slope coefficients[1]						Related statistics[2]				
	Intercept		Per capita income		Price		$\overline{Q}_{ij}$	n	R^2	S	S_y
	B_0	t	B_1	t	B_2	t					
			1,000 dollars		*Cents/ounce*		*Cents/ounce*				
Varietal table wines											
Red	3 61	35 3	0 33	6 1	-0 77	-17 3	3 02	683	0 31	0 57	0 69
White	3 32	29 3	34	5 8	- 64	-10 3	2 87	493	19	56	62
Pink	3 68	29 2	38	6 1	- 93	-12 7	3 12	381	35	50	62
Concord	3 80	36 0	15	3 5	- 86	-12 4	2 80	600	21	52	58
Nonvarietal table wines											
Red	3 84	101 1	25	12 4	- 94	-44 6	3 19	4,035	34	61	76
White	3 64	83 9	33	14 2	- 89	-38 1	3 10	3,043	35	58	71
Pink	4 01	110 8	18	7 2	- 99	-47 3	3 32	2,616	46	57	78
Dessert wines											
Sherry	3 16	45 6	22	7 00	- 51	-13 3	2 82	1,319	15	56	62
Port	3 87	52 8	17	4 8	- 90	-16 9	3 07	822	27	55	64
Sparkling wines											
Champagne	2 84	15 9	52	6 6	- 43	-5 5	2 85	436	14	67	72
Cold Duck	2 80	17 8	26	3 6	- 24	-3 6	2 75	351	07	56	58
Sparkling burgundy	3 26	13 7	20	1 9	- 41	-2 7	2 81	82	09	57	59
Flavored wines											
Apple	2 89	32 5	15	3 7	- 35	-5 5	2 72	471	09	47	49
Berry	2 84	33 1	23	6 0	- 36	-6 6	2 69	534	13	45	48
Citrus	3 59	35 5	31	6 0	- 87	-15 7	2 93	581	32	55	67
Vermouth	3 61	29 9	02	[3] 4	- 74	-9 3	2 72	325	21	45	51
Brandy											
Flavored	4 01	20 8	04	[3] 4	- 66	-7 5	2 59	44	60	31	48
Natural	2 87	9 5	26	2 1	- 31	-3 0	2 58	40	28	35	40

[1] Parameters of the demand functions estimated via ordinary least squares

[2] Related statistics $\overline{Q}_{ij}$ = mean of the dependent variable, n = number of observations, R^2 = coefficient of determination, S = standard error of the estimate, and S_y = standard deviation of the dependent variable

[3] Not statistically significant, the standard error of the slope coefficient is greater in value than the value of the estimated slope coefficient

Table 3—Table wines: Firm-level demand functions

Wine type and firm	Slope coefficients[1]								Related statistics[2]				
	Intercept		Price		Per capita income		Substitute price		$\overline{Q}_{ijk\ell}$	n	R^2	S	S_y
	B_0	t	B_1	t	B_2	t	B_3	t					
			Cents/ounce		*1,000 dollars*		*Cents/ounce*						
Varietal table wines:													
Gallo:													
All types	3.78	12.4	-0.89	-4.0	0.16	1.1	...	...	2.83	83	0.17	0.44	0.48
United Vintners:													
Red	3.64	15.0	-.95	-9.6	.43	3.6	...	...	3.16	117	.49	.49	.67
White	3.17	10.0	-.81	-4.8	.50	4.5	...	...	2.89	39	.47	.37	.49
Pink	4.56	15.5	[3] -1.49	-7.1	.15	1.1	...	...	3.36	48	.54	.41	.60
Almaden:													
All types	3.56	8.3	-.80	-3.5	.37	2.0	...	...	2.94	41	.27	.51	.58
Guild:													
Red	3.12	4.2	-.42	[4] -.7	.40	1.1	...	...	3.37	10	.18	.46	.45
Paul Masson:													
Red	2.36	4.0	-.42	-1.5	.68	4.1	...	...	2.54	10	.71	.28	.46
Christian Brothers:													
Red	3.88	6.2	-.59	-1.9	...	...	...	...	2.70	10	.31	.39	.45
Mogen David:													
Concord	3.87	20.9	-.81	-6.1	...	...	...	...	2.78	179	.17	.56	.61
Nonvarietal table wines:													
Gallo:													
Red	3.86	45.4	-.99	-17.3	.23	5.8	...	...	3.19	805	.30	.55	.66
White	4.14	27.2	[3] -1.37	-16.3	.18	3.4	0.14	1.3	3.14	453	.38	.54	.68
Pink	4.07	37.1	[3] -1.24	-18.6									
United Vintners:													
Red	3.93	27.0	-.92	-10.7	.19	2.6	...	...	3.10	288	.29	.54	.63
White	3.57	24.4	-.96	-9.3	.39	5.6	...	...	3.16	252	.31	.51	.62
Pink	3.95	21.8	-.91	[4] -.3	.15	1.3	...	...	3.16	172	.34	.52	.64
Franzia Brothers:													
Red	4.00	12.6	-.77	-2.4	...	...	...	...	3.29	29	.17	.60	.65
White	3.08	7.9	[3] -1.32	-5.3	.39	2.9	.63	1.9	3.30	43	.46	.35	.45
Almaden:													
Red	4.08	15.3	-1.52	-9.8	.63	5.8	...	...	3.06	105	.56	.44	.65
White	4.24	14.3	[3] -1.59	-9.5	.45	4.2	.26	1.2	3.11	117	.38	.53	.68
Pink	4.25	10.0	-1.27	-4.7	.23	1.5	...	...	2.97	48	.38	.48	.60
Guild:													
Red	4.16	9.9	-1.96	-7.5	.38	3.4	.62	1.7	3.69	84	.45	.60	.79
White	4.16	12.4	[3] -1.82	-7.1	.62	3.6	...	...	3.31	49	.58	.48	.72
Pink	4.73	30.9	-1.15	-6.4	...	...	...	...	3.83	35	.55	.37	.54
Paul Masson:													
Red	3.43	4.7	-.97	-2.9	.19	1.1	.70	1.1	2.87	37	.26	.65	.72
White	3.17	6.6	-.74	-3.5	.19	1.1	.47	1.4	2.78	68	.21	.55	.61
Pink	3.72	10.0	-.91	-5.6	.16	1.1	.38	1.5	2.91	52	.41	.45	.57

See notes at end of table.

Table 3—Table wines: Firm-level demand functions (Continued)

Wine type and firm	Slope coefficients[1]								Related statistics[2]				
	Intercept		Price		Per capita income		Substitute price		$\overline{Q}_{ijk\ell}$	n	R^2	S	S_y
	B_0	t	B_1	t	B_2	t	B_3	t					
			Cents/ounce		*1,000 dollars*		*Cents/ounce*						
Christian Brothers:													
Red	4.10	13.0	−.88	−4.4	...	...	...	...	2.78	22	0.49	0.48	0.65
White	3.83	14.1	−.83	−6.1	.27	2.1	...	...	2.71	38	.39	.43	.54
Pink	3.95	27.4	[3]−.61	−6.6	...	...	...	...	3.11	33	.55	.42	.62

. . . = not available.

[1] Parameters of the demand functions estimated via ordinary least squares.

[2] Related statistics: $\overline{Q}_{ijk\ell}$ = mean of the dependent variable; n = number of observations; R^2 = coefficient of determination; S = standard error of the estimate; and S_y = standard deviation of the dependent variable.

[3] Indicates that the firm slope coefficient differs significantly at the 0.05 level from the industry slope coefficient; that is, the price elasticities differ significantly.

[4] Not statistically significant; the standard error of the slope coefficient is greater in value than the value of the estimated slope coefficients.

Table 4—Dessert wines: Firm-level demand functions

Wine type and firm	Slope coefficients[1]								Related statistics[2]				
	Intercept		Price		Per capita income		Substitute price		$\overline{Q}_{ijk\ell}$	n	R^2	S	S_y
	B_0	t	B_1	t	B_2	t	B_3	t					
			Cents/ounce		*1,000 dollars*		*Cents/ounce*						
Sherry:													
Gallo	2.98	9.4	−0.28	−4.5	0.37	4.2	...	...	2.94	237	0.16	0.53	0.58
United Vintners	3.01	4.7	[3]−1.78	−6.6	.35	2.5	1.05	2.5	2.90	66	.45	53	.70
Almaden	4.10	10.0	[3]−1.14	−4.7	.25	1.3	...	...	2.81	53	.31	.42	.48
Taylor	3.99	12.4	[3]−1.11	−6.2	.07	.9	.32	2.2	2.78	120	.27	.45	.52
Christian Brothers	3.21	9.0	−.53	−2.2	.26	1.6	...	...	2.69	33	.15	.36	.38
Port:													
Gallo	4.01	23.3	−.85	−5.4	...	...	...	...	3.05	165	.15	.60	.65
United Vintners	4.43	10.8	−1.45	−4.6	...	...	...	...	2.74	30	.37	.45	.56
Taylor	4.37	13.6	−1.23	−5.8	.30	4.0	...	...	2.83	69	.39	.37	.47

. . . = not applicable.

[1] Parameters of the demand functions estimated via ordinary least squares.

[2] Related statistics: $\overline{Q}_{ijk\ell}$ = mean of the dependent variable; n = number of observations; R^2 = coefficient of determination; S = standard error of the estimate; and S_y = standard deviation of the dependent variable.

[3] Indicates that the firm slope coefficient differs significantly at the 0.05 level from the industry slope coefficient; that is, the price elasticities differ significantly.

Table 5—Flavored wines. Firm-level demand functions

Wine type and firm	Slope coefficients[1]								Related statistics[2]				
	Intercept		Price		Per capita income		Substitute price		$Q_{ijk\ell}$	n	R^2	S	S_y
	B_0	t	B_1	t	B_2	t	B_3	t					
	—	—	*Cents/ounce*		*1,000 dollars*		*Cents/ounce*						
Gallo													
Apple	3.02	17.4	-0.13	-3.0	0.46	1.8	—	—	2.74	192	0.06	0.46	0.46
Berry	3.18	15.6	[3]-.81	-4.2	.30	3.5	—	—	2.73	80	.25	.37	.42
Citrus	3.77	15.8	-1.07	-11.6	.13	1.6	.19	1.7	2.99	162	.49	.45	.62
United Vintners													
All types	3.59	21.5	-.62	-4.3	—	—	—	—	2.90	164	.10	.55	.58
Mogen David													
Berry	2.68	5.0	[3]-.77	-1.3	.70	2.4	—	—	2.47	17	.30	.44	.49
Paul Masson													
All types	2.96	2.8	-.90	-1.3	.70	2.4	—	—	2.47	17	.30	.44	.49

— = not applicable

[1] Parameters of the demand functions estimated via ordinary least squares

[2] Related statistics $\bar{Q}_{ijk\ell}$ = mean of the dependent variable, n = number of observations, R^2 = coefficient of determination, S = standard error of the estimate, and S_y = standard deviation of the dependent variable

[3] Indicates that the firm slope coefficient differs significantly at the 0.05 level from the industry slope coefficient, that is, the price elasticities differ significantly

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In Earlier Issues

Agricultural economics without question will ultimately be judged by how much it can help people solve their problems Yet, in the last 15 years, agricultural economists have paid less and less attention to the vital problems and issues [of land problems and policies] The refinements in marginal analysis, in particular, have little to offer in devising solutions for land problems and guiding the formulation of land policies Yet decisions are always being made, and land policy is continually being formed or modified It is difficult to avoid the conclusion that agricultural economists are abdicating their responsibilities in an area in which their training, research, and judgment should be of value.

Raymond J Penn
Vol 6, No 4, Oct 1954, p 127

Predicting Debt Reschedulings in Developing Countries

By Eileen M. Manfredi*

Export credits permitting the delayed financing of imported goods are generally used by official agencies of exporting countries to stimulate foreign purchases Credit offered by commercial suppliers is usually short term, whereas the official export credit sales program of the Commodity Credit Corporation (CCC) provides credit to foreign governments for U S agricultural exports for up to 36 months The Government also tries to induce banks to provide more private financing by insuring some loans against nonrepayment for various commercial and noncommercial reasons The increased number of reschedulings of external debts—that is, the change in the repayments schedule of previously contracted debts—by developing countries in recent years has made bankers less willing to assess "sovereign risk," for a country's default on payments Thus, objective measures are needed to evaluate an individual country's probability of debt rescheduling.

Because of growing interest in using statistical models to predict debt reschedulings for a specific developing country for a given year, I compared the results of two models published in 1971 and 1977 (see (*3*)) [1] Applying 1972-77 data for 60 developing countries to the Frank/Cline discriminant function and to the Feder/Just logit analysis revealed two interesting points First, there was no significant difference between the accuracy of predicting debt reschedulings in the years before the first major oil price increase by the Organization of Petroleum Exporting Countries (OPEC) and those for subsequent years Second, the Feder/Just system worked far better than the Frank/Cline system because it includes a capital flows variable

The Frank/Cline Model

The Frank/Cline quadratic discriminant function is based on the relationship between four external debt and trade variables in the form of the two ratios and a critical value determined from the sample countries (*2*) The sample included 26 countries and 13 reschedulings in the 1960-68 period The equation (*4*) states that a country is predicted to reschedule in a given year if

$$35\,6\,X_1^2 - 342\,8\,X_1X_2 - 54\,4\,X_2^2$$

$$+ 42\,1\,X_1 + 73\,1\,X_2 \geqslant 9\,643$$

where

X_1 = total debt service payments (principal plus interest) in year *t* divided by merchandise exports in year *t*, thus, X_1 = the debt service ratio (DSR)

X_2 = amortization payments (principal payments only) on the debt in year *t* divided by the total external debt outstanding, disbursed only, lagged 1 year, that is, in year $t - 1$, thus, X_2 = the amortization ratio (AMR)

The debt service ratio (DSR) is an important variable for assessing a country's debt problems because it measures that country's ability to finance debt service payments out of current export earnings The operation, 1 - DSR, gives the proportion of export earnings left over to purchase imports without using other sources of foreign exchange Debt service payments are a previously assumed contractual obligation at set maturity and interest rates A high DSR, according to the Frank/Cline equation, increases the likelihood of a debt rescheduling, thus, it is a warning that a country is vulnerable to shortrun fluctuations in export earnings Each country controls the level of new debt it incurs, therefore, the level of debt service payments (the numerator of the DSR) can remain constant or can change as the result of government policy However, a country has limited control over the value of its annual exports. Thus, with a fixed numerator, any decline in the denominator will cause a rise in the DSR and further constrain a country's ability to import

The amortization ratio (AMR) is a measure of the maturity structure of a country's external debt A high AMR indicates a short, average repayment period or a bunching of maturities which are about to come due that may cause financial problems unless new loans are extended A high AMR indicates a higher concentration of borrowings from private sources than from official sources, which tend to have longer maturities Although repaying in a shorter period puts greater strain on a country's foreign exchange earnings, a high AMR may indicate that the country has excellent economic growth potential because of its ability to attract loans from private sources A high AMR, according to the Frank/Cline equation, decreases the likelihood of a debt rescheduling In general, countries with low AMR's are also those with the lowest per capita incomes and the least developed economies They depend almost entirely on foreign aid for capital inflows

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[1] Italicized numbers in parentheses refer to items in the references at the end of this article Here I employ the original coefficients of the two models without attempting to reestimate them

New Analysis with Frank/Cline Equation

Using 1972-77 data, I reapplied the Frank/Cline discriminant function to 60 countries (a wider group than previously), and I compared predictions of debt reschedulings with actual multilateral reschedulings (table 1) The ability of the equation to predict debt reschedulings correctly has not changed since its formulation in 1971 However, both the number and percentage of type I errors (failures to predict a rescheduling) and type II errors (failures to predict no rescheduling) vary widely each year This variability of the equation in correctly predicting debt reschedulings could result from missing variables that were not modeled by Frank/Cline Either other economic variables compensate for those in the Frank/Cline function so that a country exhibiting a type II error can avoid reschedulings or that country will have taken some policy steps to preclude rescheduling

A sharp rise in the DSR in one year is a characteristic of countries that the Frank/Cline model predicts would have rescheduled but that did not Usually, the faulty prediction was due to an unexpected deterioration in export earnings (as for Zambia in 1977) or to a large debt service payment for 1 year (as for the Sudan in 1975) A rescheduling can be avoided if the economic effects are short term and if other capital flows can be tapped or if foreign exchange reserves can be drawn down for that year Other countries avoided such predicted reschedulings each year by attracting large private capital inflows (for example, Mexico) or by obtaining large foreign aid grants (for example, the Yemen Arab Republic) Other variables and policies, such as financing from the International Monetary Fund, were not accounted for in the Frank/Cline function

The Feder/Just Model

The Feder/Just model was based on logit analysis which uses a binary-valued, dependent variable (*1*) For each country in any given year, the probability of rescheduling can be predicted by the following equation, which is based on 1965-72 data for 41 countries and 21 reschedulings

$$ln \frac{P}{1 - P} = 59\ 2\ X_1 + 0\ 4\ X_2 - 39\ 6\ X_3 - \ 01\ X_4$$

$$- 2\ 9\ X_5 - 52\ 6\ X_6$$

where

- P = probability of rescheduling debt,
- X_1 = debt service payments divided by exports of goods and services (DSR),
- X_2 = imports divided by total international reserves (including foreign exchange and gold holdings),
- X_3 = amortization payments divided by total debt outstanding, including undisbursed debts (AMR),
- X_4 = per capita income,
- X_5 = total capital inflows divided by debt service payments, and
- X_6 = growth rate of merchandise exports in previous 8 years

Table 1—Frank/Cline discriminant function, 1972-77

Indicator	1972	1973	1974	1975	1976	1977
			Countries			
Predicted reschedulings	11	8	6	11	7	11
Actual reschedulings[1]	2	2	4	2	2	1
Correctly predicted to reschedule	1	2	0	1	0	1
Correctly predicted not to reschedule	48	52	50	48	51	49
Missed reschedulings (type I error)[2]	1 (50)	0 (0)	4 (100)	1 (50)	2 (100)	0 (0)
False predictions (type II error)[3]	10 (17)	6 (10)	6 (11)	10 (17)	7 (12)	10 (17)
Total number of countries	60	60	60	60	60	60

Note Numbers in parentheses are percentages
[1] Multilateral debt reschedulings
[2] The percentage of type I errors is calculated from the ratio of missed reschedulings to actual reschedulings
[3] The percentage of type II errors is calculated from the ratio of false predictions to the actual number of countries that did not reschedule

All variables, except debt service payments and exports, are lagged 1 year

Two of the six variables used by Feder/Just are the same as those used by Frank/Cline, except for minor differences in definition In the Feder/Just formula, X_1 includes exports of merchandise sales alone, X_3 uses a denominator of all external debt outstanding (including undisbursed debts)

X_2 is the ratio of imports to reserves As accumulated foreign exchange reserves are another means (in addition to export earnings) of paying for debt servicing, they should be included in predictions of reschedulings However, the level of reserves should be included as a ratio so that comparisons of a specific country's reserve position can be made across countries and over time As reserves are generally considered a buffer to pay for imports in times of low export earnings, it is common to use an imports-to-reserves ratio

X_4 is the level of per capita income It is related to the past growth of the domestic economy When X_4 is used as a separate variable, the growth of the domestic economy is not significant because, in most developing countries, it is highly correlated with export growth, which is a separate variable However, the per capita level of income is significant, a high level indicates a greater ability to reduce imports of consumer goods to pay for debt servicing

X_5 is the ratio of all capital flows to debt service payments In many poorer countries, capital flows—especially grants and official loans—equal or surpass the value of annual export earnings Therefore, capital flows can explain how a country with a high DSR or other unfavorable indicators can manage to avoid debt rescheduling in a given year The ratio is a good short-term indicator of a country's ability to meet debt service payments However, the flow of external capital from all sources is extremely variable This ratio may fluctuate widely from year to year for a given country, in several cases, when capital outflows exceeded inflows the ratio was negative

X_6 is the growth of exports over the previous 8 years This dynamic variable contrasts with the static use of exports as a denominator in X_1 Because export earnings are the primary stable source of funds for making debt service payments, a good growth rate is a favorable economic indicator

The signs of the coefficients in the Feder/Just formula are the same as those predicted from theory, that is, high values for X_1 and X_2 lead to a greater probability of rescheduling, as the coefficient signs are positive and as in each case a high ratio implies a lower debt servicing capacity For X_3 to X_6, high values imply a lower probability of rescheduling, as the coefficient signs are negative For X_3, a high ratio implies a long-term debt problem, but it does not imply a need for immediate rescheduling For X_4 to X_6, higher levels and ratios imply a better ability to service debt and, therefore, a lower probability of rescheduling

Evaluation of New Analysis

Table 2 gives statistics on predictions of reschedulings, enabling us to compare the Feder/Just logit analysis with actual reschedulings

The Feder/Just model had less annual variability than the Frank/Cline model in terms of type I errors—that is, the failure to predict countries which actually rescheduled, it showed an improvement in the latter half of the study period However, its average of type I errors for the 6-year period was no better than that in the Frank/Cline model The real strength of the Feder/Just system is its superiority in minimizing type II errors—that is, false predictions of reschedulings The Feder/Just system falsely predicted 17 of 325 reschedulings, with an average error rate of 6 percent over the 6-year period The Frank/Cline model falsely predicted 49 of 360 reschedulings, with an average error rate of 14 percent

An analysis of changes in the variables and of the rescheduling probabilities for the sample countries during the 1972-77 period shows that deterioration in X_1 (debt service ratio) and in X_5 (capital flows ratio) generally caused a country to move from a zero or a low probability to a high probability Countries predicted to reschedule tended to have high debt service and import-to-reserve ratios and low per capita in comes and capital flows ratios An outflow of capital funds from a country facing adverse economic or political conditions was decisive in many cases in predicting a rescheduling Table 3 shows the range of values for each variable for all the rescheduling predictions

The capital flows variable, with its sharp changes in magnitude and direction, gives the Feder/Just model a greater degree of annual variation in the probability of rescheduling and fewer false predictions than does the Frank/Cline model Many countries with unfavorable levels for other variables can avoid rescheduling their debts if they can maintain capital inflows at a high rate Continuous flows of grant aid to the poorest countries and private capital flows to the developing countries with higher incomes can serve this purpose The other

Table 2—Feder/Just logit function, 1972-77

Indicator	1972	1973	1974	1975	1976	1977
			Countries			
Predicted reschedulings (P > 0 5)	4	5	3	3	4	7
Actual rescheduling[1]	2	2	4	2	2	1
Correctly predicted to reschedule	0	1	1	1	1	0
Correctly predicted not to reschedule	49	49	49	51	50	42
Missed reschedulings (type I error)[3]	2 (100)	1 (50)	3 (75)	1 (50)	1 (50)	[2] 0 (0)
False predictions (type II error)[4]	3 (6)	3 (6)	1 (2)	1 (2)	3 (6)	6 (12)
Total number of countries[5]	55	55	55	55	55	50

Note Numbers in parentheses are percentages
[1] Multilateral debt reschedulings
[2] The Zaire rescheduling in 1977 was not counted as a miss because of the lack of necessary data for a probability
[3] The percentage of type I errors is calculated from the ratio of missed reschedulings to actual reschedulings
[4] The percentage of type II errors is calculated from the ratio of false predictions of reschedulings to the actual number of countries that did not reschedule
[5] Although 60 countries were initially included, some missing data excluded 5 countries in the 1972-76 period and 10 countries in 1977

Table 3—Ranges of variables for rescheduling predictions

Variable	Actual values			Values multiplied by Feder/Just coefficients[1]			
	High	Low	Median	High	Low	Median	Range
X_1 Debt service ratio	0 402	0 016	0 167	+23 8	+0 947	+9 89	23 0
X_2 Imports reserves	99 2	2 06	7 33	+39 7	+ 824	+2 93	38 9
X_3 Amortization ratio	195	015	063	-7 72	- 594	-2 49	7 13
X_4 Per capita income	1,070	100	230	-10 7	-1 00	-2 30	9 70
X_5 Capital debt service	3 24	-9 5	1 08	-9 40	+27 6	-3 13	37 0
X_6 Export growth rate	220	- 03	056	-11 6	+1 58	-2 95	13 2

[1] The signs are from the Feder/Just coefficients, however, high, low, and median are listed as corresponding to the actual values multiplied by the coefficients For example, the low actual value for X_5 (-9 5) times the coefficient (-2 9) equals +27 6 In that case (Mauritius, 1977), the *ln* (P/1 - P) = 0 947 + 1 86 - 0 594 - 6 8 + 27 6 - 11 6 = 11 4, and the probability of rescheduling was 1

countries—those not receiving large flows of foreign aid and those not achieving sufficient export and domestic growth to attract private capital—tend to reschedule their external debts

Table 4 gives the values for each of the six Feder/Just variables for those countries which had multilateral debt reschedulings during the 1972-77 period All the variables, except X_3, show a wide range between the high and low values However, if the highest and lowest values are eliminated, we can see that those countries which rescheduled tended to have the following characteristics (a) debt service ratios of 11 to 16 percent, (b) import to reserve ratios of 2 9 to 5 4, (c) amortization ratios of 0 02 to 0 03 (indicating long-term debts averaging 30-50 years maturity), (d) per capita incomes of $120-$300, (e) capital inflows to debt service ratios of 1 to 2 (indicating little net inflow left over), and (f) annual export growth rates of 6-13 percent

Table 4—Values of variables for rescheduling observation

Year and country	X_1	X_2	X_3	X_4	X_5	X_6	P
1972							
Chile	0 100	4 80	0 026	760	0 339	0 072	0 004
Pakistan	211	5 28	022	130	4 300	065	030
1973							
India	191	2 06	034	120	940	055	981
Pakistan	147	2 57	022	110	2 090	036	448
1974							
Chile	115	7 37	060	720	490	060	012
Ghana	037	2 88	023	300	042	130	001
India	167	3 39	037	120	1 130	059	900
Pakistan	138	2 46	022	120	2 350	069	034
1975							
Chile	286	23 00	080	1070	-1 34	160	1 000
India	126	4 66	034	120	1 89	135	003
1976							
India	109	5 44	031	140	2 07	136	001
Zaire	113	18 10	021	130	1 08	055	997
1977							
Zaire	100	12 9	072	130			
High value	286	23 00	080	1070	4 30	160	1 000
Low value	037	2 06	021	110	-1 34	036	001
Median value	126	4 80	031	130	1 13	069	034

= Data not available

All those countries with multilateral debt reschedulings in the period had positive, although occasionally low, probabilities of rescheduling with the Feder/Just model The Feder/Just model generally assigned a high probability of rescheduling to countries that actually rescheduled

Conclusion

Of the two prediction systems, the one with the capital flows variable (X_5 in the Feder/Just Model) did a better job of avoiding false predictions—that is, of indicating countries for which capital flows offset other unfavorable indicators The interrelationship of many indicators is important, using the debt service ratio without other variables leads to overpredicting debt reschedulings. Although the Feder/Just model is superior to the Frank/Cline model because it produces fewer type II errors, further work is needed to lower type I errors Using the Feder/Just model is a simple way to judge a country's external financial position and creditworthiness A more dependable system would require reestimating coefficients with the most recent data and also experimenting with other variables, different lag structures, and other mathematical forms

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Special Lectures in Economics

As delivered by E. B. Wilson, John R. Commons, John D. Black, and Frank H. Knight before the Graduate School, U.S. Department of Agriculture, February-March 1930. 45 pages.

Reviewed by Harold F. Breimyer*

A question to be asked about the content of any scientific discipline at any time is What part is temporal, and what part is perennial?

A review of four lectures delivered a half-century ago reveals which topics have proved to be only of-the-moment and which have persisted The test can also be reversed we can learn which issues in the early eighties have half-century antecedents, suggesting that they may remain with us a while longer, and which are new

The 1930 lectures by distinguished scholars were intended to enhance the prestige of two then-young institutions—the USDA Graduate School and the Bureau of Agricultural Economics (BAE) Both have survived—the former intact, the latter imperfectly in a series of reorganizations [1]

The Four Speakers

The four speakers were truly distinguished E B Wilson was president of the Social Science Research Council John R Commons was the renowned institutional economist at the University of Wisconsin, aging, but still a firebrand John D Black, after moving from the University of Minnesota, had achieved eminence at Harvard The younger Frank H Knight was on his way to economic fame at the University of Chicago In the late thirties Black was a frequent USDA lecturer, the others were rarer guests of the Department

Students of economic thought will remember that in 1930 classical and neoclassical ideas rivaled for acceptance Chamberlin and Robinson had not yet published their theories of monopolistic and imperfect competition, and J M Keynes was an obscure Englishman deeply involved in denying that Germany could or should pay World War I reparations

Also, at the time of the USDA lectures, only 6 months had elapsed since the stock market crash, unemployed people had scarcely begun to sell apples for a nickel on city sidewalks, and the impending Great Depression was not on these four scholars' minds Worth noting with whimsy, however, is the forgotten fact that the late twenties were supposed to usher in a New Era What an era it (the thirties) turned out to be!

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[1] BAE was the founding agency of the current Economics and Statistics Service (ESS)

Furthermore, contemporary events were largely neglected Three speakers, sensitized to the needs of the nascent BAE, addressed the nature of science and the scientific method Frank Knight was more interested in human nature As economic events revolve around the behavior of human beings, said Knight, those bipeds are the proper target of analysis

The Four Research Approaches

Amazingly, the speakers offered the new BAE no heady optimism They were chary about applying the scientific method to economic data Ironically, this viewpoint was the only consensus among them The four shared few common idioms Wilson, in fact, began by saying that the biggest problem is definition Implicitly, the other three corroborated, as each did his own definitional "thing " (Is there common language in economics today? Probably not)

Perhaps the best coinage is to classify the four scientists' ideas for research proposals as (1) institutional, (2) mathematical, (3) statistical, and (4) qualitative Dividing the mathematical and statistical may seem strange to us but a distinction was made, notably by Wilson Presumably mathematical is the generic concept, and statistical is a specific application

For what must have been the 99th time, John R Commons restated his institutional thesis He then stood by, awaiting attack—which came Like Knight, Commons began with an evaluation of human nature, which he then converted to a denunciation of the premises of classical economics Human beings are irrational and selfish There is no "preordained harmony of individual interests" as Adam Smith supposed Moreover, as early as 1798, Mathus had "attempted to disillusion the economists" who saw man as rational Man "is a being of passion, stupidity, and justification " Therefore, the only recourse is to accept "concerted action in control of individual action," the essence of institutionalism

John D Black, who had studied at Wisconsin, treated the ideas of Commons gingerly, but negatively They never go beyond "qualitative terms," he complained Frank Knight was less biting In fact, "there is much justification for an 'institutional' approach " But Knight believed it would take us only a little way toward analytical discreteness (Knight doubted very much else would, as noted below)

In 1930 BAE economists were experimenting with mathematical tools in general and statistical analysis in particular Despite the prominence already earned by Mordecai Ezekiel and Elmer Working in correlation techniques, the four speakers were less than enthusiastic Said Wilson, "The mathematical method is not yet through in economics but it is likely largely to remain the work of a small fraction of students of economics " Commons vouchsafed only a quick satirical comment economists, like physicists, he alleged, are becoming anxious that their science may be "resolved into nothing but pure mathematics We are being enticed into pure number " Black endorsed all quantitative studies, then regretted that data are usually inadequate

Knight, Wilson, and Commons shared distrust of statistical techniques, and for similar reasons Knight, the philosopher-economist, was by far the most eloquent He declared as his main theme "the contrast in character and method between the natural sciences and those which deal with man in society " Further, "The root of the difficulty in regard to explaining and controlling human beings is the fact that the explainers and controllers are likewise human beings " Wilson was sure "periodogram" analysis could be applied to the stars but feared economic phenomena were not that dependable "Time series are treacherous "

Knight cited with approval the Kantian vision of a conflict between "the mechanical and ethical view of human nature " Also engaging, but too involved for futher comment here, are Knight's notes on the "problematic" in human affairs In human behavior, "the ends of action are problematic in about as great a degree as the means " (Then what can be treated as given, as exogenous? we could ask)

Not surprisingly, Knight concludes that economic analysis is more an art than a science, and "we should learn from the way in which the arts are learned and taught rather than from physical science and engineering technique "

With regard to qualitative approaches in general, the four scholars were respectful Knight stressed "meaning" in economic events Black ticked off genetics (essentially historical), case study, and other methods, all approvingly But Black turned sardonic when he complained that even qualitative analysis has pitfalls because "very few economists know about logic "

The four essays are prosaic in places, yet sparkle with occasional gems During the seventies, economic thought suffered a blow as inflation undercut the deficiency-of-purchasing-power ideas that were a legacy of the Great Depression and a mainstay of Keynesian thought (Now the popular slogan is supply-side economics or reindustrialization) It is, therefore, significant that Commons, always prescient, anticipated the purchasing power theme as early as February 1930 His sharp logic is engaging It was discovered during the break in farm commodity prices after World War I, he observed, that "not food was scarce, but purchasing power " Moreover, "purchasing power is an institution Food is a commodity "

The Commons doctrine that still carries a punch today is that the courts are the most influential economic institutions, the Supreme Court above all Commons insists that the Supreme Court "has in its hands the exercise of two powers of sovereignty the mandatory and the injunctive power " But among institutions classed as fairly new in 1930, "the most powerful" was "doubtless the Federal Reserve System "

The final vignette is a line from Wilson, who complained that economic analysis is made difficult because nothing stays put Doubtless with tongue in cheek he suggested that what was needed was "a prolonged period of relative stagnation [as it] might help toward the discovery of some economic laws " Yet he could not stay with it, he added a caveat that such an experience might tempt "to a feeling of security with its inevitable resulting dogmatism "

That note invites 50-year updating Whatever else may be said about the ensuing half-century, it has not been one of constancy Not dogma, but disputation, surely marks economic theory today Perhaps, despite Wilson's fears, we too would like a breathing space of stability, we might get our theorizing in some degree of order

Which of the issues of 1930 have proved lasting, perennial? Possibly, just possibly, we have a little more faith in analytical technique than the four authors expressed in 1930 Nonetheless, conceptualization of the scientific method and its applicability in a field where human behavior plays so instrumental a role are surely interminable issues Is economics a science? Not a few scholars still ask

Analysis of Economic Time Series: A Synthesis

Marc Nerlove, David M. Grether, and Jose L. Carvalho, New York: Academic Press, 1979. 480 pp. $29.50

Reviewed by Robert V. Bishop*

A question that comes immediately to mind when one reads this text is "For whom was it written?" The ideas that the authors have collected from many sources and have surveyed here are of tremendous importance to applied researchers, but their exposition—with its emphasis on spectral methods—is probably quite unfamiliar to many members of this large potential audience For those familiar with spectral analysis and the methodology of time series analysis as developed by Box and Jenkins (*1*),[1] this book provides an excellent (although often challenging) text For others, it is probably not very useful

The chapters vary in readability, some are quite lucid, while others are obtuse However, all are relevant for economic researchers and present important considerations for this group to ponder

The authors begin with a brief, but interesting, historical description, recalling the development of the conceptual framework and empirical methodologies from which researchers may model unobserved components in economic data The decomposition of an observed data series into its trend, cyclical, seasonal, and irregular "unobserved" components is far from being new to economists, however, its rich, though controversial, history provides interesting reading

The authors introduce spectral analysis of a single time series early in their text and present different hypothetical spectral density functions,[2] their material is quite technical, and they provide two appendixes to help the reader Appendix B, "Some Requisite Theory of Functions of a Complex Variable," reviews the elements of the theory of complex variables, and appendix C provides "intuitive" insight into the Fourier transform Much of the text is devoted to using spectral techniques to examine data in the frequency domain Therefore, an understanding of this material is essential if one is to benefit from this section, or even from the remainder of the text

The authors provide a number of innovative extensions of the time series methodology suggested by Box and Jenkins (*1*), using the "frequency domain" as a vehicle for "identifying" or, as the authors prefer, "formulating" the appropriate orders of the moving-average and/or autoregressive components that characterize the series being tested Their discussion is extremely helpful as this "formulation" is not at all straightforward in the time domain when the appropriate model is of a mixed, autoregressive, moving-average (ARMA) characterization

They give considerable attention to the "correction" of data to remove seasonality They build on earlier studies (*2, 4*), and their analysis is relevant for anyone who uses economic data They note the essential considerations which researchers confront when they must choose between "raw" unadjusted or seasonally adjusted data (such as that transformed by the Bureau of the Census X-11 procedure) One example of the problem a researcher might face when using adjusted data is the case of overadjustment—that is, when the series has too much of the "seasonal" component extracted One can view this as the excessive removal of power at the seasonal frequencies, thus resulting in "dips" in the power spectrum at those frequencies The authors note that

> While this was not regarded as especially serious in and of itself, corresponding to the dips, there must exist intermediate peaks at frequencies between the seasonal ones Such peaks, if large enough, might induce spurious fluctuations in the adjusted series—a disturbing possibility (p 150)

A paper by Wallis (*6*), not referenced by the authors, describes this overadjustment problem in the time domain as resulting in negative autocorrelation in the regression residuals of an order determined by the period of the seasonal component that has been "removed" (that is, removing seasonality in quarterly data often leads to negative fourth-order autocorrelation in the residuals) The authors report a result from Nettheim (*5*) that describes a case in which turning points in a series which had undergone a correction for "overadjustment" differed by as much as 2 to 3 months from those in the seasonally overadjusted series They offer several ideas on seasonal adjustment, but obviously much work remains to be done before an "optimal" seasonal adjustment mechanism can be defined

Later they describe the formulation of distributed lag models in the following manner

> The extent and variety of topics to which distributed-lag analysis has been applied in empirical

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

[2] The spectral density function is the Fourier transform (described in appendix C) of the autocorrelation function of the variable under test

> economics is astounding, but what is more remarkable is the virtual lack of theoretical justification for the lag structures superimposed on basically static models This extraordinary neglect of the dynamic underpinnings of the models actually fitted to the data is what Griliches (*3*, p 42) has called "theoretical ad-hockery" (p 291)

I believe that their comment is quite appropriate and expresses one of the major problems currently faced by economic model builders It addresses the necessity of moving away from contrived lag-structures, which are often specified only to provide values needed for "future" right hand side variables so an "econometric" model will "solve" for some forecasted period, and of moving toward a recognition of the way in which expectations are actually formed To this end, the authors briefly describe several early "expectations" models—such as the cobweb model, the extrapolative expectations model, and the adaptive expectations model These early models contrast with the rational expectations model, which currently permeates much of the technical economic literature They define rational expectations as "expectations or forecasts (that) are simply the conditional expectations of the variable being forecast, based on all observations of it and related variables up to the time of the forecast" (p 292) They develop the concept of quasi-rational expectations (which arise when anticipated endogenous variables are replaced by forecast variables), and they demonstrate ways in which these might be generated

One area the authors do not address is the concept of Granger Causality I mention this omission because most tests of the rational expectations hypothesis are derived from this important methodology It is thus a serious oversight

The authors conclude their text with a time series model for the U S. cattle industry that introduces an objective function which is maximized over time Computational difficulties with this approach restrict its application, but it appears to be a promising area

The book offers much to the researcher who has some background in sophisticated time series modeling and spectral analysis, and it serves as an excellent reference text in that field It might be a good supplemental text for an advanced econometrics course, and the individual who works through it may gain considerable insight into many of the problems that have plagued economic researchers for decades

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The Planning of Investment Programs in the Fertilizer Industry

Armeane M. Choksi, Alexander Meeraus, and Ardy J. Stoutjesdijk. Baltimore: Johns Hopkins University Press, 1980. 333 pp. $16.95 (cloth), $6.95 (paper)

Reviewed by Robert B. Rovinsky and David A. Torgerson*

Several years ago, the World Bank began producing publications detailing several of their planning methodologies and applications This volume, by three staff economists at the Bank, is one of a series that deals with the use of mathematical programming in investment analysis Its methodology closely follows that adopted in the first volume of the series (*The Planning of Industrial Investment Programs A Methodology* by D A Kendrick and A J Stoutjesdijk), and builds a standard, medium-sized, linear programming model designed to analyze and plan fertilizer investment strategies We have serious reservations about the content, style, policy recommendations, and general usefulness of this book, yet, we think it deserves careful attention and raises important questions about the proper use of analytical methods in agricultural planning and development

Its contents are standard and straightforward The authors take a well-known methodology (linear programming) and apply it to a common problem (industrial investment) in a general development context (agricultural and planning and fertilizer use) The authors focus on a particular example (Egyptian fertilizer production) of interest to the World Bank In addition to the theoretical equations of a linear model, their book contains many tabulations and interpretations useful to both planners and policymakers unfamiliar with linear programming

The authors carefully document their equations and assumptions In the first part, they present a clear and nontechnical introduction to the chemical fertilizer industry and to their methodology Separate chapters describe the production processes of phosphatic, potassic, nitrogenous, and multinutrient fertilizers, their investment planning model, and associated linear programming tableaux

In the second part, they apply their methodology to the Egyptian fertilizer sector They focus on exogenous factors, such as demand, imports, and prices, they describe their 1975 model and give two solutions—a base solution and one which includes interplant shipments under a full-capacity policy

In the final chapters, the authors extend their 1975 model to a medium-term, dynamic planning model of the Egyptian fertilizer sector They use their base solution to derive policy conclusions concerning plant development in the areas of the Suez Canal and Aswan Dam An appendix lists the computer input and reference data for the Egyptian model

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The book has several possible audiences It will appeal to economists and agriculturalists looking for a practical introduction to linear programing, as well as to operations researchers and applied mathematicians looking for new applications for this technique The writing, while somewhat dry and pedantic, is succinct We found the index, appendixes, and copious tables of great assistance

Nonetheless, we found the book incomplete in many respects and difficult to categorize Although it is presented as a textbook, we were forced to conclude that it is essentially a consultant's report We found no bibliography, no historical background, and no consideration of alternative methods It presents no clear rationale for considering the fertilizer investment problems, the particular example of the Egyptian sector, or the choice of solution We assume the World Bank had an interest in the project, although its purposes are nowhere referred to in the text Unlike many similar development or planning studies, the report never questions methods, choices, and assumptions

And yet, it is precisely the interrelationships of conflicting objectives and the necessity of carefully choosing a methodology in full knowledge of its flaws and premises that constitute the real work of development economics and planning Although the book includes a short introduction to the Egyptian fertilizer industry in 1975, it describes neither the role of the Egyptians—none of whom is even mentioned—nor the model's ultimate value, if any, to Egypt or to the World Bank

This study has limitations from our analytical viewpoint, even if one accepts the appropriateness of a linear programing process model of the fertilizer industry As a consultant's report, the work is flawed by its apparent blindness to the larger policy context and other economic constraints For example, the objective function of the model is essentially to minimize plant nutrient costs But, is it desirable for Egypt to be totally self-sufficient in fertilizer (as is implicitly assumed)? Can one legitimately advocate the further construction or expansion of fertilizer plants when other projects compete for scarce capital resources? The book does not address the needs of planners in capital-constrained countries such as Egypt who must choose among projects with positive benefit/cost ratios

Furthermore, we find the author's assumptions and modeling work suffers from a similar myopia The authors seem to suggest that all planning decisions can be made from linear programing However, there are many useful alternatives to linear programming, most of which can be explained in a straightforward manner, the literature in planning and development is filled with such methods and decisions criteria More important, the authors need to explain the economic assumptions and the limitations of linear programming to readers, especially those who are planners and policymakers with little formal training in agricultural economics or operations research

We question whether several of the authors' policy conclusions are fully supported by their model For example, they conclude that 5 million Egyptian pounds might be saved if farmers switched from traditional fertilizer to urea, and they suggest that an expenditure up to this amount should be made on education extension and demonstration plots However, this recommendation implicitly assumes, contrary to known development experience, that all farmers have a similar profitmaking incentive for using urea The authors also recommend the addition of ammonia capacity in the Suez, rather than its production in Helwan This conclusion assumes a stable transportation network with current unit costs and disregards their earlier demonstration of the model's sensitivity to changes in the transportation structure It would have been relatively easy to conduct a parametric analysis which would considerably strengthen their advocacy of such a major decision

How can these studies be used? We believe this text would provide excellent supplementary reading or be useful as a casebook for any extensive course in agricultural development It is a far more accessible and representative example of World Bank modeling activity than many larger projects, and it might stimulate thoughtful classroom discussions It could also serve as a "cookbook" for planners interested in applying linear programming Here we should mention one of the well-known strengths of linear programming work—its strong focus on data needs, an element which the book handles well Finally, the chapters on fertilizer technology and basic linear modeling are extremely well written

In Earlier Issues

Only through careful study of past changes can [agricultural economists] understand the relative significance of the forces that brought them about and only with such understanding can they do a reasonably good job of forecasting future changes

Marguerite C Burk and Martin J Gerra
Vol 6, No 2, Apr 1954, p 33