MARYLAND INTERINDUSTRY FORECASTING PROJECT

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The Demand for Equipment by Input-Output Sectors

by

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This memorandum describes the estimation of the equipment purchasing equations currently employed in the University of Maryland Interindustry Forecasting Model. These new equations are closely related to those used in the Maryland Project's initial forecasts presented last October. But due to the use of more recent data in the estimation of the new equations, they should perform significantly better. Nevertheless, they must be viewed as only the first generation of what we hope to be an ever-improving lineage. At the end of this memorandum we shall indicate some of the directions which subsequent generations may follow.

I. The Specification of the Equations

The basic specification of the equipment sector is what we might call a "variable lag stock adjustment equation." It is estimated with ordinary least squares regression techniques.

The rationale for this type of equation runs as follows. We suppose that at any given time firms have some idea of the amount of equipment which they deem optimal for a given level of output. Typically, the actual stock of equipment falls short of this optimum, and investment in excess of replacement requirements takes place. Earlier input-output models assumed that such net investment was sufficient to keep stocks at their optimal levels. But this assumption is unnecessary and unwarranted. A more reasonable view is that firms adjust their stocks to the desired (or optimum) levels in a lagged fashion. Moreover, we might surmise that the speed of adjustment varys, perhaps as the result of financial considerations such as the availability of funds.

This notion may be expressed as

$$(1)\quad I_{it} = B_{it}\,[K^{*}_{it} - (1-\delta_i)K_{it}],$$

where I_{it} = investment

B_{it} = the adjustment rate, $0<B_{it}<1$

K^{*}_{it} = the optimal stock of equipment

K_{it} = the actual stock of equipment

δ_i = the depreciation rate

and the subscripts i and t refer to the i th equipment sector and the t th year. The bracketed term in (1) represents the amount of investment required to close the gap between the actual and optimal stocks, and B_{it} represents the fraction of that amount of investment which will be undertaken in year t.

Equation (1) is, of course, too general to serve as a regression equation. We need to specify the form of B_{it} and K^*_{it}. With reference to the former, we hypothesize that the adjustment rate depends upon the "relative" availability of cash flow, upon the ratio of total cash flow (CF_{it}) to the size of the gap to be filled. If this dependence is linear, we may write

$$(2) \quad B_{it} = c_1 + c_2 \, CF_{it}/[K^*_{it} - (1-\delta_i)K_{it}],$$

where CF_{it} is cash flow (capital consumption allowances plus undistributed profits) and the "c's" are constants to be estimated.

The desired stock of equipment is thought to depend primarily upon output and secondarily upon the cost of equipment. Neglecting the latter and once again assuming a linear relationship, we obtain

$$(3) \quad K^*_{it} = c_3 + c_4 \, Q_{it},$$

where Q represents output.

In both equations (2) and (3) numerous variants are possible. The adjustment rate, for example, may depend upon current cash flow, last year's cash flow, or perhaps a weighted average of the two. Much the same can be said for output in equation (3). In general, the exact lag specification is a matter for empirical testing. But with annual, as opposed to quarterly, data, the regression results are frequently insensitive to the choice of lags, as might be expected from <u>a priori</u> reasoning.

A regression equation may be obtained from (1), (2), and (3) by substitution. Fortunately, the equation has the following simple, linear form:

$$(4) \quad I_{it} = c_1c_3 + c_1c_4Q_{it} - c_1(1-\delta_i)K_{it} + c_2 \, CF_{it}.$$

By estimating the coefficients of output, the stock of equipment, cash flow, and the intercept, it is possible to solve for the structural parameters, i.e., c_1, c_2, etc.

In this specification it is possible for the capital output ratio to vary over time for two distinct reasons. First, due to the lagged response ($B_{it}<1$), the actual stock of equipment is not always proportional to the optimum stock. Thus even with a constant ratio of desired stock to output, the capital output ratio may exhibit variations. Second, due to the inclusion of an intercept in (3), the desired capital-output ratio (K^*_{it}/Q_{it}) may vary. This is entirely appropriate, although one might suppose that the same purpose could more suitably be served by including a trend term in (3) to account for this "biased" technology change. The reason for not doing so is largely econometric. Preliminary results obtained with such a specification were unsatisfactory.

II. The Data

To estimate equation (4), we require data on investment, output, equipment stocks, depreciation rates, and cash flow for each of the equipment purchasing sectors. Largely because of insufficient data, the number of investment purchasing sectors is less than the number of producing sectors currently used in the model. Notable examples are in mining and non-ferrous metals, where data limitations prevented our using the same degree of disaggregation as that contained in the 1958 input-output table.

Estimates of equipment investment in the manufacturing sectors were constructed from the Bureau of the Census's Census of Manufacturers and Annual Survey of Manufacturers. For further details, see David Curry's "Equipment Investment Series for Manufacturing Industries," Research Memorandum No. 3, University of Maryland Interindustry Forecasting Project. The construction of the non-manufacturing estimates follows a more eclectic path, a description of which will appear in a forthcoming memorandum. The deflation procedure uses OBE price indices for producing industries and converts them into indices for purchasing industries by utilizing the capital input-output matrix.

The regressions reported in this memorandum were run on investment data through 1967 even though the Census figures are unavailable for that year. These data were obtained by estimating investment spending from the two-digit estimates reported in the Survey of Current Business. A more detailed description of this procedure will also be reported in a forthcoming memorandum.

Output estimates are based on value of shipments data for manufacturing industries and to a large extent on value added data or physical indices in the non-manufacturing industries.

Equipment stocks are built-up by cumulating net investment using depreciation rates given in the Treasury guidelines. It is generally possible to obtain investment data going back to 1925, although not at the desired level of aggregation for years prior to 1947. Benchmark stocks in that year were essentially constructed on the assumption that investment shares in the larger aggregates remained at their 1947-1948 levels throughout the 1925-1947 period.

Data on cash flow are available from OBE and periodically published in the *Survey of Current Business*. In some cases, insufficient detail is available, and estimates are then constructed on the assumption that sub-industries have the same ratio of cash flow to sales as the aggregate. The problem of deflation is avoided by setting cash flow equal to the ratio of cash flow to sales multiplied by output in constant dollars.

The cash flow data present several problems. For one, they refer only to corporations. Hence we implicitly assume that the ratio of cash flow to sales is the same in the corporate and non-corporate sub-sectors. More important is the difficulty of obtaining meaningful cash flow data when many corporations earn their cash flow from sales in several input-output industries.

III. The Results

The equations finally selected for the forecasts appear in the accompanying tables. The first set, those which were unconstrained, were obtained by estimating equation (4) with the usual least squares procedure. Their selection depended upon goodness of fit and whether or not coefficients possessed the expected sign. The latter is especially important. All too frequently, equations with unexpected signs (for example, negative income coefficients) produce unsatisfactory forecasts even though they may give good fits to the historical data.

All equations utilize output and cash flow lagged one year, and the capital stock is on a beginning of the year basis. Alternative lags were tested, but the results were not significantly different from those presented here. But the one year lag possesses an advantage over non-lagged specifications in that more current observations may be included. Output estimates, for example, are not presently available for 1967 nor are cash flow estimates.

Of the unconstrained equations, most have reasonably good fits considering the degree of disaggregation and the relatively simple nature of the regression specification. The cash flow variable performed relatively well, and it was included in many of the final equations. Its exclusion, however, from the other equations does not necessarily indicate a lack of "success" in those industries. Sometimes the cash flow variable was dropped even when its coefficient was positive and "significant" because the output coefficient had a negative sign.

In some industries the stock variable ended up with a positive, instead of a negative, coefficient; and frequently in such cases the output variable had a negative coefficient. When this occurred, the procedure followed was to constrain the stock coefficient to a negative value. Ordinarily the constrained value was taken as close as possible to the least squares value, usually within two or three standard deviations. Under these circumstances, the fit is not substantially changed, but the forecasts are more reliable.

The most persistent and general implication of these equations is that the current investment boom has nearly run its course. In most industries the gap between actual and desired stocks of equipment appears to have narrowed. Even if the economy remains at full employment levels, the assumption employed in our forecasts, equipment spending may decline in the next two or three years. Needless to say, this prospect would be strengthened by any slackening of aggregate demand such as might occur after a possible Viet Nam settlement. At this time, however, anticipations data for 1968 show no such indications.

IV. The Forecasts

No attempt can be made here to summarize the forecasts which these equations produce in conjunction with the other parts of the Maryland Model. But we might indicate briefly how the equations produce the forecasts.

Since investment data through 1967 are available, the first year in which the equations are used to forecast investment is 1968. The model forecasts investment in 1968 and subsequent years by taking the lagged values of the independent variables, multiplying them by their coefficients, and summing. The model does not directly forecast cash flow. It simply forecasts the percent change in the ratio of cash flow to output for all industries. In the current forecasts, we assume that the 1967 ratio of cash flow to output will remain constant over the forecasting years.

The procedure is not materially complicated by non-lagged variables in the investment equations even though in this case a change in current investment will affect current output; and since investment depends upon current output, there will be a certain "feed back" effect. This can be handled through a simple iterative calculation. At present, however, the investment sector interacts with the remainder of the model in "leap frog" fashion. Today's investment affects today's final demands and industry outputs, which in turn affect tomorrow's investment demands.

V. Further Developments

There seem to be two fruitful directions in which the investment sector of the Maryland model might travel. The first involves attempts to refine the present general regression methods by trying out alternative specifications. One possibility is to use the cost of capital (which includes prices, interest rates, depreciation rates, tax rates, and similar items) as an explanatory variable. Dale Jorgenson has obtained good results with this variable on certain two digit industries.

The second possibility is to place more reliance on specific information about various industries. This may involve a number of diverse approaches. The simplest is to use specific information to pinpoint years which were abnormal for any of a number of reasons and to account for the abnormality through the use of, say, dummy variables. Since highly disaggregated industries are more likely than highly aggregated industries to have such abnormalities occur in a non-random fashion, this approach may produce useful results, yielding more reliable equations and forecasts.

UNCONSTRAINED REGRESSION EQUATIONS

	IO Sector	Regression Coefficients and Standard Errors				
		Constant	Sales	Cash Flow	Capital Stock	R^2
1.	Agriculture	1164.2 (2606.7)	.216 (.183)		-.0864 (.0679)	.09
5.	Mining Except Oil and Gas	798.8 (428.7)	.225 (.083)		-.0617 (.0456)	.31
11.	Contract Construction	-539.6 (295.4)	.0969 (.0240)		-.0828 (.0338)	.70
15.	Dairy Products	-253.9 (88.8)	.0523 (.0152)		-.0852 (.0496)	.62
19.	Sugar Products	-61.04 (21.29)	.0467 (.023)	.5772 (.373)	-.01454 (.0348)	.90
21.	Beverages	165.29 (121.5)	.04782 (.039)	.5386 (.4586)	-.2339 (.186)	.72
22.	Misc. Food Products	75.85 (32.08)	.003058 (.0078)	.3293 (.202)	-.06441 (.078)	.65
24.	Fabrics and Yarn	257.6 (155.9)	.062840 (.021)		-.4040 (.194)	.46
25.	Misc. Textiles	54.3 (12.7)	.025904 (.005)		-.18746 (.055)	.61
27.	Hsehld. Textiles, Upholstery	11.82 (9.14)	.014750 (.009)	.37554 (.16)	-.311 (.165)	.77
28.	Lumber Products	-151.9 (108.0)	.05376 (.024)		-.02257 (.06)	.65
30.	Hsehld. Furniture	-15.0 (16.7)	.01642 (.012)		-.01107 (.11)	.60
32.	Paper Products	-476.7 (186.3)	.1477 (.065)	.3129 (.44)	-.16858 (.092)	.79
33.	Paper Containers	-68.15 (18.0)	.05268 (.017)	.2025 (.13)	-.1477 (.06)	.91
34.	Printing and Publishing	-38.4 (96.0)	.030773 (.03)		-.037 (.18)	.68

IO Sector	Constant	Sales	Cash Flow	Capital Stock	R^2
	Regression Coefficients and Standard Errors				
35. Basic Chemicals	161.8 (85.1)	.1611 (.036)		-.30 (.09)	.85
36. Plastics and Synthetics	35.3 (198.5)	.06798 (.052)	.05789 (.597)	-.02849 (.19)	.81
37. Drugs and Toilet Items	252.7 (96.6)	.1559 (.012)	.0277 (.122)	-.277 (.14)	.46
38. Paint and Allied Products	25.26 (8.7)	.004343 (.0066)	.1808 (.07)	-.179 (.073)	.65
39. Petroleum Refining	242.5 (78.9)	.01214 (.0111)		-.1229 (.07)	.19
40. Rubber	-95.16 (19.70)	.06063 (.0122)		-.0787 (.058)	.97
41. Leather Tanning	12.58 (7.79)	.02188 (.006)	.1092 (.106)	-.2845 (.113)	.53
43. Glass	-127.7 (51.1)	.03651 (.047)	.9903 (.376)	-.09469 (.06)	.75
44. Stone and Clay Products	27.22 (68.1)	.051845 (.028)		-.04031 (.06)	.59
46. Nonferrous Metals	-17.46 (90.33)	.036630 (.028)	.32145 (.19)	-.13329 (.06)	.72
50. Fabricated Metals	-5.04 (16.9)	.02784 (.006)		-.12466 (.044)	.76
51. Screw Machine Products, Stampings	-68.5	.0556		-.0899	.55
55. & 56. Construction and Material Handling	-6.82 (23.9)	.004171 (.0069)	.29169 (.085)	-.007347 (.036)	.80
57. Metalworking Machinery	-30.18 (33.7)	.042855 (.009)	.2305 (.1346)	-.06498 (.032)	.76
59. Gen. Industrial Machinery	-34.1 (18.0)	.02738 (.0074)	.1607 (.0755)	-.021445 (.0298)	.92

IO Sector	Constant	Sales	Cash Flow	Capital Stock	R^2
	Regression Coefficients and Standard Errors				
62. Service Industry Machines	22.7	.01877		-.1116	.50
	(11.5)	(.005)		(.07)	
63. Electrical Equipment	3.04	.02991	.1908	-.1033	.78
	(32.73)	(.008)	(.135)	(.056)	
64. Hsehld. Appliances	85.52	.0171		-.1036	.11
	(53.7)	(.012)		(.09)	
65. Electric Lighting Equipment	-40.49	.03172	.1377	-.007	.78
	(14.10)	(.015)	(.148)	(.074)	
68. Misc. Electrical Machinery	4.28	.03456	.1058	-.141	.83
	(12.5)	(.007)	(.1085)	(.057)	
69. Motor Vehicles and Equipment	446.40	.02761		-.1479	.66
	(358.1)	(.005)		(.085)	
70. Aircraft and Parts	24.9	.00277		.0946	.65
73. Optical Equipment	-.36	.03134		-.01396	.82
	(6.0)	(.013)		(.0714)	
75. Transportation	945.5	.36944		-.26267	.70
	(1596.7)	(.09)		(.134)	
76. & 77. Communications	-547.1	.2664	.7268	-.04709	.98
	(266.5)	(.164)	(.422)	(.14)	
78., 79., & 80. Electric, Gas, Water Utilities	264.5	.1800		-.0185	.74
	(531.3)	(.18)		(.149)	

CONSTRAINED REGRESSION EQUATIONS

	IO Sector	Regression Coefficients and Standard Errors		
		Constant	Sales	Capital Stock
8.	Oil and Gas Wells	2145.3	.477	-.1875
14.	Meat Packing	-10.4	.00861	-.0433
16.	Preserved Foods	36.5	.0424	-.154
17.	Grain Mill Products	79.36	.0186	-.0769
18.	Bakery Products	-59.06	.0663	-.1390
20.	Confection Products	-69.59	.06251	-.0682
23.	Tobacco	-86.0	.03374	-.06493
26.	Apparel	116.15	.00691	-.08
29.	Wooden Containers	4.11	.007646	-.02823
31.	Office Furniture	8.0	.000289	-.1
42.	Shoes and Other Leather Products	-39.0	.02185	-.05139
45.	Iron and Steel	-530.0	.0732	-.0263
49.	Metal Containers	-48.7	.06315	-.09482
52.	Hardware	-126.6	.0468	-.04807
53.	Engines and Turbines	-56.31	.05991	-.04199
54.	Farm Machinery	-31.35	.03085	-.00318
58.	Special Industrial Machinery	-59.2	.04453	-.0356
60.	Machine Shops	0.	.0298	-.0037
61.	Office and Computing Machines	2.73	.04847	-.0856
66.	Communications Equipment	18.80	.015413	-.02455

IO Sector	Constant	Sales	Capital Stock
	Regression Coefficients and Standard Errors		
67. Electronic Components	24.66	.03581	-.0641
71. Other Transportation Equipment	18.87	.02231	-.135
72. Scientific Instruments	.0	.02451	-.08682
74. Misc. Manufacturing	78.43	.00575	-.0013
81. Trade	-1216.32	.1048	-.0823
82. & 83. Finance, Insurance, Real Estate	265.1	.01523	-.009