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Development of the Activity Vectors Used in "Energy and Manpower Effects of Alternate Uses of the Highway Trust Fund"

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TABLE OF CONTENTS

The Activity-Industry Matrix

The activity-industry matrix represents a highly detailed disaggregation of the final demand sector of a static open input-output model. It is referred to as the activity-industry matrix because the columns of the matrix represent a comprehensive functional breakdown of the public and private economic activities comprising gross national product. The rows of the matrix are comprised of input-output industries and the matrix thus transforms expenditures on economic activities and programs (stated in terms of constant 1958 dollars) into direct output requirements--final demands. The latest version of this matrix contained in the Center for Advanced Computation (CAC) policy simulation model was developed in the spring of 1972 and contains 93 public activities, 66 Federal programs and 27 state and local government programs, and 125 private sector activities. These activities account distinctly and comprehensively for total gross national product.

The input-output industry system used in this matrix generally follows the 80-order level of industry detail used by the Department of Commerce in recent interindustry studies. With the exception of the ersatz Research and Development industry (74) the major changes in industry numbering were made in the last industries. These changes were due to some of the rather unique conventions followed in the construction of the activity-industry matrix, and the last industries refer to special categories of income transfers, employee compensation, government subsidies, and so forth. The rationale for the creation of some of these special industries and the use of them will become apparent below.

In general, the structure of many of the vectors in the activity-industry matrix is often determined as much by the expenditures allocated to the particular category as by other considerations. It is apparent that the distribution of the coefficients within a specific vector category will be very different depending on whether the expenditures allocated to that category are composed wholly or in part of purchases, transfers, subsidies, grants, compensation, imports, exports, accounting entries, or dummy categories.

Forecasting Activity Structures:
Some General Considerations

Ideally, it would be desirable to have available for use in models of the CAC variety thousands of input vectors, each one representing the manner in which funds allocated to a specific economic program or activity generate direct industrial output requirements for a given period of time. These bills of goods distributions would be stored in a computer system and indexed by function, year and level of disaggregations in a manner which would permit ready and efficient access to them. These distributions could then be combined into different data sets and inserted in the general model to study the impact of different types of economic programs and budget priorities. The level of aggregation and time period would depend on the purpose of the investigation. Examples of the potential usefulness of this type of system are given in the highway trust fund impact study, in "The Employment Effects of Counterbudget" (70), where more aggregate categories are used to simulate the employment effects of the Urban Coalition's Recommended budget priorities for the 1970's, and in "Alternate Manpower Forecasts for the Coming Decade: Second Guessing the U.S. Department of Labor" (69) where the full category detail were was used to develop alternate manpower forecasts for the coming decade. These and other simulations with the CAC model are discussed more fully in The Systematic Forecasting of Manpower Requirements: Theory and Applications (67). Unfortunately, the scarcity of the necessary data and the almost complete lack of basic research in this area implies that this type of ideal system still lies in the future.

In general, two distinct types of technological change will influence the elements of the activity-industry matrix, and both of these must be simultaneously taken into account in projecting the future structure of this matrix. First of all, changes in the structure of the input requirements of different economic activities will be reflected in the model as changes in the columns of this matrix. These changes are unique to individual input vectors and are caused by a variety of factors. For example, new methods of housing construction may result in the substitution of certain materials for others, and would generate a change in the

input coefficients for this activity reflecting the larger purchases required from some industries and the smaller purchases required from others. Similarly, if for reasons of combat efficiency the military switches to weapons containing more aluminum and plastic and less steel, then some of the military input vectors would have to be adjusted to reflect the greater direct requirements for the outputs of the plastic and aluminum industries generated by defense expenditures. On the other hand, technological changes unique to a specific industry may affect most or all activities as the output of the industry becomes more or less attractive as an input to different types of programs and activities. Thus, many of the coefficients of the activity-industry will be affected simultaneously by both types of changes, and this must be taken into account in forecasting structural changes. To indicate more clearly the nature of the problem the derivation of each of the activity vectors utilized in the highway trust fund impact study is described below.

Derivation of Specific Activity Vectors

In "Energy and Manpower Effects of Alternated Uses of the Highway Trust Fund" we analyzed the energy and manpower consequences of transferring a large portion of the highway trust fund expenditures to other government programs. Aside from highway construction, to which the highway trust fund has been exclusively devoted in the past, the activities analyzed were Railroad and Mass Transit Development, Educational Facilities construction, waste treatment plant construction, Criminal Justice and Civilian Safety, and a comprehensive program of National Health Insurance. The first four of these activities, highways, railroads and mass transit, educational facilities and waste treatment plants, refer to different types of construction activities. The derivation of these four activities shall thus be discussed below as a group and the primary and secondary data sources used in developing and projecting each of these activity vectors shall be identified. The derivation of the other three activity vectors shall then be discussed individually.

Derivation of the four construction activity vectors

In disaggregating final demand into individual activity categories the consideration of different types of public construction programs was appropriate for a number of reasons. First of all, construction activity has consistently been a large and significant portion of GNP and public construction activities are often used as contracyclical devices. Secondly, the construction industry is ideally suited for being transferred from the processing sector to the autonomous sector of an input-output system, for the value of all new construction activity, which is about 75 percent of the total construction activity, is distributed exclusively to final markets. Third, a large amount of preliminary analysis of the industrial and labor requirements of various types of construction projects has been completed in the last three decades. Finally, and most importantly, the highway trust fund is used for the construction of new highway systems and the three other types of construction activities considered represent viable alternate uses of these monies.

The first step in formulating bills of goods for separate construction activities was to remove the new construction and the maintenance and repair construction industries from the intermediate sector of the input-output table and to convert them into distinct components of final demand. In the U.S. input-output studies construction expenditures are included as purchases made by separate final demand categories such as private investment and Federal purchases. Since the activity-industry matrix includes separately a large number of individual construction activities (four of which were utilized here) which account for all construction in the economy, in developing the other activity vectors it was necessary to exclude all purchases from industries 11 and 12--new construction and maintenance and repair construction, and to adjust the input coefficients for these categories accordingly. Thus, double counting in either total expenditures or coefficient weights was avoided. Secondly, in the processing sector the construction industry contained a large value added component and when this industry became a component of final demand it was necessary to create a special industry in the labor inverse to reflect and distribute the wage and salary component of this value added leakage--this "construction compensation" is one of the special industries referred to earlier.

To estimate the highway construction activity vector we had a wealth of both qualitative and quantitative data to work with. The building of highways has long been recognized as an important component of new construction and was analyzed in detail in the 1947, 1958, and 1963 input-output studies. Further, many independent investigations of the structure and economic and employment effects of highway construction have been completed over the past two decades by individual researchers and by the Bureau of Labor Statistics. To determine what the direct requirements of highway construction are likely to be in 1975 we assembled all of the relevant data for past years to get a general idea of what the trend of highway construction requirements were in the postwar years. For those industries for which the change in requirements appeared to be following a strong and consistent trend we extrapolated this trend using a simple least squares algorithm. For a few industries in which the changes in requirements showed no consistent trend or appeared to fluctuate randomly such a curve fitting technique was not considered to be valid

and we held these industry input coefficients to their most recent value. For industries in which the coefficients were very small or actually zero for most years we used the identical convention--the cutoff point was a coefficient value of .0005 or less. The value added component was adjusted to conform to the portion of direct highway construction costs estimated to be absorbed by nonmaterial inputs by 1975. After we had obtailed an estimate of the 1975 highway construction vector in this manner it was normalized and thus forced to sum to 1.0000. The estimated vector was then examined to see if this normalization had resulted in distortion of any of the observed dominant trends in coefficients. For any industires where this was found to be the case the input coefficient was held to its most recent value while the vector was renormalized. General references, primary and secondary data sources used in the development of the highway construction activity vector were the following: 1, 5, 6, 7, 8, 9, 12, 13, 14, 15, 16, 17, 19, 22, 23, 26, 27, 28, 35, 36, 37, 38, 39, 40, 42, 50, 51, 52, 54, 55, 57, 58, 59, 62, 63, 64, 65, 66, 67, 68, 70, 72.

The activity vectors for the other three construction activities used in the analysis, Railroad and Mass Transit Construction, Educational Facilities Construction and Waste Treatment Plant Construction were developed in a manner identical to that described above for the highway construction vector. For educational facilities construction even more data and special analyses were available than for new highway construction; for these construction categories the data base was somewhat smaller. The structure of the Waste Treatment Plant Construction activity vector had to be assumed to be similar to what it was in the late 1960's, for there did not exist a reliable set of time series observations on this activity. General references, primary and secondary data sources used in the development of the Railroad and Mass Transit Construction, Educational Facilities Construction and Waste Treatment Plant Construction activity vectors were the following: 1, 3, 5, 6, 7, 8, 9, 12, 13, 14, 16, 17, 19, 20, 22, 23, 26, 27, 28, 29, 30, 31, 32, 34, 36, 37, 38, 39, 40, 42, 43, 46, 47, 49, 50, 51, 52, 53, 54, 55, 57, 58, 59, 60, 62, 63, 64, 65, 66, 67, 68, 70, 71, 72.

Devrivation of the three nonconstruction activity vectors

One of the three nonconstruction program alternatives we wished to analyze was a program of general tax reduction. This was important for our analysis, for one feasible alternative to reduction in expenditures on federal highway construction, or on any other government program, is to return the money to taxpayers in the form of a tax reduction. Decrease in expenditures for one type of government program does not necessarily mean an equivalent increase in funds devoted to another government program.

To develop a bill of goods vector for tax relief we had to make the simplifying assumption that the marginal propensity to consume out of these funds would be unity; otherwise we would have been forced to distribute these funds in some manner among saving and investment. This is a realistic assumption, since the marginal propensity to consume in this country has traditionally been in excess of 95 percent.

We assumed that the hypothesized tax reduction would be distributed equally to all consumers and income classes. To develop any complex tax reduction functions was clearly outside of the scope of our analysis here. We thus distributed the tax reduction proportionately to all categories of personal consumption expenditures based on the forecast distribution of PCE among 83 types of products in 1975. These estimates of expenditure controls were then distributed to the input-output industries using an 83-order "bridge" table. This bridge table, which is a collection of 83 columns showing how expenditures on each PCE product type are distributed as direct output requirements, was derived from historical bridge tables and from projections of these tables to 1980 developed by the Bureau of Labor Statistics. The development of the tax relief bill of goods vector, once the simplifying assumptions had been made, thus presented little problem. We assumed that the detailed PCE coefficients would change at the same rate through the 1970's as was implied in the BLS projections. General references, primary and secondary data sources used in the development of tax relief bill of goods were the following: 2, 4, 5, 13, 16, 17, 18, 19, 21, 22, 23, 24, 25, 28, 36, 37, 38, 39, 40, 41, 42, 50, 51, 52, 53, 54, 55, 56, 57, 58, 66, 67, 68, 70, 72, 73.

To understand the manner in which an activity vector for National Health Insurance was derived it is necessary to realize that a National

Health Insurance program would transfer the burden of paying for medical and health programs from the individual to the federal government. While at the aggregate level this may influence the demand for, the quality of, and the distribution of health services, at the micro level little would change: the individual would still require the same types of medical and health services and would either pay them and be reimbursed by the government or have them charged directly to the government. Accordingly, the structure of our National Health Insurance activity vector is an aggregation of the health service and medical products vectors of the estimated 1975 personal consumption expenditures final demand matrix and was developed directly from that matrix. The general references primary and secondary data sources used to develop the National Health Insurance activity vector thus correspond to those listed directly above.

Finally, we wished to include a Criminal Justice and Civilian Safety program alternative because we felt that this alternative would be especially relevant for the near future. Unfortunately, the only major source of data for the direct output requirements created by this type of program is the 1963 Department of Commerce input-output study. These data were used intact here with only minor modifications made to the value added component and to adjust the coefficients for projected price changes. General references, primary and secondary data sources used in the development of the Criminal Justice and Civilian Safety activity vector are the following: 10, 11, 18, 25, 28, 50, 58, 63, 64, 65, 67, 68.

Evaluation

The most serious qualification involved in our analysis is the assumption of fixed coefficients throughout all nonstochastic components of the CAC model. This is a very strong assumption. Within the activity-industry matrix it implies that no matter what the level of expenditures on any individual activity, the distribution of direct input requirements generated by that activity--the normalized final demand vector--will remain fixed. In relation to the Leontief inverse matrix it implies that the relative distribution of direct and indirect output requirements generated among industries by the required delivery of a dollar's worth of output to final demand by any single industry will remain constant no matter what

the required level of activity in that industry. The assumption of constant employment-output ratios implies that the relationship between gross output and required employment within an industry remains fixed over all levels of output in that industry. Finally, the use of an industry-occupation matrix with fixed coefficients implies that the requirements for workers within different occupations varies proportionately as the total level of employment in an industry changes.

Theoretically, these assumptions are quite restrictive, for they imply that all industries possess production functions exhibiting constant returns to scale and thus deny the possibility of increasing or decreasing returns to scale, of substitution between labor and capital at different levels of plant utilization, or of substitution between different occupations and levels of skill within industries. In a purely theoretical sense these assumptions cannot be defended, for we know that economics of scale do exist, that capital and labor can be substituted for one another, and that as industries contract or expand employment all occupations are not affected proportionately. Unfortunately, the empirical data do not exist which would allow us to incorporate these nonlinear relationships into our model. Theoretical rigor thus had to be sacrificed in the cause of empirical feasibility.

Testing the accuracy of our estimates or of any component of the model is difficult, for errors in the estimates of output or employment requirements can be caused by any one or combination of the following: 1) forecasting errors resulting from the econometric model used to generate economic parameters and expenditure estimates, 2) errors in breaking down expenditure aggregates into detailed category allocations, 3) errors in constructing the columns of the activity-industry matrix, 4) errors in estimating the coefficients of the Leontief inverse, 5) errors in estimating labor productivity and employment requirements within each input-output industry, 6) errors in reconciling the input-output industries with those of the occupation matrix, and 7) errors in specifying the rows of the occupation matrix. Here we would be concerned primarily with the third type of error. However, while theoretically it should be possible to factor out the errors resulting from each of these causes, empirically it has been impossible to do so.

Nevertheless, our work does represent the best possible given the present state of the arts. Continuing improvements are being made in the CAC model to make it a more useful and reliable tool for policy analysis.

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