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TOWARD MANPOWER AND ENERGY DIMENSIONS FOR THE FEDERAL BUDGET

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ABSTRACT

This paper analyzes the impact on manpower and energy requirements of Federal expenditures for 20 major programs. The impacts on requirements for specific occupations and for primary energy resources per billion dollars spending for each program are estimated and the trade-offs between manpower requirements and energy requirements are indicated. The findings indicate that the functional distribution of Federal spending can have a significant impact on manpower requirements and energy utilization and that the goals of full employment and energy conservation may be compatible.

Introduction

The impact which the Federal budget has on the economy is understood by economists and politicians, and it is recognized that different Federal spending programs can have very different effects on the economy as a whole, on different regions of the nation and on the labor markets for occupations. More recently, it has become painfully clear that this nation's supply of energy is not limitless and the Federal government has undertaken an ambitious program to encourage energy conservation. But is it possible to decrease energy usage without decreasing employment? Here we analyze one aspect of this important question by estimating the detailed manpower and energy intensities of 20 major Federal government programs and indicating the trade-offs between energy requirements and manpower requirements likely to result from different Federal spending priorities. The model used to derive these estimates is described in the following section. The next section presents detailed manpower (by

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occupation) and energy (by source) profiles for major Federal government programs, and the last section discusses the implications of these findings for manpower policy as it relates to energy conservation.

The Model

To estimate the manpower and energy intensities of Federal programs we utilized several components of the Center for Advanced Computation (CAC) Energy-Manpower Simulation Model.[1] This model permits the simulation of the detailed energy and employment effects of a wide range of social, economic, and technological policy alternatives. Analytically, the model is an integrated econometric input-output model supplemented with data on energy requirements, labor productivity, and manpower and skill requirements. The basic equation of the system is that of the Leontief open model:

$$x = (I - A)^{-1} y \qquad (1)$$

where x is a total output vector, y is a final demand vector, and $(I - A)^{-1}$ is the Leontief inverse matrix whose coefficients a_{ij}^* indicate the total output requirements generated from industry i by industry j per dollar delivery to final demand, y. In our model the final demand vector is disaggregated into the product of an activity-industry matrix, P, and an expenditure vector, q:

$$y = Pq \qquad (2)$$

In the above equation P is a matrix whose coefficients P_{ij} show the direct requirements for the outputs of industry i generated per dollar of expenditure on activity j, and q is a vector whose elements q_j show the expenditures allocated to activity j. This matrix contains 200 columns, each of which shows how a dollar of expenditure for a distinct public or private economic activity is distributed as direct output requirements from every industry in the economy. For this study we aggregated the columns of this matrix representing Federal activities into the 20 major Federal programs listed in Table 1.

To translate industry output requirements into employment demands the Leontief inverse is premultiplied by a matrix of employment-output coefficients, θ:

$$\theta (I - A)^{-1} Y = M \qquad (3)$$

where Y is a diagonal matrix of the final demand elements generated in equation (2) and M is an interindustry-employment matrix showing the total employment generated by and within each industry by a specified expenditure

[1] The CAC model discussed in Bezdek [1], Bezdek and Hannon [2], and Herendeen [3].

Table 1. Manpower and Energy Requirements Generated by $1 Billion Spending for Federal Programs[a]

Program	*Manpower (total number of jobs)*	*Energy (billions of BTU's[b])*
1. Military Operations and Administration	79,190	6,683
2. Military Research and Development	68,979	4,466
3. Military Construction	83,157	6,067
4. Military Procurement	69,026	5,511
5. U.S. Army Corps of Engineers Projects	69,384	5,614
6. Atomic Energy Commission (AEC)	58,880	11,031
7. National Aeronautics and Space Admin. (NASA)	85,661	4,220
8. Education	118,191	3,713
9. Sanitation	78,954	3,728
10. Direct Health Assistance	133,717	4,031
11. Other Health Programs	117,794	3,305
12. Social Security (OASDI)	108,196	5,655
13. Law Enforcement	75,601	3,401
14. Highway Construction	84,933	6,102
15. Mass Transit Construction	83,536	2,410
16. Public Housing	84,524	5,973
17. Public Assistance	99,406	5,502
18. Postal Service	97,616	2,210
19. Conservation and Recreation	88,415	6,479
20. Federal Enterprises	81,298	2,740

[a] Estimates for 1963.
[b] British Thermal Units.

distribution. Using a matrix showing the per cent distribution of industry employment among occupations, B, interindustry employment requirements are disaggregated into demands for 185 occupations:

$$RB = S \quad (4)$$

where R is a diagonal industry employment matrix derived from the row sums of M, and S is an industry-occupation matrix showing the total occupational requirements generated within each industry.[2] The occupational manpower requirements generated by each program are read off the matrix S.

Energy requirements are generated in the following system of equations:

$$E = [Q(I - A)^{-1} + T]Y \quad (5)$$

where Q is a matrix of energy sales (in BTU's) of energy sector i to industry

[2] The occupational coefficients were derived from Bureau of Labor Statistics data published in [5].

j per unit of output of industry j, and T is a diagonal matrix of energy of type i sold to final demand activity j. The term in brackets we denote by Σ and refer to as the total energy matrix. Any element Σ_{ij} of it gives the total output (BTU) of energy sector i required for the economy to deliver a dollar's worth of the output of industry j to final demand.[3] The elements E_i of the vector E show the total required energy output (BTU's) of each energy sector i. These sectors are coal, crude petroleum products, refined petroleum, electricity and natural gas. Total primary energy is defined as all coal, crude petroleum (including natural gas) and the fossil fuel equivalent of hydro and nuclear electricity.

Because of the lag with which the data required by the model become available, the model presently pertains to 1963—although it is in the process of being revised and updated to 1967.[4] We wished here to identify the detailed impacts on manpower and energy requirements likely to result from a given level of spending for each of the 20 Federal programs. To accomplish this we utilized the appropriate "final demand" vectors from the model, each of which showed how funds devoted to a specific program were likely to be distributed as direct output requirements. A separate manpower impact simulation was conducted for each program alternative. Each simulation showed how one billion dollars allocated to a specific program was likely to be translated into direct and indirect occupational manpower requirements.

To determine the likely direct and indirect energy requirements of each of the program alternatives we utilized the energy components of the model developed at the 367 level of industry detail for 1963.[5] First, we aggregated the energy matrix to match the 90-order sector detail of the activity-industry matrix. Then, using the distribution of the total inputs to each activity, we determined the energy intensity (BTU/$) of each specified program alternative by multiplying the total primary (direct and indirect) energy vector by the activity-industry vector. Finally, we estimated the total energy cost of one billion dollar expenditures for each program times the total energy intensity of that activity. This step completed our simulation of the energy and employment effects of various Federal programs.

Before discussing the empirical results of this study, it is important to note the assumptions involved in our analysis. First of all, the input-output model assumes that all industries possess a linear homogeneous production function and experience constant returns to scale. Our approach thus implies that output, energy and manpower requirements will change proportionately with

[3] See Herendeen [3];

[4] The 1963 input-output study was not published until 1969 [4]; the 1967 input-output study was not published until early 1974 and the full detail of the 1967 study did not become available until the summer of 1974.

[5] The 86 industry level of detail did not contain sufficient detail on the energy sectors.

the level of production in each industry. Second, we assume that an increase or decrease in spending on any of the programs will not change the distribution of expenditures on the program inputs, and, analogously, that any change in total employment requirements for an industry will be reflected in proportionate changes in demand for the occupations employed within that industry. Especially for some programs and certain industries these are very strict assumptions but the incorporation of comprehensive nonlinear relationships into the model was not feasible. Finally, the employment concept used here is short run and does not include any employment effects which may arise circuitously from the expenditure shifts simulated. Thus, for example, while our analysis allows us to estimate the manpower requirements likely to result from one billion dollars spent for highway construction, we make no attempt to estimate the occupational effects which may come about from increased automobile use stimulated by highway construction.

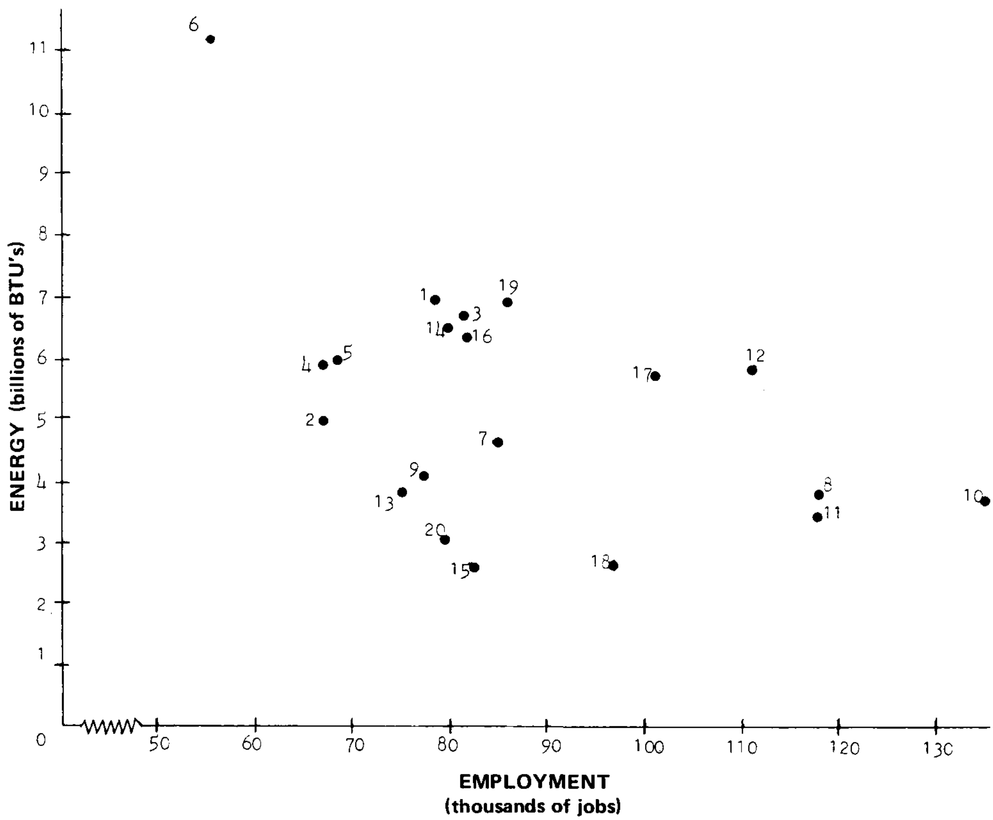
The Manpower and Energy Intensities of Federal Programs

The likely effect on total manpower and energy requirements of one billion dollars allocated to each of 20 major Federal programs is given in Table 1. The programs listed here are interpreted in a straightforward manner. Most include both the purchases of goods and services as well as the employee compensation involved in administering the program. Several programs, such as Atomic Energy Commission (AEC) and National Aeronautics and Space Administration (NASA), refer to specific agencies. Several other programs, such as Highway Construction and Army Corps of Engineers Projects, consist of new construction activities, while the input distributions for Social Security and for Public Assistance reflect the expenditure patterns of the special classes of consumers to whom such transfer payments accrue.[6]

Table 1 indicates that the impact on both manpower and energy requirements per dollar of expenditure varies widely among functional Federal government programs. Looking first at the total impact on employment, we see that some programs, such as AEC expenditures and Military Procurement, generate relatively few jobs per dollar, while other programs, such as Direct Health Assistance and Education generate a relatively large amount of employment. Similar comments apply to the energy intensities of Federal programs, although the range of the energy impact is even larger than that of the employment impact. The most energy intensive program (AEC) generates five times the energy requirements as the least energy intensive program (Postal Service), whereas the most employment intensive program (Direct Health Assistance) generates only slightly more than twice as much employment as the least manpower intensive program (AEC).

[6] For a detailed discussion of the development of the program vectors see Chapter 4 of Bezdek [1].

The economic development of the United States was accompanied by the substitution of relatively cheap energy for relatively expensive labor, and perhaps a more useful way in which to view the data in Table 1 is in terms of the trade-off between energy and manpower requirements generated by the different spending programs. This is illustrated in Figure 1 which graphs energy requirements along the vertical axis and manpower requirements along the horizontal axis. Programs falling in the northwestern portion of this graph generate relatively large energy requirements but relatively few jobs, while points falling in the southeastern portion of this figure generate a relatively large amount of employment but low energy requirements. It is clear from this figure that there are certain Federal programs such as AEC, Corps of Engineer Projects and Military Procurement, which are highly energy intensive and which generate relatively few jobs, and that there are certain other programs, such as Health and Education programs, which generate a large amount of employment but generate relatively low energy requirements. However, no clear cut pattern emerges indicating that some energy intensive programs are not also labor intensive or vice versa.



[a] Program numbers are identical to those in Table 1

Figure 1. Energy and manpower intensities of Federal programs[a].

The preceding discussion concerned total manpower requirements and total energy requirements. But in reality both skilled manpower and various energy sources are in relatively short supply and it is important to determine the impact of Federal spending on the requirements for specific occupations and for specific types of energy. With our model we are able to estimate the impact of different Federal programs on demand for 185 occupations and for five energy types. To illustrate the detailed impact on manpower and energy requirements of the Federal budget we have listed in Table 2 the impact of one billion dollar spending for Military Research and Development, Education, and Highway Construction on the demand for five types of energy and for 25

Table 2. Detailed Manpower and Energy Impacts of Three Federal Programs

	Military Research and Development	*Education*	*Highway Construction*
		Energy (Billions of BTU's)	
Coal	1,774	1,187	1,764
Crude Oil	2,436	2,337	4,125
Refined Oil	1,100	1,185	2,154
Electricity	431	315	358
Natural Gas	1,390	1,219	1,957
		Selected Occupations (Total Number of Jobs)	
Aeronautical Engineers	703	34	39
Chemical Engineers	103	74	85
Civil Engineers	228	410	801
Electrical Engineers	228	300	266
Mechanical Engineers	705	246	273
Chemists	240	188	49
Biological Scientists	98	64	160
Physicists	118	32	43
Physicians and Dentists	287	1,727	22
Elementary and Secondary Teachers	562	14,504	51
College Teachers	242	2,835	9
Economists	66	25	29
Statisticians	99	37	33
Psychologists	217	179	9
Architects	64	64	67
Carpenters	278	1,755	3,491
Concrete Finishers	10	164	365
Electricians	560	678	1,276
Structural Metalworkers	12	171	351
Machinists	1,280	410	499
Glaziers	11	40	73
Opticians	29	29	13
Semiskilled Textile Workers	126	94	49
Drivers and Deliverymen	1,483	2,924	4,613
Welders	874	575	922

selected occupations. This table indicates that the detailed energy and manpower impacts of Federal programs are likely to vary much more than the impact on total energy or manpower requirements. For example, in terms of energy a dollar spent for Highway Construction would generate about the same requirements for coal as would a dollar spent for Military Research and Development, but would require twice as much refined oil and crude oil.[7] And despite the fact that highway construction is more energy intensive in total than Military Research and Development, the latter program generates requirements for 20 per cent more electricity, per dollar, than does Highway Construction.

The impact on detailed manpower requirements is even more varied, with most programs generating a unique set of occupational requirements. Thus, while a specified level of expenditures for Highway Construction or Military Research and Development will generate far fewer jobs than an equivalent amount spent for Educational programs, Highway Construction will have a much more important impact on requirements for some occupations. It is clear from Table 2 that the impact of Federal spending on requirements for specific occupations will depend critically on which types of programs are emphasized.

Conclusions and Implications

Here we utilized a large scale interindustry model supplemented with data on the structure of Federal spending programs and on employment, skill, and energy requirements to estimate the manpower and energy impacts of different areas of Federal spending. We found that the impact on the nation's manpower requirements and energy utilization of different Federal programs varied widely, both in terms of total employment and energy demand as well as for requirements for specific occupations and types of energy. While in general there appears to be no clear cut trade-off between employment and energy, it does appear that certain Federal programs generate a high degree of energy requirements relative to employment and that other programs have the opposite impact.

Of course, the results presented here must be regarded as tentative. Aside from the strict theoretical assumptions of linearity involved in the model, our estimates also refer to 1963 and are based on the structural, labor and energy relationships which existed in that year. Thus, for example, manpower requirements were generated on the basis of 1963 productivity and skill requirements and use of the 1963 input coefficients implied that we could not take into consideration pollution devices on automobiles which reduce gasoline mileage and other factors which have increased in importance since 1963.

[7] The manpower and energy effects of several alternatives to highway programs are analyzed in Bezdek and Hannon [2].

Nevertheless, despite these qualifications, several policy implications emerge from this study. First of all, it is clear that the functional distribution of Federal expenditures can have a significant impact on the level and structure of the nation's manpower requirements and energy requirements. Obviously, no one would advocate that the likely impact on the labor market or on energy requirements should be the major determinant of Federal spending priorities—Federal spending must be decided by the political process on the basis of some type of social welfare function. But the impact of Federal programs on manpower and energy resources must be recognized and should enter the decision making process at some point. To cite only one relevant example, if the United States is likely to be faced with a continuing shortage of petroleum throughout the 1970's it may be advisable for the government to reevaluate at least some of its budget proposals on the basis of the impact of particular programs on petroleum consumption, utilizing information such as that contained in the upper portion of Table 2. Similar comments apply to the manpower impacts identified in that table.

Secondly, and perhaps more importantly, our findings indicate that, at least as far as some major Federal spending programs are concerned, the goals of conserving energy resources and maintaining full employment of human resources may be compatible. Clearly, whatever the other relative merits, a redistribution of Federal expenditures in favor of certain programs at the expense of others could reduce energy requirements while at the same time increase employment.

We hope that our work here will stimulate additional studies of the economic, manpower, and energy impact of Federal programs. Accurate and detailed manpower and energy dimensions for major Federal spending programs would be of interest to government administrators and can aid in the formulation of rational long-range manpower and energy policies.

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