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ENERGY AND MANPOWER EFFECTS OF ALTERNATE USES OF THE HIGHWAY TRUST FUND

by

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ABSTRACT

The direct and indirect dollar, energy, and employment costs of reinvesting the $5 billion (1975) Highway Trust Fund in six alternative federal programs are determined using a large linear computer model. These alternative programs are: Railroad and Mass Transit Construction, Educational Facilities Construction, Waste Treatment Plant Construction, the Law Enforcement Program, National Health Insurance Program, and Tax Relief Program.

Energy consumption would be reduced by shifting the Highway Trust Fund to all of these categories except the Tax Relief Program. Employment would be increased in all cases. Energy consumption impact by type of energy and employment impact by occupation are given.

The highway and railway transport systems are compared in detail, and an energy-conserving, employment-increasing tax is suggested.

INTRODUCTION

One of the most important policy controversies in governmental and environmental circles is the diversion of funds from the Federal Highway Trust Fund into Mass Transit Development and other programs. Some environmentalists believe that the fund precludes other important federal programs. Others suspect that it serves as a promotional device which leads to a high energy-use transportation system. Many lawmakers, builders, automakers, trucking and oil company executives believe the fund provides a highly flexible land transportation network which is vital to healthy growth of the United States economy and to national defense. They emphasize that such expenditures also produce many jobs in the highway construction area.

In this paper we present findings which will hopefully serve to clarify the debate centering on these issues. We compute the net energy and manpower impacts likely to result from a reallocation of the projected 1975 Highway Trust Fund ($5 billion) to six other types of government programs: Railroad and Mass Transit Development, Educational Facilities Construction, Waste Treatment Plant Construction, the Law Enforcement Program, National Health Insurance Program, and Tax Relief Program. The Railroad and Mass Transit alternative is considered as a direct substitute for highway construction; the remaining programs are considered as feasible alternate uses of these federal funds in the near future. The six alternatives thus provide a range of choices for government policymakers, and by detailing and contrasting the energy and occupational employment impacts of each expenditure allocation, we provide additional vital information necessary for rational policy formulation.

SIMULATION OF THE EMPLOYMENT AND ENERGY IMPACTS

To estimate the net employment and energy impact of reallocating the 1975 Highway Trust Fund to other types of programs we used the Center for Advanced Computation (CAC) Energy-Manpower Policy Simulation model.[1] This model allows the user to simulate 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:

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

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:

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

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 220 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 our study here we employed the seven columns of this matrix representing highway construction and the six program alternatives mentioned previously.

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

$$(3) \quad \Theta\ (I-A)^{-1}Y = M$$

where Y is a diagonal matrix of the final demand elements generated in equation (2) and M is an interindustry-employment matrix show ing the total employment generated by and within each industry by a specified expenditure distribution. Using a matrix showing the percent distribution of industry employment among occupations, B, interindustry employment requirements are then disaggregated into demands for 185 categories of occupational manpower resources:

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

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. The total occupational manpower requirements generated by each expenditure allocation can then be read off the matrix S.

Energy requirements are generated in the following system of equations:

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

where Q is a matrix of energy sales (in Btu's) of energy sector i to industry 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 ε and refer to as the total energy matrix. Any element ε_{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.[2] The elements E_i of the vector E show the total required energy output (Btu's) of energy sector i. These sectors were: 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.

The first step in simulating the net employment impacts of alternative uses of the Highway Trust Fund required projecting broad economic parameters and control data to 1975 to provide an economic framework for simulation. This required projecting gross national product, capital investment, rates of price change, and other aggregate economic variables on the basis of regression analyses of time series data on these variables for the postwar period. We estimated that by 1975 the size of the Highway Trust Fund was likely to be about $5 billion. While this estimate may turn out to be somewhat in error, the point is that we were concerned here with determining the energy and manpower effects of reallocating a specified level of funds from highway construction to other uses.

To generate the direct output requirements of $5 billion of expenditures on each of the seven program alternatives considered here, we utilized the appropriate "final demand" vectors from the 1975 version of the CAC energy-manpower policy simulation model. Each of these vectors showed how funds devoted to each program were likely to be distributed as direct output requirements in the near future. Since the base year of the model is presently 1958, expenditures on each type of program had to be first translated from current (1975) dollars into 1958 constant dollars via separately derived price deflators. Once this was done a separate manpower impact simulation was conducted for each program alternative. Each simulation showed how $5 billion dollars allocated to a specific program was likely to be translated into direct and indirect occupational manpower requirements in the near future.[3]

The program alternatives considered here can be interpreted in a straightforward manner. Four of them--Highway Construction, Railroad and Mass Transit Development, Educational Facility Construction, and Waste Treatment Plant Construction--refer to different types of construction programs. Criminal Justice and Civilian Safety refer to public expenditures on all types of law enforcement and criminal justice programs, while National Health Insurance pertains to a comprehensive federal program of direct medical assistance payments. The simulated tax relief alternative was developed assuming an across-the-board tax cut equal to the size of the Highway Trust Fund and proportioned among the different detailed categories of personal consumption expenditures.[4] We assume that an increment of increased or decreased spending on any of the programs will not change the distribution of expenditures on the program inputs; i.e., a program will expand or contract its expenditure patterns proportionately. This is certainly an erroneous assumption when the current spending for a program is small compared to the proposed increase or decrease. At the very least, however, one can obtain the effects of a small unit shift in expenditure from the results of our program.

At the time our research was being conducted the necessary data were not yet available which would permit us to project the energy input coefficients to 1975. To determine the likely direct and indirect energy requirements of each of the program alternatives we had to utilize the energy components of the model developed at the 367 level of industry detail for 1963. 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. We next deflated the projected $5 billion 1975 Highway Trust Fund to 1963 prices to convert it into the constant dollar units of the energy matrix. Finally, we estimated the total energy cost of the expenditures on each program alternative by multiplying the deflated expenditures on each program times the total energy intensity of that activity. This step completed our simulation of the energy and employment effects of the Highway Trust Fund and of various alternatives.

EMPIRICAL RESULTS

The estimated energy and employment impact of the Highway Trust Fund and the six program alternatives to it are summarized in Table 1. For every program alternative to Highway Construction except Tax Relief, energy requirements decrease. If the funds are spent on Railroad and Mass Transit rather than Highway Construction, the total primary energy demands would be about 64 percent lower, mainly because of significantly lower steel and concrete usage. But if the reduction in the Highway Trust Fund is used to provide relief to taxpayers, resulting in increased personal consumption expenditures, then energy demands increase nearly 41 percent relative to Highway Construction. This assumption of respending includes proportionate increases in the direct purchases of energy, which largely explains the high energy intensity of personal consumption. Spending the Highway Trust Fund for the Construction of Waste Treatment Facilities reduces energy requirements by 12 percent; spending it for the construction of Educational Facilities decreases energy demands by 8 percent; while reallocating it to a National Health Insurance Program or to a Criminal Justice and Civilian Safety Program decreases energy requirements by 34 percent and 16 percent, respectively.

The effects on total employment requirements can be read in a similar manner from Table 1. Here we see that each of the program alternatives considered generate higher total labor requirements. The net job creating advantage of some programs, such as Railroad and Mass Transit Development and Waste Treatment Plant Construction, is likely to be quite low (three percent and one percent, respectively); while the increase in total employment resulting from a reallocation to other programs, such as National Health Insurance or Criminal Justice and Civilian Safety, is likely to be substantial. The results of Table 1 should thus be of special interest to federal executives and legislators concerned with energy and manpower policies. It is clear that certain programs have low energy and high employment demands relative to Highway Construction. All of the alternative construction programs are less energy and more labor demanding.

For manpower policy, however, it is important to break down the aggregate employment shifts listed in Table 1 into the net effects upon demand for specific occupations, jobs, and levels of skill. The net positive and negative effects of each of the simulated program alternatives upon selected categories of manpower resources are given in Tables 2 through 7. Each of these tables summarizes the major net occupational manpower shifts likely to result from transferring Highway Trust Fund monies to one of the six program alternatives. The occupational changes in these tables were weighted by the total forecast 1975 U. S. employment in that occupation, and ranked in descending order of impact for each program alternative.

Tables 2 through 7 illustrate that the net effects on the demands for jobs and skills will be quite different depending upon which program is emphasized at the expense of the Highway Trust Fund. Despite the fact that each expenditure reallocation simulated resulted in an increase in the total number of jobs required, in each case requirements for certain occupations will probably increase due to the shift while requirements for others will likely decline. It is impossible to generalize because the detailed occupational effects depend on the specific program alternative considered. The important point is that these diverse positive and negative occupational impacts do exist and will have to be dealt with when considering any reform of the Highway Trust Fund.

Table 8 shows the direct and indirect energy demand for the four basic types of energy created by the seven federal spending options of 5 billion 1975 dollars. Personal consumption provides the major demand for all types of energy, except coal, where Waste Treatment Plant Construction is the highest, probably because of a relatively high consumption of basic structural steel (coke). Highway Construction is the largest consumer of refined petroleum primarily through cement manufacturing. National Health Insurance is the second major user of electricity (to run small machines, air conditioners, and lighting). Most (77 percent) of the Health Insurance funding goes into the highly labor intensive medical services sector. Highway Construction is also a leading consumer of natural gas, again probably due to cement manufacturing. Law Enforcement, Mass Transit Construction, and Educational Facilities Construction require a very diverse range of products. It is therefore difficult to make a priori estimates of the energy use in these three categories, as it is almost all consumed indirectly by the many industrial and commercial sectors involved.

In the following section we examine the systemic effects of the analyzed programs and, in particular, attempt to assess the long range energy and labor implications of the Highway and Railway Construction Programs.

SYSTEMIC EFFECTS OF THE EXPENDITURE ON HIGHWAYS AND RAILROADS

The unprecedented freedom offered by the private automobile, and the unparalleled flexibility of motor freight are the obvious advantages of the highways built by Highway Trust Fund expenditures. Traffic accidents, litter collection, patrol and maintenance costs are expenses diffused through the public directly or through other levels of government. For example, in 1972, auto traffic accidents claimed twenty-one times the number of lives per 100 million passenger miles as did railroad passenger traffic.[5] Thus, it is difficult, if not impossible, for the public to make a "benefit-cost" comparison.

Some economists argue that trucks are not paying their share of the construction and maintenance costs.[6] According to a 1964 Federal Highway Administration study, the three-axle semitrailer truck, by far the most common style, paid $737 in taxes but incurred $901 in construction and maintenance costs. Autos paid nearly their share. By 1969, all combination trucks were paying about 76 percent of their incurred costs while the largest trucks (semi plus full trailers) were paying only 56 percent of their allotted cost from interstate highway use. Railroads had major subsidies in the mid 1800s, but today they are highly regulated and apparently out subsidized, resulting in a substantial diversification of corporate railroad attention.

Although more freight is shipped by railroad than ever before, the railroad share of total ton miles is declining.[7] A reason offered by trucking firms for the rise in their portion of freight hauling is the lack of flexibility of the railroads. Rail, they argue, simply cannot deliver to the widely distributed modern centers. The reason for this distribution may be the desire for the auto and its ubiquitous highway. However, intercity trucking, along interstate highways, representing direct competition with the railroads, rose from 16.3 percent in 1950 to 22.2 percent in 1971, of all freight ton miles hauled.[8]

Another important comparison lies in the cost per mile of highways and railroads. Assuming that one-half (two lanes) of an interstate highway is equivalent to one modern railroad track, we find the following costs per rural mile in 1969: highways; $258,000 for construction and about $2,100/year for maintenance:[9] railroads; $103,200 for construction and $4,440/year for maintenance.[10] These construction costs do not include land, structures, signs, or signals.

We must also compare the average speed and load factor of trucks, cars and trains in order to estimate the convenience aspect of these forms of transport. The average car is about 50 percent faster than the average passenger train, and the average intercity truck is about 175 percent faster than the average freight train.[11] Relative passenger load factors are given in Table 9.

A final point of comparison is circuity, the deviation of the length of a transport mode distance from the corresponding great circle distance. Average railroad circuity is 1.24 compared to 1.21 for highways.[12] No cost corrections for this small difference have been made.

Ultimately, a comparison is desired of the total dollars, energy and labor per unit of service provided for the entire functioning of highways and railroads. Table 9 presents such a comparison. Here all the costs (operating, maintenance, manufacturing, right-of-way construction, parking, etc.) of rail and auto passenger service, and rail and truck service are compared. In calculating this information, we noted that right-of-way construction accounted for less than 10 percent of the total system energy. We find the ratio of dollar, energy, and employment costs for the car/rail system are 1.30, 1.18, and 0.80, respectively. The same comparisons for the truck/rail system are 4.87, 2.56, and 1.48, respectively. In the passenger case, rail requires fewer dollars and less energy but more labor. These ratios would change in a complex manner if equivalent load factors were used. Railroad passenger energy and labor intensity would probably decrease if a 50 percent load factor were achieved. The remarkable feature of the freight comparison is the magnitude of the ratios. Trucking is far more expensive than rail in all categories.

One is tempted to estimate the amount of dollars and energy saved and jobs lost in a switch from cars and trucks to rail, based on the information in Table 9. It is a dangerous procedure to calculate the effects of a full shift to rail since such data might change dramatically as the shift occurred. For example, the reason for the difference in unit cost noted in Table 9 may be due in part to the fact that one type of service is actually different (e.g., faster, more flexible freight hauling) from its apparent competitor. Slower deliveries mean, for example, greater inventory and warehousing investment. Thus, dollar savings of the magnitude noted may not actually be realized in a shift from a faster--more energy consuming--to a slower--less energy consuming--mode. Nevertheless, we have calculated the effects of shifts in 1963 to demonstrate the complexities of the procedure.

Clearly, in the shift from either car or truck to rail there would have been a dollar savings. In order to avoid adverse multiplier effects on employment, these savings, which would accumulate in the hands of consumers, must be respent. We assume several scenarios for respending. First, we assume that consumers will respend their dollar savings through a proportional increase in average Personal Consumption Expenditures (PCE). This seems justified as any savings will be small on an individual basis, and will be well distributed over time. In 1963, PCE required 86,000 BTU per dollar and 10.9 jobs per 100,000 dollars.[13] A second manner in which savings might have been consumed was through taxation with government respending on specified programs.

In Table 10 we compare the results of car to rail and truck to rail transfers calculated from Table 9 and Table 1. This Table shows that when we make the car to rail passenger transfer, the dollar, energy and labor changes are: a 0.97 cents per passenger mile decrease, a 1020 BTU per passenger mile decrease, and an increase of 1.10 jobs per million passenger miles, respectively. When the dollar savings were absorbed as average Personal Consumption Expenditures (PCE), the energy and labor changes are: a 186 BTU per passenger mile decrease and an increase of 2.16 jobs per million passenger miles, respectively. If such a change can be proportionately extrapolated to all intercity auto traffic, nearly 0.92 billion gallons of gasoline annually are saved, and 1.3 million jobs created. If the dollar savings from a car to rail passenger transfer were absorbed as a tax and respent on Railroad and Mass Transit Construction (a Railroad Trust Fund), the resulting energy savings and labor increase are 4.0 billion gallons of gasoline (equivalent) and 1.2 million jobs, respectively. Such a linear extrapolation is not necessarily accurate, as the rail and auto establishments would change their structure radically from that of 1963 under such a shift. However, the direction of that change is clear and the change may even be underestimated here since rail travel could become increasingly energy efficient. The chief source of error in the above estimate is probably the fact that people would travel less as rail transportation is substituted for automobile transportation.

When the same concept is applied to truck-rail substitution, the unit change after respending (Table 10) shows a significant increase in employment and energy demand. Only if the dollar savings were absorbed as a tax and spent on programs such as National Health Insurance or Railroad and Mass Transit Construction could energy be saved and employment increased.

The linear extrapolation shows that if all highway auto passenger and truck freight had been shifted to rail and the dollar savings absorbed as a federal tax and spent on rail facilities construction, the annual energy savings and employment increase would have been about 7.4 billion gallons--2 percent of the U.S. total energy consumed--and 2.4 million jobs-- 3.4 percent of the work force in 1963--respectively.

CONCLUSION

If energy conservation were a goal of a federal budget policymaker, it could be achieved by switching Highway Trust Fund expenditures into any of several other federal alternative programs (except tax relief), especially Railroad and Mass Transit Construction (see Table 1). Total employment would increase in each alternative spending pattern examined. For example, shifting construction monies from highways to railroads reduces the energy demanded for construction by about 64 percent and increases employment by 3.2 percent. The resulting detailed occupational and fuel shifts are given in Tables 2 through 8.

From a study of the dollar, energy and employment requirements of the transportation system which moves by highway and by rail, we conclude the following:

1. Rail passenger transport was much less dollar and energy demanding and required more labor than car transport in 1963. If the dollar savings were respent in an average way by consumers, the net impact would have been to reduce the energy savings and further increase employment. A similar conclusion was reached in a study of bus substitution for autos in urban areas.[17] If the marginal substitution effects hold over the whole range of change, and the dollar savings were spent constructing railways, then about 0.9 billion gallons of gasoline could have been saved annually and 1.3 million new jobs created.
2. Rail freight transport was less dollar, energy and labor expensive compared with truck transport in 1963. If under a national shift to rail freight the dollar savings were absorbed as Personal Consumption Expenditures a net increase of labor and energy would have ensued. If the dollar savings were absorbed as a tax and respent on Railroad and Mass Transit Construction, about 3.4 billion gallons of gasoline (energy equivalent) would be conserved annually and new jobs created, under a complete shift to rail.

A full shift from intercity car and truck to rail with dollar savings spent on railway construction could have saved 7.4 billion gallons of gasoline (energy equivalent) and created 2.4 million new jobs in 1963.

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FOOTNOTES

1. For a description of the model see Roger H. Bezdek, The Systematic Forecasting of Manpower Requirements: Theory and Applications (in press).
2. See Robert A. Herendeen, "Use of Input-Output Analysis to Determine the Energy Cost of Goods and Services," CAC Document No. 69, University of Illinois at Urbana-Champaign, Urbana, Illinois, 4 March 1973; "Derivation of the 1963 and 1967 Total Employment Vectors for 362 I/O Sectors," CAC Document No. 63, University of Illinois at Urbana-Champaign, 30 July 1973: CAC 79
3. For a similar analysis of Army Corps of Engineers' projects see Bruce M. Hannon and Roger H. Bezdek, "The Job Impact of Alternatives to Corps of Engineers Projects", Journal of Professional Activities, Proceedings of the American Society of Civil Engineers, Vol. 99, No. PP4, October, 1973.
4. For a discussion of the development of the program vectors see Bezdek, op. cit., Chapter 4.
5. U. S. Department of Transportation, "1972 National Transportation Report," Appendix A (Washington, D. C.: Government Printing Office, July, 1972), p. 36.
6. U. S. Congress, House, House Document 124, 89th Congressional Session, 24 March 1965, 66; and U. S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads, "Allocation of Highway Cost Responsibility and Tax Payments, 1969," (Washington, D. C.: Government Printing Office, May, 1970), Table 25.
7. Association of American Railroads, "Yearbook of Railroad Facts, 1973," (Washington, D. C., 1973), p. 36.
8. Ibid.
9. Construction cost: Letter to Bruce Hannon from W. S. Mendenhall, Jr., acting chief, Construction and Maintenance Division, Office of Highways Operations, Federal Highway Administration, Department of Transportation, Washington, D. C., No. HHO-32, 31 August 1973. Maintenance Cost: U. S. Department of Transportation, Federal Highway Administration, "Highway Statistics, 1969," (Washington, D. C.: Government Printing Office, 1970), Tables SF-4A and M1; Roads under state jurisdiction only.

10. Construction Cost: American Association of Railroads, Economic and Finance Department, "Cost of Track," (Washington, D. C., 5 February 1969) prepared by Mr. Kenneth Hurdle; Maintenance Cost: Association of American Railroads, Op. Cit., "Yearbook," p. 16, 48.
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13. U. S. Department of Transportation, Office of Systems Analysis and Information, "Summary of National Transportation Statistics" (Washington, D. C.: Government Printing Office, November, 1972), p. 38.
14. "The Dollar, Energy and Employment Impacts of Air, Rail and Auto Passenger Transportation," ERG Report to Energy Policy Project, 1776 Mass. Avenue, N. W., Washington, D. C., in press, October 1973.
15. U. S. Department of Transportation, Op. Cit., "Summary of National Transportation Statistics", p. 37,44.
16. Automobile Manufacturers Association, "1970 Motor Truck Facts," and "1971 Auto Facts and Figures" (Detroit: Automobile Manufacturers Association) p. 48 and p. 67, respectively; and U. S. Department of Commerce, "Input-Output Structure of the U. S. Economy, 1963", Vol. I (Washington, D. C.: Government Printing Office, 1969), p. 195; and U. S. Department of Transportation, Op. Cit., "Summary of National Transportation Statistics," p. 46, and Robert A. Herendeen, Op. Cit.
17. "Urban Auto-Bus Substitution: The Dollar, Energy and Employment Impacts", ERG Report to Energy Policy Project, 1776 Mass. Avenue, N. W., Washington, D. C. In press, August, 1973.
18. Automobile Manufacturers Association, Op. Cit., "Motor Truck Facts," p. 48.

19. "Energy Intensiveness of Passenger & Freight Transport Modes, 1950-1970," Eric Hirst, Oak Ridge National Lab, Oak Ridge Tennesee, ORNL-NSF-EF-44, April 1973, p.5.

FEDERAL PROGRAM	BTU[b] per $(1963) of PROGRAM	TOTAL ENERGY-TRILLION BTU	% DECREASE[c]	JOBS PER HUNDRED THOUSAND $(1975) OF PROGRAM	TOTAL JOBS	% INCREASE[c]
HIGHWAY CONSTRUCTION	61,020	222.71	-----	8.1	256,180	-----
R.R. AND MASS TRANSIT CONSTRUCT.	22,000	80.30	+63.9	8.4	264,430	+ 3.2
WASTE TREATMENT PLANT CONSTRUCT.	54,000	197.03	+11.5	8.2	259,490	+ 1.3
EDUCATIONAL FACILITIES CONSTRUCT.	56,000	204.36	+ 8.2	8.5	268,980	+ 4.7
NATIONAL HEALTH INSURANCE	40,190	146.68	+34.2	13.4	423,220	+65.2
CRIM. JUSTICE & CIVILIAN SAFETY	51,080[a]	186.46	+16.3	12.4	393,520	+53.6
PERSONAL CONSUMPTION EXPENDITURES (Tax Relief)	86,000[a]	313.90	-40.9	8.7	275,120	+ 7.4

(a) Includes energy to provide offices and supplies for government workers.
(b) British Thermal Units.
(c) Percent changes are relative to highway construction program.
(d) 1975 dollars. This amount is equal to $3.65 Billion in 1963 and $3.165 Billion in 1958 dollars.
Calculated with the ERG Energy and Employment Policy Model, July, 1973.
No attempt was made to correct for the technological impact on energy use efficiency between 1963 and 1975. It is generally expected that 1975 technology will be more energy intensive.
(e) Includes Direct Energy purchases, trade and transportation margin's energy and labor demand.

Table 1. The Energy and Employment Impact (Direct and Indirect) of a $5 Billion[d] Investment in 7 Federal Programs

Table 2

Employment Shifts for Selected Occupations:
Highway Construction to Railroad and Mass Transit Construction

Positive Changes	Net Job Creation
1. Laborers, Except Farm and Mine	10,884
2. Carpenters	12,584
3. Painters and Paperhangers	5,959
4. Plumbers and Pipefitters	4,811
5. Electricians	3,403
6. Excavating, Grading Machine Operators	4,385
7. Brickmasons and Tilesetters	3,869
8. Civil Engineers	2,297
9. Sheet Metal Workers	903
10. Structural Metalworkers	1,136
Negative Changes	
1. Waiters and Waitresses	-1,128
2. Cashiers	-1,139
3. Drivers and Deliverymen	-2,382
4. Motor Vehicle Mechanics	-1,206
5. Janitors and Sextons	- 577
6. Office Machine Operators	- 785
7. Laundry, Dry Cleaning Operatives	- 133
8. Accountants and Auditors	-1,000
9. Machinists and Related Occupations	- 663
10. Shipping, Receiving Clerks	- 479

Table 3

Employment Shifts for Selected Occupations:

Highway Construction to Construction of Waste Treatment Facilities

Positive Changes	Net Job Creation
1. Carpenters	6,382
2. Laborers, Except Farm and Mine	6,864
3. Painters and Paperhangers	3,000
4. Plumbers and Pipefitters	2,490
5. Electricians	1,876
6. Brickmasons and Tilesetters	1,959
7. Civil Engineers	1,176
8. Miscellaneous Mechanics and Repairmen	355
9. Crane, Derrick, Hoist Men	532
10. Structural Metalworkers	571
Negative Changes	
1. Stenographers, Typists, Secretaries	-1,899
2. Cashiers	- 750
3. Motor Vehicle Mechanics	- 715
4. Deliverymen and Routemen	- 594
5. Class A Metalworking Assemblers	- 438
6. Janitors and Sextons	- 281
7. Office Machine Operators	- 436
8. Machinists and Related Occupations	- 493
9. Accountants and Auditors	- 522
10. Electrical Engineers	- 330

Table 4

Employment Shifts for Selected Occupations:

Highway Construction to Educational Facilities Construction

Positive Changes	Net Job Creation
1. Sewers and Stickers, Mfg.	122
2. Metalworking Assemblers	1,273
3. Laborers, Farm and Mine	2,060
4. Miscellaneous Service Workers	352
5. Cashiers	469
6. Machinists and Related Occupations	742
7. Machine Tool Operators	481
8. Metalworking Inspectors	440
9. Shipping and Receiving Clerks	370
10. Toolmakers and Diemakers	401
Negative Changes	
1. Drivers, Bus, Truck, Tractor	-1,749
2. Mine Operators and Laborers	-3,037
3. Accountants and Auditors	- 301
4. Excavating, Grading Machine Operators	-1,026
5. Carpenters	- 781
6. Painters and Paperhangers	- 507
7. Miscellaneous Craftsmen	- 146
8. Civil Engineers	- 306
9. Railroad Brakemen and Switchmen	- 137
10. Cement and Concrete Finishers	- 496

Table 5

Employment Shifts for Selected Occupations:

Highway Construction to National Health Insurance

Positive Changes	Net Job Creation
1. Attendants, Hospital and Other Institutional	21,796
2. Professional Nurses	16,810
3. Practical Nurses	8,825
4. Medical and Dental Technicians	7,741
5. Physicians and Surgeons	7,314
6. Miscellaneous Medical and Health Workers	4,332
7. Dentists	2,495
8. Janitors and Sextons	10,968
9. Optometrists	399
10. Stenographers, Typists Secretaries	18,906
Negative Changes	
1. Laborers, Except Farm and Mine	-12,635
2. Drivers and Deliverymen	- 7,519
3. Carpenters	- 9,406
4. Welders and Flame-Cutters	- 2,316
5. Painters and Paperhangers	- 4,357
6. Electricians	- 3,161
7. Plumbers and Pipefitters	- 3,742
8. Excavating, Grading Machine Operators	- 4,755
9. Cement, Concrete Finishers	- 1,449
10. Roofers and Slaters	- 897

Table 6

Employment Shifts for Selected Occupations:

Highway Construction to Criminal Justice and Civilian Safety

Positive Changes	Net Job Creation
1. Police and Other Law Enforcement Officials	45,971
2. Firemen	23,219
3. Stenographers, Typists, Secretaries	21,580
4. Sewers and Stickers, Mfg.	786
5. Guards, Watchmen, Doorkeepers	12,749
6. Hospital and Institutional Attendants	346
7. Miscellaneous Professional and Technical Workers	6,745
8. Office Machine Operators	3,092
9. Janitors and Sextons	2,233
10. Personnel and Labor Relations Workers	3,801
Negative Changes	
1. Drivers and Deliverymen	-6,432
2. Laborers, Except Farm and Mine	-4,356
3. Bookkeepers	-1,659
4. Carpenters	-4,940
5. Welders and Flame-Cutters	-1,680
6. Machinists and Related Occupations	- 773
7. Excavating, Grading Machine Operators	-2,302
8. Plumbers and Pipefitters	-1,788
9. Brickmasons and Tilesetters	-1,564
10. Metalworking Assemblers (Class A)	- 153

Table 7

Employment Shifts for Selected Occupations:

Highway Construction to Tax Relief

Positive Changes	Net Job Creation
1. Private Household Workers	12,495
2. Elementary and Secondary School Teachers	4,854
3. Hospital and Institutional Attendants	2,298
4. Sewers and Stickers, Manufacturing	3,423
5. College Teachers	948
6. Professional Nurses	1,766
7. Practical Nurses	1,028
8. Farmers and Farm Workers	8,849
9. Medical and Dental Technicians	799
10. Sales Workers	11,569
Negative Changes	
1. Laborers, Except Farm and Mine	-8,854
2. Drivers, Bus, Truck, Tractor	-6,389
3. Carpenters	-9,655
4. Miscellaneous Mechanics and Repairmen	-2,286
5. Painters and Paperhangers	-4,669
6. Electricians	-3,265
7. Plumbers and Pipefitters	-3,898
8. Welders and Flame-Cutters	-1,672
9. Excavating and Grading Machine Operators	-4,779
10. Civil Engineers	-2,140

Table 8

Direct & Indirect Energy Use by Type[(a)] for a $5 Billion (1975) Expenditure on 7 Alternative Federal Programs[(c)]

	Coal (Million Tons)	Refined Petroleum (Million Gallons of Gasoline Equivalent)	Electricity (Billion Kilowatt-Hrs.)	Natural Gas (Billion Cubic Feet)
Highway Construction	2.48	629	3.83	69.1
Mass Transit Construction	1.22	177	1.63	22.9
Waste Treatment Construction	3.36	374	3.23	57.5
Education Construction	2.99	460	4.06	62.1
National Health Insurance	1.47	444	4.39	47.0
Criminal Justice[(b)]	1.81	325	4.15	60.9
Personal Consumption[(d)]	2.48	1213	6.15	93.7

(a) Coal, 26 million BTU per ton; Gasoline, 125,000 BTU per gallon; Electricity, 3412 BTU per kilowatt-hour; Natural Gas, 1034 BTU per cubic foot.

(b) Includes energy to provide offices and supplies for government workers.

(c) No attempt was made to correct for the technological impact on energy use efficiency between 1963 and 1975. It is generally expected that 1975 technology will be more energy intensive.

(d) Includes direct energy purchases, trade and energy demand of the transport margins.

Table 9

A Comparison of the Estimated Dollar, Energy and Employment Costs[a] of the Main Transport Modes Using Highways or Railroads for 1963.

Mode	Cost or Revenue[b]	Total Energy Use[b]	Total Employment Demand[b]
Auto[c][e]	.0419	6800	4.48
Rail Passenger[e]	.0322	5780	5.58
Truck[d]	.0638	3920	2.95
Rail Freight[e]	.0131	1530	2.00

(a) Costs are: Dollars and energy: $ and BTU per passenger or ton mile; Employment, man-years per million passenger or ton miles. Employment does not include household or government industries.

(b) Does not include the energy or labor used by state police or roadside mowing and snow removal.

(c) Intercity autos assumed to be 15% more fuel efficient than average auto in 1963: 2.4 passengers per intercity auto: no cost for owner acting as chauffeur: (2,14). (Note that Hirst calculates this number at 22% in 1972 (19)). 5000 BTU per passenger mile for a subcompact auto getting 21.4 miles per gallon. Similar figures for the intercity bus in 1963 are: cost = .028 dollars; energy = 2450 BTU; employment = 3.70 jobs (15).

(d) (Class I common carrier, intercity (a); Contract carrier was 7.13¢.) (See note 13), energy and labor.[14]

(e) Approximate 1963 passenger load factors: car, 45%; train, 34%; plane, 53%. For details of all costs, (see note 14).

Table 10. Energy and Labor Consequences of Shifts from Car and Truck to Rail, 1963

(Positive Means Increase)

Transfer	Dollar[a] Savings Spent On ...	Resulting Unit Change in ...[b]			Change[c] Resulting From a Complete National Shift	
		Dollars	Energy	Labor	Energy	Labor
Car to Rail	PCE	0	- 186	+2.16	- 0.92	+1.34
	RRC	0	- 806	+1.91	- 4.00	+1.18[d]
Truck to Rail	PCE	0	+1970	+4.58	+ 5.30	+1.54
	RRC	0	-1275	+3.31	- 3.43	+1.20[d]

(a) PCE = Personal Consumption Expenditures; RRC = Railroad and Mass Transit Construction. Savings spent on rail construction is assumed to have no effect on rail price since construction cost of existing track is now fully amortized.

(b) Energy; BTU per passenger or ton mile; Employment: jobs per million passenger or ton miles.

(c) Energy: Billions of gallons of gasoline (energy equivalent); Labor: Millions of jobs. 645.2 billion auto-miles in 1963, assume 40% are intercity; 2.4 people per intercity auto (see note 14). 336.2 billion intercity ton miles by truck in 1963.[18] The complete shift is shown to demonstrate the nature of the process and is subject to error. See text.

(d) Lower bound. Derived from the estimated 1975 labor intensity; 1963 data not available. Note that PCE was 25% more labor intensive in 1963 than in 1975.

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15. Supplementary Notes

16. Abstracts

The direct and indirect dollar, energy, and employment costs of reinvesting the $5 billion (1975) Highway Trust Fund in six alternative federal programs are determined using a large linear computer model. These alternative programs are: Railroad and Mass Transit Construction, Educational Facilities Construction, Waste Treatment Plant Construction, the Law Enforcement Program, National Health Insurance Program, and Tax Relief Program.

Energy consumption would be reduced by shifting the Highway Trust Fund to all of these categories except the Tax Relief Program. Employment would be increased in all cases. Energy consumption impact by type of energy and employment impact by occupation are given.

The highway and railway transport systems are compared in detail, and an energy-conserving, employment-increasing tax is suggested.

17. Key Words and Document Analysis. 17a. Descriptors

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Railroads
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17b. Identifiers/Open-Ended Terms

Math Model

17c. COSATI Field/Group

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