Energy, Manpower, and the Highway Trust Fund

Energy consumption would be reduced by reinvesting the highway trust fund in five alternative federal programs.

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One of the most important policy controversies in governmental and environmental circles in the United States 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, and trucking and oil company executives believe that the fund provides for a highly flexible land transportation network which is vital to healthy growth of the United States economy and to national defense. These people emphasize that such expenditures also produce many jobs in the highway construction area.

In this article we present findings that may serve to clarify the debate centering on these issues. We compute the net impacts on energy consumption and manpower that are 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, water and waste treatment facilities 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 alternative uses of these federal funds in the near future. The six alternatives thus provide a range of choices for government policy makers. By detailing and contrasting the effects that each expenditure allocation would have on energy consumption and employment, we provide additional information that is vital for rational policy formulation.

Simulation of the Employment and Energy Impacts

To estimate the net impact on employment and energy consumption of reallocating the 1975 highway trust fund to other types of programs we used the energy-manpower policy simulation model prepared by the Center for Advanced Computation (CAC). This model (*1*, *2*) allows the user to simulate the effects of a wide range of social, economic, and technological policy alternatives on energy and employment. 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:

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

where **x** is a total output vector, **y** is a final demand vector, and $(\mathbf{I} - \mathbf{A})^{-1}$ 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**:

$$\mathbf{y} = \mathbf{P}\mathbf{q} \tag{2}$$

In Eq. 2, **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 our study described 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 matrix is premultiplied by a matrix of employment-output coefficients, θ:

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

where **Y** is a diagonal matrix of the final demand elements generated in Eq. 2 and **M** is an interindustry-employment matrix showing the total employment generated by and within each industry by a specified expenditure distribution. By means of a matrix showing the distribution, on a percentage basis, of industry employment among occupations, **B**, interindustry employment requirements are then disaggregated into demands for 185 categories of occupational manpower resources:

$$\mathbf{R}\mathbf{B} = \mathbf{S} \tag{4}$$

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

Energy requirements are generated in the following system of equations:

$$\mathbf{e} = [\mathbf{Q}(\mathbf{I} - \mathbf{A})^{-1} + \mathbf{T}]\mathbf{y} \tag{5}$$

where **Q** is a matrix of energy sales (in British thermal units) 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 $\bar{\varepsilon}$ and refer to it as the total energy matrix. Any element ε_{ij} of

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Table 1. The impact on energy consumption and employment of a $5 billion investment (1975 dollars) in seven federal programs. Five billion 1975 dollars are equal to $3.65 billion in 1963 and $3.165 billion in 1958. Data calculated from (*1, 3*). 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.

Federal program	Energy consumption			Employment demand		
	Requirement per 1963 dollar of program (Btu)	Total requirement (10^9 Btu)	Decrease* (%)	Jobs per $100,000 of program (1975)	Total No. of jobs	Increase* (%)
Highway construction	112,200†	409.53		8.1	256,180	
Railroad and mass transit construction	43,100	157.32	+ 61.6	8.4	264,430	+ 3.2
Water and waste treatment facilities construction	65,400	238.71	+ 41.7	8.2	259,490	+ 1.3
Educational facilities construction	70,600	257.69	+ 37.1	8.5	268,980	+ 4.7
National health insurance	40,400	147.46	+ 64.0	13.4	423,220	+ 65.2
Criminal justice and civilian safety	118,500	432.53	− 3.4	12.4	393,520	+ 53.6
Personal consumption expenditures (tax relief)	86,000‡	313.90	+ 23.4	8.7	275,120	+ 7.4

* Percent changes are relative to highway construction program. † As in all programs this number is for a technology of estimated efficiency. The actual energy intensity of all highway construction in 1963 was 98,000 Btu per dollar (*3, 4*). Similar construction (Army Corps of Engineers) varied from 92,000 to 146,000 Btu per dollar, the highest of all government programs. ‡ Includes direct energy purchases and the energy and labor required for trade and transportation margins.

this total energy matrix 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, 4*). The elements e_i of the vector **e** show the total required energy output (in 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 our 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 period following World War II. 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 amount of funds from highway construction to other uses.

To generate the direct output requirements of $5 billion of expenditures on each of the seven alternative programs 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

Table 2. Employment shifts for selected occupations: highway construction to railroad and mass transit construction.

Occupation	Net job creation
Positive changes	
1. Laborers, except farm and mine	10,884
2. Carpenters	12,584
3. Painters and paperhangers	5,959
4. Plumbers and pipe fitters	4,811
5. Electricians	3,403
6. Excavating, grading machine operators	4,385
7. Brickmasons and tile setters	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 water and waste treatment facilities.

Occupation	Net job creation
Positive changes	
1. Carpenters	6,382
2. Laborers, except farm and mine	6,864
3. Painters and paperhangers	3,000
4. Plumbers and pipe fitters	2,490
5. Electricians	1,876
6. Brickmasons and tile setters	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.

Occupation	Net job creation
Positive changes	
1. Sewers and stitchers, manufacturing	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	−1,206
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

were likely to be distributed as direct output requirements in the near future. Since the base year of the model is 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 allocated to a specific program was likely to be translated into direct and indirect occupational manpower requirements in the near future (*5*).

The alternative programs considered here can be interpreted in a straightforward manner (*6*). Four of them—highway construction, railroad and mass transit development, educational facilities construction, and water and waste treatment facilities 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 on the assumption that there would be 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 (*7*). In developing this last alternative we assumed that all of this tax rebate would be spent by the consumer and that it would be spent proportionately among detailed personal consumption goods and services (*8*).

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 alternative programs we had to utilize the energy components of the model developed for the 367 commercial and industrial sectors for 1963 (*9*). First we aggregated the energy matrix to match the 90 sectors of the activity-industry matrix. Then, using the distribution of the total inputs to each activity, we determined the energy intensity (Btu per dollar) of each specified alternative program 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 alternative program by multiplying the deflated expenditures on each program by 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.

Before discussing the empirical results of this study it is important that we 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 exhibit constant returns to scale. Our approach thus implies that output, energy, and manpower requirements will change proportionately with 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 this is a very strict assumption, but the incorporation of comprehensive nonlinear relationships into our model was not feasible. Finally, the employment concept used here has a short-term basis and does not include any employment effects which may arise indirectly from the expenditure shifts simulated. Thus, for example, while our analysis allows us to estimate the change in manpower requirements likely to result from transferring $5 billion from highway construction to mass transit development, we make no attempt to estimate here the net occupational effects which may come about as commuters begin to shift to mass transit from automobiles.

Empirical Results

The estimated impact of the highway trust fund and the six alternative programs on energy consumption and on employment are summarized in Table 1 (*10*). For every program, except criminal justice, that is considered as an alternative to highway construction, energy requirements would decrease. If the funds were spent on railroad and mass transit rather than on highway construction, the total primary energy demands would be about 62 percent lower, mainly because of significantly lower steel and concrete usage. But if the reduction in the highway trust fund were used to provide an expanded criminal justice program, then energy demands would increase nearly 3 percent relative to highway construction. This assumption of respending includes the direct purchases of energy, such as the use of gasoline in police cars. If the highway trust fund were spent for the construction of water and waste treatment facilities, energy requirements would be reduced by 42 percent; if it were spent for the construction of educational facilities, energy demands would decrease by 37 percent; while if it were reallocated to a national health insurance program or to a tax relief program (increased personal consumption), energy requirements would decrease by 64 percent and 23 percent, respectively.

Table 1 also shows that each of the alternative programs considered generate higher total labor requirements. The net job-creating advantage of some programs, such as railroad and mass transit development and water and waste treatment facilities construction, would probably be low (3 percent and 1 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, would probably be substantial. The results shown in 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 demanding 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, numbers of jobs, and levels of skill. The net positive and negative effects of each of the simulated alternative programs 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 alternative programs. The occupational changes in these tables were weighted by the total amount of U.S. employment in that occupation that was forecast for 1975, and ranked in descending order of impact for each alternative program.

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

Table 8 shows the direct and indirect energy demand that would be created by investing 5 billion 1975 dollars in each of the seven alternative federal programs. Criminal justice would provide the major demand for all types of energy, except refined petroleum, and electricity, for which highway construction and personal consumption would be the highest, respectively. Highway construction would be the largest consumer of refined petroleum, primarily through cement manufacturing. Water and sewer facilities, 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, because the energy would almost all be consumed indirectly by the many industrial and commercial sectors involved.

In the following section we examine a wide range of effects of the programs we have analyzed and, in particular, attempt to assess the long-range implications of the highway and railway construction programs as they relate to energy consumption and employment.

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, automobile traffic accidents claimed 21 times the number of lives per 100 million passenger miles as did railroad passenger traffic (*11*). Thus, it is difficult, if not impossible, for the public to make a "benefit-cost" comparison.

Some investigators argue that trucks are not paying their share of the construction and maintenance costs (*12*). 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. Automobiles paid nearly their share. By 1969, all combination trucks were paying about 76 percent of their incurred costs while the largest trucks (semitrailers plus full trailers) were paying only 56 percent of their allotted cost from interstate highway use. This estimate is probably high since it can be argued that extra highway lanes on interstate highways, for example, may be needed strictly because of truck usage. Railroads had major subsidies in the mid-1800's, but today they are highly regulated and

Table 5. Employment shifts for selected occupations: highway construction to national health insurance.

Occupation	Net job creation
Positive changes	
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 pipe fitters	− 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.

Occupation	Net job creation
Positive changes	
1. Police and other law enforcement officials	45,971
2. Firemen	23,219
3. Stenographers, typists, secretaries	21,580
4. Sewers and stitchers, manufacturing	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 pipe fitters	−1,788
9. Brickmasons and tile setters	−1,564
10. Metalworking assemblers (class A)	− 153

Table 7. Employment shifts for selected occupations: highway construction to tax relief.

Occupation	Net job creation
Positive changes	
1. Private household workers	12,495
2. Elementary and secondary school teachers	4,854
3. Hospital and institutional attendants	2,298
4. Sewers and stitchers, 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 pipe fitters	−3,898
8. Welders and flame-cutters	−1,672
9. Excavating and grading machine operators	−4,779
10. Civil engineers	−2,140

apparently receive fewer subsidies than other modes of transportation, so that there is a substantial diversification of railroad investment.

Although more freight is shipped by railroad than ever before, the railroad share of the total ton-miles of freight shipment is declining (*13*, p. 36). 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 now widely distributed production and consumption centers. The reason for this distribution may be the desire of the public for the automobile 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 (*13*).

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. For highways, $258,000 per mile was spent for construction and about $2100 per mile was spent annually for maintenance (*14*). For railroads, $103,200 per mile was spent for construction and $4440 per mile was spent annually for maintenance (*15*). 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 (*16*). Relative passenger load factors are given in Table 9.

A final point of comparison is circuity. The distance between two points may be greater for one mode of transport than another; circuity is the deviation from the corresponding great circle distance. Average railroad circuity is 1.24 compared to 1.21 for highways (*17*). No cost corrections for this small difference have been made.

Table 9 gives a comparison of the total number of dollars and total amount of energy and labor requirements per unit of service provided for the entire functioning of highways and railroads. All the costs (operating, maintenance, manufacturing, right-of-way construction, parking, for example) of railroad and automobile 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 amount of energy utilized by the car-railroad system. We found that the ratio of dollar, energy, and employment costs for the car-railroad system are 1.30, 1.18, and 0.80, respectively. The same comparisons for the truck-railroad system are 4.87, 2.35, and 1.40, respectively. In the case of passenger transport, transport by rail requires fewer dollars and less energy but more labor. These ratios would change in a complex manner if equivalent load factors were used. Energy consumption and labor intensity for passenger transport by railroad 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 difference in unit cost noted in Table 9 may be due in part to the fact that one type of service is actually different from its apparent competitor, for example, freight hauling by truck is faster and more flexible than freight hauling by train. Slower deliveries mean greater inventory and warehousing investment. Thus, dollar savings of the magnitude noted would not actually be realized in a shift from a faster, more energy-consuming mode to a slower, less en-

Table 8. The direct and indirect energy demand that would be created by investing 5 billion 1975 dollars in seven alternative federal programs. Data are given for the four basic types of energy: 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 (*10*). 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.

Federal program	Coal (10^6 tons)	Refined petroleum (10^6 gallons of gasoline equivalent)	Electricity (10^9 kw-hr)	Natural gas (10^9 cubic feet)
Highway construction	2.58	2157	4.31	81.0
Railroad and mass transit construction	1.64	362	3.35	64.5
Water and waste treatment facilities construction	3.41	680	3.45	63.0
Educational facilities construction	3.10	797	4.52	74.0
National health insurance	1.47	682	4.40	47.1
Criminal justice and civilian safety	3.42	1841	5.16	117.6
Personal consumption expenditures*	2.48	1213	6.15	93.7

* Includes direct energy purchases, and energy demand of the trade and transport margins.

Table 9. A comparison of the estimated dollar, energy, and employment costs of the main transport modes using highways or railroads for 1963.

Mode	Cost or revenue* (1963 dollars per passenger- or ton-mile)	Total energy use* (Btu per passenger- or ton-mile)	Total employment demand*† (man-years per 10^6 passenger- or ton-mile)
Automobile‡§	0.0419	6800	4.48
Rail passenger§	0.0322	5780	5.58
Truck‖	0.0638	3600	2.79
Rail freight§	0.0131	1530	2.00

* Does not include the energy or labor used by state police or roadside mowing and snow removal. † Does not include household or government industries. ‡ Intercity automobiles are assumed to be 15 percent more fuel efficient than average automobiles in 1963. Data are for 2.4 passengers per intercity automobile with no cost for owner acting as chauffeur (*3, 4, 21*) [note that Hirst calculates this fraction at 22 percent in 1972 (*22*)]. Tentative estimates for the intercity bus in 1963 are: cost, 0.028 dollar; energy, 2450 Btu; employment, 3.70 (*23*). § Approximate 1963 passenger load factors: car, 45 percent; train, 34 percent; plane, 53 percent. For details of all costs [see (*21*)]. ‖ Class I common carrier, intercity; contract carrier was 7.13 cents (*23*).

Table 10. The consequences, in terms of energy consumption and employment, of shifting from car and truck transportation to railroad transportation in 1963. Increases are shown by a plus sign, decreases by a minus sign.

Use of dollar savings*	Resulting unit change†			Change resulting from a nationwide shift‡	
	Dollars	Energy	Labor	Energy	Labor
	Transfer from car to railroad				
Personal consumption expenditures	0	− 186	+2.16	−0.92	−1.34
Railroad and mass transit construction	0	− 602	+1.91§	−2.98	+1.18§
	Transfer from truck to railroad				
Personal consumption expenditures	0	+2290	+4.73	+6.16	+1.59
Railroad and mass transit construction	0	+ 115	+3.48§	+0.30	+1.17§

* Savings spent on rail construction is assumed to have no effect on the price of railroad transportation because the construction cost of existing track is now fully amortized. † Energy: Btu per passenger- or ton-mile; employment: jobs per 10^6 passenger- or ton-miles. ‡ Energy; 10^9 gallons of gasoline (energy equivalent); labor: 10^6 jobs. Data are for 645.2 billion auto-miles in 1963, and we assume that 40 percent are intercity; data are for 2.4 people per intercity car [see (*19*)]; 336.2 billion intercity ton-miles by truck in 1963 (*23*). The complete shift is shown to demonstrate the nature of the process and is subject to error (see text). § This estimate is on the low side and is derived from the estimated 1975 labor intensity; 1963 data were not available. Note that personal consumption expenditure was 25 percent more labor intensive in 1963 than in 1975.

ergy-consuming mode. Nevertheless, we have calculated the effects of shifts in 1963 to demonstrate the complexities of the procedure (*18*).

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 because 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 (*19*, p. 38; *20*). A second manner in which savings might have been consumed was through taxation with government spending instead on the specified programs.

In Table 10 we compare the results of shifting transportation from car to railroad and truck to railroad, calculated from Table 9 and Table 1. Table 10 shows that when we transfer passengers from car to railroad, the changes in dollar and energy expenditures and in labor demand are: a 0.97 cent 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 are absorbed as average PCE's, 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 could be proportionately extrapolated to all intercity automobile traffic, nearly 0.92 billion gallons of gasoline (equivalent) annually would be saved, and 1.34 million jobs created. If the dollar savings from the transfer of passengers from car to railroad transportation were absorbed as a tax and spent on railroad and mass transit construction (a railroad trust fund?), the resulting energy savings and labor increase would be 2.98 billion gallons of gasoline and 1.2 million jobs, respectively. Such a linear extrapolation is not necessarily accurate, because the railroad and automobile 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 were substituted for automobile transportation.

When the same concept is applied to the substitution of railroad transportation for trucking, the unit change after respending on personal consumption (Table 10) shows a significant increase in employment and energy demand. If the dollar savings were absorbed as a tax and spent on programs such as national health insurance or railroad and mass transit construction, energy would not be saved but employment would be increased. Energy could be saved if the dollar savings were absorbed as a tax and spent on postal services, however.

The linear extrapolation shows that if all highway automobile passengers and truck freight had been shifted to railroads 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 2.7 billion gallons (about 1 percent of the total amount of energy consumed in the United States) 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 policy maker, such conservation could be achieved by reinvesting the highway trust fund in any of several other alternative federal programs (except criminal justice), especially in railroad and mass transit construction and national health insurance (see Table 1). Total employment would increase in each alternative program examined. For example, if construction monies were shifted from highways to railroads, the energy required for construction would be reduced by about 62 percent and employment would increase by 3.2 percent.

By comparing the dollar, energy, and employment requirements of a highway transportation system with such requirements for a railroad transportation system, we obtained detailed information from which we concluded the following:

1) Passenger transport by railroad was much less dollar and energy demanding and required more labor than car transport in 1963. If the dollar savings had been 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 automobiles in urban areas (*20*). If the marginal substitution effects would have held over the whole range of change, and the dollar savings had been spent on the construction of railways, then about 3.0 billion gallons of gasoline could have been saved annually and 1.2 million new jobs created.

2) Freight transport by railroad was less expensive, in terms of dollar, energy, and labor requirements, than was truck transportation in 1963. If, under a national shift to rail freight, the dollar savings had been absorbed

as personal consumption expenditures, a net increase of labor and energy would have ensued. If the dollar savings had been absorbed as a tax and respent on railroad and mass transit construction, about 0.3 billion more gallons of gasoline (energy equivalent) would have been consumed annually and 1.2 million jobs created, under a complete shift to rail.

Had there been a full shift from intercity car and truck transportation to transportation by railroad with dollar savings spent on railway construction, 2.7 billion gallons of gasoline (energy equivalent) could have been saved and 2.4 million new jobs could have been created in 1963.

References and Notes

1. For a description of the Center for Advanced Computation model see R. H. Bezdek, *Socioecon. Plann. Sci.* **7**, 511 (1973); B. M. Hannon, *Technol. Rev.* **76**, 24 (February 1974). Development of the data used in this study is described by R. H. Bezdek, in "Development of the activity vectors used" in *Energy and Manpower Effects of Alternate Uses of the Highway Trust Fund* (Center for Advanced Computation, Document No. 106, University of Illinois at Urbana-Champaign, Urbana, May 1973). See also Bezdek (*2*).
2. R. H. Bezdek, *The Long-Range Forecasting of Manpower Requirements: Theory and Applications*, in press.
3. R. A. Herendeen, *Use of Input-Output Analysis to Determine the Energy Cost of Goods and Services* (Center for Advanced Computation, Document No. 69, University of Illinois at Urbana-Champaign, Urbana, March 1973).
4. ———, *Proc. Annu. Meet. Am. Soc. Mech. Eng.* (1973), p. 5.
5. For a similar analysis of Army Corps of Engineers' projects see B. M. Hannon and R. H. Bezdek, *Eng. Iss.* **99**, 521 (1973).
6. We could also have considered various combinations of the programs totaling $5 billion; however, here our objective was to identify the impacts on energy and manpower of highway construction as opposed to each of six other programs.
7. For a discussion of the development of the program vectors see Bezdek (*2*, chap. 4).
8. A more comprehensive tax relief alternative would have required the consideration of different progressive and regressive tax rebate schemes, analysis of the impacts of reduced taxes on both consumption and investment and the impact of tax reduction on demand for detailed consumer goods and services and for the outputs of detailed input-output industries. This would have been a major research project in itself.
9. Because we used the 1963 energy input coefficients, we could not take into consideration pollution devices on automobiles which reduce gasoline mileage and other factors which have increased in importance since 1963.
10. Conversion factors are as follows: 1 Btu is equivalent to 1055 joules; 1 gallon is equivalent to 3.6 liters; 1 cubic foot is equivalent to 2.83×10^{-2} cubic meters.
11. U.S. Department of Transportation, *1972 National Transportation Report* (Government Printing Office, Washington, D.C., July 1972), appendix A, p. 36.
12. U.S. Congress, House, House Document 124, 89th Congressional Session, 24 March 1965, 66; U.S. Department of Transportation, Federal Highway Administration, Bureau of Public Roads, *Allocation of Highway Cost Responsibility and Tax Payments, 1969* (Government Printing Office, Washington, D.C., May 1970), table 25.
13. Association of American Railroads, *Yearbook of Railroad Facts, 1973* (Association of American Railroads, Washington, D.C., 1973).
14. Construction cost from W. S. Mendenhall, Jr., Office of Highways Operations, Federal Highway Administration, Department of Transportation, Washington, D.C., Record No. HHO-32, 31 August 1973. Maintenance cost obtained from U.S. Department of Transportation, Federal Highway Administration, *Highway Statistics, 1969* (Government Printing Office, Washington, D.C., 1970), tables SF-4A and M1; only roads under state jurisdiction were considered.
15. Construction cost obtained from K. Hurdle, *Cost of Track* (American Association of Railroads, Economic and Finance Department, Washington, D.C., February 1969). Maintenance cost obtained from Association of American Railroads (*13*, pp. 16, 48).
16. *Interstate Commerce Commission Transport Statistics* (Government Printing Office, Washington, D.C., 1969), pt. 1, pp. 19, 61, 62; [see also (*13*), pp. 20, 25].
17. D. E. Church, *Picadad—A System for Machine Processing of Geographic and Distance Factors in Transportation and Marketing Data* (U.S. Department of Commerce, Bureau of the Census, Transportation Division, Washington, D.C., August 1970).
18. As noted, the input-output model assumes constant returns to scale and does not take into account the increasing returns often found in rail services. This may understate the railroad's and rail transit's benefits.
19. U.S. Department of Transportation, Office of Systems Analysis and Information, *Summary of National Transportation Statistics* (Government Printing Office, Washington, D.C., November 1972).
20. Energy Research Group, *Urban Auto-Bus Substitution: The Dollar, Energy and Employment Impacts* (Report to Energy Policy Project, 1973, 1776 Massachusetts Avenue, NW, Washington, D.C., in press).
21. Energy Research Group, *The Dollar, Energy and Employment Impacts of Air, Rail and Auto Passenger Transportation* (Report to Energy Policy Project, 1973, 1776 Massachusetts Avenue, NW, Washington, D.C., in press).
22. E. Hirst, *Energy Intensiveness of Passenger and Freight Transport Modes, 1950–1970* (Oak Ridge National Laboratory, Report ORNL-NSF-EF-44, Oak Ridge, Tenn., April 1973), p. 5.
23. Automobile Manufacturers Association, *1970 Motor Truck Facts* (Automobile Manufacturers Association, Detroit, Mich., 1970), p. 48; ———, *1971 Auto Facts and Figures* (Automobile Manufacturers Association, Detroit, Mich., 1971), p. 67; U.S. Department of Commerce, *Input-Output Structure of the U.S. Economy, 1963* (Government Printing Office, Washington, D.C., 1969), vol. 1, p. 195; [see also, (*19*) p. 46, and Herendeen (*4*)].

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NEWS AND COMMENT

The Nixon Administration: End of a Long Campaign

With the Nixon resignation, the long agon of Watergate ended like a tragedy without a last act. In Washington there was no state occasion to mark the change of Presidents, only a pompless transfer of power and, in the city half abandoned in the August exodus, an atmosphere of relief and regret and a sense of another beginning.

As the transition proceeds, consideration for the new President seems to have muted critical stocktaking of the Nixon Administration, which, after all, substantially remains on the job—minus Nixon. In the case of science and technology, of course, the sectarian view is that science suffered in budget and status and was "down-graded" during the Nixon years. In retrospect, admittedly in circumstances that make it easier to see the trees than the forest, it looks rather as if Nixon as President was preoccupied in his first term with the initiatives in foreign affairs which were the triumphs of his Administration and in the second term with Watergate which destroyed it, and that for him science was at most an afterthought.

At least it is possible to say that Nixon science policy was consistent. When Richard M. Nixon took office he had made it clear that he felt research should contribute more directly to the solution of national problems, particularly to advancing the cause of national security and national prestige. In general, treatment of science hewed to this philosophy.

Grand technology seemed to have had a special fascination for Nixon. This was most evident in his enthusiasm for the Apollo program, particularly through the first landing on the moon in July 1969. He appeared to relish the company of astronauts, perhaps because they embodied the steadiness under pressure which Nixon has proclaimed as a personal ideal, and he even put in a call to Armstrong and Aldrin when they were on the moon's surface.

Nixon was a strong advocate of the supersonic transport (SST), emphasizing its implications for American technological leadership, and he persisted in this advocacy of the SST even after