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FINAL REPORT

THE ECONOMIC IMPACT OF NASA R & D SPENDING

EXECUTIVE SUMMARY

PREPARED FOR:

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

UNDER CONTRACT NO. NASW-2741

WASHINGTON, D. C.

PREPARED BY:

MICHAEL K. EVANS

CHASE ECONOMETRIC ASSOCIATES, INC.

BALA CYNWYD, PA.

APRIL, 1976

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Abstract

In this study Chase Econometrics, Inc., has undertaken an evaluation of the economic impact of NASA R & D programs. The crux of the methodology and hence the results revolve around the interrelationships existing between the demand and supply effects of increased R & D spending, in particular, NASA R & D spending. The demand effects are primarily short-run in nature and have consequences similar to that of other types of government spending. The supply effects, which represent the results of a higher rate of technological growth manifested through a larger total productive capacity, are long-run in nature and have consequences very dissimilar to that of general types of government spending.

The study is divided into two principal parts. In the first part, the INFORUM Inter-Industry Forecasting Model is used to measure the short-run economic impact of alternative levels of NASA expenditures for 1975. The principal results of this part of the study are that a shift toward higher NASA spending within the framework of a constant level of total Federal expenditures would increase output and employment and would probably reduce the inflationary pressures existing in the economy. Hence, Chase concludes that NASA spending is more stabilizing in a recovery period than general government spending.

In the second part of the study, an aggregate production function approach is used to develop the data series necessary to measure the impact of NASA R & D spending, and other determinants of technological progress, on the rate of growth in productivity of the U. S. economy. The principal finding of this part of the study is that the historical rate of return from NASA R & D spending is 43 percent.

In the final part of the study, the measured relationship between NASA R & D spending and technological progress is simulated in the Chase Macro-econometric Model to measure the immediate, intermediate, and long-run economic impact of increased NASA R & D spending over a sustained period. The principal findings of this part of the study are that a sustained increase in NASA spending of $1 billion (1958 dollars) for the 1975-1984 period would have the following effects:

1) Constant-dollar GNP would be $23 billion higher by 1984, a 2% increase over the "baseline," or no-additional-expenditure projections.

2) The rate of increase in the Consumer Price Index would be reduced to the extent that by 1984 it would be a full 2% lower than indicated in the baseline projection.

3) The unemployment rate would be reduced by 0.4% by 1984, and the size of the labor force would be increased through greater job opportunities so that the total number of jobs would increase by an additional 0.8 million.

4) By 1984 productivity in the private non-farm sector would be 2.0% higher than indicated in the baseline projection.

Other simulations, of $100 to $500 million increases, show proportional results.

The large beneficial economic effects of NASA R & D programs, particularly the unique combination of increased real GNP and a lower inflation rate, stem from the growth in general productivity resulting from NASA programs. Growth in productivity means that less labor (and/or capital) is needed per unit of output. This results in lower unit labor costs and hence lower prices. A slower rate of inflation leads in turn to a more rapid rise in real disposable income, which provides consumers with the additional purchasing power to buy the additional goods and services made possible by the expansion of the economy's production possibility frontier. Finally, the increase in real consumer expenditure leads to an increase in demand for the services of labor.

Introduction

Chase Econometric Associates, Inc. has undertaken an evaluation of the economic impact of NASA R & D spending on the U. S. economy. This study reports on both the short-run and long-run effects of changing levels of spending. Both the Chase Econometrics macro model and input-output model are used to calculate the impact of different spending levels on the overall economy and on specific industries in the short-run part of the study. The long-run part of the study includes an estimate of the relationship between NASA R & D spending and the rate of technological growth. This relationship is used to determine how much higher spending levels would raise aggregate supply and increase the total productive capacity of the economy. The demand effects stemming from an increase in spending are not substantially different from traditional multiplier analysis and are primarily short-run in nature. The supply effects do not begin to have a significant effect on aggregate economic activity until five years later, but the ultimate effects are much larger and very different than the effects of most forms of government spending.

Short-Run Impacts of NASA R & D Spending

Description of Approach

The first part of the study deals with the short-term economic impact of NASA expenditures and attempts to answer the question of whether a higher level of NASA expenditures is more beneficial to the U. S. economy than a lower level during the year that the expenditures are made, holding the level of total

Federal spending constant. This analysis is useful in examining the effects of altering the level of NASA expenditures as part of an overall economic stabilization policy.

The economic impact was calculated by preparing two forecasts of the U. S. economy for 1975 using alternative levels of NASA expenditures, which we term NASAHI and NASALO. The NASALO forecast assumed an expenditure by NASA of $1.35 billion in 1971 dollars for goods and services (excluding NASA employee wages) during calendar 1975. The NASAHI forecast assumed an expenditure of $2.35 billion by NASA with other Federal government spending reduced by $1 billion, hence leaving the total level of government spending unchanged. Because of this, the aggregate economic impact shown for this shift is quite small.

In order to measure the differential industry effect of the NASAHI and NASALO expenditure levels, we utilized the INFORUM Inter-Industry Forecasting Model. This model, which was developed by the Interindustry Forecasting Project of the University of Maryland, has been expanded and modified by Chase Econometrics and has been linked to the Chase Econometrics Macroeconomic Forecasting Model to provide consistent economic forecasts for the industries included in the model. Through use of this model, it is possible to forecast the impacts on major economic indicators such as inflation, employment, GNP, and productivity of a shift in the Federal budget to a higher level of NASA spending.

Short-Run Results

The effects of the two alternative forecasts on the aggregate economy, as estimated through use of INFORUM, are shown in Tables 1 and 2. While the results are not dramatic, they do indicate that the direction of change in economic activity from an increase in the level of NASA expenditure is positive

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TABLE 1

MACROECONOMIC IMPACT OF NASAHI AND NASALO EXPENDITURES

	NASALO 1975	NASAHI 1975
Gross National Product	1529.9	1530.1
Gross National Product (1958$)	820.7	820.7
Consumer Price Index (% change)	10.5	10.5
Disposable Personal Income	1084.9	1085.0
Federal Government Deficit	17.0	16.9

All figures are in billions of dollars except where indicated otherwise.

NASAHI = NASA expenditures during 1975 of $2.35 billion in 1971 dollars.

NASALO = NASA expenditures during 1975 of $1.35 billion in 1971 dollars.

TABLE 2

EMPLOYMENT BY INDUSTRIES AFFECTED BY A NASA SPENDING SHIFT

EMPLOYMENT BY SELECTED INDUSTRIES			HI (thousands)	LO	DIFF
Industry Number	Industry	SIC Code			
5	Missiles and Ordnance	19	154	142	+12
59	Machine Shop Products	359	191	190	+ 1
67	Communication Equip.	366	404	402	+ 2
71	Aircraft		501	488	+13
	Total				+28
22	Logging and Lumber	241, 242	307	308	- 1
25	Furniture	25	543	544	- 1
27	Paper and Products	26	501	502	- 1
30	Printing & Publishing	27	688	689	- 1
31	Industrial Chemicals		295	296	- 1
72	Shipbuilding	373	169	171	- 2
	Total				- 7
	Net gain in Manufacturing Employment (thousands of jobs)				+20

and beneficial. The magnitudes are small because the total Federal expenditure has not been altered and these improvements result solely from a shift within total Federal expenditures. Nonetheless, these results do indicate that NASA expenditures are less inflationary than other Federal government expenditures, and that a shift toward higher NASA spending with a constant Federal expenditure is not inflationary in the present economy. Conversely, it would follow that a shift away from NASA to other Federal programs could be relatively inflationary in the present economy. Further, the employment effect of NASA expenditures is beneficial, although not large for this small change, and thus both goals of higher employment and lower rates of inflation would be hindered by a lower level of NASA expenditure

Thus in this section of the study we show that a shift to NASA expenditures from other Federal government spending will stimulate the economy without raising prices. In particular, we found the following effects of a shift of $1 billion in 1971 dollars.

1) A higher level of NASA expenditures would not have had an inflationary impact on the U. S. economy during 1975 and would probably have reduced the inflation pressures in the economy.

2) A shift of $1.0 billion in 1971 dollars, or $1.4 billion in 1975 estimated prices, from other Federal non-defense expenditures to NASA expenditures would have reduced the inflationary pressures in several key basic materials industries.

3) A shift to increase NASA expenditures would have increased employment by 25,000 in the missile and ordnance and aircraft industries. While it would have reduced employment in ten other industries, the net increase in the manufacturing sector would have been 20,000 jobs.

4) Output would have been stimulated in twenty-one industries. The principal industries which would have been affected had considerable excess capacity in 1975 and were producing at levels well below their peak years and in most cases below the average of the past five years.

The general conclusion reached in this section is that a shift toward higher NASA spending within the framework of a constant level of total Federal expenditures creates jobs without raising the rate of inflation, and hence is more stabilizing in a recovery period than general government spending.

The Impact of NASA R & D on the Rate of Change of Technological Progress

Description of Approach

The second part of this study is an examination of the historical relationship between NASA R & D spending and the rate of technological progress. This examination requires two steps: (1) the construction of a time series to measure the rate of change of technological progress; and (2) an empirical investigation through regression analysis of the determinants of technological progress suggested by economic theory.

(1) Time Series for γ (gamma). The time series representing the rate of change in technological progress (γ) is a somewhat elusive measure, inasmuch as it requires developing a series for potential Gross National Product (GNP) as well as related series for labor and capital inputs. The series that was developed to measure γ is based on the methodology used by the Council of

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Economic Advisers. In addition, an alternative series for γ was developed, following the methodology of E. F. Denison, to test the sensitivity of the results to a change in the formulation of the γ series.

Our formulation of γ is as follows:

$$\gamma = \frac{\Delta X}{X} - \alpha \frac{\Delta L}{L} - (1 - \alpha) \frac{\Delta K}{K}$$

where X = full capacity or maximum potential output (national income or GNP) in constant prices

L = maximum available labor force

K = capital stock, defined as $K = \sum_{i=0}^{N} \lambda^i I_{t-1}$ where λ is the rate of economic depreciation and I is fixed nonresidential investment.

α = share of potential output

γ = the rate of technological progress (that is, the rate of increase in full capacity real GNP that cannot be accounted for by a change in either the size and composition of the labor force or the size and composition of the capital stock).

(2) Determinants of γ. Economic theory and prior econometric studies suggest the following possible determinants for γ: (a) R & D spending; (b) an industry mix variable; (c) an index of capacity utilization; (d) an index of labor quality reflecting changes in age mix, sex mix, health levels, and educational levels of the labor force; and (e) an index of economies of scale. After considerable experimentation, we found the latter two determinants to be insignificant for the time period examined. The exclusion of economies of scale as an explanatory variable for γ can be justified on theoretical grounds since this variable is generally relevant to only firm

or industry or underdeveloped nation studies. The statistical insignificance of the labor quality variable may be partly explained by the fact that some of its characteristics are already reflected by the manner in which we constructed the labor force variable used to generate γ. Undoubtedly, the insignificance of the labor quality variable is also partly due to our inability to reflect significant improvements (variability) in labor education and training over an observation period as short as 15 years.

Hence, based upon both theoretical considerations and empirical investigation, we offer the following conclusions regarding the determinants of γ. First, R & D spending should be included as a determinant and should be subdivided into two explanatory variables, namely, NASA R & D spending and other R & D spending. Secondly, we found that both R & D variables could be closely approximated by a distributed lag structure that follows the general shape of an inverted U-distribution; that is, as a result of an increase in R & D spending in year 0, modest increases in the productivity growth rate begin in year 2, peak in year 5, and terminate in year 8. The actual distributed lag weights, determined by the Almon method and used in the study, are given in Table 3. Thirdly, an industry mix variable should also be used in the equation that attempts to explain movements in γ. This specification is necessary to capture the impact on γ of shifts over time in resource allocation from high- to low-technology industries. Finally, the equation expalining γ should also include a capacity utilization variable to account for the fact that shortages and bottlenecks reduce productivity growth as the economy approaches full capacity.

TABLE 3

DISTRIBUTED LAG WEIGHTS FOR R & D SPENDING

Time Lag (Yrs.)	Proportional Weight
0	0.0
1	0.0
2	0.061
3	0.164
4	0.220
5	0.232
6	0.200
7	0.123
8 and later	0.0

The Measured Effect of R & D Spending on Productivity Growth

(1) The Regression Equation. The final regression equation which was used to explain γ in this study is as follows:

$$\gamma = -1.81 + \underset{(3.9)}{0.426} \sum_{i=0}^{7} A_i \, (NRD)_{-i} + \underset{(2.0)}{0.074} \sum_{i=0}^{7} A_i \, (ORD)_{-i} \frac{(1-Cp)}{(1-\overline{Cp})}$$

$$+ \underset{(4.5)}{0.031} \, (IM - \overline{IM}) - \underset{(3.1)}{0.157} \, (Cp - \overline{Cp})$$

$\bar{R}^2 = 0.883$
DW = 1.95
Sample Period 1960-1974

where: NRD = NASA R & D spending as a proportion of GNP

ORD = other R & D spending as a proportion of GNP

IM = industry mix variable, fraction

Cp = index of capacity utilization, percent

The numbers in parentheses below the regression coefficients represent t-statistics. As can be seen from the regression results, all coefficients are statistically significant and the overall fit of the equation to the data, as measured by the $\bar{R}^2$ value of 88.3 percent, is impressively high, especially for a first difference equation.

(2) The NASA Contribution to γ. Using the regression results above, we found that the increased levels of constant-dollar GNP stemming from a $1 billion increase in constant-dollar NASA R & D spending in 1975 are as given in Table 4. For purposes of this calculation we hold the baseline level of GNP constant and ignore all interactive and dynamic demand and supply multipliers. As will be explained later, the actual changes in GNP will be considerably larger once we do include the effect of these multipliers.

TABLE 4

INCREASE IN GNP PER UNIT INCREASE IN NASA R & D SPENDING
"PURE" PRODUCTIVITY EFFECTS ONLY

Year	Cumulative Change in GNP
1975	0
1976	0
1977	0
1978	0
1979	0.26
1980	0.96
1981	1.90
1982	2.88
1983	3.74
1984 and succeeding years	4.26

The rate of return on NASA spending may be found by substituting the results of Table 4 into the conventional rate of return formula. For a \$1 increase in spending, the appropriate expression would be

$$\frac{0.255}{(1+r)^5} + \frac{0.952}{(1+r)^6} + \frac{1.888}{(1+r)^7} + \frac{2.882}{(1+r)^8} + \frac{3.736}{(1+r)^9} + 4.261 \left[\frac{\left(\frac{1}{1+r}\right)^{10}}{1 - \frac{1}{1+r}} \right] = 1.00$$

where r is the rate of return. Solving this equation yields r = 43% to the nearest percent. If we re-solve the equation by substituting $\frac{4.26}{(1+r)^{10}}$ for the last term, thus not assuming an infinite life, we find the rate of return diminishes to 38%.

Thus an increase of \$1 billion in NASA R & D spending would increase productivity and total capacity of the U. S. economy by \$4.26 billion in 1984 and each succeeding year. It should be stressed that this figure stems from a \$1 billion increase in 1975 and then a return to previous spending levels. If spending were to remain \$1 billion higher indefinitely, the first-order supply effects, i.e., disregarding interactive and dynamic effects, are shown in Table 5. As indicated above, the actual results are significantly larger because of the demand and multiplier effects calculated by simulating the Chase macroeconomic model.

TABLE 5

CUMULATIVE EFFECT ON GNP OF A SUSTAINED INCREASE IN NASA R & D SPENDING "PURE" PRODUCTIVITY EFFECTS ONLY

1975														
1976														
1977														
1978														
1979	0.26												=	0.26
1980	0.96	+	0.26										=	1.22
1981	1.90	+	0.96	+	0.26								=	3.12
1982	2.88	+	1.90	+	0.96	+	0.26						=	6.00
1983	3.74	+	2.88	+	1.90	+	0.96	+	0.26				=	9.74
1984	4.26	+	3.74	+	2.88	+	1.90	+	0.96	+	0.26		=	14.00

Macroeconomic Impacts of NASA R & D-Induced Technological Progress

The third part of the study uses the relationship which has been developed between NASA R & D spending and the rate of technological progress to translate an increase in spending into a higher overall level of productivity for the U. S. economy. This section features a number of simulations with the Chase Econometrics macro model which determine the total effect of higher NASA R & D spending on the economy when interactive and dynamic effects are taken into account. These simulations consider the supply side of the economy as well as the demand side, and stress the fact that real GNP can be expanded by increasing productivity and lowering prices as well as by increasing government spending.

Approach to Determining Macroeconomic Effects

Up to this point we have considered only the static supply or "pure" productivity effects of NASA R & D spending. We now employ the Chase Econometrics macro model to determine the effects of an increase of $1 billion in constant prices (1958 dollars) in NASA R & D spending. We assume that such spending is increased by this amount at the beginning of 1975 and remains in force throughout the next decade. There are two types of effects from this increased spending.

The first type of effect is the ordinary expenditure (demand) impact of increased government spending. The second type of effect--this effect being what really differentiates NASA R & D from other types of government spending--is the longer run impact of NASA R & D-induced changes in the rate of technological progress. These changes lead to an expansion in the productive capacity of the economy and ultimately lead to an increase in society's standard of living.

(1) The Expenditure (Demand) Impact of NASA R & D. In a period of economic slackness, an increase in government spending leads to increased real GNP and lower unemployment. These expenditure effects for NASA R & D are not markedly different than those experienced for most increases in other types of government spending or for the release of funds to the private sector for construction. It should be noted, however, that NASA R & D expenditure increases have a larger impact per dollar than similar spending on welfare or low productivity type job programs.

(2) The Important Productivity Impacts of NASA R & D. The productivity impacts of NASA R & D generate social benefits in a somewhat more complex manner. We have already shown above (Table 5) the magnitude of increase which will occur in the productive capacity of the economy for an increase in NASA R & D spending. However, there is no automatic increase in demand which will occur just because total supply is now higher, and until this newly created capacity is utilized through higher demand no social benefits are realized.

There is an economic mechanism through which increased supply does create its own demand. Greater R & D spending leads to an increase in productivity, primarily in the manufacturing sector. As a result of this increase, less labor is needed per unit of output. This in turn lowers unit labor costs, which leads to lower prices. Yet this decrease is not immediately transferred into higher output and employment. As prices are lowered (or grow at a less rapid rate), real disposable income of consumers increases at a faster rate. Consumers can then purchase a larger market basket of goods and services, which in turn are now available because the production possibility frontier has moved outward. Yet these decisions are not instantaneous and frictionless, as they would be in an oversimplified static model. We do not see significant effects of increased technology on aggregate demand until 1980.

Results of Macroeconomic Simulations

Once the increase in productive capacity has worked itself into aggregate demand through the mechanisms discussed above, real growth is then fairly steady as can be seen from Table 6. In particular, we find that real GNP rises near $5 billion per year faster than would be the case under the

TABLE 6

CHANGE IN SELECTED VARIABLES WITH AN INCREASE IN NASA R & D SPENDING OF $1 BILLION

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Gross National Product, Billions of 1958 Dollars										
Base	788.1	834.0	869.6	859.8	868.5	922.4	977.7	1012.2	1059.6	1090.8
NASA	790.2	836.5	871.7	862.1	871.7	928.6	988.0	1035.0	1077.4	1114.1
Change	2.1	2.5	2.1	2.3	3.2	6.2	10.3	13.8	17.8	23.3
% Change	.3	.3	.2	.3	.4	.7	1.1	1.4	1.7	2.1
Consumer Price Index, 1967 = 100.0										
Base	161.1	173.9	188.4	204.9	219.4	232.0	244.2	257.0	270.9	286.5
NASA	161.0	173.8	188.4	204.7	219.0	231.0	242.2	254.0	266.9	280.7
Change	-0.1	-0.1	0.0	-0.2	-0.4	-1.0	-2.0	-3.0	-4.0	-5.8
% Change	0.0	0.0	0.0	-0.1	-0.2	-0.5	-0.8	-1.1	-1.5	-2.0
Rate of Inflation, %										
Base	9.1	7.9	8.3	8.7	7.1	5.8	5.2	5.2	5.4	5.8
NASA	9.1	7.9	8.3	8.6	7.0	5.5	4.9	4.9	5.0	5.3
Change	.0	.0	.0	-.1	-.1	-.3	-.3	-.3	-.4	-.5
Unemployment Rate, %										
Base	9.0	8.2	7.4	8.6	9.9	9.2	8.0	7.1	6.5	6.0
NASA	8.9	8.0	7.3	8.5	9.8	9.1	7.7	6.8	6.1	5.6
Change	-.1	-.2	-.1	-.1	-.1	-.1	-.3	-.3	-.4	-.4
Employees on Payrolls, Millions										
Base	76.9	79.9	82.8	83.3	83.2	85.3	88.1	90.5	92.5	94.3
NASA	77.0	80.0	82.9	83.4	83.3	85.5	88.4	90.9	93.1	95.1
Change	.1	.1	.1	.1	.1	.2	.3	.4	.6	.8
% Change	.1	.1	.1	.1	.1	.2	.3	.4	.6	.8
Index of Industrial Production, Manufacturing Sector, 1967 = 100.0										
Base	109.1	120.2	129.6	125.3	122.4	132.6	145.3	154.6	162.2	168.6
NASA	109.9	121.2	130.5	126.3	123.5	134.3	148.1	158.1	166.5	174.0
Change	.8	1.0	.9	1.0	1.1	1.7	2.8	3.5	4.3	5.4
% Change	.7	.8	.7	.8	.9	1.3	1.9	2.3	2.7	3.2
Index of Labor Productivity, 1967 = 100.0										
Base	110.2	112.1	113.3	112.5	115.2	120.1	123.9	126.9	129.9	132.0
NASA	110.3	112.2	113.4	112.7	115.5	120.8	125.1	128.6	132.0	134.7
Change	0.1	0.1	0.1	0.2	0.3	0.7	1.2	1.7	2.1	2.7
% Change	0.1	0.1	0.1	0.2	0.3	0.6	1.0	1.3	1.6	2.0
Change in Labor Productivity, %										
Base	-.4	1.7	1.1	-0.7	2.4	4.3	3.2	2.4	2.4	1.6
NASA	-.3	1.7	1.1	-0.6	2.7	4.6	3.6	2.7	2.7	2.0
Change	.1	.0	.0	0.1	.1	.3	.4	.3	.3	.4

Base = baseline projection with current estimates of NASA R & D spending for next decade.

NASA = an increase of $1 billion in 1958 dollars in NASA R & D spending.

Change = NASA - Base

% Change = $\frac{\text{NASA - Base}}{\text{Base}}$. Since the unemployment rate is already given in percentage terms, we do not calculate this item for unemployment.

baseline simulation which does not include increased NASA R & D spending. Thus constant-dollar GNP is $6 billion higher in 1980, $10 billion in 1981, $14 billion in 1982, $18 billion in 1983, and $23 billion higher in 1984. If we were to continue this simulation farther into the future, we would find that the gap between GNP in the two simulations would continue to increase at approximately $5 billion per year--$28 billion in 1985, $33 billion in 1986, and so on.

As greater productivity is translated into higher demand, we find that the economy can produce more goods and services with the same amount of labor. This has two beneficial effects. First, unit labor costs decline, hence lowering prices. Second, lower prices enable consumers to purchase more goods and services with their income, hence leading to further increases in output and employment.

We find that the consumer price index grows at a slower rate with higher NASA R & D spending than without, and is a full 2% lower by 1984 than would otherwise be the case. Once again, this change does not occur in the early years of the simulation, but begins to become important in 1980.

One of the major effects of the higher level of real GNP and aggregate demand is the reduction in the unemployment rate of 0.4% by 1984. Since the labor force will be approximately 100 million strong by that date, this indicates, as a first approximation, an increase of 400,000 jobs. However, if we take into account the increase in the size of the labor force, the total will rise to 0.8 million new jobs. The increase in the labor force will occur for three principal reasons. First, the derived demand for labor will be greater because the marginal productivity of labor has increased. Second, the supply of labor will rise because the real wage has increased. Third, and probably most important, the increase in aggreagte demand will reduce the amount of hidden unemployment as more entrants join the labor force.

It is also important to note that labor productivity rises substantially as a result of the increased NASA R & D spending. The index of labor productivity for the private nonfarm sector grows at a rate of 2.75% during the 1980-1984 period, compared to an average annual rise of 2.40% with no increase in spending. By 1984 the level of labor productivity is 2.0% higher than the baseline projection.

Further details and comparisons are given in Table 6 for a $1 billion increase in NASA R & D spending. We also calculated alternative runs for $0.5 and $0.1 billion and found that the results were approximately linear for other levels of spending change of equal or smaller magnitude. Similarly a decrease in NASA R & D spending of $1 billion would have reverse effects of the same magnitude on economic activity.

Significance and Reliability of Findings

Significance of Findings

One does not need an econometric model to show that an increase in government spending will raise GNP and lower unemployment. We learned many years ago that it is easy to spend our way out of a recession if no other constraints are involved. Yet having just recently come from the realm of double-digit inflation and the first postwar decline in labor productivity, it is clear that alternative policies must be examined not only from the point of view of their effect on demand and employment but on the real growth rate and the rate of inflation as well.

NASA R & D spending increases the rate of technological change and reduces the rate of inflation for two reasons. First, in the short run, it redistributes demand in the direction of the high-technology industries, thus improving aggregate producitivty in the economy. As a result, NASA R & D spending tends to be more stabilizing in a recovery period than general government spending.

Second, in the long run, it expands the production possibility frontier of the economy by increasing the rate of technological progress. This improves labor productivity further, which results in lower unit labor costs and hence lower prices. A slower rate of inflation leads in turn to a more rapid rise in real dispoable income permitting consumers to purchase the additional goods and services being produced and generating greater employment.

In assessing these results, we once again stress the importance of distinguishing between demand and supply effects. A $1 billion increase in NASA spending will have an immediate effect on real GNP, raising it approximately $2.1 billion the first year and $2.5 billion the second year. These demand multiplier effects are not markedly different than those which would have occurred for a similar increase in other purchases of goods and services by the government sector or for release of funds to the private sector for construction projects. They are, however, substantially higher than the effects which would be obtained from a $1 billion increase in transfer payments or low-productivity jobs programs. In particular we have found that the demand multiplier is smallest and the increase in inflation is largest for a unit change in transfer payments. When we turn to the supply side, however, the multiplier effects of lowering prices and increasing real income are more than twice as large. Other government spending programs which do not expand the production possibility frontier and improve productivity have no additional effect on the economy after the initial increase in demand.

Reliability of Findings

The results found for the equation estimating γ are all in agreement with economic theory, as the signs and magnitude of the coefficients are within the range expected from a priori expectations. Similarly, the statistical results indicate a high degree of correlation and no bias in the regression coefficients, or the goodness-of-fit statistics or the standard errors of estimate. In addition, the results are in accord with the findings of other econometric studies. Nevertheless, a number of criticisms have been raised about the final equation for γ, suggesting that the results might be significantly different if relatively minor changes were made to the function. These suggested changes focus on three areas; the choice of γ_C (the CEA series) instead of $\dot{\gamma}_D$ (the Denison series), the inclusion of the Cp term by itself and in conjunction with ORD, and the exclusion of the indexes of labor quality, particularly the level of education. To test the validity of these suggestions, we calculated sixty regression equations, including a "least favorable" case which incorporated all of the above changes. The sample period fits are somewhat worse, indicating that γ_D contains a larger random component than γ_C, but the coefficient of the term for NASA R & D spending is similar for these regressions. Even the "least favorable" case does not change the general conclusions of the study concerning either the rate of return or the economic impact of changes in NASA R & D spending.