Public Investment and Economic Growth

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In the years following World War II, the papers of any major city . . . told daily of the shortages and shortcomings in the elementary municipal and metropolitan services. The schools were old and overcrowded. The police force was under strength and underpaid. The parks and playgrounds were insufficient. Streets and empty lots were filthy, and the sanitation staff was underequipped and in need of men. . . . Internal transportation was overcrowded, unhealthful, and dirty. . . . The discussion of this public poverty competed, on the whole successfully, with stories of ever-increasing opulence in privately produced goods.

J. K. Galbraith (1958), p. 253

After a lively debate in the late 1950s and early 1960s about the merits of John Kenneth Galbraith's theory of social balance (*The Affluent Society*), the economics profession dismissed (or forgot) Galbraith's admonitions about the perils of neglecting the public infrastructure. David Aschauer, however, rekindled a great deal of interest in the efficiency of public capital spending by showing that additional spending by governments for nondefense capital goods apparently had a very large positive effect on private productivity and, hence, output.

Although economists were not surprised that public infrastructure spending could promote private output growth, the magnitude of the effect found by Aschauer was startling to most. Aschauer estimated that additional public capital spending would increase the output of private firms by more than 1 1/2 times as much as would an equivalent dollar increase in the firms' own capital stock.

A Congressional Budget Office (CBO) study of the effects of public infrastructure spending concluded that Aschauer's results merited some skepticism because "the statistical results are not robust [and] there is a lack of corroborating evidence" (CBO 1991, p. 25). The CBO observed that other empirical

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research, including cost-benefit studies, found private output to be more responsive to investments in private capital than to investments in public capital. There were a number of other studies in response to Aschauer.[1] Some of the studies found the effects of public investment on economic growth to be smaller than Aschauer found them to be.

Alicia Munnell, formerly of the Federal Reserve Bank of Boston, tried a different statistical approach to measuring the productivity of government spending. Although Munnell (1990), like Aschauer, used a production function approach to evaluate the effects of government infrastructure spending, she approached the problem by estimating her production functions from cross-sectional state-by-state data.

Munnell (1990) used estimates of gross state product and of private inputs of capital to develop estimates of public capital stocks for 48 states over the 1970–86 time period. She then used the state-by-state data to estimate the production functions, concluding that "the evidence seems overwhelming that public capital has a positive impact on private output, investment, and employment" (p. 94).

Munnell's (1990) estimates of the relative effects of public investment were smaller than those made by Aschauer. Hulten (1990), commenting on Munnell, observed that her findings of smaller relative effects were consistent with other studies that analyzed state data but that her findings differed sharply from the results of studies that were based upon time series.

The CBO (1991), in summarizing the results of cost-benefit studies, noted that there has been little support for the view that across-the-board increases in public capital programs have remarkable effects on economic output. Rather, they concluded that "cost-benefit analysis paints a fairly consistent picture of high returns to maintaining the existing stock of physical infrastructure and to expanding capacity in congested urban highways and runway traffic and air traffic control at major airports" (p. 40).

Indeed, it seems clear that a sensible approach to spending for government infrastructure would not include across-the-board increases in government investment spending as a means of stimulating economic growth. Rather, any project should stand on its own merits and be able to withstand a cost-benefit analysis. Given this caveat, however, there is interest in what sorts of public investment spending would tend to have the most impact on economic growth. If the most important sectors can be isolated, project proposals within those categories can be given priority in setting governmental budgetary goals.

The types of government infrastructure spending evaluated by Aschauer and Munnell and commented upon by the Congressional Budget Office fall

[1] The many evaluations of Aschauer's results include Aaron (1990), Hulten (May 1990), Hulten and Schwab (1991), Jorgenson (1991), Rubin (1991), and Tatom (1991).

into the category of physical capital investment, but government also invests in its people. This latter type of investment produces human capital if it improves the job skills (potential and actual productivity) of its citizens.

This article examines the effects on economic growth of government investment in both physical (nonhuman) and human capital, paying particular attention to the relative social returns of investments in human capital. As noted earlier, Aschauer, Munnell, and others use the aggregate production function approach to evaluating the effects of government spending. While such a method works well for evaluating the effects of government spending for physical capital, it is not clear that it is equally appropriate for human capital.

Investments in human capital may affect aggregate production possibilities in ways that are far more complicated than investments in physical capital. In the case of physical capital, it seems reasonable to assume that the government stock of physical capital enters an aggregate production function in a manner that is symmetric to, or at least quite similar to, private capital. It is far more difficult to isolate, a priori, the role played by government spending for human capital in an aggregate production function.

Fortunately, other statistical techniques are available to evaluate the effects of government spending on economic growth (see Cullison [1993]). The methodologies used for this article are Granger-causality tests and simulations from a vector autoregressive (VAR) model. These techniques also have the advantage of requiring data only on investment flows rather than on stocks of capital. The data on investment flows are readily available in disaggregated form, thus facilitating the article's research plan of evaluating the effects of government spending by functional component.

The Granger-causality tests are used to determine what types of government investment spending are correlated with economic growth. The VAR model is a modified version of the model that Ireland and Otrok (1992) used to test the effects on economic growth of reducing the federal debt by cutting defense spending 20 percent over six years. The attractive feature of the VAR model is that it is atheoretical, imposing no structure on the data. As a result, it is not necessary to know exactly how government-provided human capital enters into the aggregate production function.

1. DATA ON GOVERNMENT SPENDING BY FUNCTION

The Department of Commerce publishes annual data on total government expenditures by function. The functions include the following: (1) expenditures for central executive, legislative, and judicial activities; (2) international affairs; (3) space; (4) national defense; (5) civilian safety; (6) education; (7) health and hospitals; (8) income support, social security, and welfare; (9) veterans benefits and services; (10) housing and community activities; (11) recreational and cultural activities; (12) energy; (13) agriculture; (14) natural resources; (15)

transportation; (16) postal service; (17) economic development, regulation, and services; (18) labor training and services; (19) commercial activities; (20) net interest paid; and (21) other.

When government investment is defined broadly, including both human and nonhuman capital, some items in most of the 21 categories denoted above probably would be classified as investment. Examples discussed below include government expenditures for space, national defense, civilian safety, education, health and hospitals, income support, veterans benefits, housing, agriculture, transportation, economic development, labor training, and commercial activities.

Government spending for space and national defense are likely to result in innovations useful for private production. In addition, much spending for space and national defense is contracted from private business. Government spending for civilian safety (police protection) provides an environment in which the private economy can operate efficiently. Government spending for education enhances human capital directly. One must at least be able to read, write, and cipher to hold even menial jobs in the current job market. Higher education is necessary to hold better jobs.

Government spending for health and hospitals also enhances human capital by curing maladies and injuries that can impair the productivity of individuals in the labor force. Income support programs such as aid to families can help to keep families together so that the children can become productive members of the labor force. Veterans benefits can help veterans reenter society as productive members by improving their physical and mental abilities. Housing expenditures, by providing housing for those who otherwise might not be able to afford it, can also enhance human capital by providing better-quality workers as well as providing the homeless an entry into the labor force (by providing them with an address).

Government spending for agriculture has for decades provided for basic agricultural research through the land grant college system and other arms of the Department of Agriculture. The fruits of such research are distributed throughout the country by the county agricultural extension system. Government spending for transportation enhances the productivity of the private economy by providing roads and other methods of getting products from producers to purchasers. Economic development programs can bring modern technology to less developed areas of the United States, thus putting formerly underutilized resources to work. Labor training programs can enhance human capital by improving the job skills of recipients of the program. Government commercial activities increase GDP in and of themselves and provide job experience to the work force.

Given that there are so many conceivable ways in which government spending can affect the private economy, this article will start by evaluating all 21 categories mentioned above to determine which actually had empirically observable effects. Intuitively, it would seem that education, space, national defense, civilian safety, transportation, agriculture and labor training would have the more pronounced effects on the growth of the private economy. As a preliminary procedure, a simplified version of the so-called Granger-causality test is used to determine those categories of government spending that seem most likely to have promoted economic growth.

2. GRANGER-CAUSALITY TESTS

A Granger-causality test examines whether the variable to be tested adds explanatory power to an existing relationship between one (or more) other variable(s) and its (their) lags. For example, if Z_t is a dependent variable and Z_{t-1} is the variable lagged one period, then $Z_t = f(Z_{t-1}, v_t)$ would represent a statistical relation between the two, when v_t is some unknown source of variation in the functional relation between them. For the Granger test, a known variable would be put into the functional relation of Z_t and Z_{t-1} with various lags and leads to determine whether it helped to reduce v_t.

The Granger-causality tests and the VAR simulations reported in this article are consistent in using only one lagged value of the relevant variables. The tests are restricted to one lagged value because the short span of the available annual data necessitates economizing on degrees of freedom—the shortage of degrees of freedom being especially acute for the VAR analysis.

Table 1 shows the results of a Granger-causality test run on each of the various classes of government expenditures. The equation used for the test is

$$\Delta \ln(Y_t) = a + b_1 \cdot \Delta \ln(Y_{t-1}) + b_2 \cdot \Delta \ln(X_{t-1}), \qquad (1)$$

where Y is private gross domestic product, X is the government spending variable to be tested, and a, b_1, and b_2 are parameters to be estimated.[2] The notations "Δ" and "ln" represent, respectively, one-year first differences and natural logarithms, and the "t" subscripts are time indexes (in years). All variables are calculated in real (1987) dollars.

As the table shows, when X = ALL GOVERNMENT (total government spending), the t-statistic for the coefficient b_2 is 0.24, which is not statistically significant. However, education spending and spending for labor training, both of which enhance human capital, are statistically significant at the 5 percent level. Spending for income support, agriculture, civilian safety and net interest (negatively signed) are significant at the 15 percent level.[3]

[2] All estimations in this article use ordinary least squares (OLS).

[3] Transportation spending was not statistically significant, according to the Granger-causality tests. This result was somewhat surprising because the Finn analysis in this issue of the *Economic Quarterly* found highway capital to have a significant, if imprecise, effect on productivity. Finn's analysis, however, deals with the *stock* of highway capital, while this article deals with the *flow* of

Table 1 Granger-Causality Test Results, Government Purchases, 1955 to 1992

Equation: $\Delta \ln(Y_t) = a + b_1 \cdot \Delta \ln(Y_{t-1}) + b_2 \cdot \Delta \ln(X_{t-1})$,

where

Y = private gross domestic product in 1987 dollars,

X = government spending variable, measured in 1987 dollars, and

Δ = an operator designating the year-to-year first difference.

X Equals	b_2	"t" Value	Corrected R^2
ALL GOVERNMENT	0.037	0.24	0.00
AGRICULTURE	0.03	1.87	0.05
CIVILIAN SAFETY	0.295	1.64	0.03
COMMERCIAL ACTIVITY	0.002	1.25	0.00
ECON. DEVELOPMENT	0.028	0.85	0.00
EDUCATION	0.269	2.33†	0.10
ENERGY	−0.011	−0.35	0.00
EXECUTIVE, LEGISLATIVE & JUDICIAL	0.03	0.26	0.00
HEALTH & HOSPITAL	−0.05	−0.54	0.00
HOUSING	0.007	0.179	0.00
INCOME SUPPORT	0.151	1.71	0.04
INTERNATIONAL AFFAIRS	0.004	0.10	0.00
LABOR TRAINING	0.080	2.74†	0.14
NATIONAL DEFENSE	−0.039	−0.60	0.00
NATURAL RESOURCES	0.018	0.36	0.00
NET INTEREST PAID	−0.12	−1.69	0.04
POSTAL SERVICE	0.003	0.28	0.00
RECREATION & CULTURE	−0.007	−0.121	0.00
SPACE*	0.020	1.12	0.06
TRANSPORTATION	0.080	0.745	0.00
VETERANS' BENEFITS	0.094	0.95	0.00
OTHER	0.082	1.28	0.00

* The effects of space spending are estimated over the 1961–92 period because space spending was zero in 1955–60.
† Statistically significant at the 5 percent level.

government transportation spending. The Finn article also uses quite different statistical methodology. In addition, the transportation spending category used in this article includes expenditures for air, rail, water, and transit as well as highways. In deference to Finn's results, however, transportation spending was also examined with the VAR model, explained below. While the F-statistic for transportation with one lag indicated that transportation had a significant effect on real private GDP, the 95 percent confidence interval for the impulse-response function was practically symmetrical around zero, indicating no clear direction of the resulting change in the level of real private GDP.

Surprisingly, neither government spending for national defense nor space spending had statistically significant effects on the growth of the real private economy. In the case of space, the results may have been influenced by the shorter span of available data (1961–92).[4]

The results of the tests shown in Table 1 lead to the conclusion that the types of government spending most likely to have a statistically significant effect on economic growth are education and labor training. Thus, the analysis implies that the most efficient way to increase economic growth by increasing government spending would be to channel expenditures to well-thought-out education or labor training projects without ignoring projects in agriculture, civilian safety, and income support and policies designed to reduce government interest payments. The analysis, however, gives little information about the relative effectiveness of the different types of government spending. For that, it is necessary to move to the simulations from the VAR model mentioned earlier.

3. SIMULATIONS FROM A VAR MODEL

The Ireland-Otrok VAR model can be modified to test the effects of various types of government spending on economic growth. Since the analysis in Section 2, above, provides evidence that government expenditures for education and labor training have statistically significant impacts on private economic growth, the analysis that follows will examine those variables. In addition and for completeness, the economic effects of spending on agriculture, civilian safety, and income support will also be considered.[5]

The following VAR model is estimated over the 1953–91 time period.

$$X_t = \sum_{s=1}^{k} B_s \cdot X_{t-s} + u_t, \qquad (2)$$

where

$$X_t = [RDEF_t, GSF_t, RDEBT_t, \mathrm{M2}_t, Y_t]. \qquad (3)$$

RDEF is the growth rate of real defense spending, *RDEBT* is the growth rate of real government debt, *GSF* is defined as the growth rates of the various types of real government spending, *Y* is the growth rate of real private gross domestic product, and M2 is the growth rate of money.

[4] When space spending is combined with other government spending data and the resulting sums are evaluated for Granger-causality, the addition of space spending usually improves the statistical results. That cannot be said of defense spending, the addition of which usually lowers the statistical significance of the resulting aggregate.

[5] Since the Ireland-Otrok model includes a federal debt variable, net interest paid will not be evaluated separately.

Empirical Results from the Model

Table 2 reports some results of estimating the system of equations with one-, two-, and three-year lags. F-statistics were computed to evaluate the effects on real private GDP growth of spending on education, labor training, agriculture, income support, and civilian safety with one-, two-, and three-year lags. The table shows agriculture not to have been a statistically significant factor at any of the three lag lengths. The other four types of spending showed statistical significance at 5.5 percent or less. For the subsequent analysis/forecasts from the VAR, the lag length $k = 1$ was chosen to conserve degrees of freedom.

The estimates for the parameters of the model with one lag were used to develop impulse-response functions outlining the effects on real economic growth of cuts in defense spending and the federal debt and increases in the government spending categories noted above. The cuts in defense spending and

Table 2 F-Statistics for Government Spending and Real Private GDP, 1952 to 1991

Lags	Variable	F-Statistics for Combined Lags	Significance Levels	Degrees of Freedom
	(F-statistics calculated as a part of VAR system)			
1	EDUCATION	20.86	0.00007*	32
1	LABOR TRAINING	12.69	0.001*	32
1	AGRICULTURE	0.26	0.613	32
1	CIVILIAN SAFETY	3.98	0.055*	32
1	INCOME SUPPORT	6.61	0.015*	32
1	ED + L TRAIN + C SAF	27.00	0.00001*	32
2	EDUCATION	7.76	0.002*	26
2	LABOR TRAINING	2.46	0.105	26
2	AGRICULTURE	0.94	0.404	26
2	CIVILIAN SAFETY	0.42	0.661	26
2	INCOME SUPPORT	1.69	0.205	26
2	ED + L TRAIN + C SAF	7.88	0.002*	26
3	EDUCATION	7.07	0.002*	20
3	LABOR TRAINING	1.43	0.263	20
3	AGRICULTURE	0.85	0.484	20
3	CIVILIAN SAFETY	0.21	0.891	20
3	INCOME SUPPORT	2.12	0.130	20
3	ED + L TRAIN + C SAF	6.76	0.002*	20

* Six percent or smaller probability that the variable's effect on GDP growth was due to chance.

Note: All variables are in 1987 dollars and measured as changes in natural logarithms.

the federal debt are reported because the next step in the analysis will be to perform a policy experiment similar to that done in the Ireland-Otrok study (1992) in which both defense spending and the debt were reduced.[6]

Figures 1-A through 1-G depict impulse-response functions that show what might happen to the level of real private GDP if there were a one-time one-standard-deviation shock to the growth rate of a particular type of government spending. It is customary in the literature for the researcher to apply a shock of the magnitude of one standard deviation of the variation in the series to be tested. Limiting the shock to one standard deviation ensures that it will be within the purview of the data from which the model is estimated.

Figure 1-A shows the effect of a one-time $7.95 billion (one standard deviation of the growth rate) cut in defense spending, while Figure 1-B shows the effect of a one-time $26.8 billion (one standard deviation of the growth rate) reduction in the federal debt. The dotted lines represent 95 percent confidence limits for the impulse-response predictions. Since the areas between the dotted lines in each figure include 0.0, the results do not conclusively show even the direction of the effect on real private GDP of cutting defense or the debt.

Figures 1-C through 1-G show the responses of real private GDP to one-standard-deviation shocks to spending for agriculture, civilian safety, education, labor training, and income support. As might be expected, the magnitudes of the one-standard-deviation shocks vary considerably. One standard deviation for education spending, for example, is $3.1 billion in 1987 dollars, while one standard deviation for labor training is only $0.6 billion. The magnitudes of the standard deviations of the various series are reported in Table 3.

As the impulse-response figures show, shocks to spending for education and labor training might be expected to result in a cumulative increase in the level of real private GDP, an expectation predicted with 95 percent confidence. The impulse-response analysis for income support payments, on the other hand, not only showed the 95 percent confidence band to be practically symmetrical around zero, but the prediction itself to be for no change in the level of real GDP. Income support payments, therefore, were dropped from consideration as possible sources of economic growth, while education and labor training expenditures were considered likely sources worthy of further examination.

A Policy Experiment with the Model

In 1991, the Bush Administration presented a proposal entitled “The Future Years Defense Program” (popularly known as the “1991 plan”) that called for a 20 percent reduction in real defense spending between 1992 and 1997. Ireland

[6] For the purpose of generating the impulse-response functions, the ordering of the variables assumes that policy decisions that change defense spending and the distribution of its proceeds are made before contemporaneous values of money and output are observed.

Figure 1 Response of Growth Rate of Private GDP

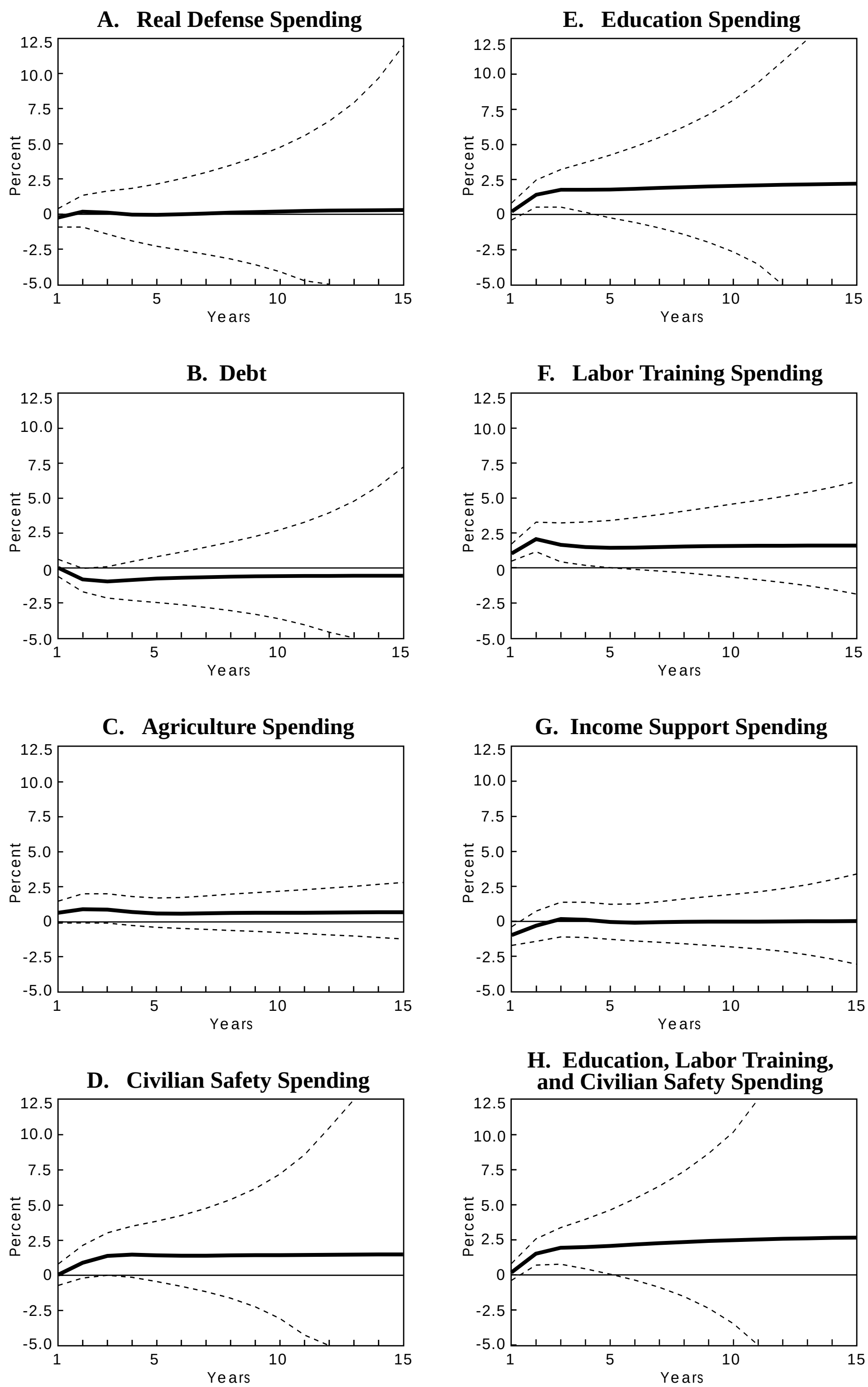


Table 3 Standard Deviations of the Growth Rates of Selected Data Series, 1952 to 1991

Data Series	Standard Deviation
(converted into billions of 1987 dollars)	
Agriculture	$ 2.8
Civilian Safety	0.6
Education	3.1
Federal Debt	26.7
Income Support	9.5
Labor Training	0.6
National Defense	8.0

and Otrok (1992) evaluated the 1991 plan with their VAR model. They found, using data from 1931 to 1991, that implementation of the 1991 plan with the proceeds going to federal debt reduction would be likely to reduce private GNP in the short run but increase it slightly after 13 or more years.

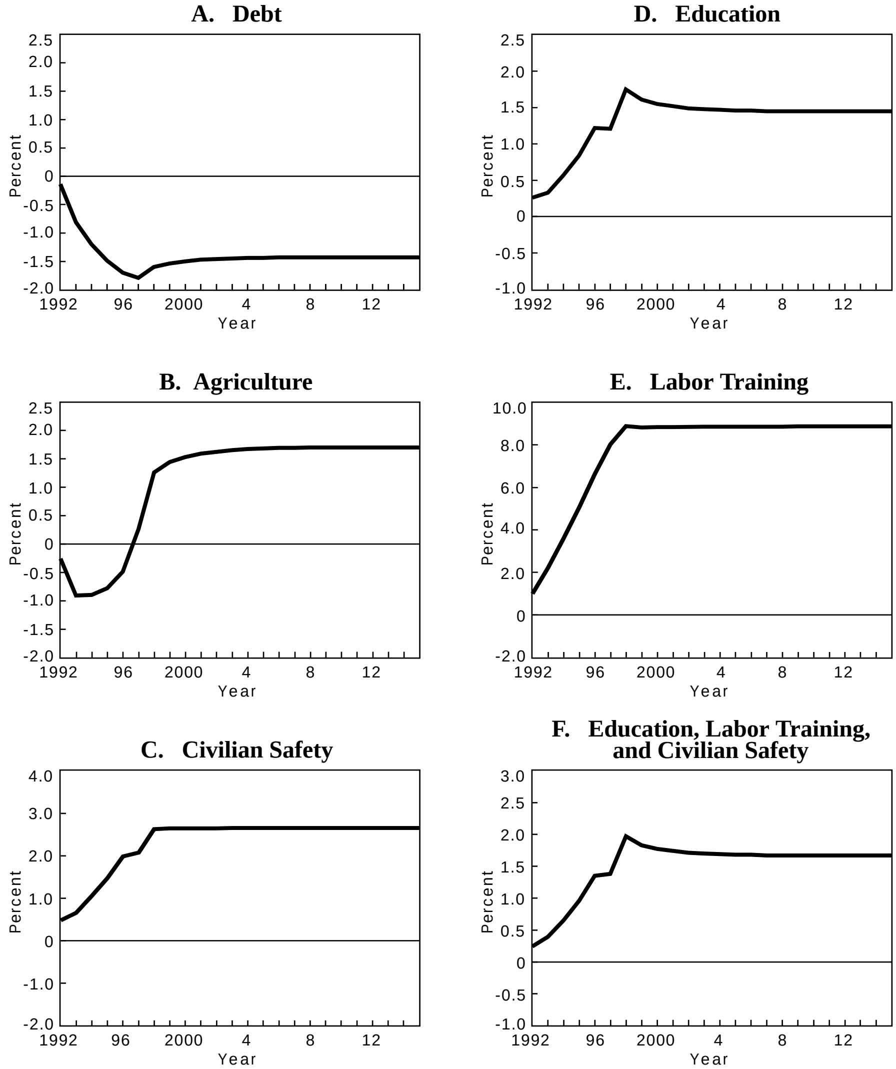
As a complement to the Ireland-Otrok study, the policy experiment reported here will also evaluate the 1991 plan. The new simulations, however, will assume that only a portion of the proceeds of the defense cuts are used for federal spending reductions. The remainder will be used to raise government spending on a specified function. An implicit assumption in the policy experiment is that any new spending programs would be as cost-benefit effective as has been average government spending for each function tested over the past 40 years.

Six simulations were made assuming the defense cutbacks of the 1991 plan, but with differing uses of the proceeds. The goal of the 1991 plan, recall, was to cut defense spending by 20 percent between 1992 and 1997. In 1987 dollars, this meant cutbacks of $17 billion in 1992, $21.7 billion in 1993, $10.2 billion in 1994, $9.0 billion in 1995, $6.5 billion in 1996, and $7.0 billion in 1997.

The simulations distributed the proceeds of the defense cutbacks either (1) all to federal debt reduction as in Figure 2-A or (2) a portion to a one-standard-deviation increase in one of the four types of government spending with the remainder going to federal debt reduction (Figures 2-B, 2-C, 2-D, and 2-E). The simulation with all of the proceeds of the defense cutbacks going to debt reduction shows the resulting level of real private GDP to be a persistent 1.5 percent below what it would have been with no change in defense spending.[7]

[7] This result differs from the result found by Ireland and Otrok using 1931–91 data and their slightly different model. However, when their model was reestimated over the 1955–91 and 1947–91 time periods, the results were quite similar to the results found here.

Figure 2 Forecasts of Difference in Output Between Base Case and 1991 Plan



As Figures 2-C, 2-D, and 2-E show, this outlook changes considerably when a portion of the proceeds of the defense cuts are used to increase spending on civilian safety, education, or labor training. These simulations put the level of real private GDP persistently above what it otherwise would have been even though most of the proceeds of the defense cuts are still used to reduce the federal debt. For example, the simulation channeling $3.1 billion per year of the defense cuts (25 percent of the total defense reduction) to education raises the level of real GDP 1.5 percent.

Surprisingly, the simulation with $0.6 billion per year of the defense cuts going to labor training has the level of real private GDP rising a whopping 9 percent above what it otherwise would have been. The magnitude of this result is not credible. It probably indicates that the model has been affected by some kind of spurious correlation with respect to labor training, which is a very small part (0.5 percent) of government spending.

The predicted effects of civilian safety spending also seem suspiciously large. The simulation has $0.6 billion per year in additional spending for civilian safety raising the level of private GDP almost 3 percent higher than it otherwise would have been. Given the error structure of the impulse-response function depicted in Figure 1-D, however, the forecast errors on the civilian safety simulation would undoubtedly be relatively large, were they available.[8]

The policy experiment was run with a variable that combined government spending for civilian safety, education, and labor training (Figure 2-F). The simulation using this variable, which was significant for the F-test reported in Table 2, and which had an impulse-response function (Figure 1-H) that was significantly greater than zero, predicts that the level of real private GDP will be persistently 1.8 percent larger with the policy experiment than without it. The increase in real GDP comes about as a result of $3.47 billion per year apportioned among civilian safety, labor training, and education during the years of the defense cuts. Over the six-year period, this experiment results in a cumulative $20.8 billion increase in civilian safety, education, and labor training and a $50.6 billion reduction in the federal debt.

4. CONCLUSIONS AND POLICY IMPLICATIONS

First some caveats. The analysis in this article uses past data to simulate future events. Although that approach is the only one available for empirical studies, it is always subject to question. One should have good reason to believe that past trends will continue if one is to put much credence in simulations of the type reported in this article. Moreover, while one can find certain correlations between past events and guess that one event may cause another, it is virtually impossible for an economist to *prove* that one economic occurrence in the real world caused another. Thus, the results of this study cannot be considered to

[8] The effects of spending on labor training and civilian safety were examined further to find whether or not they were likely to have been the result of reverse causation. Reverse Granger-causality tests were run to determine whether GDP determined labor training or civilian safety spending. Lagged GDP did not have a statistically significant effect on either.

be conclusive.

The results of the study, however, imply that government spending on education and labor training (and perhaps also civilian safety) have statistically significant, and numerically significant, effects on future economic growth. It is noteworthy that spending for education, civilian safety, and labor training directly affect human capital rather than physical capital. The VAR simulations with education, labor training, and civilian safety spending show effects so strong, in fact, that policies to reduce defense spending 20 percent and apportion the proceeds between debt reduction and one or all of those three spending types were estimated to result in higher levels of real private GDP than would have resulted with no reductions in defense spending.

As noted above, however, the results reported here are based upon correlations of past events and the correlations may or may not continue in the future. Thus, programs to increase government spending for, say, education or labor training should not be undertaken willy-nilly, justified by the promotion of economic growth. Rather, any such program should stand up to a cost-benefit analysis and prove itself worthy on its own merits.

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