Applied Economics, 1994, **26**, 535–542

Government spending and economic growth: the G-7 experience

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Building on Barro's (1990) endogenous growth model, attempts are made to untangle the nature of the relationship between government expenditure and economic growth by examining the intertemporal interactions among the growth rate in per capita real GDP, the share of government spending, and the ratio of private investment to GDP for the Group-of-Seven countries. A multivariate time series analysis is conducted, with particular attention paid to the causal pattern and the shape of impulse-response function in the context of vector autoregressions. The analysis is based on the historical data for the Group-of-Seven countries. The empirical results suggest that the relationship between government spending and growth can vary significantly across time as well as across the major industrialized countries that presumably belong to the same 'growth club'. This finding may partly explain the differences in results among previous cross-sectional studies. Most importantly, no consistent evidence is found that government spending can increase per capita output growth. Neither is there consistent support for the negative argument. Besides, for most of the countries under study, public spending is found to contribute at best a small proportion to the growth of an economy.

I. INTRODUCTION

The relationship between the growth rate of real per capita output and the share of government spending has long been a subject of analysis and debate. The analysis bears upon the question of the role of government in economic growth. If changes in the share of government spending can affect the output growth rate, the size of government can be a potentially important factor explaining the observed disparity in long-term growth rates among different countries.

In a recent study, Barro (1990) examines an endogenous growth model that suggests a possible relationship between the share of government spending in GDP and the growth rate of real per capita GDP. In contrast to traditional models of economic growth (e.g., Cass, 1965 and Solow, 1956), endogenous growth models are interesting in that they do not depend on exogenous technological changes or labour growth (e.g., Becker *et al.*, 1990, Lucas, 1988, Rebelo, 1991, and Romer, 1986, 1990). The key feature of Barro's (1990) growth model is the presence of constant returns to capital that broadly includes private capital and public services. To the extent that public services are considered an input to production, a possible linkage arises between the size of government and economic growth.

Several studies have examined this relationship empirically. For example, Landau (1983), in a cross-sectional study of over 100 countries in the period 1961–76, reported evidence of a negative relationship between the growth rate of real per capita GDP and the share of government consumption expenditure in GDP. Based on post-war data from 47 countries, Kormendi and Meguire (1985) found no significant cross-sectional relationship between the growth rate of real GDP and the growth rate or the level of the share of government consumption spending. Following Kormendi and Meguire's analysis, Grier and Tullock (1987) studied 115 countries and found evidence of a negative relationship between the growth rate of real GDP and the growth rate of the government share in GDP. Barro (1991) examined 98 countries for the period 1970–85 and reported a negative relationship between the output growth rate and the share of

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government consumption expenditure. When the share of public investment was considered, however, Barro (1991) found a positive but statistically insignificant relationship between public investment and the output growth rate.

The previous empirical studies are primarily based on cross-sectional analysis. In this study a set of time series data on real per capita GDP and the share of government expenditure on goods and services in GDP for the Group-of-Seven countries is examined. The use of long time series data appears natural, since the issue under examination concerns long-term economic growth and the long series can provide useful information about their low-frequency dynamics.

Moreover, time series analysis allows one to reveal causal relationships between variables, while cross-sectional analysis can identify correlation but not causation between variables. According to Barro (1990), the share of government spending in GDP may have a significant effect on the growth rate of real per capita GDP. On the other hand, one can also argue that economic growth may influence the demand for government services such as economic infrastructures and public education. The relationship between public expenditures and output growth can therefore go in either direction. It follows that significant correlation between the two variables may exist, regardless of whether Barro's (1990) causal argument holds or not. To provide appropriate information about such causality, the time series relationship between the economic variables has to be exploited carefully.[1]

Further, as discussed fully later, the relationship between the share of public spending in GDP and the GDP growth rate can be positive or negative, depending upon the prevailing size of the government in the relevant country. Barro (1990) shows that more public spending may affect economic growth positively (or negatively) if the government currently spends too little (or too much) on productive public services. Again, cross-sectional analysis cannot capture such country-specific nature of the government spending and growth relationship.

II. A MODEL OF GOVERNMENT SPENDING AND ECONOMIC GROWTH

The analysis proceeds with a brief discussion of Barro's (1990) growth model and its testable implications. The representative individual is assumed to choose a consumption path $\{c_t\}$ so as to maximize an intertemporal utility function with a constant elasticity of substitution (σ):

$$U=\int_0^{\infty} e^{-\rho t}u(c_t)dt = \int_0^{\infty} e^{-\rho t}(c_t^{1-\sigma}-1)(1-\sigma)^{-1}\,dt \quad (1)$$

subject to a capital accumulation constraint $\dot{k}=y-g-c$, a government budget constraint $g=\tau y$, and a production function $y=k\phi(g/k)$, where $\rho>0$ is the time discount rate, y is the per capita output, g is the per capita government purchases, k is capital per worker, and τ is the average tax rate. The model specifically allows government services such as education, training, and public infrastructures to enter as a separate input to private production.[2]

Following the model above, the steady-state growth rate (γ) can be shown as

$$\gamma=\dot{c}/c=[(1-g/y)(1-\eta)\phi(g/k)-\rho]/\sigma \quad (2)$$

where η is the elasticity of y with respect to g such that $(1-\eta)\phi(g/k)=\partial y/\partial k$, which is the marginal product of capital. A change in g/y can therefore affect γ in two counteracting ways. An increase in g/y reduces $(1-g/y)$, crowds out private investment and hence lowers the growth rate. On the other hand, a higher g/y makes private capital more productive, raises $\partial y/\partial k$ and thereby leads to a higher γ. The net effect can be illustrated by the derivative

$$\partial\gamma/\partial(g/y) = \phi(g/k)(\phi'-1)/\sigma \quad (3)$$

the sign of which depends on the size of the government. If the government is too large such that $\phi'<1$, then $\partial\gamma/\partial(g/y)<0$, implying that a further expansion of government spending will depress the growth rate. If the government is too small in the sense that $\phi'>1$, then $\partial\gamma/\partial(g/y)>0$, suggesting that an increase in government spending can raise the growth rate. If the size of the government is optimal in that $\phi'=1$, however, $\partial\gamma/\delta(g/y)=0$ and a growth-maximizing share of government spending can be determined. At optimum, any further marginal change in spending will not affect the growth rate, implying little correlation between g/y and γ.

When government consumption services (h) are also introduced, Equation 1 becomes

$$U = \int_0^{\infty} e^{-\rho t}((c^{1-\beta}h^{\beta})^{1-\sigma}-1)/(1-\sigma)dt \quad 0<\beta<1 \quad (4)$$

and the steady-state growth rate will have to be modified as

$$\gamma=\dot{c}/c=[(1-g/y-h/y)(1-\eta)\phi(g/k)-\rho]/\sigma \quad (5)$$

[1]The potential simultaneity problem in estimating the relationship between government spending and growth has also been noted by Landau (1983). To deal with the problem, Landau suggests the use of two-stage least squares estimation. Nonetheless, the cross-sectional results can tell little about the causal relationship between government spending and growth.

[2]The production function is assumed to satisfy the usual conditions for positive and diminishing marginal products. In addition, the analysis abstracts from externalities associated with the use of public services.

The diagnoses for the effect of productive government spending on growth are the same as before. Since $\partial\gamma/\partial(h/y) = -(1-\eta)\phi(g/k)/\sigma < 0$, however, an expansion of government spending if applied largely to consumption services will unambiguously lower the growth rate.

The sign implications of the model with both g and h present are summarized in Table 1. Increasing government spending on nonproductive services will lower the growth rate, independent of the size of the government. In contrast, an increase in government spending on productive services can either raise or lower the growth rate, depending on the size of the government. While information on total government expenditures is readily available, the model cannot be tested directly without separate data on productive and nonproductive services. Nonetheless, the results given in Table 1 suggest that working with data on total expenditures can still be informative. For example, since expenditures on consumption services always have a negative impact on the growth rate, findings of a non-negative relationship between total government expenditures and growth can be viewed as evidence of underspending in productive services. Note that when a negative linkage between government expenditure and output growth is found, no definite inference concerning the size of productive services can be made. This is because such a finding can be due to excessive spending in consumption services, regardless of the level of expenditure on productive services. Even when we have underspending in productive services, the positive effect on growth out of these services can be veiled by the negative effect from government consumption services, resulting in a net negative relationship.

III. EMPIRICAL ANALYSIS AND RESULTS

The historical experience of Canada, France, Germany, Italy, Japan, the United Kingdom and the United States are examined, using the data on the annual growth rate of real per capita GDP and the share of government expenditure on goods and services in annual GDP. The real per capita GDP from 1885 to 1979 is taken from Maddison (1982) and is updated to 1987 based on various issues of the *OECD Main Economic Indicators*. The output growth rate is constructed as the first difference in the natural logarithm of the real per capita GDP series. The share of total public expenditure on goods and services in the respective country is computed based on data on total public expenditures and GDP taken from *One Hundred Years of Economic Statistics* recently compiled by Liesner (1989). Due to World War II, uninterrupted data for France, Germany and Japan are available only for the post-war period. The corresponding sample periods for the seven countries are: Canada (1926–87), France (1950–87), Germany (1950–87), Italy (1885–1987), Japan (1952–87), the United Kingdom (1885–1987) and the United States (1889–1987).

In addition to the share of total public expenditure in GDP, data on the share of private investment in GDP are also considered. The investment to GDP ratio serves as a measure of the propensity to save and re-invest in the economy. Some growth models suggest that the investment to GDP ratio can affect the long-term growth rate through embodiment of technical progress in capital accumulation. In view of this, our analysis is extended by estimating three variable vector autoregressions. In effect, we examine the relationship between the per capita output growth rate and the share of government spending, adjusted for the potential effects of private investment.

As a preliminary data analysis, all data series are first checked for stationarity. If the series are nonstationary, standard econometric techniques can lead to misleading results. Both the augmented Dickey–Fuller or ADF(p) test and the Phillips–Perron $Z_t(q)$ test for a unit root (Dickey and Fuller, 1979 and Phillips and Perron, 1988) are performed on each individual series. Table 2 contains the results of the unit-root tests that allow for a time trend and use different values of the lag parameters: $p, q = 1$, 3 and 5. For all the per capita growth rate series (DY_t), the hypothesis of a unit root can be rejected at either 10% or 5% significance level. For the share of government spending in GDP (GR_t) and the ratio of private investment to GDP (IR_t), the test results indicate that all the series are stationary, except for France and Germany, which seem to be nonstationary. While failing to reject the unit root hypothesis can be due to the low power of the unit root tests, the statistical results reported below for France and Germany should be interpreted with the qualification concerning potential nonstationarity in mind.

The dynamic relationships among the growth rate of real per capita GDP, the share of government spending in GDP, and the share of private investment in GDP are examined

Table 1. *Implications of Barro's growth model*

	Underspending in productive services	Optimal spending in productive services	Overspending in productive services
Expenditures on productive services	$\partial\gamma/\partial(g/y)>0$	$\partial\gamma/\partial(g/y)=0$	$\partial\gamma/\partial(g/y)<0$
Expenditures on consumption services	$\partial\gamma/\partial(h/y)<0$	$\partial\gamma/\partial(h/y)<0$	$\partial\gamma/\partial(h/y)<0$
The sign of the combined effects	+ or −	−	−

Table 2. *Testing for stationarity*

Series	The Dickey–Fuller ADF(p) test			The Phillips–Perron $Z_t(q)$ test		
	$p=1$	$p=3$	$p=5$	$q=1$	$q=3$	$q=5$
DY_t:						
Canada	−4.099**	−4.651**	−3 585**	−4.451**	−4.482**	−4.341**
France	−2.646	−2.959	−3.849**	−4.428**	−4 550**	−4.476**
Germany	−5.120**	−3.074	−3.623**	−5.195**	−5.244**	−5 317**
Italy	−6.246**	−4 935**	−4 774**	−7.369**	−7.281**	−7.183**
Japan	−3.212*	−3.342*	−2.420	−3.933**	−3.936**	−3 979**
UK	−5.459**	−5.588**	−5.103**	−8 201**	−8.277**	−8.208**
USA	−6.176**	−5.932**	−4.254**	−8.219**	−8.206**	−8.097**
GR_t:						
Canada	−5.072**	−3.927**	−2.870	−3.802**	−3.830**	−3.447*
France	−2.565	−2.618	−1 620	−2.262	−2.242	−2.285
Germany	−2.530	−2.451	−2 003	−2.142	−2 158	−2.172
Italy	−4.012**	−4.198**	−3.211*	−2.856	−3 191*	−3 185*
Japan	−3.268*	−3.301*	−3 397*	−3.298*	−3.241*	−3.089
UK	−4.635**	−4.192**	−3 315*	−2.945	−3 264*	−3.163*
USA	−5.072**	−3.927**	−3 870**	−3.802**	−3 830**	−3.447*
IR_t:						
Canada	−3 174*	−3.190*	−3 353*	−2.869	−3.252*	−3.227*
France	−0 641	−0.129	−0.022	−0.931	−0 893	−0.780
Germany	−2.788	−2.318	−1.270	−2.289	−2 170	−2 057
Italy	−4.192**	−3 943**	−3.411*	−3.966**	−4.005**	−3 892**
Japan	−3.567**	−3.713**	−3.655**	−3.654**	−3.278*	−3.187*
UK	−2.676	−3 401*	−3.489*	−2 110	−2.296	−2.285
USA	−3.045	−3 254*	−3 343*	−2.535	−2 679	−2 562

The variable for the growth rate of real per capita GDP is given by DY_t, that for the share of government spending on goods and services in GDP by GR_t, and that for the share of private investment in GDP by IR_t The null hypothesis is that the relevant series contains a unit root The parameter p gives the lag length employed in the Dickey–Fuller test The parameter q indicates the lag length used in the Phillips–Perron test For the two unit root tests applied, a time trend is allowed. Critical values for the tests are tabulated by Fuller (1976) Statistical significance is indicated by ** at the 5% level and * at the 10% level

using vector autoregressive (VAR) analysis (e.g., Sims, 1980). The estimated model is described by

$$\begin{bmatrix} \pi_{11}(L) & \pi_{12}(L) & \pi_{13}(L) \\ \pi_{21}(L) & \pi_{22}(L) & \pi_{23}(L) \\ \pi_{31}(L) & \pi_{32}(L) & \pi_{33}(L) \end{bmatrix} \begin{bmatrix} x_{1t} \\ x_{2t} \\ x_{3t} \end{bmatrix} = \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \end{bmatrix} \quad (6)$$

where $x_{1t}=DY_t$, $x_{2t}=GR_t$, $x_{3t}=IR_t$, the elements $\pi_{ij}(L)$ are the p-th order polynomials in the lag operator L, $[c_1, c_2, c_3]'$ is a vector of constants, $[e_{1t}, e_{2t}, e_{3t}]'$ is a serially independent random vector with mean zero and covariance matrix $\sum$. The lag order p of the vector autoregression is selected using both the Akaike information criterion (AIC) and the Schwarz information criterion (SIC).[3] Once the lag order was determined, the corresponding estimated residuals were further tested for the presence of autocorrelation. The estimated lag length would be used when the residuals could pass the autocorrelation test. If they could not, the lag length would be increased until autocorrelations in residuals were removed. Due to the degree-of-freedom consideration, the maximum lag length entertained was set to eight. Further, for the data that cover sample periods of the two world wars, dummy variables for the war time periods were included in estimating the VAR model. These dummy variables were found to be statistically significant in most of the cases.

Given that each equation in the VAR system contains the same regressors, the system can be efficiently estimated by least squares. Because of the presence of cross-equation feedbacks and the tendency for the estimated coefficients on successive lags to oscillate, the VAR parameter estimates are

[3]If the true model has a finite-ordered VAR representation, the SIC can asymptotically select the correct model with probability one. If no finite-ordered VAR representation exists, the AIC can provide asymptotically minimum mean squared prediction error approximations (Shibata, 1980).

generally hard to interpret. We therefore follow the usual practice and focus on impulse-response functions and variance decompositions.

Both impulse-response functions and variance decompositions are derived from tracing out the effects of innovations in the vector moving average representation of the VAR system. An impulse response function describes the responses of the system over time to a unit shock in any one of the system variables, as represented by a one-standard-deviation innovation in that variable. For variance decompositions, the multi-step-ahead forecast error variances are divided into different percentages attributed to individual innovations of the variables in the system.[4]

The results reported below are based on an estimated VAR system, with variables ordered as DY_t, GR_t and IR_t. Since a change in the ordering can alter the decomposition factor, the empirical results are potentially sensitive to the ordering selected. Given that there is no prior reason to choose any particular ordering over another, we experiment our analysis with some other orderings of the three variables. It is found that while the empirical estimates, especially those for variance decompositions, can be affected quantitatively by the different orderings, most of the basic results are rather robust qualitatively, without affecting our conclusions concerning the relationships among the growth rate, the share of government spending, and the share of private investment in GDP in the various countries.

In addition to impulse-response and variance decomposition analyses, the temporal linkages among DY_t, GR_t and IR_t can be examined using Granger's (1969) test for causality, which tests for the exclusion of all lags of x_{it} from the equation for x_{jt} for $i \neq j$. For example, if the share of government expenditures in GDP does not influence the growth rate of real per capita GDP, $\pi_{12}(L)=0$. On the other hand, if the output growth rate does not affect the share of government spending in GDP, $\pi_{21}(L)=0$. The relationship between the share of private investment in GDP and the growth rate can similarly be studied based on exclusion tests on $\pi_{13}(L)$ and $\pi_{31}(L)$.

The results of the causality tests are summarized in Table 3. The optimal lags selected for estimating the VAR models for individual countries are also given in the table. The exclusion test statistics are provided together with their corresponding p-values, which are the marginal significance level at which the null hypothesis of no causal effect of the corresponding variable on another one can be rejected. According to the results in Table 3, an increase in the share of government spending has a statistically significant effect on the growth rate of real per capita GDP for Canada, Japan and the United Kingdom, though not for the other countries. Changes in the output growth rate, on the other hand, seem to be a factor explaining part of the movements in the share of government spending in GDP for Germany, Italy and the United States. Hence, no uniform causal pattern is found between the growth rate and the share of government spending in GDP across countries. Furthermore, changes in the private investment to GDP ratio have significant effect on the growth rate in five out of the seven countries, namely

Table 3. *Summary results of Granger-causality tests*

	Canada	France	Germany	Italy	Japan	UK	USA
VAR lags used	6	5	5	7	4	2	6
Lagged GR_t on DY_t							
F-value	2 109*	0.301	1.144	1.302	2.246*	3.057*	1.144
p-value	0 076	0.906	0.376	0.262	0.100	0.052	0.346
Lagged IR_t on DY_t							
F-value	2.485**	0.092	2.680*	0.816	2.803*	4.504**	2.585**
p-value	0.041	0.992	0.058	0.577	0 055	0.014	0.025
Lagged DY_t on GR_t							
F-Value	0.503	0.453	2.692*	2.026*	1.735	0.624	3.997**
p-value	0.802	0 806	0 057	0.063	0.184	0.538	0 002
Lagged DY_t on IR_t:							
F-value	0.706	0.638	0 581	0 992	0.774	0.178	1.281
p-value	0.647	0.674	0.714	0.444	0.556	0.837	0.277

The estimated system includes three variables: per capita GDP growth rate (DY_t), government spending to GDP ratio (GR_t), and private investment to GDP ratio (IR_t). Statistical significance is indicated by * at the 10% level and ** at the 5% level

[4]Since the residuals can be correlated across equations, the Choleski factor G, where $\Sigma_p = GG'$, is used to transform the innovation covariance matrix to a diagonal form, thereby allowing the researcher to investigate the system responses when the variables of the system are independently shocked.

Canada, Germany, Japan, the United Kingdom and the United States. However, there is no significant evidence of feedbacks from changes in the output growth rate to the share of private investment in GDP.

Turning to the impulse-response analysis reported in Table 4, we first examine how the output growth rate responds to shocks in government spending. In general, the results do not show consistent dynamic behavioural pattern across countries, nor across time. Looking at the whole of the impulse-response function paints a very mixed scenario. Within shorter lags, government spending seems to slow down economic growth. For instance, five years after the shock, the effect of government expenditure is negative in five of the seven countries. Ten years after, negative impacts are seen in four of the seven cases. At longer lags, however, the picture is reversed. Either four or five of the seven estimates from the spending shock are positive after 15 years or longer. Nonetheless, the magnitude of the effects is quite small in each of the cases.

Across time, changes in the pattern of the effect of public expenditure on growth are also apparent. In five of the seven countries, including Germany, Italy, Japan, the United

Table 4. *Impulse–response functions* ($\times\ 10^{-3}$)

Lag	Canada	France	Germany	Italy	Japan	UK	USA
GR_t Shock on DY_t:							
2	−1 392	−3.588	−4.494	6.120	−6.252	1.438	−2.735
4	−4.821	0.811	−1.615	−4.447	−1.657	−2.226	−2.399
5	6.714	3.221	−3.230	−5.154	−3.328	−1.457	−1.446
10	−1.769	0.344	−0.196	0.042	−4.375	0.281	−0.806
15	0.469	1.254	0.264	−0.820	−1.462	0.203	0.564
20	−0.460	0.600	−0.095	0.419	0.158	0.195	0.343
25	−0.434	−0.081	0 305	0.005	0.114	0.185	−0.040
30	−0.527	−0 173	0.054	0.103	0.036	0.176	0 300
35	−0.462	−1.314	0.204	0.097	0.035	0.167	0 147
IR_t Shock on DY_t:							
2	−3 996	−1.093	2.855	−0.342	−9.280	1.638	6 940
4	2.668	−2.044	−3.157	−2.060	−5.913	2.204	9.579
5	−7.227	−2.075	−5.641	−4.106	−3.215	1.822	0.218
10	−0.035	1.405	−0.603	3.963	−3 463	1.212	2 154
15	0.075	−0.792	0.103	1.387	−1 109	1.172	−0 592
20	0.407	1.117	0.221	1.743	0.245	1 112	0.599
25	0.617	0.312	−0.192	1.141	0.322	1 055	0.149
30	0.668	0.880	−0.268	1.111	0.209	1.002	0 106
35	0.689	0.842	0 139	0.874	0.055	0 951	0 218
Lagged DY_t on GR_t:							
2	6.585	0.760	−0.710	2.478	−1.790	6.141	0.599
4	6.262	0 786	1.623	0.370	−0.624	2.760	1.040
5	0.492	−0 140	1.162	4 185	0.001	1.353	−8 316
10	4 863	−0 447	0.844	−1.881	0.179	0.453	9 672
15	2.678	0 737	0.707	0.757	0.175	0.473	−0.884
20	3.375	−0.154	0.249	1 224	0 033	0.447	3.851
25	3.262	1 144	−0.151	0.670	0.006	0.424	3.214
30	3.393	0.321	−0.424	0.587	−0.013	0.403	2.448
35	3 425	1 031	−0.410	0.536	−0.009	0.382	2 979
Lagged DY_t on IR_t:							
2	6.489	0.743	2 895	1.058	5.390	−0.665	7.118
4	6.089	0.245	0 412	0.629	3.678	−0.044	5.346
5	5.392	1.493	−0.626	0.182	1.377	0.240	6.304
10	4.627	1.067	−0.777	4.728	−0.216	0.430	−0.429
15	5.306	0.824	−1.327	2.705	−0.489	0.398	1.813
20	5.082	0 965	−0 418	1.874	−0.208	0.378	0.016
25	5.263	−0.562	0.036	1.714	−0.088	0.359	0.473
30	5.330	−0.128	0.133	1 434	0.008	0.341	0.456
35	5.392	−1.724	0.224	1.165	0.022	0.324	0.315

The statistical results are based on a three-variable VAR system of per capita GDP growth rate (DY_t), government spending to GDP ratio (GR_t) and private investment to GDP ratio (IR_t)

Kingdom and the United States, the estimates are negative in the shorter run and then turn to be positive in the long run. The result for France is just the reverse: positive effect in the short run and negative effect in the long run. The only case among the seven which seems to have revealed quite consistent response to government spending is Canada and the effect on economic growth is negative. In sum, it is difficult to provide any conclusive diagnosis from the ambiguous picture depicted above concerning the impact of government expenditure on growth as shown in Table 1.

Except for Germany, the United Kingdom and the United States, the impulse-response estimates also show reversal of the relationship between growth rate and private investment/GDP ratio over time. Within shorter horizons, investment ratio reduces growth. On the other hand, the effect generally becomes positive after 20 lags. Consistent dynamic pattern is seen for the United Kingdom and the United States. In these cases the results indicate that investment promotes growth. The estimates for Germany are simply too ambiguous to provide any meaningful interpretation.

In respect to the effect of the growth rate on government spending, again no uniform pattern is found across countries. At the very long run, negative effects are found for Germany and Japan, and positive effects are found for the other five countries. On the other hand, only Canada, Italy and the United Kingdom show quite consistently over time that growth increases the demand for public spending.

Table 5 contains the results of variance decomposition analysis. The question of major interest is the proportions of the forecast error variance of the output growth rate explained by shocks in government spending and private investment. The results are found to vary significantly across countries. For Japan, innovations in the share of investment in GDP explain more than 41% of the variance of the growth rate, while innovations in the share of government spending in GDP explains less than 6% of the variance. In no other countries have innovations in the share of private investment in GDP accounted for so much variance of the growth rate. On the other hand, it is just the opposite for Canada, where innovations in government spending play a fairly important role in explaining the variance of the growth rate. More than 25% of the variance of the growth rate in Canada are attributed to innovations in the share of government spending in GDP, while only less than 10% of the variance are attributed to innovations in the share of private investment in GDP. The results for Germany lie in the middle between those for Japan and Canada. Innovations in the share of government spending and the share of private investment in GDP both explain about 21% of the variance of the growth rate. For the other four countries, France, Italy, the United Kingdom and the United States, no more than 8% of the variance of the growth rate can be accounted for by innovations in either government spending or private investment. Taking it all in all, there seem to be large, unexplained variations in output growth for many of the countries examined.

A remark concerning the empirical estimates for Japan is in order. The variance decomposition estimates seem inconsistent with the common observation that the Japanese government plays a very important role in Japan's economic

Table 5. *Variance decompositions* (%)

Step	Canada	France	Germany	Italy	Japan	UK	USA
GR_t explaining DY_t:							
2	19.45	2 51	8.59	1.11	3.66	0.15	0.38
4	24.54	3 88	16.29	3.74	5.89	1.02	1 68
5	24.00	5 49	17 17	4.43	7.07	1.17	1.69
10	25.20	6.33	20 57	4.61	5.85	1.20	4.72
15	25.53	5.96	20 55	4.64	5.71	1.21	4.80
20	25.43	6.41	20 78	4.65	5.72	1.22	4.79
25	25.42	6 16	20 76	4.64	5.72	1.23	4.81
30	25.37	6 08	20 77	4.63	5.72	1.23	4.82
35	25.32	6 47	20.78	4.63	5.72	1.24	4.82
IR_t explaining DY_t:							
2	1.60	0.23	3.47	0.00	14.68	0.21	2.48
4	3.96	0.91	10.43	0.95	29.39	0.97	8.54
5	7.20	1.63	17.64	1.41	29.47	1.23	8.16
10	8.99	2.07	19.74	5.07	40.03	1.85	7.65
15	9.03	2.17	21 34	5.43	41.35	2.37	7.69
20	9.22	2.32	21.52	5.74	41.38	2.83	7.67
25	9.35	2.67	21.80	5.95	41.43	3.24	7.66
30	9.42	2.75	21.85	6.11	41.46	3.61	7.67
35	9.52	3.28	21.88	6.22	41.47	3.93	7.68

growth. We observe that the empirical estimates can still suggest a potentially significant effect of productive government spending on economic growth in Japan. Unlike the usual national income accounts, the Japanese accounts classify most of the investment spending by the government, along with private investment, as a component of national investment. The variance decomposition estimates for Japan can therefore be consistent with the proposition that productive government spending is important for economic growth.

IV. CONCLUSION

This study attempts to untangle the nature of the relationship between the growth rate and government expenditures by examining the intertemporal interactions among the growth rate in per capita real GDP, the share of government spending, and the ratio of private investment to GDP. A multivariate time series analysis is conducted, with particular attention paid to causal patterns and the shape of impulse-response function in the context of vector autoregressions. The analysis is based on the historical data for the Group-of-Seven countries. The empirical results suggest that the relationship between government spending and growth can vary significantly across time as well as across the major industrialized countries that presumably belong to the same 'growth club' (Baumol, 1986). This finding may partly explain the differences in results among previous cross-sectional studies. Most importantly, we find no consistent evidence that government spending can increase per capita output growth. Neither do we find consistent support for the negative argument. Besides, for most of the countries under study, public spending is found to contribute at best a small proportion to the growth of an economy.

REFERENCES

Barro, R. J (1990) Government spending in a simple model of endogenous growth, *Journal of Political Economy*, **98**, S103–25.

Barro, R. J. (1991) Economic growth in a cross section of countries, *Quarterly Journal of Economics*, **106**, 407–43.

Baumol, W. J. (1986) Productivity growth, convergence and welfare: what the long-run data show, *American Economic Review*, **76**, 1072–85.

Becker, G. S., Murphy K. M. and Tamura R. (1990) Human capital, fertility, and economic growth, *Journal of Political Economy*, **98**, S12–37.

Cass, D. (1965) Optimum growth in an aggregative model of capital accumulation, *Review of Economic Studies*, **32**, 233–40

Dickey, D. A and Fuller W. A. (1979) Distribution of the estimators for autoregressive time series with a unit root, *Journal of the American Statistical Association*, **74**, 427–31.

Fuller, W A. (1976) *Introduction to Statistical Time Series*, Wiley, New York

Granger, C. W. J. (1969) Investigating causal relations by econometric models and cross-spectral methods, *Econometrica*, **37**, 424–38.

Grier, K. B and Tullock G. (1987) An empirical analysis of cross-national economic growth, 1950–1980, Working Paper, California Institute of Technology.

Kormendi, R C and Meguire, P. G. (1985) Macroeconomic determinants of growth· cross-country evidence, *Journal of Monetary Economics*, **16**, 141–63

Landau, D. (1983) Government expenditure and economic growth: a cross-country study, *Southern Economic Journal*, **49**, 783–92.

Liesner, T. (1989) *One Hundred Years of Economic Statistics*, The Economist Publications, New York

Lucas, R. E., Jr (1988) On the mechanics of economic development, *Journal of Monetary Economics*, **22**, 3–42.

Maddison, A. (1982) *Phases of Capitalist Development*, Oxford University Press, Oxford.

Phillips, P. C. B. and Perron, P. (1988) Testing for a unit root in time series regression, *Biometrika*, **75**, 335–46

Rebelo, S. (1991) Long-run policy analysis and long-run growth, *Journal of Political Economy*, **99**, 500–21.

Romer, P M (1986) Increasing returns and long-run growth, *Journal of Political Economy*, **94**, 1002–38

Romer, P M. (1990) Endogenous technological change, *Journal of Political Economy*, **98**, S71–S102

Shibata, R. (1980) Asymptotically efficient selection of the order of the model for estimating parameters of a linear process, *The Annals of Statistics*, **8**, 147–64

Sims, C A (1980) Macroeconomics and reality, *Econometrica*, **48**, 1–48.

Solow, R M (1956) A contribution to the theory of economic growth, *Quarterly Journal of Economics*, **70**, 65–94