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AN EMPIRICAL CHARACTERIZATION OF THE DYNAMIC EFFECTS OF CHANGES IN GOVERNMENT SPENDING AND TAXES ON OUTPUT

Olivier Blanchard
Roberto Perotti

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ABSTRACT

This paper characterizes the dynamic effects of shocks in government spending and taxes on economic activity in the United States in the post-war period. It does so by using a mixed structural VAR/event study approach. Identification is achieved by using institutional information about the tax and transfer systems and the timing of tax collections to identify the automatic response of taxes and spending to activity, and, by implication, to infer fiscal shocks.

The results consistently show positive government spending shocks as having a positive effect on output, and positive tax shocks as having a negative effect. The multipliers for both spending and tax shocks are typically small. Turning to the effects of taxes and spending on the components of GDP, one of the results has a distinctly non-standard flavor: Both increases in taxes and increases in government spending have a strong negative effect on investment spending.

Olivier Blanchard
Department of Economics
E52-373
MIT
Memorial Drive
Cambridge, MA 02139
and NBER
blanchar@mit.edu

Roberto Perotti
Department of Economics
Columbia University
420 W 118th St., 10th Floor
New York, NY 10027
rp41@columbia.edu

An empirical characterization of the dynamic effects of changes in government spending and taxes on output.

Olivier Blanchard   Roberto Perotti *

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1 Introduction

This paper characterizes the dynamic effects of shocks in government spending and taxes on economic activity in the United States in the postwar period. It does so by using a structural VAR approach that relies on institutional information about the tax and transfer systems and the timing of tax collections to identify the automatic response of taxes and spending to activity, and, by implication, to infer fiscal shocks.

One would have thought that such an exercise would have been carried out already. But, as far as we can tell, it has not. Of course, large-scale econometric models provide estimates of dynamic fiscal multipliers. Because of their very structure however, they largely postulate rather than document an effect of fiscal policy on activity. There exists also a large number of reduced-form studies. But these have typically concentrated either on the effects of some summary statistic of fiscal policy such as a cyclically adjusted deficit, or on spending, or on taxes. Most theories do not suggest however

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that the effects of fiscal policy on activity can be summarized by a single measure such as the adjusted deficit, and studies that focus on either taxes or spending implicitly make strong assumptions about the lack of correlation between the included and the excluded fiscal variable, assumptions that would appear unlikely to hold in general.[1]

This paper can be seen as doing for fiscal policy what a number of studies (in particular Bernanke and Mihov [1998]) have recently done for monetary policy. Indeed, the structural VAR approach would seem better suited to the study of fiscal policy than of monetary policy, for at least two reasons. First, budget variables move for many reasons, of which output stabilization is rarely predominant; in other words, there are exogenous (with respect to output) fiscal shocks. Second, in contrast to monetary policy, decision and implementation lags in fiscal policy imply that, at high enough frequency—say, within a quarter—there is little or no discretionary response of fiscal policy to unexpected movements in activity. Thus, with enough institutional information about the tax and transfer systems and the timing of tax collections, one can construct estimates of the automatic effects of unexpected movements in activity on fiscal variables, and, by implication, obtain estimates of fiscal policy shocks. Having identified these shocks, one can then trace their dynamic effects on GDP. This is what we do in this paper.

One methodological twist —one that was imposed on us by the data but is likely to be useful in other contexts—is that we combine this structural VAR approach with one akin to an event-study approach. Occasionally, the data provide us with examples of large discretionary changes in taxation or expenditure, for instance the large legislated tax cut that took effect in the second quarter of 1975. These changes are too large to be treated as realizations from the same underlying stochastic process and must be treated separately. Thus we trace the effects of these large, one-time, changes by studying the dynamic response of output to an associated dummy variable

[1]For a study of the effects of fiscal policy in twelve large macroeconometric models, see Bryant [1988]. A non-exhaustive list of reduced form studies includes Barro [1981] and Ahmed and Rogers [1995] (who look at the effect of expenditures), Blanchard and Watson [1986] (who look at the effect of an index of fiscal policy), Poterba [1988] (who looks at the effects of tax cuts). The four studies closest to ours are by Rotemberg and Woodford [1992] and Fatas and Mihov [1998], who study the dynamic response of government spending to identified shocks in standard VARs, and Ramey and Shapiro [1997], Edelberg et al. [1998], who trace out the effects of spending dummy variables in a reduced form VAR. Of these, only Fatas and Mihov [1998] includes a revenue variable. We compare our results to these four studies below.

that we include in the VAR specification.[2] As we show when we look at the 1950s, not all such large fiscal events can be used so cleanly; when they can, as in the case of the 1975:2 temporary tax cut, we find a high degree of similarity between the impulse responses obtained by tracing the effects of estimated VAR shocks, and by tracing the effects of these special events.

Our results consistently show positive government spending shocks as having a positive effect on output, and positive tax shocks as having a negative effect. The size and persistence of these effects vary across specifications (for instance, whether we treat time trends as deterministic or stochastic) and periods; yet, the degree of variation is not such as to cloud the basic conclusion. Turning to the effects of taxes and spending on the components of GDP, one of our results has a distinctly non-standard flavor: We find that both increases in taxes and increases in government spending have a strong negative effect on investment spending. (Keynesian theory, while agnostic about the sign, predicts opposite effects of tax and spending increases on investment.)

The paper is organized as follows. Section 2 presents the main specification, and discusses identification. Section 3 presents the data and discusses their main properties. Section 4 discusses the contemporaneous relations between shocks to government spending, net taxes and output. Section 5 presents the dynamic effects of tax shocks. Section 6 does the same for spending shocks. Section 7 discusses robustness; among other things, in this section we take up the important issue of anticipated fiscal policy. Section 8 extends the sample to cover the period 1949:1-1959:4, and shows what can be learned from the Korean war buildup. Section 9 presents the response of the individual output components. Section 10 concludes.

2 Methodological issues

Both government expenditure and taxation affect GDP: since the two are presumably not independent, to estimate the effects of one it is also necessary to include the other. Hence, we focus on two-variable breakdowns of the budget, consisting of an expenditure and a revenue variable.

We define the expenditure variable as total purchases of goods and services, i.e. government consumption plus government investment. We call

[2] This is also the approach taken by Ramey and Shapiro [1997] and further developed in Edelberg et al. [1998].

it "government spending", or simply "spending" for short. We define the revenue variable as total tax revenues minus transfers (including interest payments). We call it "net taxes", or "taxes" for short. We discuss the data in more detail in section 3.

2.1 The VAR

Our basic VAR specification is:

$$Y_t = A(L,q)Y_{t-1} + U_t \tag{1}$$

$Y_t \equiv [T_t, G_t, X_t]'$ is a three-dimensional vector in the logarithms of quarterly taxes, spending, and GDP, all in real, per capita terms.[3] We use quarterly data because, as we discuss below, this is essential for identification of the fiscal shocks. We allow either for deterministic (quadratic trends in logs), or stochastic (unit root with slowly changing drift) trends, but defer a discussion of this choice to the next section. We also allow for the presence of a number of dummy variables; again we defer a discussion of this issue to later.

$U_t \equiv [t_t, g_t, x_t]'$ is the corresponding vector of reduced form residuals, which in general will have non-zero cross correlations.

$A(L,q)$ is a four-quarter distributed lag polynomial that allows for the coefficients at each lag to depend on the particular quarter q that indexes the dependent variable. The reason for allowing for quarter-dependence of the coefficients is the presence of seasonal patterns in the response of taxes to economic activity. Some taxes—such as indirect taxes, or income taxes when withheld at the source—are paid with minimal delays relative to the time of transaction. Other taxes—such as corporate income taxes—are often paid with substantial delays relative to the time of the transaction; in addition, if the bulk of the payment is made in one or two specific quarters of the year, the delay varies depending on the quarter. Suppose, for illustrative purposes, that a tax is paid in the last quarter of each year, for activity over the year: then, in the last quarter, the tax revenue will depend on GDP in the current and past three quarters; in the other three quarters, it will be equal to zero and thus will not depend on GDP.[4] We have collected evidence

[3] We use the GDP deflator to express the variables in real terms. This allows us to express the impulse responses as shares of GDP. Results using the own deflator to express spending in real terms are very similar.

[4] Note that the use of seasonally adjusted data does not eliminate the problem: the

on quarter dependence in tax collection over the sample period from various institutional sources. The appendix lists the main relevant features of the tax code.[5]

2.2 Identification

As is well known, the reduced form residuals t_t, g_t and x_t from (1) have little economic significance: they are linear combinations of the underlying "structural" tax, spending, and GDP shocks. Without loss of generality, we can write:

$$\begin{aligned} t_t &= a_1\, x_t + a_2\, e_t^g + e_t^t \\ g_t &= b_1\, x_t + b_2\, e_t^t + e_t^g \\ x_t &= c_1\, t_t + c_2\, g_t + e_t^x \end{aligned} \tag{2}$$

where e_t^t, e_t^g, and e_t^x are the mutually uncorrelated structural shocks that we want to recover.

The first equation states that unexpected movements in taxes within a quarter, t_t, can be due to one of three factors: the response to unexpected movements in GDP, captured by $a_1\, x_t$, the response to structural shocks to spending, captured by $a_2\, e_t^g$, and to structural shocks to taxes, captured by e_t^t. A similar interpretation applies to unexpected movements in spending in the second equation. The third equation states that unexpected movements in output can be due to unexpected movements in taxes, unexpected movements

seasonal adjustment corrects only for the "normal" seasonal variation in tax revenues, not for the effects on tax revenues of changes in GDP that are not seasonal. To continue the previous example, suppose GDP has been constant every quarter for a long time. A seasonal adjustment like the X-11 method will correctly attribute approximately one fourth of the last quarter's tax revenue to each quarter of the year. Suppose now there is a shock to GDP in quarter 3. The seasonal adjustment will leave a large seasonally adjusted value for taxes in quarter 4. The relation between this increase and the increase in GDP will only be captured by a quarter dependent regression. Note also that, because equation (1) is a reduced form, quarter dependence in the relation of taxes to GDP can show up in all three equations; we thus have to allow for quarter dependence in all three equations.

[5] A warning is in order here. In some cases the pattern of collection lags has changed—slightly—over time. Allowing for changes in quarter dependence in the VAR over time would have quickly exhausted all degrees of freedom. We have not done it; as a result, our adjustment is better than none, but still not quite right.

in spending, or to other unexpected shocks, e_t^x. Our methodology to identify this system can be divided into three steps.

(1) We rely on institutional information about tax, transfer and spending programs to construct the parameters a_1 and b_1. In general, these coefficients could capture two different effects of activity on taxes and spending: the automatic effects of economic activity on taxes and spending under existing fiscal policy rules, and any discretionary adjustment made to fiscal policy in response to unexpected events within the quarter. The key to our identification procedure is to recognize that the use of quarterly data virtually eliminates the second channel. Direct evidence on the conduct of fiscal policy suggests that it takes policymakers and legislatures more than a quarter to learn about a GDP shock, decide what fiscal measures to take in response, pass these measures through the legislature, and actually implement them. The same would not be true if we used annual data: to some degree, fiscal policy can be adjusted in response to unexpected changes in GDP within the year.

Thus, to construct a_1 and b_1, we only need to construct the elasticities to output of government purchases and of taxes minus transfers. To obtain these elasticities, we use information on the features of the spending and tax/transfer systems:

We could not identify any automatic feedback from economic activity to government purchases of goods and services; hence, we take $b_1 = 0$.

Turning to net taxes, write the level of net taxes, $\tilde{T}$, as $\tilde{T} = \sum \tilde{T}_i$, where the $\tilde{T}_i$'s are positive if they correspond to taxes, negative if they correspond to transfers.[6] Let B_i be the tax base correspond to tax $\tilde{T}_i$ (or, in the case of transfers, the relevant aggregate for the transfer program, i.e. unemployment for unemployment benefits). We can then write the within-quarter elasticity of net taxes with respect to output, a_1, as:

$$a_1 = \sum_i \eta_{T_i,B_i} \, \eta_{B_i,X} \, \frac{\tilde{T}_i}{\tilde{T}} \tag{3}$$

where, η_{T_i,B_i} denotes the elasticity of taxes of type i to their tax base, and $\eta_{B_i,X}$ denotes the elasticity of the tax base to GDP.

[6]The use of the tilde to denote the *level* of net taxes comes from the fact that we have used T earlier to denote the *logarithm* of net taxes per capita.

To construct these elasticities, we extend earlier work by the OECD (Giorno et al. [1995]), which calculated output elasticities of four separate categories of taxes (direct taxes on individuals, corporate income taxes, social security taxes, and indirect taxes) precisely using the formula above, i.e. as the product of the tax base elasticity of each type of tax revenues and of the GDP elasticity of the tax base. The need to extend the OECD work comes from the fact that OECD estimates are computed with respect to annual changes, while we need them with respect to quarterly changes. Both the elasticities of taxes to their base, the η_{T_i,B_i}s in expression (3), and the elasticities of the tax bases to GDP, the $\eta_{B_i,X}$ s, can be quite different at quarterly and annual frequencies:

The quarterly tax base elasticities of tax revenues to their tax base can differ from the annual elasticities because of tax collection lags. In the United States, collection lags are probably relevant only for corporate income taxes (see the Appendix).

A more important source of divergence is the difference in the quarterly and annual elasticities of the tax bases with respect to GDP. For instance, the contemporaneous elasticity of profits to GDP, estimated from a regression of quarterly changes in profits on quarterly changes in GDP, is substantially higher than the elasticity obtained from a regression using annual changes —4.50 versus 2.15, respectively. The reverse is true of the elasticity of unemployment to output changes: it is, not surprisingly, lower when using quarterly changes rather than annual changes.

The value of a_1 we obtain following this procedure varies over time, both because the ratios of individual taxes and transfers to net taxes— the terms $\widetilde{T}_i/\widetilde{T}$ in expression (3) above—and the tax base elasticities of tax revenues— the terms η_{T_i,B_i}s—have changed over time. The average value of our measure of a_1 over the 1947:1-1997:4 period is 2.08; it increases steadily from 1.58 in 1947:1 to 1.63 in 1960:1 to 2.92 in 1997:4.

(2) With these estimates of a_1 and b_1, we can construct the *cyclically adjusted* reduced form tax and spending residuals, $t'_t \equiv t_t - a_1 x_t$ and $g'_t \equiv g_t - b_1 x_t = g_t$ (as $b_1 = 0$). Obviously t'_t and g'_t may still be correlated with each other, but they are no longer correlated with e^x_t. Thus, we can use them as instruments to estimate c_1 and c_2 in a regression of x_t on t_t and g_t.

(3) This leaves two coefficients to estimate, a_2 and b_2. There is no convincing way to identify these coefficients from the correlation between t'_t and

g_t': when the government increases taxes and spending at the same time, are taxes responding to the increase in spending (i.e. $a_2 \neq 0, b_2 = 0$) or the reverse? We thus adopt an agnostic approach. We identify the model under two alternative assumptions: in the first, we assume that tax decisions come first, so that $a_2 = 0$ and we can estimate b_2; in the second, we assume that spending decisions come first, so that $b_2 = 0$ and we can estimate a_2. It turns out that, in nearly all cases, the correlation between t_t' and g_t' is sufficiently small that the ordering makes little difference to the impulse response of output.

2.3 Impulse responses

Having identified the tax and spending shocks, we can study their effects on GDP. One of the implications of quarter dependence is that the effects of fiscal policy vary depending on which quarter the shock takes place. One way to deal with this would be to derive four impulse responses, depending on the quarter where the initial shock occurs. This however would be cumbersome. We adopt a simpler procedure. We use a quarter dependent VAR to obtain the estimated covariance matrix, and thus the coefficients in equation (2) and the contemporaneous effects of fiscal shocks. We then use a VAR estimated without quarter dependence (except for additive seasonality) to characterize the dynamic effects of the shocks; this gives, admittedly only in a loose sense, the average dynamic response to fiscal shocks.

We then consider a number of different impulse responses. We consider the response of the three variables to a shock to taxes, both when taxes are ordered first ($a_2 = 0$), and when they are ordered second ($b_2 = 0$). Symmetrically, we consider the response of the three variables to a shock in spending, both when spending is ordered first ($b_2 = 0$) and when it is ordered second ($a_2 = 0$).

The identified VAR also allows us to consider a number of counterfactual experiments. Take for example the case of a shock to spending, when ordered first ($b_2 = 0$). We can ask how the response of output would have looked, had taxes not responded within the quarter; this corresponds to putting a_2 also equal to 0. We can go further and ask how the response of output would have looked, had taxes not responded at all; this is done by looking at the subsystem in the VAR composed of the terms in spending and output in the spending and the output equation.[7]

2.4 Discussion

Although the logic of our approach is similar to that of Bernanke and Mihov [1998] and Gordon and Leeper [1994], our approach to identification is different in one important respect. In those papers on monetary policy, identification is achieved by assuming that private sector variables, like GDP and even interest rates (as in Gordon and Leeper [1994]), do not react to policy variables contemporaneously. By contrast, we assume that economic activity does not affect policy, except for the automatic feedback built in the tax code and the transfer system.[8]

No identification is without flaws, and ours is no exception. One implicit assumption in our construction of a_1 is that the relation between the various tax bases and GDP is invariant to the type of shocks affecting output. For broad based taxes, such as income taxes, this is probably fine. It is more questionable, say, for corporate profit taxes: the relation of corporate profits to GDP may well vary depending on the type of shocks affecting GDP.[9]

3 The data

We define net taxes as the sum of *Personal Tax and Nontax Receipts*, *Corporate Profits Tax Receipts*, *Indirect Business Tax and Nontax Accruals*, and *Contributions for Social Insurance*, less *Net Transfer Payments to Persons* and *Net Interest Paid by Government*. Government spending is defined as *Purchases of Goods and Services*, both current and capital. The source is the Quarterly National Income and Product Accounts, with the exception of

[7] In reporting these counterfactual experiments, we admit to committing two crimes: We ignore the Lucas critique. We violate the intertemporal government budget constraint. With respect to the second, one interpretation is, barring Ricardian equivalence, that the increase in taxes are pushed far into the future.

[8] Thus, our approach is more akin to that of Sims and Zha [1996], who have argued that cutting off the contemporaneous effects of policy on private sector variables might give a misleading view of the importance of policy innovations.

[9] Another issue is that we do not control for inflation. Much of government spending is set in nominal terms, and unexpected inflation leads to unexpected movements in real government spending. We are working on it.

Corporate Profits Tax Receipts, which are obtained from the Quarterly Treasury Bulletin.[10] All these items cover the general government, i.e. the sum of the federal, state and local governments, and social security funds.[11] All the data are seasonally adjusted by the original source, using some variant of the X-11 method.[12]

3.1 High-frequency properties

Figure 1 displays the behavior of the ratio of government spending (i.e. purchases of goods and services) and of net taxes (i.e. taxes minus transfers) to GDP over the longest sample, 1947:1 to 1997:4. It is immediately obvious that these series display a few extremely large quarterly changes in taxes and spending, well above three times their standard deviations of 4.3 percent and 1.9 percent, respectively.

There are two particularly striking changes in net taxes. First, the increase in 1950:2 by about 26 percent (more than 6 times the standard deviation), followed by a further increase in 1950:3 by about 17 percent (or about 4 times the standard deviation). These episodes represent in part the reversal of the temporary 8 percent fall in net taxes in 1950:1, caused by a large once-off payment of National Service Life Insurance benefits to the war veterans; but mostly they represent a genuine increase in tax revenues. The second episode is the large temporary tax rebate of 1975:2, which resulted in a net tax drop by about 33 percent.[13]

[10] The Quarterly National Income and Product Accounts report taxes on a cash basis, except for the Corporate Profits Tax and the Indirect Business Tax, which are reported on an accrual basis. We used the Quarterly Treasury Bulletin to obtain data on Corporate Profit Tax on a cash basis. We could not find data on indirect taxes on a a cash basis; however, the difference between receipts and accruals for the latter is very small.

[11] We do not have data on the corporate profit tax on a cash basis for state and local governments. This represents about 5 percent of total corporate profit tax receipts at the beginning of the sample, and about 20 percent at the end.

[12] Corporate profit tax receipts are only reported without a seasonal adjustemnt. We used the RATS EZ-X11 routine to seasonally adjust this series with the X-11 method.

[13] See Blinder [1981] for a detailed analysis of this tax cut, and its effects on consumption. The 1975:2 tax rebate (which was combined with asocial security bonus for retirees without taxes to rebate) corresponded to an increase in disposable income of about $100 billion at 1987 prices; by comparison, the 1968 surtax decreased disposable income by $16 billion and the 1982 tax cut increased disposable income by $31.6 billion, always at 1987 prices: see Poterba [1988].

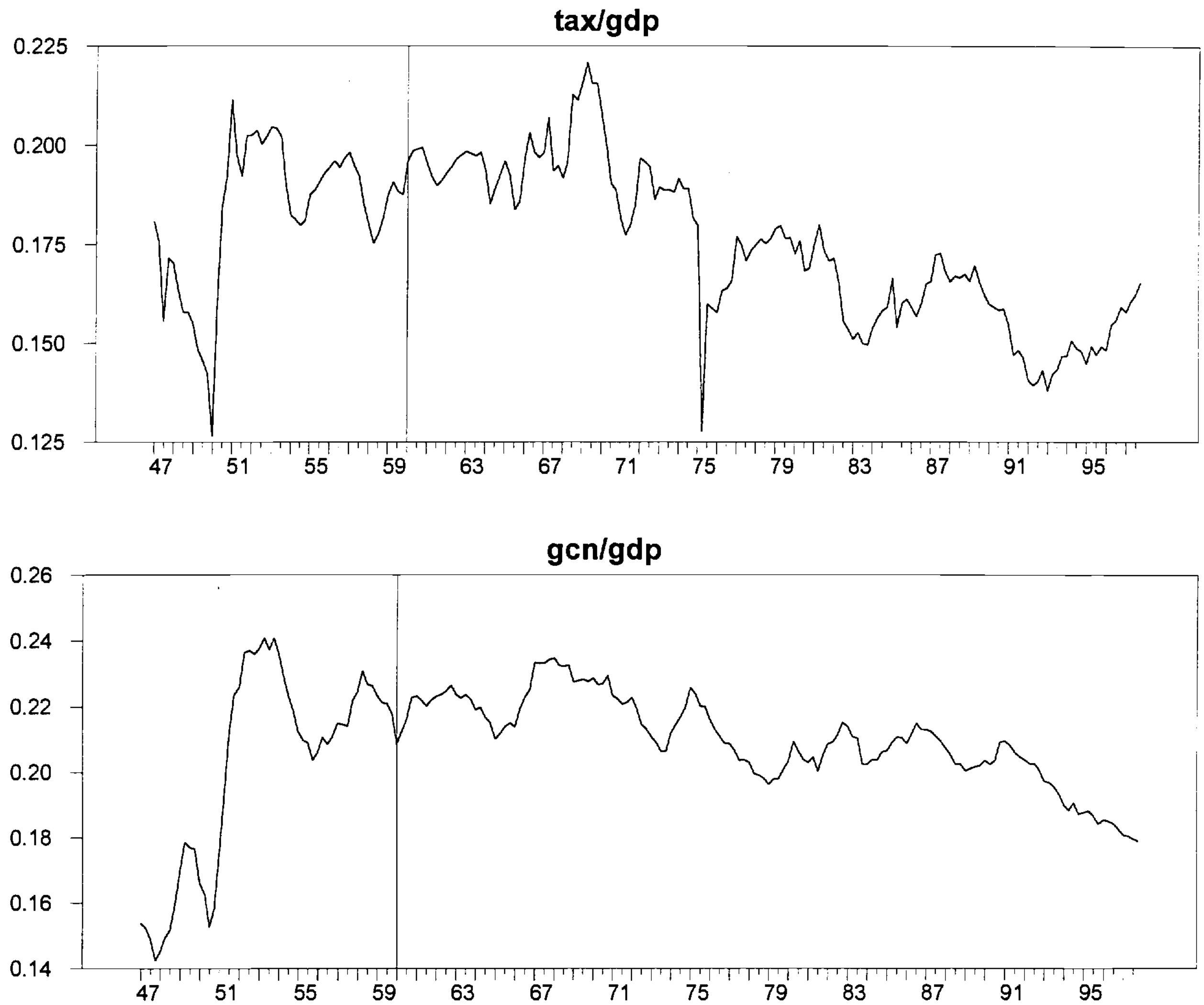

Figure 1: Net taxes and spending, shares of GDP

Table 1: Large changes in net taxes and spending.

sd(Δ log G)		sd(Δ log T)	
0.019		0.049	
Δ log $G > 3$ sd		Δ log $T > 3$ sd	
1951:1	0.103	1950:2	0.266
1951:2	0.112	1950:3	0.171
1951:3	0.108	1975:2	-0.335
		1975:3	0.240
$2 < \Delta$ log $G < 3$ sd		$2 < \Delta$ log $T < 3$ sd	
1948:2	0.039	1947:3	-0.117
1948:4	0.043	1947:4	0.107
1949:1	0.049	1951:1	0.097
1949:2	0.043		
1950:4	0.054		
1951:4	0.051		
1952:2	0.041		
1967:1	0.041		

On the expenditure side, the Korean war stands out: in 1951:1, at the onset of the Korean war buildup, government spending increases by 10 percent (more than 5 times the standard deviation), and continues to grow at about the same quarterly rate during the next two quarters, 1951:2 and 1951:3; after this, spending continues to increase at more than twice the standard deviation in 1951:4 and again in 1952:2. It is difficult to think of the early 1950s as being generated by the same stochastic process as the rest of the data. Thus, our strategy is to proceed in two steps. For most of the paper, we run a benchmark regression starting from 1960:1. In section 8, we extend the sample back to include the 1950s and look at what we can learn from this longer sample.

Note that our benchmark sample still includes a large net tax episode,the 1975:2 tax cut. This episode is a well-identified, isolated, temporary, tax cut which was reversed after one quarter. Hence, it can be easily and clearly dummied. This allows us to compare two different types of impulse responses to a net tax shock: one tracing the dynamic effects of the estimated estimated net tax shocks, the other tracing the effects over time of a unitary shock to the 1975:2 dummy variable.

3.2 Low-frequency properties

The general visual impression from Figure 1 is one of no clear trends, but clear low–frequency (say decade to decade) movements in both spending and taxes. One may be surprised by the general absence of upward trends in spending and net taxes; but recall that we are looking at government spending *not including transfers*, and that net taxes are taxes *net of transfers*. Thus, the figures hide the trend increases in taxes and transfers, which have indeed taken place during this period.

The main practical issue, for our purposes, is how to treat these low-frequency movements in our two fiscal series in relation to output. We have conducted a battery of integration tests for T, G and X. Formal tests (Augmented Dickey-Fuller and Phillips-Perron, with a deterministic time trend) do not speak strongly on whether we should assume stochastic or deterministic trends for each variable. We have also conducted a battery of cointegration tests. One obvious candidate for a cointegration relation is the difference between taxes and spending, $T - G$:[14] In fact, the stationarity of

[14] Recall that T includes interest payments.

the deficit is the basic idea underlying the tests of "sustainability" of fiscal policy by Hamilton and Flavin [1986] and Bohn [1991].[15] Figure 2 displays the logarithm of the tax/spending ratio. Again, formal test results do not speak strongly: one can typically reject the null of a unit root at about the 5% level, but no lower.[16]

In the light of these results, we estimate our VARs under two alternative assumptions. In the first, we formalize trends in all three variables as deterministic, and allow for linear and quadratic terms in time in each of the equations of the VAR. In the second, we allow for three stochastic trends. We take first-differences of each variable, and, to account for changes in the underlying drift terms, we subtract a changing mean, constructed as the geometric average of past first differences, with decay parameter equal to 2.5 percent per quarter (varying this parameter between 1 and 5 percent makes little difference to the results).[17] For brevity, in what follows we will refer to the two specifications as 'DT' (for 'deterministic trend') and 'ST' (for 'stochastic trend'), respectively. In both specifications, we allow for the current value and four lags of a dummy for 1975:2.

In our benchmark specifications, we do not impose a cointegration restriction between the tax and the spending variable. Later, we present results under the restriction that $T - G$ are integrated. This makes little difference to the results.

From now on, unless otherwise noted (in particular in section 8), our results are based on the 1960:1-1997:4 sample.

[15] Note however that we test cointegration between the *logarithms* of taxes and spending. This is equivalent to testing cointegration between the logarithms of the net tax/GDP ratio and of the spending/GDP ratios.

[16] This lack of strong evidence for cointegration between T and G is consistent with a number of recent empirical studies: see e.g. Bohn [1998], who tests for cointegration over the 1916-95 period using annual data.

[17] A popular approach to dealing with changing trends is to apply a two-sided filter such as the Hodrick-Prescott filter, or the filter developed by Baxter and King [1996] and Stock and Watson [1997]. When the filtered data are used for econometric purposes, these two-sided filters have the disadvantage that future events can heavily influence today's trend: for example, a large temporary increase in defense spending in a given quarter will cause the estimated trend to increase long before that quarter, causing a large fall in the detrended series before and a large increase after the event (the graph of filtered defense spending in Stock and Watson [1997] illustrates this point vividly). Our filter is one-sided, and thus not subject to this problem.

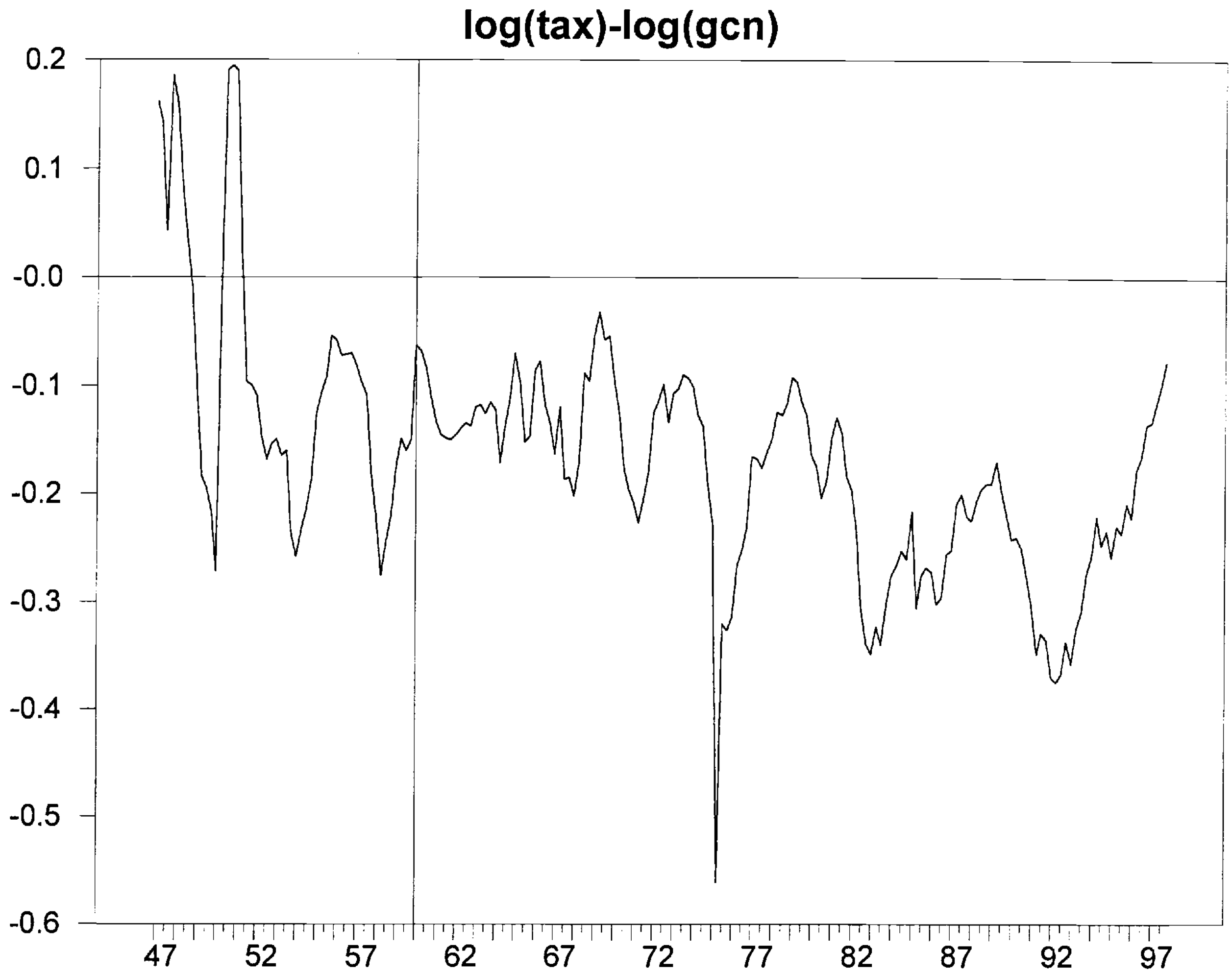

Figure 2: log (net taxes) - log (spending)

4 Contemporaneous effects

The first two panels of Table 2 give the estimated coefficients of the contemporaneous relations between shocks in equation (2), under DT and ST, and, for a_2 and b_2, under the two alternative assumptions that taxes come first, or that spending comes first.[18] For convenience of interpretation, while the original estimated coefficients have the dimension of elasticities, the table reports derivatives, evaluated at the point of means (dollar change in one variable per dollar change in another). Table 2 yields two main conclusions.

The first is that the signs of the contemporaneous effects of taxes and of spending on GDP —c_1 and c_2—are those one would expect — the former negative and the latter positive, and are rather precisely estimated. The two coefficients have very similar absolute values, and are also very similar across the two specifications, DT and ST. Under DT, a unit shock to spending increases GDP by 0.96 dollars, while a unit shock to taxes decreases GDP by 0.87 dollars. The estimated negative effect of taxes on output depends very much on the use of instruments: the simple correlation between unexpected movements in cyclically unadjusted taxes, t_t, and unexpected movements in output, x_t, is *positive* and equal to 0.38. This raises the issue of the robustness of the construction of cyclically adjusted taxes to the specific value of a_1; we return to the issue below.

The second conclusion is that the correlation between cyclically adjusted tax and spending innovations is low (–0.09 in our sample) yielding relatively low estimated values of a_2 and b_2 under either of the two alternative identification assumptions. These small values imply that the ordering of taxes and spending makes little difference to the impulse responses.

5 Dynamic effects of taxes

5.1 Effects of estimated tax shocks

The top panel of Figure 3 shows the effects of a unit tax shock assuming that taxes are ordered first ($a_2 = 0$), under DT; the bottom panel does the

[18] Note that, in constructing the cyclically adjusted tax shock t'_t, we use the time-varying elasticity a_1, not its mean.

Table 2: Estimated contemporaneous coefficients.

	c_1	c_2	a_2	b_2
		DT		
coeff.	-0.868	0.956	-0.047	-0.187
t-stat.	-3.271	2.392	-1.142	-1.142
p-value	0.001	0.018	0.255	0.255
		ST		
coeff.	-0.876	0.985	-0.057	-0.238
t-stat.	-3.255	2.378	-1.410	-1.410
p-value	0.001	0.019	0.161	0.161

DT: Deterministic Trend; ST: Stochastic Trend.
Sample: 1960:1 - 1997:4.
c_1: effect of t on x within quarter;
c_2: effect of g on x within quarter;
a_2: effect of g on t within quarter (assuming $b_2 = 0$, i.e. when spending is ordered first);
b_2: effect of t on g within quarter (assuming $a_2 = 0$, i.e. when net taxes are ordered first).
All effects are expressed as dollar for dollar.

Table 3: Responses to tax shocks.

	1qrt	4qrts	8qrts	12qrts	20qrts	peak
			DT			
GDP	-0.69*	-0.74*	-0.72*	-0.42*	-0.22	-0.78*(5)
TAX	0.74*	0.13	-0.21*	-0.20*	-0.11	
GCN	-0.05*	-0.12*	-0.24*	-0.26*	-0.16*	
			ST			
GDP	-0.70*	-1.07*	-1.32*	-1.30*	-1.29*	-1.33*(7)
TAX	0.74*	0.31*	0.17	0.16	0.16	
GCN	-0.06*	-0.10*	-0.17*	-0.20*	-0.20*	

DT: Deterministic Trend; ST: Stochastic Trend. A '*' indicates that 0 is outside the region between the two one-standard error bands. In parentheses besides the peak response is the quarter at which it occurs. All reduced form equations include lags 0 to 4 of the 1975:2 dummy. Sample: 1960:1 - 1997:4.

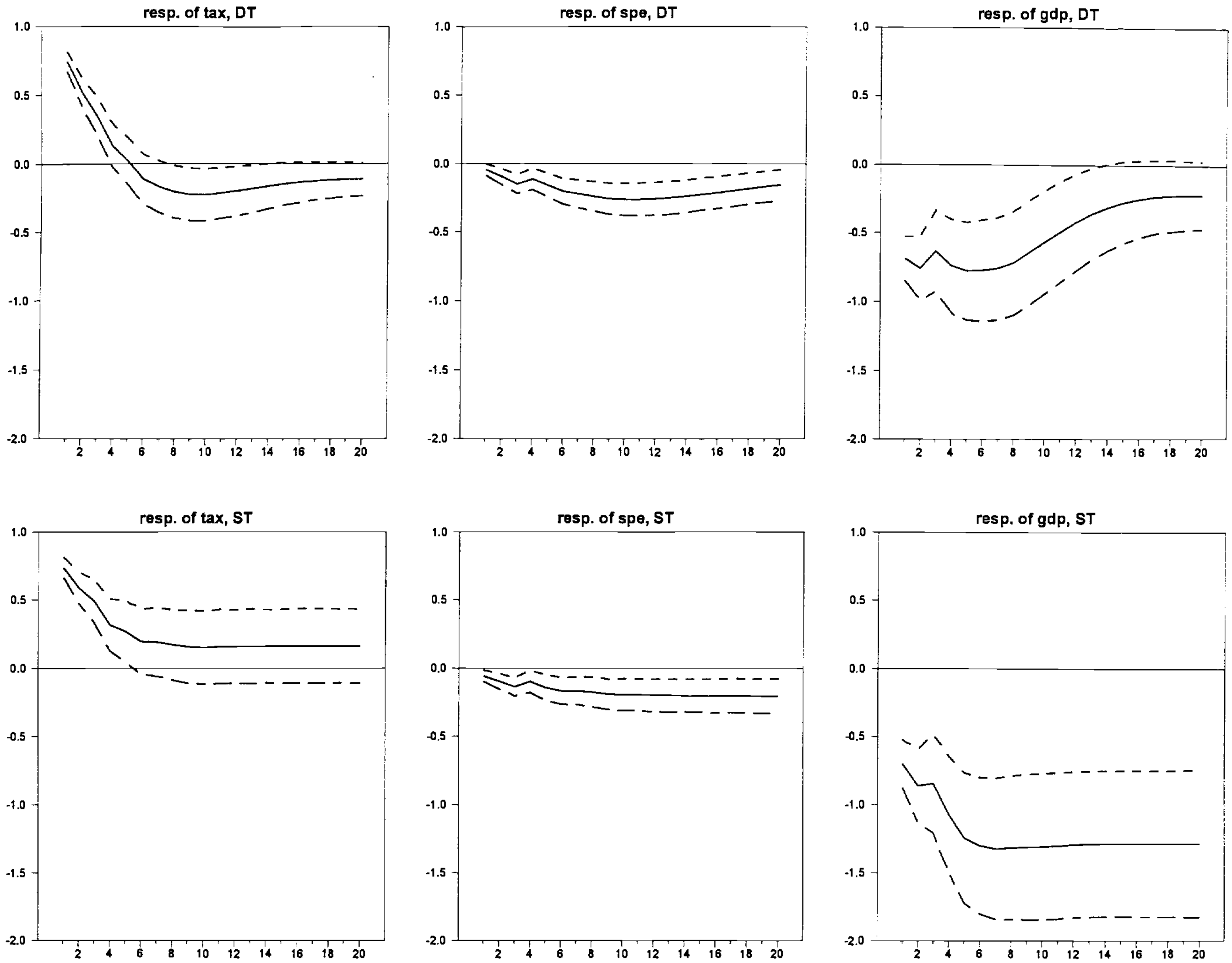

Figure 3: Response to a tax shock

same under ST.[19] For visual convenience, the impulse responses in these and the following figures and tables are transformations of the original impulse responses, and give the dollar response of each variable to a dollar shock in one of the fiscal variables. The solid line gives the point estimates. The broken lines give one-standard deviation bands, computed by Monte Carlo simulations (assuming normality), based on 500 replications. Table 3 summarizes the main features of the responses of the three variables. This table will be useful to compare in a compact way the results from the benchmark specifications to alternative specifications.

Under DT (top panel of Figure 3 and of Table 3), output falls on impact by about 70 cents and keeps falling for another year, reaching a trough 5 quarters out, with a multiplier (defined here and below as the ratio of the trough response of GDP to the initial tax shock) of 0.78. From then on, output increases steadily back to trend. The effect of tax shocks on government spending is small at all horizons, with the largest effect being -0.26 after 12 quarters, but it is precisely estimated.

Under ST (bottom panel of Figure 3 and of Table 3), the response of output is stronger and more persistent. Tax shocks have a very similar effect on output on impact, but the output trough is larger (-1.33 against -0.78 under DT), taking place after 7 quarters instead of 5; after this, the response of output stabilizes at around the peak response. The effect on taxes is slightly more persistent than in the DT case, while the effect on spending is similar.

Thus, under both specifications tax increases have a negative effect on output. In both cases, the effect on output takes time to build up, with the largest response occurring after 5 or 7 quarters depending on the specification. The negative response of output is more pronounced under the assumption of a stochastic trend.

When taxes are ordered second, the results (not shown) are virtually identical to those in Figure 3. This comes from the low correlation between cyclically adjusted tax and spending innovations, which in turn leads to a small value of a_2.

The counterfactual GDP impulse responses in which government spending is taken to be constant over time (not shown) are almost identical to those in Figure 3.[20] The reason is again clear from Figure 3: the response of

[19] Note that the initial value of taxes is not exactly 1. A unit tax shock ϵ_t^t translates into a less than unit change in taxes t_t, since GDP falls in the same quarter.

[20] We compute the counterfactual responses by using the subsystem composed of the

spending to changes in taxes is small anyway; setting it equal to zero makes little difference to the rest of the results.

5.2 Dynamic effects of the 1975:2 net tax cut

The two panels of Figure 4 trace out the dynamic effects of a unit shock to the 1975:2 dummy variable, under DT and ST respectively.[21] As we are looking at a tax *decrease*, the signs are reversed relative to Figure 3. But the effects are very similar. The impulse response captures well the fact that this tax decrease was temporary: taxes are back to normal after a quarter. The effects on output take some time to build up, reaching a peak after 4 quarters with a multiplier of 0.75 under DT and 1.02 under ST, thus close to the multipliers in Table 3. As usual, the response of output is more persistent under ST. The effects on spending are again small.

We find this similarity of results with the impulse responses from identified shocks comforting. The main difference is that the largest output response is reached sooner than in the impulse response to the typical tax shock; this is plausibly explained by the smaller persistence of the tax shock in the 1975:2 episode than of the typical tax shock in Figure 3.

6 Dynamic effects of spending

The two panels of Figure 5 show the effects of a unit spending shock on GDP when spending is ordered first ($b_2 = 0$) under DT and under ST. As in the case of taxes, Table 4 summarizes the main features of the responses to a spending shock under alternative specifications.

Under DT (top panel of Figure 5 and of Table 4) spending shocks are longer lasting than tax shocks: 95 percent of the shock is still there after 2 years. GDP increases on impact by 0.84 dollars, then declines and rises again, to reach a peak effect of 1.29 after almost 4 years. Net taxes also respond positively over the same horizon, probably mostly as a consequence of the response of GDP (notice that the shape of the tax response mimics closely the shape of the output response).

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output and the tax equation only in the VAR.

[21] In this and in figure 7 the standard errors are computed by bootstrapping instead than by Monte Carlo integration.

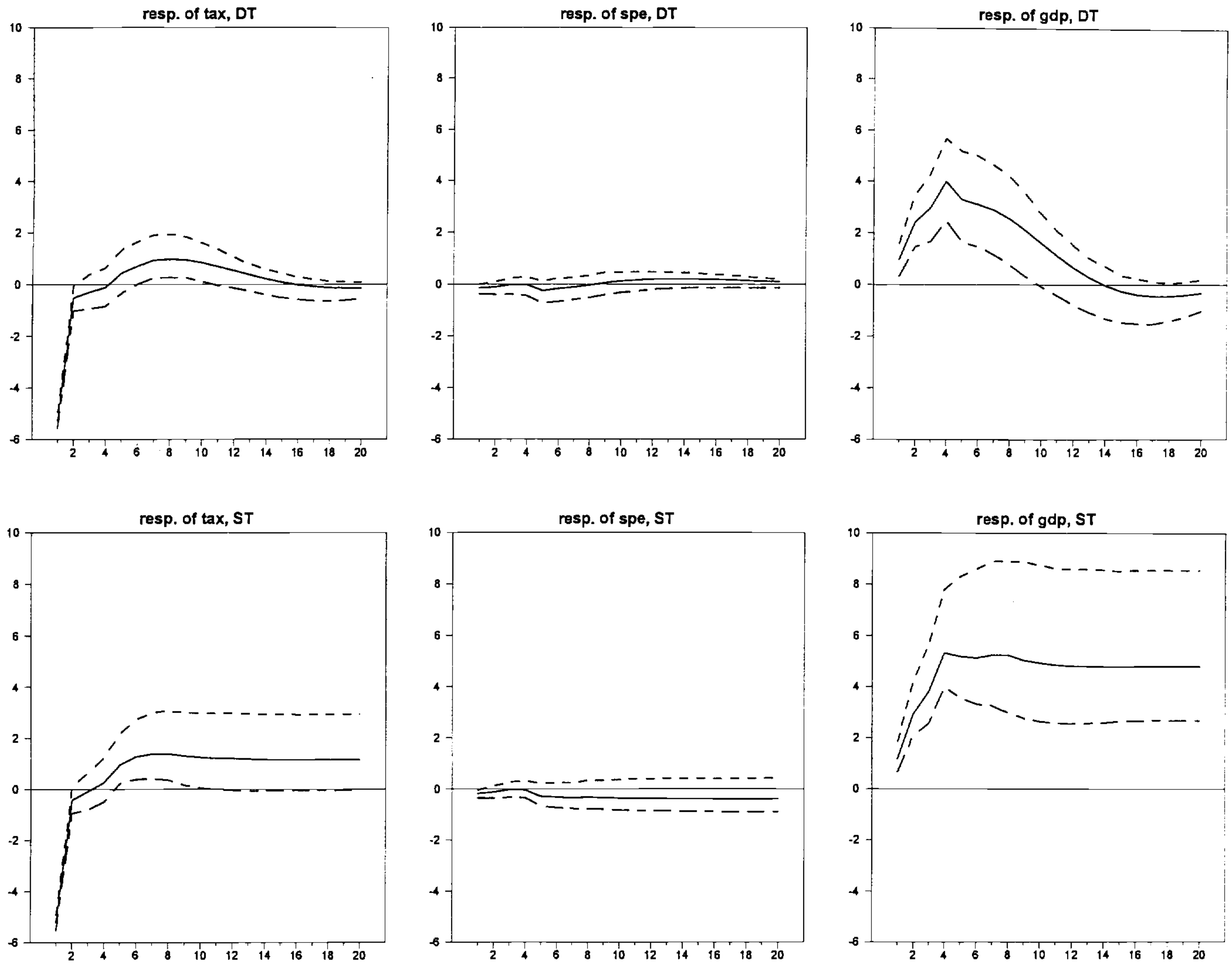

Figure 4: Response to a shock to the 1975:2 dummy

Table 4: Responses to spending shocks.

	1qrt	4qrts	8qrts	12qrts	20qrts	peak
			DT			
GDP	0.84*	0.45	0.54	1.13*	0.97*	1.29*(15)
GCN	1.00*	1.14*	0.95*	0.70*	0.42*	
TAX	0.13	0.14	0.17	0.43*	0.52*	
			ST			
GDP	0.90*	0.55	0.65	0.66	0.66	0.90*(1)
GCN	1.00*	1.30*	1.56*	1.61*	1.62*	
TAX	0.10	0.18	0.33	0.36	0.37	

See notes to Table 3.

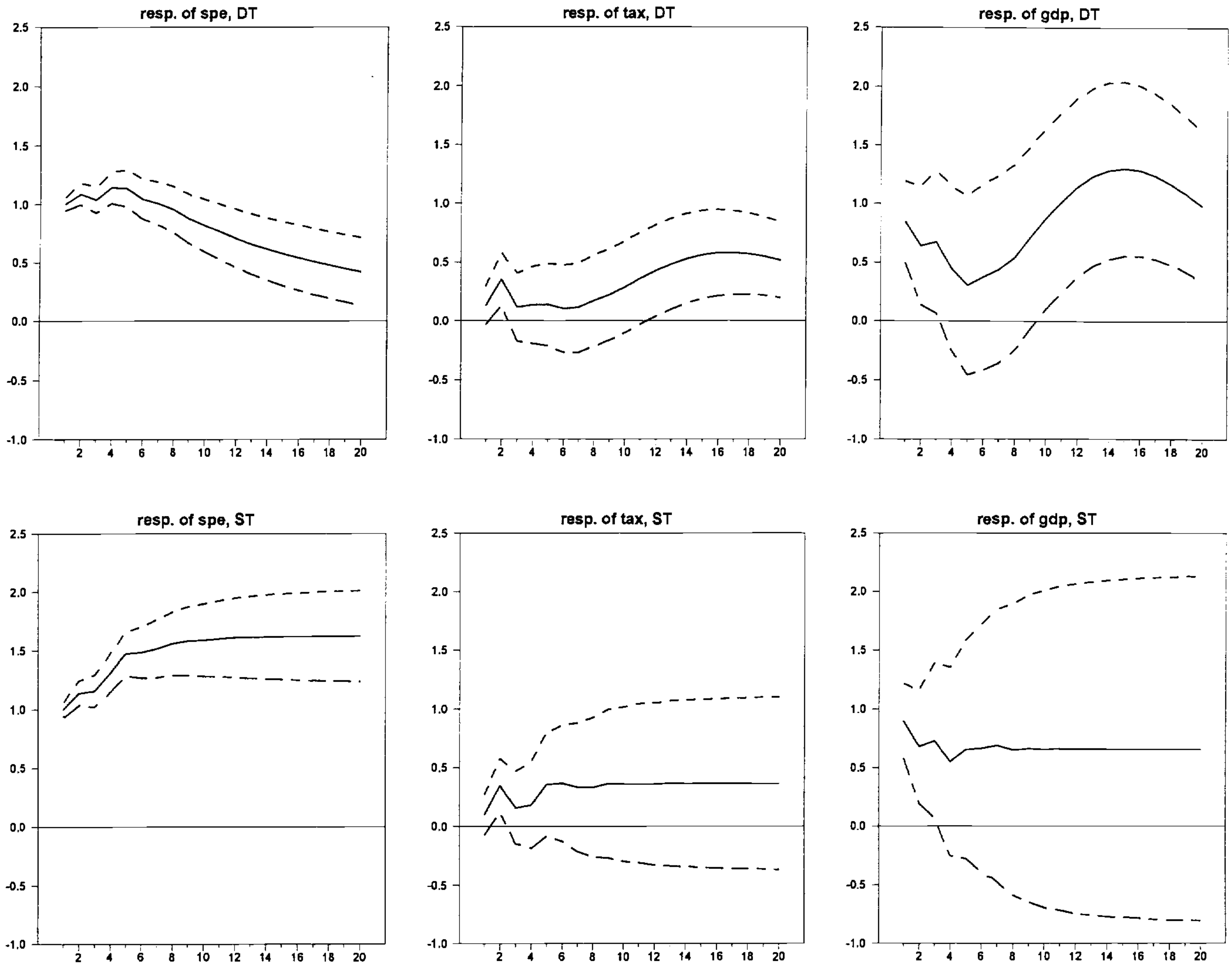

Figure 5: Response to a spending shock

The peak output response is smaller under ST (bottom panel of Figure 5 and of Table 4), 0.90 against 1.29. The peak effect is now reached on impact rather than after 4 years; notice also that the impact response is very similar under DT and ST. The standard error bands are also quite large, so that the response of output becomes insignificant after only 4 quarters. Note the strong response of spending, which stabilizes at about 1.6 after 2 years.

Thus, in all specifications output responds positively to a spending shock. Spending reacts strongly and persistently to its own shock. Depending on the specification, the spending multiplier is larger or smaller than the tax multiplier.

As in the case of taxes, the ordering of the two fiscal variables does not matter for the response to spending shocks: when taxes are ordered first, a shock to spending yields virtually identical effects on output (not shown) to those in Figure 5.

Given the strong response of taxes to spending, one is tempted to ask: If taxes did not increase in response to spending, how much larger would the response of output to such a 'pure' change in spending be? Recall that in the benchmark responses in Table 4 taxes continue to increase, reaching 0.52 and 0.37 (under DT and ST, respectively) after 5 years. Hence, when we set the path of taxes exogenously to 0, we obtain a larger GDP response (not shown), particularly at longer horizons. Under DT, the peak multiplier and the GDP response after 5 years are 1.43 and 1.34, against 1.29 and 0.97, respectively, in the benchmark case of Table 4. Under ST, the same numbers are 0.98 and 0.88 in the counterfactual exercise, against 0.90 and 0.66 in the benchmark impulse response.

7 Robustness

7.1 Sub-sample stability

Subsample stability is an important concern in a VAR that covers nearly 40 years. Unlike monetary policy, fiscal policy does not lend itself easily to a periodization based on alternative policy regimes. Hence, we check for subsample stability by dropping one decade at a time.[22] Table 5 reports the results from this exercise. The left and right parts summarize the impulse

[22] In performing this exercise, each time we recompute the average value of a_1 over the relevant sample.

Table 5: Stability of responses to tax and spending shocks.

Net taxes excl. period	Net taxes max. GDP response	Spending excl. period	Spending max. GDP response
DT			
60-69	-1.18*(1)	60-69	1.44*(1)
70-79	-0.90*(5)	70-79	1.47*(10)
80-89	-0.49*(2)	80-89	0.96*(3)
90-97	-1.45*(7)	90-97	1.73*(12)
ST			
60-69	-1.45*(11)	60-69	1.25*(1)
70-79	-1.48*(4)	70-79	0.62*(1)
80-89	-0.83*(7)	80-89	1.80*(3)
90-97	-1.52*(7)	90-97	0.85*(12)

See notes to Table 3.

responses of output to a net tax shock and a spending shock, respectively, obtained by dropping one decade at a time.

The exclusion of the eighties causes a substantial drop in the magnitude of the tax multiplier, under both ST and DT. The instability is more pronounced under DT: the tax multiplier ranges from -0.49 when the eighties are excluded to -1.45 when the nineties are excluded. There is also evidence of some instability in the spending multiplier, in particular under ST: the multiplier when the eighties are excluded is about three times that when the seventies are excluded — 1.80 against 0.62.

7.2 Quarter dependence

How important is quarter dependence for our results? [23] In terms of F tests, not very important: Under DT, an F-test on the coefficients of the quarter-dependent lags in our reduced form equations [24] gives p-values of 0.24 in the tax equation, 0.67 in the spending equation, and 0.46 in the output equation. Under ST, the p-values are 0.12, 0.32, and 0.15.

Turning to impulse responses: The responses to tax shocks obtained from non-quarter dependent estimation (the first two panels of Table 6) are very similar to those in Table 3. The difference is larger for spending shocks (next two panels of Table 6). Under DT, the response of output on impact increases by about 40 percent, so that now the peak response occurs immediately rather than after 15 quarters; under ST, the impact response and the spending multipliers increase by about 30 percent.

7.3 Cointegration

The last panel of Table 6 summarizes the impulse response when we impose a cointegrating relation between G and T in our ST specification with quarter dependence. As one can see, there is surprisingly little difference in the

[23] Recall that we use quarter dependence only to identify the shocks, but we compute the impulse responses from a system estimated without quarter dependence.

[24] Formally, if $q1$, $q2$ and $q3$ are dummy variables for the first three quarters, we can write our system as

$$Y_t = B(L)Y_{t-1} + B_1(L) * q1 * Y_{t-1} + B_2(L) * q2 * Y_{t-1} + B_3(L) * q3 * Y_{t-1} + u_t \quad (4)$$

and run an F-test on all the coefficients of the appropriate row of B_1, B_2, and B_3.

Table 6: Robustness.

	1qrt	4qrts	8qrts	12qrts	20qrts	peak
NO QUARTER DEPENDENCE						
DT, TAX						
GDP	-0.62*	-0.66*	-0.69*	-0.43*	-0.22	-0.73*(6)
TAX	0.77*	0.15	-0.18	-0.19	-0.12	
GCN	-0.03	-0.10*	-0.23*	-0.25*	-0.16*	
DT, SPENDING						
GDP	1.22*	0.83*	0.72	1.08*	0.90*	1.22*(1)
GCN	1.00*	1.12*	0.94*	0.69*	0.40*	
TAX	0.32*	0.33	0.30	0.44*	0.48*	
ST, TAX						
GDP	-0.67*	-1.06*	-1.33*	-1.32*	-1.31*	-1.34*(10)
TAX	0.75*	0.30*	0.16	0.14	0.14	
GCN	-0.03	-0.07	-0.13*	-0.16*	-0.17*	
ST, SPENDING						
GDP	1.16*	0.87	1.00	0.99	0.99	1.16*(1)
GCN	1.00*	1.28*	1.56*	1.62*	1.64*	
TAX	0.32*	0.39	0.60	0.63	0.64	
COINTEGRATION						
TAX						
GDP	-0.66*	-0.91*	-1.17*	-1.18*	-1.17*	-1.18*(11)
TAX	0.75*	0.42*	0.27*	0.23	0.23	
GCN	-0.06*	-0.11*	-0.18*	-0.20*	-0.21*	
SPENDING						
GDP	0.94*	0.69	0.87	0.90	0.90	0.94*(1)
GCN	1.00*	1.29*	1.55*	1.60*	1.61*	
TAX	0.12	0.27	0.49	0.54	0.55	

See notes to Table 3.

impulse responses relative to our benchmark case.[25]

7.4 Alternative net tax elasticities

Our identification procedure depends crucially on using ϵ_t^t as an instrument. This series in turn depend very much on the elasticity of net taxes a_1. One may ask how sensitive the results are to alternative values of a_1. Figure 6 gives the effects of a tax shock on GDP, for DT and ST, when taxes are ordered first ($a_2 = 0$), and for three different values of a_1: the baseline value minus 0.5, the baseline value, and the baseline value plus 0.5. We believe that the range implied by these three values more than covers the relevant range for a_1. A simple way of describing our results is that a change of a_1 from the bottom to the top of the range increases the impact effect on GDP (in absolute value) by 0.5 under both specifications, and increases the maximum multiplier (in absolute value) by 0.5 under DT and by 0.8 under ST. We read this figure as saying that the broad response of output we characterized earlier is robust to the details of construction of a_1.

7.5 Anticipated fiscal policy.

Implicit in our approach is the assumption that the policy innovations we have estimated were indeed unanticipated by the private sector. While we share this assumption with the whole VAR literature, we recognize that it is particularly problematic here: most of the changes in tax and transfer programs are known at least a few quarters before they are implemented.

We do not have a general solution to this problem; but once again we can use the large tax event of 1975:2 to make some progress. Suppose the large tax cut had been anticipated by, say, one quarter; then if we add one lead of the 1975:2 dummy in our specification, it will pick up the effect, if any, of the anticipated tax cut on GDP. The coefficients on leads of the tax dummy simply pick up the residuals for GDP (in the benchmark specification) in the quarters before the change. For both 1974:4 and 1975:1, the two residuals are negative, leading to estimated negative effects, at one and two leads, of the 1975:2 tax cut on GDP in 1974:4 and 1975:1. Thus, there is no evidence of anticipated effects of the 1975:2 tax cut on GDP.

[25] In keeping with quarter dependence, we allow the coefficient of the cointegrating term $G_{t-1} - T_{t-1}$ to differ depending on the quarter.

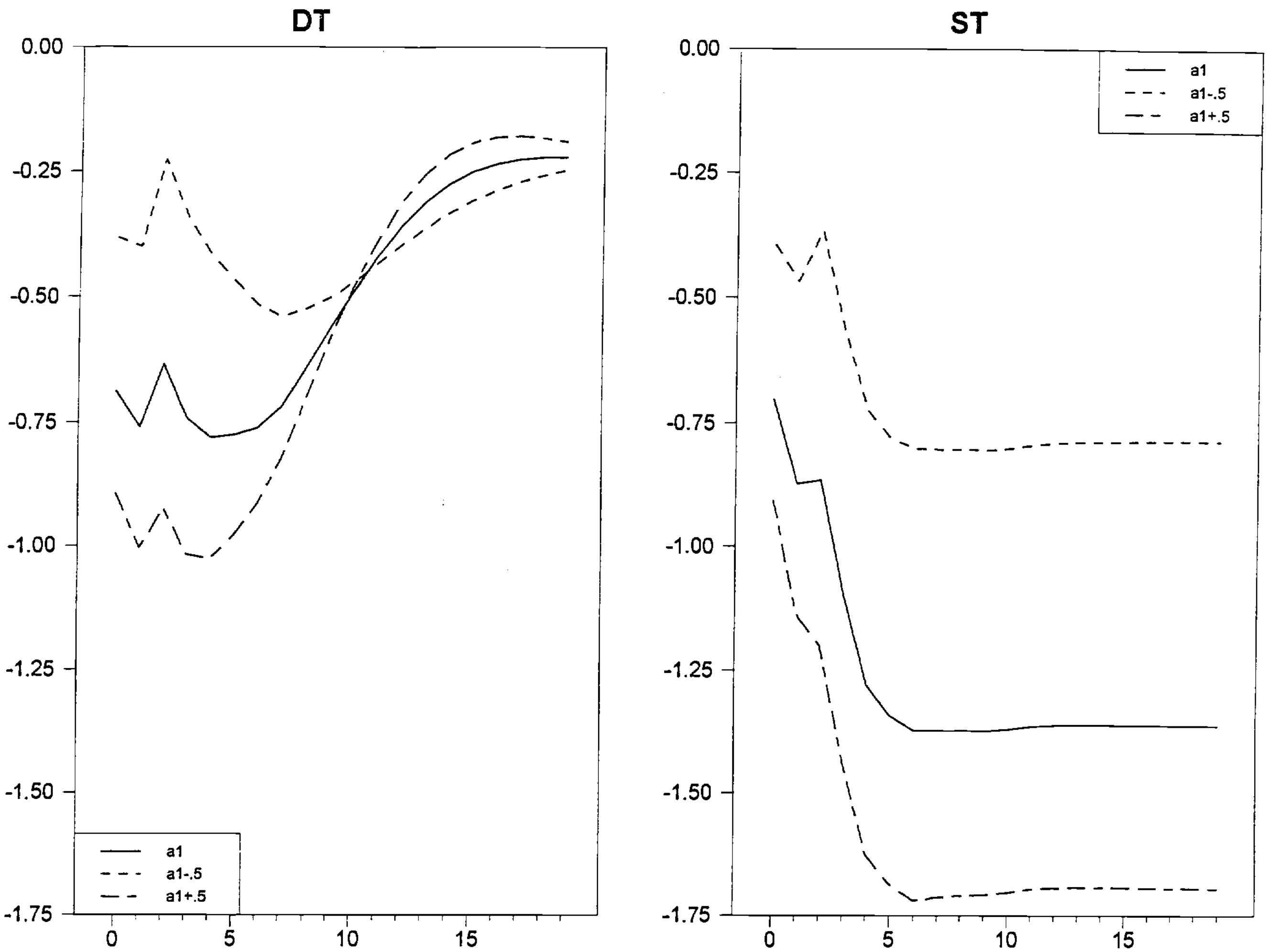

Figure 6: Response to a tax shock under alternative tax elasticities

8 Adding the fifties

We have used the post-1959 sample in the benchmark regressions presented so far. The reason, we argued, was that the 1950s, with their large spending and tax shocks, do not appear generated by the same stochastic process as the post-1959 data. Still, there is a number of ways in which the 1950s can be used to provide information on the effects of fiscal policy. We have explored two of them.

8.1 Using dummies for the major tax and spending shocks.

The first approach parallels our treatment of the 1975 tax cut. We extend the sample to start in 1949:1, use dummies for the major tax and spending episodes, then trace both the effects of normal fiscal shocks in the VAR estimated using the extended sample, as well as the effects of the dummies.

The last approach runs however into an identification problem which we did not face in the post 1960 sample. We can still trace the dynamic effects of normal fiscal shocks—ϵ_t and $epsilon_g$—on output. But if we allow the dummy associated with each major tax and spending shock to have its own distributed lag effect, we cannot identify the effects of each major spending or tax shock: they are too close in time to each other. More concretely, when looking at output for example in 1950:3, we cannot distinguish between the effect of the 1950:1 tax cut after two quarters, the effect of the 1950:2 tax increase after one quarter, or the contemporaneous effect of high spending in 1950:3. Nevertheless, something—admittedly more informal—can be learned by estimating the deviations of taxes, spending and output from normal in the early 1950s. We shall show what can be learned below.

Table 7 displays impulse responses estimated using the sample starting in 1949:1, but allowing for 13 dummies from 1950:1 to 1953:1 (equivalently 9 dummies, each with four lags; this is another way of stating the identification problem we just discussed). Under both DT and ST, the tax and spending output multipliers are similar to those of Tables 3 and Table 4, respectively. The shapes of the impulse responses are also very similar to those from the post-1959 sample. The main difference is that the output response to a spending shock under DT is much less persistent, stabilizing after about 8 quarters at around 0.20, instead of 0.65 in the post-1959 sample.

Turn now to the effects of the large fiscal shocks of the early 1950s. Figure

Table 7: 1949:1-1997:4 sample: 1950:1 and 1975:2 dummies.

	1qrt	4qrts	8qrts	12qrts	20qrts	peak
			DT, TAX			
GDP	-0.56*	-0.64*	-0.63*	-0.33	-0.11	-0.71*(6)
TAX	0.79*	0.43*	0.19*	0.15	0.09	
GCN	-0.04*	0.02	0.01	-0.01	-0.03	
			ST, TAX			
GDP	-0.62*	-0.90*	-1.10*	-1.04*	-1.04*	-1.12*(6)
TAX	0.77*	0.48*	0.38*	0.40*	0.40*	
GCN	-0.05*	0.04	0.03	0.03	0.03	
			DT, SPENDING			
GDP	0.85*	0.56	0.85*	1.38*	0.69*	1.41*(13)
GCN	1.00*	1.15*	0.82*	0.44*	0.12	
TAX	0.16*	0.10	0.03	0.23	0.11	
			ST, SPENDING			
GDP	0.68*	0.69	0.22	0.22	0.23	0.69 (4)
GCN	1.00*	1.50*	1.72*	1.76*	1.77*	
TAX	0.08	0.17	-0.07	-0.12	-0.12	

All reduced form equations include lags 0 to 12 of the 1950:1 dummy and lags 0 to 4 of the 1975:2 dummy. See also notes to Table 3.

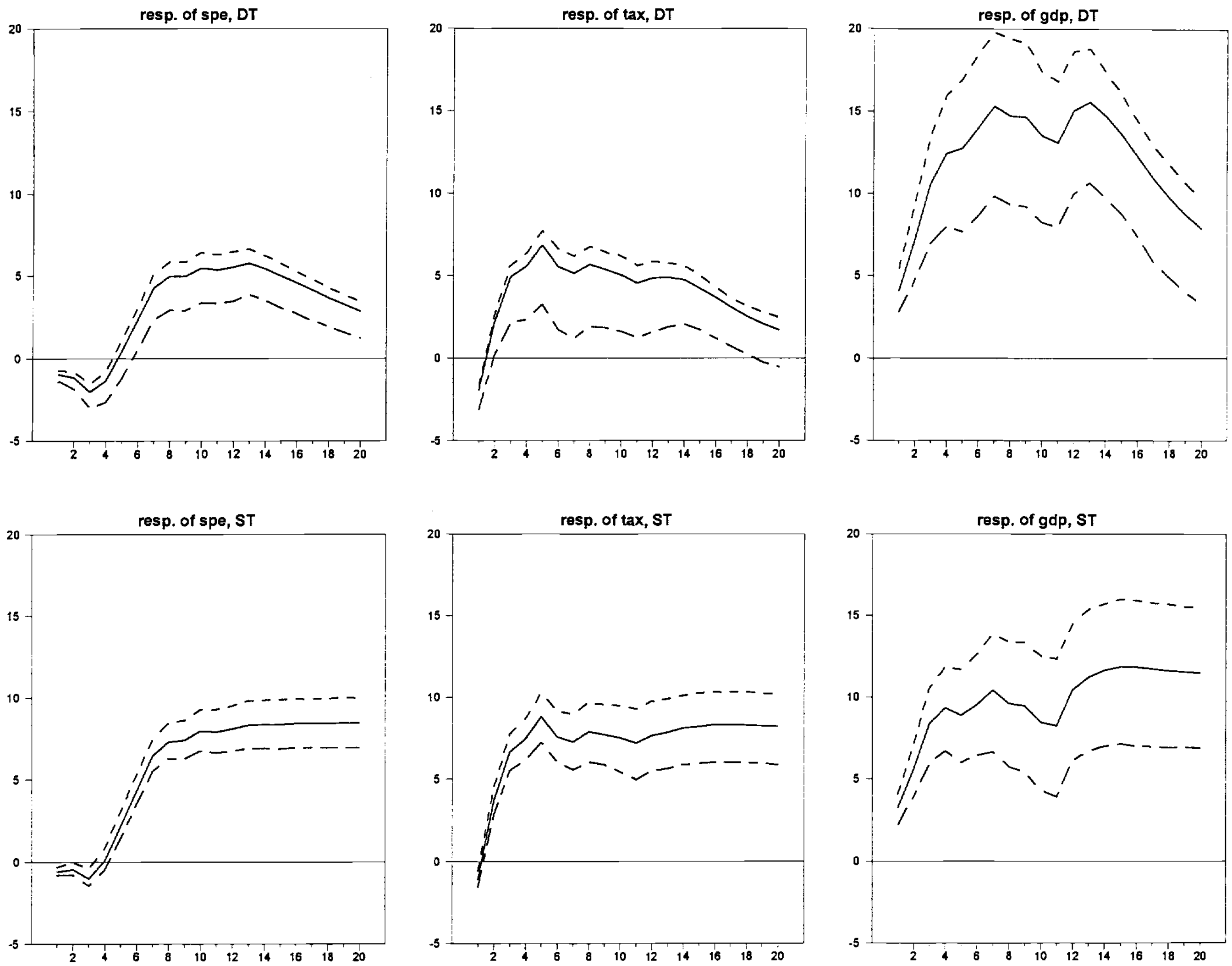

Figure 7: Response to a shock to the 1950:1 dummy

7 gives the deviations of taxes and spending from normal, starting in 1950:1, and the associated deviation of output, as captured by the coefficients on the 13 dummies and their dynamic effects through the VAR dynamics.

The figure shows an initial fall in taxes, followed by a strong increase, which after the first 2 quarters, largely mimics the path of GDP. This captures the large tax cut of 1950:1, and the larger tax increases of 1950:2 and 1950:3.

Spending initially deviates little from normal, then it increases over time. This captures the large buildup in defense spending associated with the Korean war, starting in 1951:1, and continuing until 1952:2.

We can then think of the path of GDP as the response of GDP to this complex path of taxes and spending. The response of GDP shows an initial increase—presumably to the initial tax cut—followed by further increases—presumably in response to the Korean war buildup. The effects of spending and taxes appear larger than in the post-1960 sample. In the DT case, the maximum increase in output is more than 2.5 times the maximum increase in spending (and this despite the fact that the increase in spending comes with a nearly equal increase in taxes). In the ST case, this ratio is smaller, but still equal to 1.5.

8.2 Defense vs. non-defense spending

Another way of approaching the difference between the 1950s and the rest of this sample is to note that the 1950s were dominated by shocks to defense spending, while the rest of the sample is dominated by shocks to non-defense spending. Hence, by dividing government spending between its defense and non-defense components, we can hope to capture explicitly the different persistence of the spending shocks in the early 1950s and in the rest of the sample.

Following this approach, Table 8 and Figures 8 and 9 display the impulse responses from a four-variable VAR, with defense and non defense government spending on goods and services replacing aggregate government spending on good and services. The system also includes the 1975:2 dummy variable and its first four lags.

The contemporaneous correlation between the two shocks to defense and non-defense spending is small —0.18—so the order of the first two variables makes virtually no difference to the results. We report the results in 8 so the variable whose effect is studied is ordered first. In general, the standard error bands for the GDP response are larger when we shock non-defense spending,

Table 8: Defense and non-defense, 1949:1-1997:4 sample.

	1qrt	4qrts	8qrts	12qrts	20qrts	peak
			DT, DEF			
GDP	0.87*	2.43*	2.37*	1.90*	1.06*	2.50*(6)
DEF	1.00*	1.48*	1.13*	0.63*	0.09	1.48*(4)
CIV	0.16*	0.28*	0.29*	0.27*	0.19*	0.29*(8)
TAX	0.10	0.61*	0.65*	0.51*	0.31*	0.70*(5)
			DT, CIV			
GDP	0.72*	2.10*	2.61*	1.98*	1.23*	2.67*(7)
DEF	0.21*	-0.19*	-0.26*	-0.22	-0.41*	0.21*(1)
CIV	1.00*	0.76*	0.61*	0.55*	0.45*	1.00*(1)
TAX	-0.15	0.40*	1.11*	0.86*	0.61*	1.11*(8)
			ST, DEF			
GDP	0.82*	1.78*	1.57*	1.69*	1.67*	1.91*(3)
DEF	1.00*	1.84*	2.00*	1.98*	1.99*	2.00*(7)
CIV	0.07*	0.23*	0.21*	0.21*	0.20*	0.23*(4)
TAX	0.25*	0.67*	0.61*	0.65*	0.64*	0.88*(2)
			ST, CIV			
GDP	0.29	0.22	1.03	0.73	0.75	1.03 (8)
DEF	0.08	-0.79*	-1.47*	-1.39*	-1.42*	0.08 (1)
CIV	1.00*	1.01*	0.91*	0.90*	0.91*	1.03*(5)
TAX	-0.39*	-1.19*	-0.32	-0.50	-0.50	-0.32 (8)

All reduced form equations include lags 0 to 4 of the 1975:2 dummy. Sample: 1949:1 - 1997:4. See also notes to Table 3.

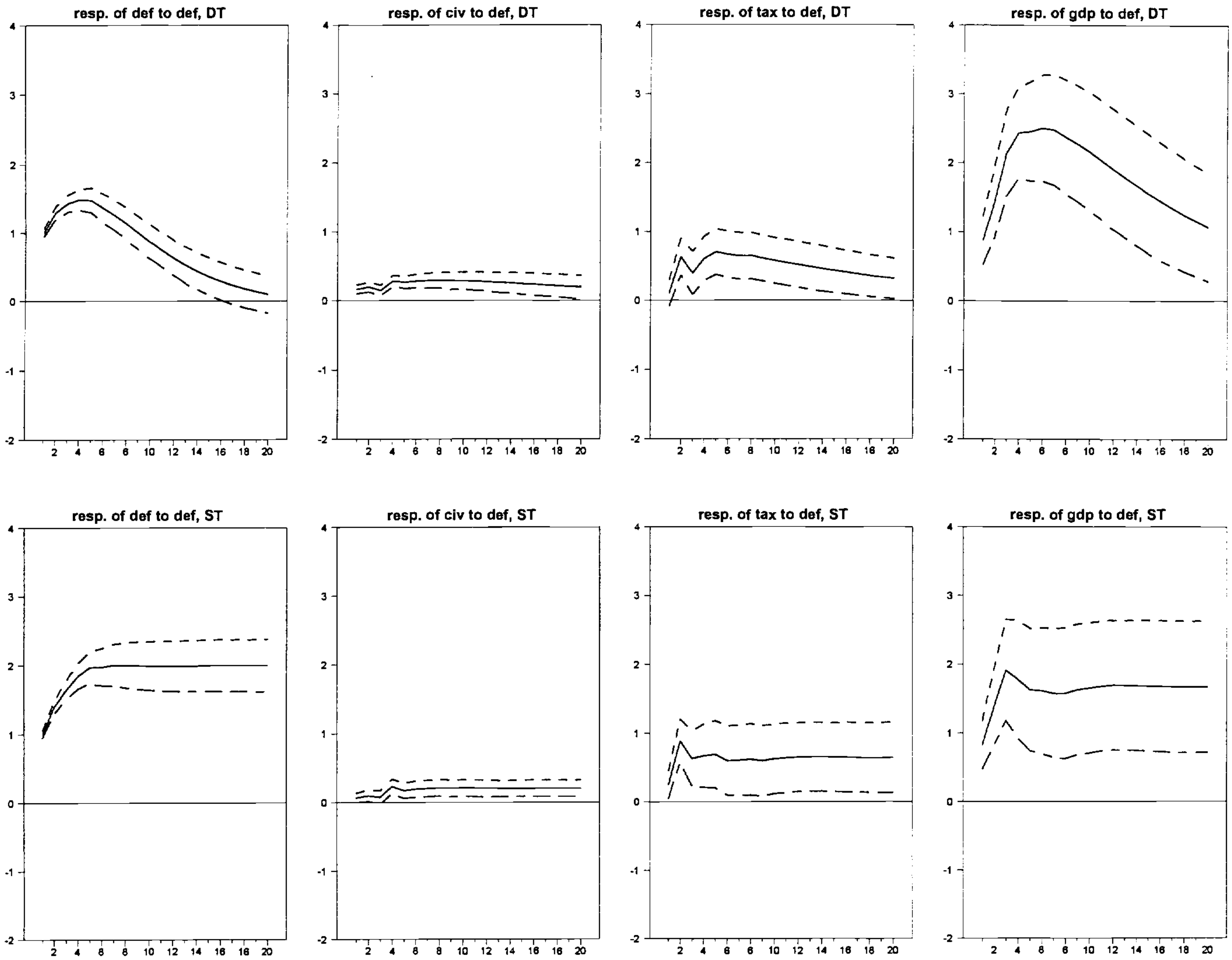

Figure 8: Response to a defense spending shock

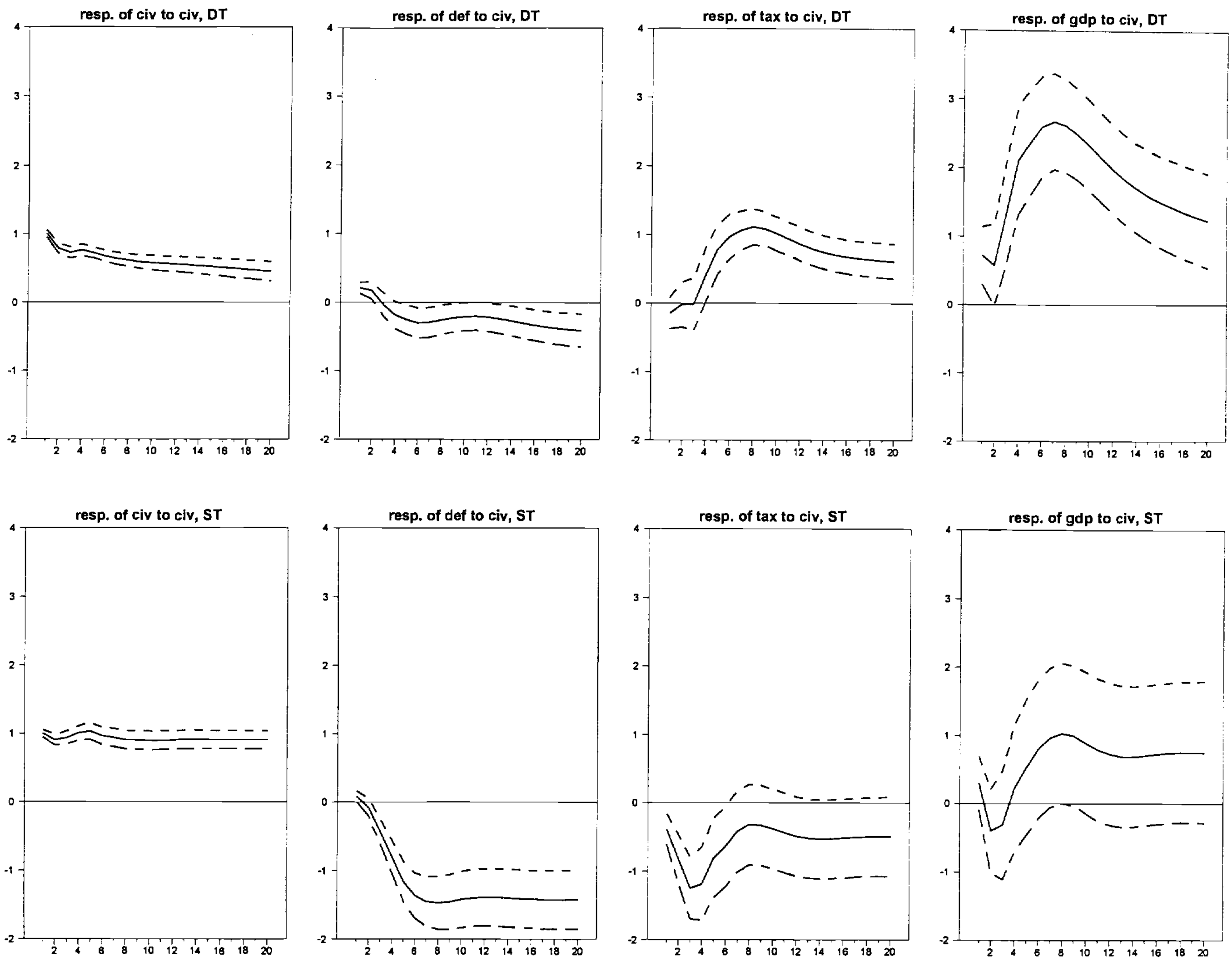

Figure 9: Response to a non-defense spending shock

reflecting the fact that the standard deviation of the latter is about half the standard deviation of defense spending.

Under DT, we obtain large and similar multipliers for defense and non-defense spending — 2.50 and 2.67, respectively —, with a bell-shaped output response in both cases. The persistence of the two spending shocks is indeed very different: defense spending keeps increasing considerably for one year after the initial shock, while non-defense spending starts falling immediately after the shock. Note also that, after a few quarters, defense spending declines substantially in response to a non-defense shock, while the response of non-defense spending stabilizes at about 0.20 after a defense shock.

Under ST, the responses to a defense shock display a similar picture— the output response is smaller and the spending response stronger and more persistent. But the output response to a non-defense shock is now small and always insignificant, despite the fact that non-defense own response is stronger and more persistent. The likely explanation is in the estimated defense response, which becomes negative very soon and exceeds, in absolute value, the response of non-defense spending. At the moment, we do not have an explanation for this lack of robustness of the impulse responses to non-defense shocks across the DT and ST specifications.

8.3 Discussion

This is the place to compare our results to those of Fatas and Mihov [1998], Rotemberg and Woodford [1992], Ramey and Shapiro [1997], and Edelberg et al. [1998]. All of these studies except Fatas and Mihov [1998] study the response of output to defense spending shocks.

The first two studies estimate impulse responses of output to fiscal variables innovations estimated from VAR's. In both cases the identification procedure differs somewhat from ours.

Fatas and Mihov's specification is closest to our benchmark: Their VAR includes output, the GDP deflator, the ratio of the primary deficit to GDP, and the interest rate; their sample starts in 1960:1. Identification is achieved by assuming that the "sluggish" private sector variables, output and prices, do not respond to changes in policy within a quarter; this, in a sense, is the exact opposite of our approach. An increase in the primary deficit by 1 percentage point of GDP leads to an increase in GDP by about 1 percentage point after about two years, while the primary deficit goes back to trend very quickly. If we interpret the increase in the primary deficit as coming from an increase in spending, then their estimated spending multiplier is similar to what we find over the same sample (see Table 4, DT), although our spending shocks are much more persistent.

Rotemberg and Woodford's specification is closest to our defense/non defense decomposition. They trace the effects of military spending and military employment shocks on output by Choleski-decomposing a four-variable VAR in personnel military expenditure, military purchases, output, and the real wage. They do not control for other spending or for taxes. Their sample covers 1947 to 1989. The estimated impact elasticity of private GDP to military purchases (when ordered first) is about 0.1, which implies an impact multiplier above 1.0 (the average ratio of military purchases to GDP has been below 10 percent after WWII), and a bit larger if one considers total GDP, as we do. This effect persists for about 4 quarters, and dies out completely after 8 quarters. Thus, they find a smaller defense multiplier than we do.

The last two studies are closest to our event study approach. Ramey and Shapiro and Edelberg, Eichenbaum and Fisher adopt a 'narrative approach' exploiting the exogeneity of military buildups. They define one dummy variable taking the value of 1 in 1950:3, 1965:1, 1980:1, and trace out its effects on a number of macroeconomic variables, including GDP. Ramey and Shapiro do so in the context of univariate models, Edelberg, Eichenbaum and Fisher in the context of a VAR.

Both sets of authors find a roughly coincidental increase of defense spending and of GDP. Based on the graphs in Edelberg, Eichenbaum and Fisher, defense spending peaks after two years at about 2.5 percentage points of GDP, and slowly declines thereafter. GDP peaks after 4 quarters at about 3.5 percent, and then goes back to trend within 2 or 3 years. Because their estimated initial increase in spending is small, the defense spending multiplier, defined as we do as the ratio of the peak response of GDP to the initial spending shock, appears to be about 28; if the multiplier is defined as the maximum increase in GDP to the maximum increase in spending, it is about 1.4.

Assuming the episodes that are captured by the dummy variable approach are truly exogenous, the advantage of their approach is that one does not need to identify the VAR in order to trace out the effects of the dummy variable. But when the dummy variable incorporates episodes with different characteristics, it is not clear exactly what response one is estimating when tracing the effects of a shock to the dummy. And the episodes appearing in the Ramey and Shapiro dummy do differ greatly, in terms both of size and of the accompanying tax policy: the Korean war buildup was accompanied by large tax increases, the (much smaller) Reagan buildup by tax cuts.

9 Effects on output components

9.1 The system

We now go back to the post-1959 sample, and decompose the output effects of tax and spending shocks into the effects on each component of GDP. This exercise is interesting in itself, and also because it helps sort out the relative merits of alternative theories. For instance, both standard neoclassical and Keynesian models imply a positive effect of government spending on output. However, neoclassical models usually predict a negative effect on private consumption (see e.g. Baxter and King [1993]), while Keynesian models usually predict the opposite sign.

We estimate a four-variable VAR, with the component of GDP whose response we are studying ordered last. The relation between residuals now becomes

$$\begin{aligned} t_t &= a_1\, x_t + a_2\, e_t^g \ + e_t^t \\ g_t &= b_1\, x_t + b_2\, e_t^t \ + e_t^g \\ x_t &= c_1\, t_t + c_2\, g_t \ + e_t^x \\ x_{i,t} &= d_1\, t_t + d_2\, g_t \ + e_t^{x_i} \end{aligned} \tag{5}$$

where "$x_{i,t}$" indicates a component of GDP, so e_t^x and $e_t^{x_i}$ are in general be correlated.

9.2 Response to a tax shock

Table 9 displays a summary of the impulse response of the various GDP components to a net tax shock, under DT and ST. The impulse responses of aggregate GDP and government spending change with each component added to the VAR, raising the issue of which one to report; in the first two lines in each case, we give the response of GDP and government spending from the three-variable model (see Table 4). The last line in each case displays the unconstrained sum of the responses of the individual components of GDP, which is denoted by 'SUM'.

Table 9: Responses of GDP components.

	1qrt	4qrts	8qrts	12qrts	20qrts	peak
			DT, TAX			
GDP	-0.69*	-0.74*	-0.72*	-0.42*	-0.22	-0.78*(5)
GCN	-0.05*	-0.12*	-0.24*	-0.26*	-0.16*	-0.05*(1)
CON	-0.18*	-0.35*	-0.32*	-0.23*	-0.20*	-0.35*(5)
INV	-0.36*	-0.00	-0.00	0.18*	0.16*	-0.36*(1)
EXP	-0.02	0.01	-0.01	0.02	0.05	-0.08 (3)
IMP	-0.01	0.02	-0.14*	-0.06	0.04	-0.14*(7)
SUM	-0.60	-0.48	-0.43	-0.23	-0.18	-0.60 (1)
			ST, TAX			
GDP	-0.70*	-1.07*	-1.32*	-1.30*	-1.29*	-1.33*(7)
GCN	-0.06*	0.04*	-0.01*	-0.00*	-0.00*	0.04*(4)
CON	-0.15	-0.40*	-0.44*	-0.43*	-0.43*	-0.44*(7)
INV	-0.35*	-0.22	-0.30	-0.27	-0.27	-0.35*(1)
EXP	-0.00	-0.01	-0.06	-0.07	-0.07	-0.10 (3)
IMP	-0.01	-0.02	-0.12	-0.12	-0.11	-0.13 (3)
SUM	-0.55	-0.57	-0.68	-0.66	-0.66	-0.73 (6)
			DT, SPE			
GDP	0.84*	0.45	0.54	1.13*	0.97*	1.29*(15)
GCN	1.00*	1.14*	0.95*	0.70*	0.42*	1.14*(4)
CON	0.50*	0.63*	0.91*	1.21*	0.90*	1.26*(14)
INV	-0.03	-0.75*	-0.69*	-0.41*	-0.35*	-1.00*(5)
EXP	0.20*	-0.47*	-0.76*	-0.70*	-0.06	-0.80*(9)
IMP	0.64*	-0.19*	-0.46*	-0.42*	-0.16*	-0.49*(9)
SUM	1.03	0.74	0.86	1.22	1.07	1.39 (15)
			ST, SPE			
GDP	0.90*	0.55	0.65	0.66	0.66	0.90*(1)
GCN	1.00*	1.30*	1.56*	1.61*	1.61*	1.00 (1)
CON	0.33*	0.34	0.42	0.43	0.44	0.46*(2)
INV	0.02	-0.74*	-0.97*	-0.96*	-0.95*	-0.98*(9)
EXP	0.17*	-0.16	-0.30	-0.37*	-0.37	-0.37*(13)
IMP	0.56*	0.03	-0.06	-0.05	-0.04	-0.08 (9)
SUM	0.95	0.72	0.77	0.76	0.78	0.95 (1)

Sample: 1960:1 - 1997:4. See also notes to Table 3.

Under DT, an increase in taxes reduces all the private components of GDP. After a small decline on impact, private consumption falls by a maximum of 0.35 (35 cents) after 5 quarters; investment falls by 0.36 on impact and then increases to become marginally positive after 2 years. The negative effect on imports and exports is very small. The sum of the responses of the components of GDP is not too far from the response of GDP in the 3-variable system.

A similar picture emerges under ST, with very similar peak negative responses of private consumption and investment, and again small responses of imports and exports. However, the difference between the GDP response in the 3-variable model and the sum of the responses of its components is more pronounced.

9.3 Response to a spending shock

The next two panels in Table 9 display the responses to an increase in government spending. The peak responses of each component are considerably larger than in the case of tax shocks.

Under DT, on impact private consumption increases by 0.50 (50 cents), while investment does not move; imports and exports now react strongly, increasing by 0.64 and 0.20, respectively. The positive effect on consumption builds up for 14 quarters, reaching a peak of 1.26; investment declines for the first 5 quarters, with a peak crowding out effect of 1. After the initial surge, exports start declining with a maximum negative effect of 0.80 after 9 quarters; similarly, after an initial positive impact imports start declining and reach a negative peak of 0.49 after 9 quarters. All these responses are precisely estimated, and the unconstrained sum of the responses is close to the impulse response of GDP in the 3-variable system.

Under ST, the basic picture is qualitatively similar, but the peak responses of consumption, imports and exports are weaker; the standard error bands for these components also become wider. Note that in this case also the output response is very close to the sum of the responses of the individual components.

Thus, we find that private consumption is consistently crowded out by taxation, and crowded in by government spending. Perhaps more surprisingly, we consistently find a considerable crowding out of investment both by government spending and to a lesser degree by taxation; this implies a strong negative effect on investment of a balanced-budget fiscal expansion.

The effects of fiscal policy on investment are clearly inconsistent with a standard Keynesian approach. In the standard Keynesian model, an increase in spending may increase or decrease investment depending on the relative strength of the effects of the increase in output and the increase in the interest rate; but, in either case, increases in spending and taxes have opposite effects on investment. This is not the case empirically. Interestingly, using a yearly panel VAR on 20 OECD countries over the same period, Alesina et al. [1999] reach the same conclusion on the effects of fiscal policy on investment. Note also the decline in imports (after a brief initial surge), which is also rather surprising in light of the considerable increase in GDP.

10 Conclusions

Our main goal in this paper was to characterize as carefully as possible the response of output to the tax and spending shocks in the post-war period in the United States. From the several specifications we have estimated and the different exercises we have performed, we reach the following conclusions:

The first is consistent with standard wisdom: When spending increases, output increases; when taxes increase, output falls. The others are perhaps more surprising:

In most cases the multipliers are small, often close to one. In the case of spending shocks, the proximate explanation is in the opposite effects they have on the different components of output: While private consumption increases following spending shocks, private investment is crowded out to a considerable extent. Both exports and imports also fall.

The responses of investment and imports are difficult to reconcile with most macroeconomic theories; thus, while we do not attempt an explanation here, we believe they certainly deserve further investigation.

Appendix

A.1 The data

All the data, unless otherwise noted, are from the *National Income and Product Accounts*. The Citibase mnemonics are given in parentheses. FG stands for Federal Government; SLG stands for State and Local Governments.

Government spending:
Purchases of goods and services, FG (GGFE) + Purchases of goods and services, SLG (GGSE).

Net taxes:
Receipts, FG (GGFR)[26] + Receipts, SLG (GGSR) [27] - Federal grants-in-aid (GGAID) - Net transfer payments to persons, FG (GGFTP) - Net interest paid, FG (GGFINT) - Transfer payments to persons, SLG (GGST) - Net interespt paid, SLG (GGSINT) + Dividend received by government, SLG (GGSDIV).

Defense spending:
Purchases of goods and services, national defense, FG (GGFEN).

A.2 Elasticities

To construct the aggregate net tax elasticity to GDP, a_1, we consider four categories of taxes: indirect taxes (IND), personal income taxes (INC), corporate income taxes (BUS), and social security taxes (SS). For each category, we construct the elasticity to GDP (X) as the product of the tax elasticity to its own base, η_{T_i,B_i}, and the elasticity of the tax base to GDP, $\eta_{B_i,X}$ (see expression (3) in the text). For each tax, we must also take into account the possible presence of collection lags and of quarter dependence.

[26]For the corporate income tax, the NIPA report only taxes on an accrual basis. We therefore replace coprorate income taxes from NIPA with corporate income tax receipts from the Quarterly Treasury Bulletin. We do not have this series for the state and local governments.

[27]Corporate income taxes collected by state and local governments are not included.

On the expenditure side, we also construct an approximate output elasticity of total transfers. The rest of this section describes our assumptions.

Indirect taxes.

We take the tax base to be GDP. (This is an approximation. In many states, food consumption is excluded. In most states, the sale of materials to manufacturers, producers and processors is also excluded (see Advisory Committee of Intergovernmental Relations [1995]). Hence:

$\eta_{B_{IND},X} = 1.0$
$\eta_{IND,B_{IND}} = 1.0$ (from Giorno et al. [1995])

Collection lags: 0.
Quarter dependence: none.

Personal income taxes.

We start from the formula for the elasticity to GDP from Giorno et al. [1995]. Let $T = t(W)W(E)E(X)$, where T is total revenues from the personal income tax, t is the tax rate, W is the wage (or earnings, in the OECD terminology), E is employment and X is GDP. Define the tax base as $B_{INC} = w * E$. Assuming constant elasticities everywhere, define:

elasticity of taxes to earnings: $D = d\log(tW)/d\log W$
elasticity of earnings to employment: $F = d\log W/d\log E$
elasticity of employment to output: $H = d\log E/d\log Y$

Totally differentiating the expression for total tax revenues,after some steps one obtains:

$\eta_{B_{INC},X} = \text{H}/(\text{F}+1)$
$\eta_{INC,B_{INC}} = (\text{FD}+1)/(\text{F}+1)$

We obtain values of D from Giorno et al. [1995]. We estimate F from a regression of the log change of the wage of production workers on the first lead and lags 0 to 4 of the log change in employment of production workers. We estimate H from a regression of the log change of employment of production workers on the first lead and lags 0 to 4 of the log change in output. The values of F and H are the estimated coefficients of lag zero of the dependent variable. We find $F = .62$ and $H = .42$.

Collection lags: 0.
Quarter dependence: none.

Note that for personal income taxes we assume the same elasticity for employees and self-employed: the former have their taxes withheld at the source, while the latter make quarterly payments based on the estimated income of that quarter. As long as there is no systematic pattern in the end-year adjustments (as it should be, if the tax system is well designed), our assumption does not introduce any substantial bias in our aggregate elasticity.

Social security taxes.
We follow exactly the same procedure as for personal income taxes. The only difference is in the value of the elasticity of taxes to earnings, D, which we also obtain from Giorno et al. [1995].

Corporate income taxes.
Each corporation can have its own fiscal year different from the tax year. Large corporations are required to make quarterly installment payments, of at least .8 of the final tax liability. No penalty was applied if the estimated tax liability is based on the previous year's tax liability; this exception has been gradually phased out from 1980 on. Hence:

$\eta_{B_{BUS},X}$: we estimate it as the lag 0 estimated coefficient from a regression of quarterly changes of corporate profits on the first lead and lags 0 to 4 of changes in output.
$\eta_{BUS,B_{BUS}}$: Giorno et al. [1995] gives a value of 1 for the annual elasticity. This would be the right value of the quarterly elasticity for tax accruals. For tax receipts, we estimate it from a regression of tax receipts on the first four lags of tax accruals, allowing for a different coefficient when the dependent variable is measured in the second quarter, and constraining the coefficients on the first four lags to be the same. Our value for $\eta_{BUS,B_{BUS}}$ is this constrained coefficient on the first four lags. We obtain a value of .85 from this procedure.

Collection lags: yes. This follows from the fact that we use a value of .85 for

$\eta_{BUS,B_{BUS}}$, as explained above. This value appears stable over time.
Quarter-dependence: yes. (for the same reason as above)

Transfers.

Among transfers, unemployment benefits certainly have a large within-quarter elasticity to the cycle. However, unemployment benefits are a relatively small component of transfers: in 1993, unemployment expenditures (defined as the sum of 'active' and 'passive' measures) represented 2 percent of total expenditure in the United States. Other categories of transfers might be sensitive to the cycle. We do not have reliable quarterly data for our sample on the components of transfers that might be sensitive to the cycle. Therefore, we use a value of -.2 for the elasticities of total tranfers to GDP. This is just a gross approximation based on the *annual* GDP elasticity estimated by the OECD for total current expenditure, -.1. As the effects are small to start with, and given our results on robustness reported in the text, this is unlikely to make any significant difference to our results.

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