Estimating the effects of fiscal policy in OECD countries

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Abstract

This paper studies the effects of fiscal policy on GDP, inflation and interest rates in 5 OECD countries, using a structural Vector Autoregression approach. Its main results can be summarized as follows: 1) The effects of fiscal policy on GDP tend to be small: government spending multipliers larger than 1 can be estimated only in the US in the pre-1980 period. 2) There is no evidence that tax cuts work faster or more effectively than spending increases. 3) The effects of government spending shocks and tax cuts on GDP and its components have become substantially weaker over time; in the post-1980 period these effects are mostly negative, particularly on private investment. 4) Only in the post-1980 period is there evidence of positive effects of government spending on long interest rates. In fact, when the real interest rate is held constant in the impulse responses, much of the decline in the response of GDP in the post-1980 period in the US and UK disappears. 5) Under plausible values of its price elasticity, government spending typically has small effects on inflation. 6) Both the decline in the variance of the fiscal shocks and the change in their transmission mechanism contribute to the decline in the variance of GDP after 1980.

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1 Introduction

While most economists would agree that an exogenous 10 percent increase in money supply will lead to some increase in prices after a while, perfectly reasonable economists can and do disagree even on the basic qualitative effects of fiscal policy. For instance, neoclassical models predict that private consumption should fall following a positive shock to government consumption, while keynesian and some (though not all) neokeynesian models predict the opposite. It would seem that empirical evidence is what is needed to make further progress. Yet, time series methods that have long been standard in the analysis of monetary policy have been applied to the study of fiscal policy only recently, and almost exclusively on US data. In this paper, I extend the structural Vector Autoregression methodology developed in Blanchard and Perotti [2002] to study the effects of fiscal policy in five countries for which I was able to assemble sufficiently detailed, non-interpolated quarterly data on the budget of the general government: the US, West Germany, the UK, Canada, and Australia. Besides studying the effects of fiscal policy on GDP and its components, I also focus on its effects on prices and interest rates.

Vector Autoregression investigations of fiscal policy in the US include Ramey and Shapiro [1997], Edelberg, Eichenbaum and Fisher [1999], Fatás and Mihov [2001], Blanchard and Perotti [2002], Canova and Pappa [2002], Canzoneri, Cumby and Diba [2002], Mountford and Uhlig [2002], Burnside, Eichenbaum and Fisher [2003], and Galí, López-Salido and Vallés [2003].[1] I discuss the main methodological aspects of these papers in section 2; in sections 5, 8, 9, and 10, I compare their empirical findings to mine.

A growing recent literature suggests that the transmission mechanism of monetary policy, or the covariance structure of the shocks to the economy, or both, have changed substantially over time.[2] If the change is assumed to take the form of a single structural break, a consensus seems to have emerged that it might be located around 1980, although a precise date is difficult to pin down. This date also falls within confidence intervals frequently estimated for structural breaks in several macroeconomic variables and relations (see e.g. Blanchard and Simon [2001] or Stock and Watson [2002]). This or a slightly earlier breakdate typically also emerge from different implementations of sup-Wald tests performed on each reduced form equation of my estimated VARs.

I find evidence of large differences in the effects of fiscal policy pre- and post-1980. Finding the reasons for these changes is a difficult exercise, which must confront the Lucas critique at every step. In this paper, I do not attempt to overcome these problems by constructing a structural model that can be used for policy simulations and that can be

[1] Favero [2002] and Marcellino [2002] estimate fiscal policy VARs using half-yearly data from four European countries: France, Italy, Spain, and Germany. In the first three countries, however, a large part of government budget data are interpolated from annual figures.

[2] See, among others, Cogley and Sargent [2001] and Boivin and Giannoni [2002]; for a partially contrarian view, see Sims [2001]. For evidence on countries other than the US, see Stock and Watson [2003] and the literature cited therein.

matched to the estimated impulse responses. However, I do conduct several exercises that are potentially informative in the short run, essentially by computing the impulse response to a certain shock while imposing a particular set of structural shocks to certain variables over the horizon of the simulation (see Sims [1999] for a defense of this method).

The main conclusions of the analysis can be summarized as follows: 1) The estimated effects of fiscal policy on GDP tend to be small: positive government spending multipliers larger than 1 can be estimated only in the US in the post-1980 period. 2) There is no evidence that tax cuts work faster or have higher multipliers than spending increases. 3) The effects of government spending shocks and of tax cuts on GDP and its components have become substantially weaker over time: in particular, in the post-1980 period significantly negative GDP, private consumption and especially private investment multipliers of government spending are the norm. 4) Because of the method sometimes used to record purchases of capital goods by the government in National Income Accounts, there can be a mechanical negative correlation between government investment and private inventories. But even when private inventories are excluded, the response of private investment to government spending shocks remains small or zero in the pre-1980 period, and negative in the post-1980 period. 5) It is difficult to find consistently positive effects of government spending shocks on nominal and real long interest rate in the pre-1980 period. In the post-1980 period, positive effects are more common. 6) In fact, when the real interest rate is held constant in the impulse responses, much of the decline in the response of GDP in the post-1980 period disappears. 7) To understand the effects of fiscal policy on prices, the price elasticity of government revenues and spending is crucial, an issue that has not been widely appreciated. Once plausible values of the price elasticity of government spending are imposed, the negative effects of government spending on prices that have been frequently estimated largely disappear; if positive, they usually remain small and rarely significant. 8) Both the decline in the variance of the fiscal shocks and the change in their transmission mechanism contribute - in some cases for non-negligible amounts - to the decline in the variance of GDP documented in most OECD countries after 1980.

The plan of the paper is as follows. Section 2 presents the identification strategy apply in the paper and briefly reviews alternative approaches to identification of fiscal shocks. Section 3 discusses some possible objections to the methodology used here. To evaluate them, it studies in some detail the methodology applied to construct the government budget data in National Income Accounts, an issue that has received little attention in the recent empirical literature. Section 4 describes the data and how the elasticities of government spending and taxes to output and inflation are constructed. The estimated effects of government spending and net taxes on GDP are presented in Sections 5 and 6. Section 7 compares the effects of spending and tax shocks, and discusses the effects of deficit shocks. Section 8 discusses the effects of fiscal shocks on private consumption and investment. Sections 9 and 10 present the responses of interest rates and inflation. Section

11 studies how changes in the variance of fiscal shocks and of the transmission mechanism of fiscal shocks over time translate into changes in the variance of GDP. Section 13 reviews the main competing models of fiscal policy, and discusses how well they can explain the main findings of the paper. It also explores a few possible explanations for the change in the effects of fiscal policy documented in the paper. Appendix A provides further details on the data, Appendix B on the construction of the tax elasticities.

2 The methodology

2.1 Specification and identification

Consider the benchmark specification, a VAR that includes the following 5 variables: the log of real government spending on goods and services per capita g_t ("government spending" or "spending" for short)[3], the log of real net primary revenues per capita ("net taxes" or "taxes" for short; defined as government revenues less government transfers, both net of property income) t_t,[4] the log of real output per capita y_t, the GDP deflator inflation rate π_t, and the 10-year nominal interest rate i_t.[5] Denoting the vector of endogenous variables by X_t and the vector of reduced form residuals by U_t, the reduced form VAR can be written as:

$$X_t = A(L)X_{t-1} + U_t, \tag{1}$$

where $X_t \equiv [g_t \quad t_t \quad y_t \quad \pi_t \quad i_t]'$ and $U_t \equiv [u_t^g \quad u_t^t \quad u_t^y \quad u_t^\pi \quad u_t^i]'$. All equations include four lags of each endogenous variable. The benchmark specification also includes a constant, quarterly dummies, and a linear time trend, all omitted from the notation for simplicity.

The reduced form residuals of the g_t and t_t equations, u_t^g and u_t^t, can be thought of as linear combinations of three components. First, the *automatic response* of taxes and government spending to innovations in output, prices and interest rates: for instance, the unanticipated changes in taxes in response to output innovations, for given tax rates. Second, the *systematic discretionary response* of policymakers to output, price and interest rate innovations; for instance, reductions in tax rates implemented systematically

[3]This variable includes current purchases (government consumption) and capital purchases (government investment). In turn, government consumption can be divided into a wage and a non-wage component.

[4]This two-way breakdown of the government budget is obviously only one of many possible. Most models predict that government spending on goods and services has different effects than transfers: only the former impacts directly on the use of resources. Summing algebraically taxes and transfers makes sense if one believes that in the short- and medium run fiscal policy operates mostly via a demand channel. See Perotti [2004] for a study of the effects of further decompositions of government spending and net taxes.

[5]The long interest rate is included because it is arguably a more important determinant of private consumption and investment than the short interest rate.

in response to recessions. Third, *random discretionary shocks* to fiscal policies; these are the "structural" fiscal shocks, which unlike the reduced form residuals are uncorrelated with all other structural shocks.[6] This is also the component one is interested in when estimating impulse responses to fiscal policy shocks.

Formally, and without loss of generality, one can write:

$$u_t^t = \alpha_{ty} u_t^y + \alpha_{t\pi} u_t^\pi + \alpha_{ti} u_t^i + \beta_{tg} e_t^g + e_t^t \tag{2}$$

$$u_t^g = \alpha_{gy} u_t^y + \alpha_{g\pi} u_t^\pi + \alpha_{gi} u_t^i + \beta_{gt} e_t^t + e_t^g \tag{3}$$

where the coefficients α_{jk} capture the other two components and e_t^g and e_t^t are the "structural" fiscal shocks, i.e. $cov(e_t^g, e_t^t) = 0$. Clearly, e_t^g and e_t^t are correlated with the reduced form residuals, hence they cannot be obtained by an OLS estimation of (2) and (3).

The approach adopted here is based on Blanchard and Perotti [2002], extended to take into account the effects of inflation and interest rates on government spending and taxes. The key to identification is the observation that it typically takes longer than a quarter for discretionary fiscal policy to respond to, say, an output shock, hence the *systematic discretionary response* is absent in quarterly data. As a consequence, the coefficients α_{jk} in (2) and (3) capture only the *automatic response* of fiscal variables to economic activity. One can then use available external information on the elasticity of taxes and spending to GDP, inflation and interest rates to compute the appropriate values of the coefficients α_{jk} (see section 4 and Appendix B);[7] with these, one can then construct the cyclically adjusted fiscal shocks:

$$u_t^{t,CA} \equiv u_t^t - (\alpha_{ty} u_t^y + \alpha_{t\pi} u_t^\pi + \alpha_{ti} u_t^i) = \beta_{tg} e_t^g + e_t^t \tag{4}$$

$$u_t^{g,CA} \equiv u_t^g - (\alpha_{gy} u_t^y + \alpha_{g\pi} u_t^\pi + \alpha_{gi} u_t^i) = \beta_{gt} e_t^t + e_t^g \tag{5}$$

which are linear combinations of the two structural fiscal policy shocks. There is little guidance, theoretical or empirical, on how to identify the two structural shocks e_t^t and e_t^g on the r.h.s. of (4) and (5). Therefore, I try both orthogonalizations: in the first, I assume that $\beta_{gt} = 0$ and I estimate β_{tg}; in the second, I assume $\beta_{tg} = 0$ and I estimate β_{gt}. As it turns out, in all cases the correlation between the two cyclically adjusted fiscal

[6] Like all definitions, this one too has an element of arbitrariness. One could argue that, in a sense, all changes in fiscal policy are discretionary: in theory, policymakers can always undo the effects of changes in output and prices on revenues and spending. While this might be true over the long run, with quarterly data the distinction appears meaningful.

[7] Importantly, these values of the elasticities of government revenues and transfers are not estimated, but computed from institutional information on statutory tax brackets, the distribution of taxpayers by income classes, the statutory unemployment benefit, etc.

shocks is very low, hence their ordering does not matter; as a benchmark, I will use the first orthogonalization.[8]

The two structural shocks thus estimated are orthogonal to the other structural shocks of the economy, hence they can be used as instruments in the remaining equations. For instance, assuming that GDP is ordered first among the other variables, one can estimate the "GDP" equation $u_t^y = \gamma_{yt} u_t^t + \gamma_{yg} u_t^g + e_t^y$, using e_t^g and e_t^t as instruments for u_t^t and u_t^g, and similarly for the other equations.[9] Once the structural shocks are identified, the impulse responses are constructed using the average elasticities over the relevant sample periods.[10]

2.2 Comparison with other identification schemes

Schematically, there are three alternative approaches to the identification of fiscal policy shocks in the VAR literature:

(i) The first method - in turn an application of the "narrative approach" of Romer and Romer [1989] to fiscal policy - consists in tracing the effects of a dummy variable capturing the "Ramey and Shapiro" fiscal episodes: the Korean war military buildup, the Vietnam war buildup, and the Reagan fiscal expansion. This is the approach taken by Ramey and Shapiro [1997], and then by Edelberg, Eichenbaum and Fisher [1999] and Burnside, Eichenbaum and Fisher [2003].

The advantages and disadvantages of this approach are well known. If these episodes are truly exogenous and unanticipated, and one is only interested in estimating their effects, there is no need to impose other potentially controversial identifying assumptions: all is needed is a reduced form regression. On the other hand, other substantial fiscal shocks, of different type or sign, might have occurred around the same time, thus polluting the identification of the military build-up shocks.[11]

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[8] Although I consider only the two Choleski orderings, one should recognize that, lacking a theory, really any *rotation* of the two shocks could be assumed. Canova and Pappa [2003] and Mountford and Uhlig [2002] develop an alternative approach based on this idea.

[9] The ordering of the remaining variables is immaterial if one is only interested in estimating the effects of fiscal policy shocks, as it is the case in this paper.

[10] Like the present paper, Canzoneri, Cumby and Diba [2002] also use the Blanchard and Perotti [2002] methodology and extend it to take into account the automatic effects of inflation and interest rate on fiscal policy. Regarding the former, they adopt the methodology that was introduced in the first version of this paper. Regarding the latter, and unlike in the present paper, their definition of net transfers includes interest payments by the government, hence they also carefully estimate the elasticity of net revenues to the interest rate. Their paper covers only the United States, and does not study differences across subsamples, a major focus of the present paper.

[11] For instance, Ramey and Shapiro date the start of the Korean war shock in 1950:3, based on the large observed increase in military spending; but in four quarters between 1948:2 and 1950:3, government spending increased by between two and three standard deviations. It is not obvious how to disentangle the effects of the Korean dummy variable from the delayed effects of these large fiscal shocks.

(ii) A second approach, represented by Canova and Pappa [2002] and Mountford and Uhlig [2002], consists in identifying fiscal shocks by sign restrictions on the impulse responses, following a methodology originally applied by Canova and De Nicolò [2002], Faust [1998] and Uhlig [1999] to monetary policy analysis. For instance, "revenue" shocks are identified by the condition that tax revenues increase while government spending does not, and that all responses such that both tax revenues and GDP increase identify a business cycle shock.

An advantage of this approach is that it can handle anticipated fiscal shocks: the estimated effect on, say, private consumption at time 0 could be the response to a revenue shock that occurs later. However, this approach cannot pin down *when* the shock occurs. A second disadvantage of this approach is that its identifying conditions might be "too strong": for instance, by identifying revenue shocks via the condition that tax revenues and output do not covary positively in response to the shock, the approach rules out by assumption a whole set of "non-keynesian" output responses to fiscal shocks.

(iii) A third approach, represented by Fatás and Mihov [2001] and Favero [2002], essentially relies on Choleski ordering to identify fiscal shocks. In the former, government spending is ordered first: in the latter, fiscal shocks are ordered last. Ordering the fiscal variables first is equivalent to assuming that all automatic elasticities of fiscal variables to GDP, inflation and interest rates are equal to 0. Ordering the policy instrument after GDP is common in monetary policy VAR's with monthly data (see e.g. Bernanke and Mihov [1998]), based on the notion that changes in the Federal Fund rate take more than a month to have effects on GDP. But extending this assumption to fiscal policy VAR's is highly questionable: because government spending is a component of GDP, this assumption imposes an implicit assumption of exactly 100 percent crowding out contemporaneously on private GDP. Similarly, taxes are a component of disposable income: ruling out *a priori* any contemporaneous effect on, say, private consumption seems an implausibly strong assumption.

3 What do quarterly fiscal shocks and impulse responses represent?

How to interpret the fiscal policy innovations u_t^t and u_t^g? I now consider some possible objections to the interpretation of these variables as exogenous differences between private sector expectations and realizations of government spending and taxes. The first three objections refer to the nature of fiscal policy decisions; the last two to the role of expectations of fiscal policy. I cast the discussion mostly in terms of government purchases of goods and services, although much of it applies also to government revenues.

Objection 1: There is just one fiscal shock per year. *There is just one well* *publicized fiscal "event" per year – the yearly budget.*

However, in all countries supplements to the budget are possible at any time, and there is often a meaningful mid-year budget. In addition, throughout the year many decisions are taken that affect the fiscal policy outcome of the current fiscal year - for instance, signing a new collective agreement with government employees, changing welfare benefits, or scrapping the development of a military aircraft.

Ultimately, this is an empirical issue. Since 1984 the Congressional Budget Office publishes forecasts of changes in government spending and revenues for the current year and the following 5 years, in the *Budget and Economic Outlook* (issued between January and March, thus often incorporating the President's Budget proposals which are issued by February) and in its *Update* (typically issued between July and September, hence usually before the passage of the Budget by Congress). Table 1 displays the average absolute revisions, as shares of GDP, in spending and revenues forecasts for years j and $j+1$ due to legislation, from the February and August publications of year j.[12] As one can see, the

Table 1: **Absolute changes in CBO forecasts, US spending and revenues**

	Feb. of yr. j	Aug. of yr. j	Feb. of yr. j	Aug. of yr. j
	for yr. j	for yr. j	for yr. j+1	for yr. j+1
mean abs. revision, spending	.17	.07	.20	.10
standard deviation	.035	.017	.061	.020
mean abs. revision, revenues	.06	.07	.07	.08
standard deviation	.024	.042	.031	.032

Source: Congressional Budget Office: *The Budget and Economic Outlook*, and *The Budget and Economic Outlook Update*, various issues. Revenues and spending are shares of GDP. Sample: 1984:1 - 2003:1.

average revenue revision is almost exactly the same in the two publications; the average spending revision is about double in February than in August, but with one exception they are all statistically significant.

Objection 2: VAR-based innovations are just delivery or cash shocks. *The present discounted value of government spending over, say, the lifetime of a military acquisition program is fixed in advance and therefore predictable; it is the timing of the actual cash disbursements or deliveries in each quarter that is partly unpredictable. But in a world with perfect credit markets, changes in the timing of deliveries or cash disbursements, which do not affect the timing and quantity of the inputs used, have little or no effect on real private sector variables. Hence, these "delivery" or "cash" shocks are*

[12] I thank Alan Auerbach for providing the data.

essentially noise.[13]

To study this issue, it is important to consider how government budget variables are recorded in the National Income Accounts, the source of the government sector data used in this paper. The 1993 System of National Accounts (which is currently followed by all the countries in this sample)[14] is based on the **accrual principle**: taxes are recorded at the time of the activity that generates the obligation to pay them (for instance, when the income is earned), and similarly for government spending. In practice, however, the alternative **cash principle**, or some variant thereof, is often used: taxes and spending are recorded at the time the cash transaction occurs (for instance, when a tax is actually paid). Table 2, based on national sources, describes how each type of purchase is recorded *de facto* (see Perotti [2003] for details).

For our purposes, it is useful to distinguish the two broad categories we have used so far, government spending on goods and services and net taxes.

(i) Purchases of goods and services

Purchases of goods and services by the government involve the use of inputs to produce the good or to provide the service. In turn, for our purposes they can be divided into three broad categories: *(i.a) Purchases of services (government wages); (i.b) Purchases of goods with short production processes; (i.c) Purchases of goods with long production processes.*

The first two items are usually recorded on a cash basis - at the time of payment for the good or the service - or on a "time-adjusted cash payment" basis to approximate accrual.[15] In either case the difference between the time of recording of the payment and the time of input use is likely to be small.

The conclusion is different for goods with long production processes purchased by the government – mostly machinery and equipment excluding software and electronics, and structures (in the US, on average over the sample these account for at most 3.5 percentage points of GDP, of which .6 defense spending - see Table 4). According to the accrual principle of the 1993 System of National Accounts (see Commission of the European Communities et al. [1993]), the inputs used in their production should be recorded in the *private sector* account in the quarter they are used; but two approaches are possible as to when they should be recorded in the *government* account. First, the **delivery** method: each quarter, the value of the inputs used in the construction of a ship by a private contractor is recorded in private inventories, first as work in progress and then as finished good; upon delivery, the whole price of the ship is recorded as purchase by the

[13] I could not find a precise written reference for this view. I consider it here because it is sometimes stated in private conversations and in conference discussions.

[14] Australia has implemented the system since 1999, and has not revised its previous figures to make them consistent with the new system.

[15] The "time-adjusted cash basis" consists in lagging cash disbursements by a fixed amount of time, to capture the average delay between, say, the provision of the service of a government employee and the moment she is paid.

government, and a corresponding negative entry is recorded in the private sector inventories. Note that this method implies a mechanical negative correlation between government spending and private investment. Second, the **work-put-in-place** method: each quarter the value of the inputs used is recorded directly in the government sector accounts as a purchase by the government. A similar distinction holds under cash accounting. Under

Table 2: **Method of recording of government purchases**

	AUS[1]	CAN	DEU	GBR	USA
Wages	P, TACP	N/A[2]	N/A	TACP	A[3]
Goods with short prod. process	P, TACP	N/A[2]	P	TACP	PC
Machinery and Equipment	P, PP	PP	PP	PP, WPIPA[4]	PP, WPIP, P,D
Structures	P, PP	PP	WPIPA	PP, WPIPA[4]	PP, P

Legend: A: "Accrual" P: "Payment" ; D: "Delivery" ; PP: "Progress Payment" ; TACP: "Time Adjusted Cash Payments" ; WPIP: "Work - Put - In - Place" ; WPIPA: "Work - Put - In - Place Approximation" .
1: Data starting in 1999Q3 are on an accrual basis. The entries in this table refer to the method of recording before 1999Q3. 2: See Statistics Canada [2001] p. 122 and Perotti [2003]. 3: But mostly interpolated: see BEA-DOC [1988] Tables II-8 and III-4 and Perotti [2003]. 4: "Speculative construction" : P.
Source: Perotti [2003].

the **payment** method, the good is recorded in the government accounts when it is paid for by the government; under the **progress payments** method, each quarter the value of the installments paid by the government is recorded.

Clearly, the work-put-in-place method tracks the actual use of inputs most closely; in fact, it is also the method recommended by the 1993 System of National Accounts for government purchases of most goods with long production processes. Nominally, this is also the method most widely applied by the countries in this study. However, a literal application of this method is difficult for two reasons: first, strictly speaking it requires data on private sector inventories; second, government budget data are usually derived from Treasury accounts, which are in cash terms.[16] Thus, in practice work-put-in-place data have to be understood as either progress payment data based on quarterly cash disbursements, or as assessment by statistical agencies of the share of the final payment accruing to each quarter - the "work-put-in-place approximation".[17] This explains the

[16]For instance, in the US all defense purchases are formally classified as accrual; however, in reality they are derived in part from Financial Reports of the Department of Defense, which mostly track cash disbursements; and in part (in the case of some purchases of aircraft, missiles and ships) from data on major components "accepted" by the Department of Defense (from Production Control Reports) and on the prices of these components (from Contract Control Documentation Reports) (see BEA-DOC [1988] pp. 32-45).

[17]The one exception is the use of a variant of the delivery method for some components of defense

prevalence of these two methods in the last two lines of Table 2. To the extent that these methods still track closely the provision of inputs, one can conclude that an unanticipated change in government purchases will be associated with an unanticipated change in the timing and quantity of inputs used by the private sector.

The widespread notion that most unanticipated fiscal policy decisions at the quarterly frequency are in reality only rearrangements of cash or deliveries over time is probably based on an incorrect reading of some recent descriptive analysis of countercyclical fiscal policies in the US, like Bartlett [1993] and Romer and Romer [1994]. These studies argue convincingly that postwar US administrations have used four types of policies whenever they perceived (usually too late, as it turns out) a need for countercyclical fiscal measures: accelerating disbursements on government acquisition programs, extending unemployment benefits, extending some temporary tax credit or exemption programs, and starting or expanding public work programs.[18] These measures can be enacted quickly because they do not require legislative approval, but only a ratification later. However, this interpretation suffers from a sample selection bias. The studies above focus on a very specific question – the timing of countercyclical fiscal policies – and therefore on a limited set of fiscal measures – precisely those that can be adopted quickly in response to a perceived downturn in the economy. As argued above, there are many fiscal policy decisions that are being taken each period, and that do not have a specific countercyclical intent.

(ii) Taxes and transfers

In practice in most cases taxes are recorded at the time of the cash receipt, or at most on a "time-adjusted cash receipt" basis, whereby cash receipts are lagged by some fixed amount of time (one or two months) to approximate the time of payment or accrual.[19] Similarly, transfers are usually recorded at the time of payment.

Fortunately, for most types of revenues and transfers the difference between accrual and cash figures is unimportant. It becomes relevant only when there are collection lags, as it is the case with income taxes on corporations and income taxes paid by the

spending on machinery and equipment in the US. in 1988, this method covered about half of total spending on battleships, aircraft, and missiles (see BEA-DOC [1988] Table II-8). The sample average of total spending on these three items is 0.44 percent of GDP.

However, even in these cases the delivery method is not too far from the progress payment method or the "work - put - in - place" approximation. Consider for instance the case of aircraft and missiles. The government purchases individual components (wings, engines etc.) and then furnishes them to private companies for "assembly and integration". Each quarter, the estimate of the purchase of each component, plus the value of integration and assembly by private firms, is recorded (see BEA-DOC [1988] p. 35).

[18] Note, however, that the last three measures do imply a change in the present discounted value of government spending or revenues.

[19] The only type of tax that is recorded on a truly accrual basis is corporate income taxes in the US. However, the Bureau of Economic Analysis supplies the data to convert all the national income account tax variables into the cash receipt basis used in the Budget. I use the accrual measure because the cash adjustment displays a marked seasonality that is difficult to eliminate.

self-employed in some countries. When this occurs, the contemporaneous elasticity of the cash measure of the revenue to its base is 0; the contemporaneous elasticity of the accrual measure, instead, is the statutory one. The construction of the net tax elasticities, described in Appendix B, takes these collection lags into account.

Objection 3: VAR-based innovations capture shocks to the private sector. *VAR-based innovations might simply "reflect shocks to the private sector that cause defense contractors to optimally rearrange delivery schedules, say because of strikes or other developments in the private sector behavior" (Eichenbaum, Fisher, and Edelberg [1999] p. 168).*

The two private sector shocks that are most likely to contaminate the fiscal shocks are strikes and productivity shocks. Given a minimum of intertemporal substitution, phenomena like strikes are unlikely to affect appreciably the provision of inputs in sectors that sell to the government over an entire quarter. Unless, of course, they are very long; but prolonged, industry - wide strikes are rare in the sample of countries of this study. In addition, they are mostly seasonally adjusted away, as was the case with perhaps the most celebrated strike in the sample, that from April to October of 1981 in the UK.

Still, a strike or a productivity shock can cause the delivery of a big item, like an aircraft or a carrier, to move from one quarter to another. While it is not clear how important this phenomenon is in the data, we have seen that the delivery method is in any case relatively rare. And a productivity shock seems unlikely to grossly distort the estimation of a fiscal shock when the progress payment method or the "work-put-in-place approximation" are used, as in most cases in this sample.

Objection 4: Anticipated future fiscal policy matters. *Most models imply that a fiscal shock should have different effects depending on the future paths of spending and distortionary taxes that are expected to follow the initial shock.*[20] *But an impulse response only shows the "typical" path of government spending and taxes after the initial shock, hence it is not very informative on the question: what are the likely effects of an unexpected change in government spending today, followed by a given path of government spending in the future (possibly different from the estimated impulse response of government spending to its own shock)?*

When anticipated fiscal policy matters, the parameters of the reduced form and of the impulse response are functions of the parameters describing the data generation process for government spending. Thus, the critique is formally correct. However, it is not different from a monetary policy VAR. As Cochrane [1998] has argued, the close relation between the shapes of the responses of the GDP and of the federal fund rate to a federal

[20]For instance, in a standard neoclassical model the effects of a given shock to government consumption depends on the wealth effect caused by the present discounted value of the change in government consumption over all following periods, and on the time path of the accompanying taxation (if not lump-sum).

fund rate shock suggests that anticipated monetary policy matters. But then the GDP impulse response just shows the *typical* response of GDP to a given shock to the federal funds rate today *and* to the *typical response* of the federal funds rate to its own shock.

Objection 5: Fiscal "shocks" are anticipated. *While decision lags help identification with high-frequency data, implementation lags make it more difficult. Unlike monetary policy measures, changes to government spending and taxes are typically decided and publicized well in advance of their implementation. As a consequence, the estimated innovations of a VAR are such only with respect to the information set of the econometrician, but not of the private sector.*

The omission of the announcement of fiscal policy from the estimated VAR has consequences for the estimated effects of both monetary and fiscal policy. Because fiscal policy is announced in advance, its effects show up almost immediately in interest rates and other financial variables, and only later in other variables; consequently, the interest rate response will pick up the effects of the anticipated component of fiscal policy - that is, of changes in fiscal policy expected to occur in the future on the basis of information dated t and available to the public but not to the econometrician.[21] But whether the impact effects of government spending shocks too are misestimated depends on subtler issues, namely the autocorrelation structure of the omitted announcement shock.

To see the issues involved, let A_t represent the "announcement" of fiscal policy, i.e. government spending budgeted in year t for year $t+1$; A_t is in the information set of the private sector in t, but not of the econometrician. Consider the following simplified structural model:

$$A_t = \lambda g_{t-1} + e_t^A \tag{6a}$$
$$g_t = \alpha_1 g_{t-1} + \alpha_2 g_{t-2} + \alpha_3 A_{t-1} + e_t^g \tag{6b}$$
$$r_t = \beta_1 g_t + \beta_2 g_{t-1} + \beta_3 g_{t-2} + \beta_4 A_t + e_t^r \tag{6c}$$
$$y_t = \gamma_1 g_t + \gamma_2 r_t + \gamma_3 g_{t-1} + \gamma_4 g_{t-2} + \gamma_5 A_t + e_t^y \tag{6d}$$

In equation (6a), λg_{t-1} captures the decision lag, while in equation (6b) the term $\alpha_3 A_{t-1}$ captures the implementation lag. e_t^A, e_t^g, e_t^r,and e_t^y are structural shocks, uncorrelated with each other; the last three are also uncorrelated over time. The econometrician ignores A_t and estimates instead the system:

$$g_t = \overline{\alpha}_1 g_{t-1} + \overline{\alpha}_2 g_{t-2} + \overline{e}_t^g \tag{7a}$$
$$r_t = \overline{\beta}_1 g_t + \overline{\beta}_2 g_{t-1} + \overline{\beta}_3 g_{t-2} + \overline{e}_t^r \tag{7b}$$
$$y_t = \overline{\gamma}_1 g_t + \overline{\gamma}_2 r_t + \overline{\gamma}_3 g_{t-1} + \overline{\gamma}_4 g_{t-2} + \overline{e}_t^y \tag{7c}$$

[21] I thank Christ Sims for a useful exchange that helped clarify this issue, and for pointing out an unpublished contribution by Leeper [1989] which provides a formalization of this argument. He shows that, when fiscal policy is anticipated by the public, the econometrician might end up attributing to monetary policy some of the effects of fiscal policy.

It is easy to see that the reduced form residuals from (7) are:

$$\overline{u}_t^g = \alpha_3 e_{t-1}^A + e_t^g \quad (8a)$$
$$\overline{u}_t^r = \beta_1 \overline{u}_t^g + \beta_4 e_t^A + e_t^r \quad (8b)$$
$$\overline{u}_t^y = \gamma_1 \overline{u}_t^g + \gamma_2 \overline{u}_t^r + \gamma_5 e_t^A + e_t^y \quad (8c)$$

Suppose for illustrative purposes that the structural shocks are identified via Choleski ordering, with g first and r second. The econometrician estimates the contemporaneous effect of a shock to g on y, $\overline{\gamma}_1 + \overline{\gamma}_2 \overline{\beta}_1$ from a regression of $\overline{u}_t^y$ on $\overline{u}_t^g$, obtaining

$$\overline{\gamma}_1 + \overline{\gamma}_2 \overline{\beta}_1 = \frac{cov(\overline{u}_t^y, \overline{u}_t^g)}{var(\overline{u}_t^g)} = \gamma_1 + \gamma_2 \beta_1 + \alpha_3(\gamma_2 \beta_4 + \gamma_5) \frac{cov(e_t^A, e_{t-1}^A)}{var(\overline{u}_t^g)} \quad (9)$$

Thus, if e_t^A is not autocorrelated, the contemporaneous effect of a shock to g on y is estimated correctly, even if the model is misspecified. If instead e_t^A is autocorrelated, the estimate of the contemporaneous effect of a shock to g on y also picks up two spurious effects: when there is a unit change to e_t^A, y increases directly by γ_5, and indirectly by $\gamma_2 \beta_4$ because of the increase in r; at the same time, g increases by α_3 times the change in A_{t-1} typically associated with a unit change in e_t^A.

While it is natural to assume $\alpha_3 > 0$ and most models would predict $\beta_4 > 0$ and $\gamma_2 < 0$, the sign of γ_5 - the effect of anticipated future government spending on GDP - is less obvious. If $\gamma_5 < 0$, the contemporaneous effect of government spending on GDP is certainly underestimated, otherwise the net effects is ambiguous. Thus the contemporaneous impact effect of a shock to government spending on output will be misesitimated only if the omitted announcement shock is serially correlated; the estimated fiscal policy shock then also picks up the effect of the omitted announcement on output, directly and indirectly via the interest rate. Notice that if the implementation lag were 0 ($\alpha_3 = 0$), then the impact effect of fiscal policy would be estimated correctly anyway.

Consider now the contemporaneous effect of monetary policy on output. The econometrician estimates $\overline{\gamma}_2$ by a regression of $\widetilde{u}_t^y$ on $\widetilde{u}_t^r$, where $\widetilde{u}_t^y$ is the residual of a regression of $\overline{u}_t^y$ on $\overline{u}_t^g$, and similarly $\widetilde{u}_t^r$ is the residual of a regression of $\overline{u}_t^r$ on $\overline{u}_t^g$:

$$\overline{\gamma}_2 = \gamma_2 + \frac{\beta_4 \gamma_5 var(e^A) \left[var(e^g) + \alpha_3^2 var(e^A)(1 - corr(e_t^A, e_{t-1}^A)^2) \right]}{var(\widetilde{u}_t^r)} \quad (10)$$

Thus, the contemporaneous effect of monetary policy will be misestimated even if e_t^A is not autocorrelated. The interest rate innovation picks up the effect of the contemporaneous fiscal announcement on the interest rate via β_4; the output innovation picks up the direct effect of the contemporaneous fiscal policy announcement on output via γ_5; and the estimate of γ_2 is biased because of the correlation between these two components.

Ultimately, whether the private sector's forecasts of fiscal policy are systematically based on policy announcements is an empirical issue. In June and December of year j, the *OECD Economic Outlook* publishes forecasts of the rate of growth of GDP and of real government purchases for years *j* and *j+1,* based on information available about 6 weeks into the quarter of publication. If the public makes forecasts based on policy announcements unobservable to the econometrician, the estimated VAR innovation should be correlated with these announcements (in equation (7a), the estimated government spending innovation $\overline{e}_t^g$ equals $e_t^g + \alpha_3 \ A_{t-1}$). If OECD forecasts also reflect these policy announcements, then the VAR-based innovations should be correlated with the OECD forecasts. Table 3 displays estimates of regressions of the reduced form residuals of government spending and of net taxes in quarter t of year j from the benchmark VAR, on the two most recently published forecasts of government spending and GDP growth for year j. With the exception of government spending in the UK and net taxes in the US, there is little evidence that the VAR innovations are predictable.

There are many reasons why fiscal decisions announced in advance might not be taken at face value by the public. The yearly budget is often largely a political document, which is discounted by the private sector as such; any decision to change taxes or spending in the future can be modified before the planned implementation time arrives; and "...changes in expenditure policy typically have involved not simply changes in program rules, but rather changes in future spending targets, with the ultimate details left to be worked out later and the feasibility of eventually meeting the targets uncertain" (Auerbach [2000], p. 16).

It is also important to note that anticipated fiscal policy is unlikely to undermine what is perhaps the most interesting result of this paper – the decline in the potency of fiscal policy over the last twenty years. While anticipated fiscal policy might bias the estimated impulse response, with one possible exception discussed in section 12 it is not clear why it should do so more in the second part of the sample.

Obviously whether the estimated innovation are truly unanticipated matters only if anticipated and unanticipated fiscal policies have different effects. This is a controversial empirical issue, largely revolving around the importance of liquidity constraints: Parker [1999] and Souleles [1999] show evidence that private consumption displays large contemporaneous responses to income tax refunds and changes in social security taxes, although both are predictable.

4 The data and elasticities

The sample includes five countries: Australia (1960:1 - 2001:2), Canada (1961:1 - 2001:4), West Germany (1960:1 - 1989:4) (Germany for short from now on), United Kingdom (1963:1 - 2001:2), and United States (1960:1 - 2001:4).[22] Throughout much of the analysis,

[22]The sources for both the fiscal and the national income accounts data are: the NIPA accounts from the Bureau of Economic Analysis for the US (http://www.bea.gov/bea/dn/nipaweb/index.asp);

Table 3: **Predictability of VAR-based innovations**

	Const.	SPE1	GDP1	SPE2	GDP2	nobs	$\overline{R}^2$
A. Spending							
USA	0.00	0.08	0.23	0.25	-0.45	84	-0.00
	(0.23)	(0.26)	(0.90)	(0.67)	(-1.30)		
DEU	-0.00	1.23	-0.10	-1.54*	0.56	41	0.06
	(-0.43)	(1.96)	(-0.28)	(-2.20)	(1.10)		
GBR	-0.01	0.39	-1.34*	0.52	2.12*	82	0.05
	(-1.85)	(0.46)	(-2.01)	(0.55)	(2.12)		
CAN	0.00	0.18	-0.34	0.14	0.14	84	-0.02
	(0.11)	(0.41)	(-1.03)	(0.31)	(0.29)		
AUS	-0.01	0.87	-0.13	0.11	0.23	82	-0.03
	(-0.73)	(1.09)	(-0.15)	(0.13)	(0.19)		
B. Net taxes							
USA	0.00	2.32 *	1.12	-3.05*	-1.28	84	0.04
	(0.40)	(2.37)	(1.30)	(-2.45)	(-1.12)		
DEU	0.00	0.79	0.16	-1.66	0.12	41	-0.05
	(0.50)	(0.59)	(0.21)	(-1.12)	(0.11)		
GBR	0.00	1.24	2.71	-0.63	-3.63	82	-0.01
	(0.37)	(0.50)	(1.38)	(-0.23)	(-1.22)		
CAN	0.02	1.29	1.31	-4.23*	-2.60	84	0.15
	(2.22)	(0.99)	(1.32)	(-3.04)	(-1.72)		
AUS	0.01	-0.58	1.45	-0.40	-1.62	82	-0.03
	(0.55)	(-0.46)	(1.06)	(-0.30)	(-0.86)		

t-statistics in parentheses.
Dependent variable: Panel A: reduced form residual of the government spending regression, from the benchmark VAR specification with a linear trend and five variables; Panel B: reduced form residual of the net tax regression.
Independent variables: let j indicate the year and t the quarter t of year j at which the dependent variable is observed: SPE1, GDP1: forecasts of government spending and GDP growth in year j, respectively, pulished in December of year *j-1* ($Q_{1,j}$), in June of year j ($Q_{2,j}$, $Q_{3,j}$), in December of year j ($Q_{4,j}$). SPE2, GDP2: forecasts of government spending and GDP growth in year j, respectively, published in June of year *j-1* ($Q_{1,j}$), in December of year *j-1* ($Q_{2,j}$, $Q_{3,j}$), in June of year j ($Q_{4,j}$).
Sample: 1980:1 (earliest available *OECD Economic Outlook* forecasts) to end of period. Source: *OECD Economic Outlook*, various issues.

I will divide the sample into two parts: the start date up to 1979:4, and 1980:1 to the end date. For Germany, the break date is 1974:4. The two subsamples will be called S1 and S2, for brevity.

The breakdates above fall almost exactly in the middle of the sample. In addition, 1980 is typically around the center of confidence intervals for estimated breaks in coefficients of monetary policy VARs, and of the data generating process of several macroeconomic time series (see e.g. Blanchard and Simon [2001] and Stock and Watson [2002] and [2003]).

Sup-Wald tests (not shown) on each reduced form equation provide evidence of the existence of a break in several equations, although the picture of the estimated break points is usually not consistent across equations for any given country.[23] Typically the point estimates of the breaks, when significant at the 10 percent level, are located between 1975 and 1980, with a prevalence towards the earlier part of the interval. 67 percent confidence intervals are typically up to 4 quarters wide. As I show below, the main results of the paper are robust to a break point in 1976:1.

The criterion for inclusion in this study is the availability of non interpolated government budget data for the general government.[24] All the data are from National Income

the DIW National Account files for Germany (http://www.diw.de); the United Kingdom National Accounts and the Financial Statistics files, from the Office of National Statistics, for the United Kingdom (http://www.statistics.gov.uk/statbase/tsdlistfiles.asp); the CANSIM database of Statistics Canada for Canada (http://www.statcan.ca/english/Pgdb/econom.htm#nat); and the Australian Bureau of Statistics database for Australia (http://www.abs.gov.au/ausstats). The data can also be downloaded from my webiste at http://www.igier.uni-bocconi.it/perotti.

Of the other OECD countries, France and Japan have quarterly general government budget figures for long enough periods; however, substantial parts of their government sector data are interpolated from annual figures (see Perotti [2003]). New Zealand has non-interpolated data, but available only since 1986. Italy has government sector cash data, mostly from Treasury accounts, starting in 1983. These are used in Giordano et al. [2004] to investigate the effects of fiscal policy in Italy using much the same methodology as applied here.

Some commercial vendors and international organizations also have quarterly or semi-annual figures on the general government budget of several other countries, but these too are to varying extents interpolated from annual figures.

[23] Although designed to detect a single break, sup-Wald tests have power against alternatives like drifting parameters.

[24] Some components of government spending on goods and services are still interpolated from annual data even in the countries of this sample. In the US compensation of civilian federal government employees is interpolated without a guide; and a substantial part of purchases by state and local governments appears to be interpolated without guides (see Perotti [2003] and BEA-DOC [1988] Tables II-5 and III-4). In the UK, local non-wage government consumption and capital expenditure is interpolated from annual figures (see Office of National Statistics [2001] p. 371). Of the other countries, compensation of government employees in Canadian municipalities with less than 10,000 inhabitants is interpolated, using compensation in the other municipalities as a guide (see Statistics Canada [2001] pp. 125-6); local government capital expenditure in Australia is extrapolated from a sample of 20 percent of localities (see Australian Bureau of Statistics [2000]); while all of the German data are genuinely quarterly, except a few very small components of government spending.

Accounts; government spending includes all spending on goods and services, both in the current account ("government consumption") and in the capital account ("government investment"). The latter is gross of capital depreciation allowances, net of net purchases of non-produced assets, and net of investment by government enterprises - hence it is largely unaffected by the process of privatization in the last two decades.[25] All real variables are deflated by the GDP deflator. All variables except the interest rate have been seasonally adjusted by the original sources. Appendix A provides the essential information on the construction of the government budget data from national sources; Perotti [2003] provides the full details.

Table 4 displays basic summary statistics on the fiscal policy variables. The sample average of government spending ranges from 20.4 percent of GDP in Australia to 23.5 in Canada; government investment is typically little more than 3 percent of GDP (it is about 4 in the US, but it would be about 3 percent if purchases of weapons and weapons delivery systems were reclassified from government investment to government consumption as in the other countries). For the US, one can also estimate an upper bound to the GDP share of government spending on goods with long production processes as the sum of total government spending on machinery and equipment (less defense spending on software and electronics) and structures: this amounts to about 3.5 percent of GDP.[26]

Table 4: **Shares of government expenditures in GDP**

	USA	DEU	GBR	CAN	AUS
Govt. spending	20.5	21.4	21.9	23.5	20.5
Govt. consumption	16.6	17.9	18.9	20.2	17.1
Govt. investment	3.9	3.5	3.0	3.3	3.4
Goods w/ long prod. process	[2.9 - 3.5]				
Net taxes	17.6	22.4	21.1	20.3	18.0

Average shares of different types of government spending in GDP, whole sample.

Appendix B describes in detail the construction of the elasticities of government spending and taxes to GDP and inflation. These are based on annual elasticities of different types of taxes, as computed by the OECD, adjusted to convert them into quarterly elasticities. The first part of Table 5 shows the net tax elasticity to output in each country over the whole sample and the two subsamples.[27] The elasticity is low in Germany, the UK and

[25]The exception is the US, where however investment by government enterprises is relatively small.

[26]This figure is actually an overestimate, because non-defense purchases of software and electronics are not separately available and cannot be subtracted; however, average non-defense spending on machinery and equipment is .6 percent of GDP, hence total spending on goods with long production process must lie between about 2.9 and 3.5 percent of GDP.

[27]Note that in general this elasticity varies over time, because so do the real wage elasticity of tax revenues per person computed by the OECD, the estimated elasticities of real wages to employment and of employment to output, and the estimated output elasticities of corporate profits. When estimating

Table 5: **Output and price elasticities of net taxes**

	Output elasticities					Price elasticities				
	USA	DEU	GBR	CAN	AUS	USA	DEU	GBR	CAN	AUS
All	1.85	.92	.76	1.86	.81	1.25	.87	1.21	.98	.94
S1	1.75	.91	.66	1.61	.75	1.09	.76	1.08	.93	.87
S2	1.97	.72	.82	2.16	.89	1.40	.98	1.32	1.02	1.01

Source: own calculations, as described in the text and in Appendix B.

Australia, for two reasons: the quarterly output elasticity of direct taxes on individuals is zero, because the estimated output elasticity of real wages to employment is zero[28] and the elasticity of employment to output is small or zero; and corporate income taxes have zero contemporaneous elasticity to their tax base, because quarterly installments are paid on the previous year's assessed tax liability. It is well known that in quarterly data corporate profits are highly elastic to output: this accounts for the high output elasticities of net taxes in Canada and USA (in both, the estimated contemporaneous output elasticity of profits is above 4), the only two countries where corporate income taxes have a positive contemporaneous elasticity to corporate profits. Note also that the output elasticities of net taxes tend to rise slightly in S2 in all countries except Germany.

5 The effects of government spending on GDP

5.1 Benchmark results

Figure 1 displays the response of government spending to a shock to e_t^g equal to 1 percentage point of GDP[29], from the benchmark VAR with 5 variables and a linear time trend described in section 2. Government spending and net taxes are ordered first and second, respectively, and the elasticity of real government spending to prices is equal to -.5. The figure also displays the two symmetric one standard error bands, computed by simulations based on 500 replications, as in e.g. Stock and Watson [2001].[30]

the model over different subsamples, each time I recompute the average elasticities over the relevant subsample. In Australia and the UK, the series for employment and wages start close to 1980. Hence, to estimate the elasticities of real wages to employment and of employment to outputy in S1, I use all the available data up to the end of the sample.

[28]In all these countries, the estimated employment elasticity of real wages is either negative (Australia, Germany) or positive but with a t-statistics below 1 (UK), hence it has been set to 0.

[29]The impulse response of government spending are multiplied by their respective average shares in GDP to express them in terms of shares of GDP. The actual response of government spending in the first quarter is usually different from 1, because of the feedback from the price level to g_t.

[30]I calculate standard errors from 500 simulations, assuming normality. Specifically, I take 500 draws from the distribution of reduced form residuals. Corresponding to each draw, a new synthetic series

In the whole sample, with the exception of Germany government spending declines steadily following the shock, and after 5 years it is about .3 percentage points of GDP above trend. In contrast, in VAR studies based on the "narrative approach" à la Ramey and Shapiro, the responses of defense spending and government spending to a defense spending shock tend to be hump-shaped. The pattern estimated in the whole sample is qualitatively similar in the two subsamples, S1 and S2; but the response is less persistent in S2 in Australia, and especially in the US and UK. This is immediately evident from Panel A of Table 6, which for compactness displays the annualized cumulative government spending response at 1 and 3 years, in S1 and S2, as well as the difference between the two subperiods, with their significance.[31]

Panel B of the same table displays the cumulative net tax response to a spending shock; it is typically positive in S1, and (except in Australia) negative in S2.

Net taxes, however, are very sensitive to the behavior of GDP, and as we will see below, GDP typically rises in S1 and falls in S2 following a government spending shock: this could explain the different behavior of net taxes in the two subperiods. To partial out the automatic effect of GDP and prices on net taxes, I compute the response of cyclically adjusted net taxes[32], displayed in panel C of Table 6. Given the very different GDP response in the two subsamples (see panel E below), the response of cyclically adjusted net taxes is smaller in S1 and algebraically larger in S2 than the response of unadjusted taxes in Panel B; but at 3 years it is still largely positive in S1 and negative in S2 in all countries except in Australia. This pattern will be important in interpreting the different responses of GDP in the two subsamples.

Panel D displays the difference between the cumulative responses of spending and net taxes to a spending shock, or the cumulative deficit response: with the exception of

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for each endogenous variable is constructed using the estimated system, conditional on the first four observation. After re-estimating the system, the impulse response corresponding to each draw can be calculated. One can then calculate the standard deviation of the impulse response at each horizon. An asterisk indicates that the impulse response plus (minus) one standard error is below (above) zero at that horizon.

[31]In this and in all subsequent tables, the cumulative responses are expressed in yearly rates, i.e. the cumulative sums of the quarterly responses are divided by 4.

To compute the standard error of the difference between the two subsamples, I take the i-th draw of the responses in the first and in the second subsamples, compute their difference, and then compute the standard error of this difference. The standard deviation of innovations in interest rates and in many other macroeconomic series has fallen considerably after about the late seventies - early eighties. As it is well known, ignoring this shift in conditional volatility could lead to a spurious finding of parameter breaks in a VAR (see e.g. Cogley and Sargent [2001] and the discussion therein). The method I use to compute the standard error of the difference between the two impulse responses is immune from this problem.

[32]Formally, cyclically adjusted net taxes are computed as : $\widetilde{t}_t^{CA} = \widetilde{t}_t - \alpha_{ty}\widetilde{y}_t - \alpha_{tp}\widetilde{p}_t$, where a "tilde" denotes an impulse response. Hence, this component can be interpreted as the "discretionary" change in net taxes. Because the elasticity in the long run can be different from that in the short run, these cyclcially adjusted measures should be interpreted with some care at longer horizons.

Table 6: **Cumulative responses to a spending shock**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Cumulative response of government spending									
S1	.88*	2.23*	.64*	1.23*	.92*	2.41*	.61*	1.41*	.74*	1.32*
S2	.72*	1.48*	.92*	1.33*	.82*	1.51*	.90*	1.99*	.58*	.99*
S2-S1	-.16*	-.75*	.28*	.10	-.10*	-.90*	.29*	.58*	-.16*	-.33*
	B. Cumulative response of net taxes									
S1	.25	1.43*	1.12*	.94*	.26*	.97*	.48*	.91*	.05	.74*
S2	-.18	-1.33*	.30*	-.45*	-.53*	-4.16*	-.40*	-1.24*	.12	.77*
S2-S1	-.43	-2.76*	-.82*	-1.39*	-.79*	-5.13*	-.88*	-2.13*	.07	.03
	C. Cumulative response of cyclically adjusted taxes									
S1	-.13	.27	.99*	.86*	.08	-.31	.30*	.88*	.14*	.95*
S2	-.25*	-1.02*	.34*	-.08	.44*	-3.47*	-.22	-.17	.12	.41*
S2-S1	-.12	-1.29*	-.65*	-.94*	.36*	-3.16*	-.52*	-1.05*	-.02	-.54*
	D. Cumulative deficit response									
S1	.63*	.79*	-.48*	.29	.66*	1.44*	.13	.50*	.70*	.59*
S2	.91*	2.80*	.61*	1.77*	1.34*	5.67*	1.30*	3.23*	.46*	.22
S2-S1	.28	2.01*	1.09*	1.48*	.68*	4.23*	1.17*	2.83*	-.23*	-.37
	E. Cumulative GDP response									
S1	1.13*	3.68*	.41*	-.11	.48*	.10	.59*	.74*	-.10	1.52*
S2	.31	.10	.40*	-1.38*	-.22	-1.23*	-.28	-2.25*	.21*	.77*
S2-S1	-.82*	-3.77*	-.01	-1.27*	-.70*	-1.33*	-.88*	-2.99*	.31	-.75*
	F. Cumulative cyclically adjusted spending multiplier									
S1	1.29*	1.67*	.61	-.08	.48*	.03	.98*	.58*	-.14	1.42*
S2	.44	.08	.47*	-1.10*	-.28	-.94*	-.32	-1.10	.38*	.69*
S2-S1	-.85	-1.59*	-.14	-1.02	-.76*	-.97*	-1.30*	-1.68*	.52*	-.73

Annualized cumulative response of GDP to government spending shock equal to 1 percentage point of GDP, from benchmark model with linear time trend, at quarters 4 and 12.

"S1" : beginningof the sample to 1979:4 (1974:4 for Germany). "S2" : 1980:1 (1975:1 for Germany) to end of sample.

An asterisk "*" in the lines labelled "S1" and "S2" indicates that 0 is outside the region between the two one-standard error bands at that horizon.

Australia, it is always positive and significant, and larger in S2, mainly because of the large decline in the response of net taxes.

Figure 2 displays the impulse response of GDP to the spending shock. In the whole sample, the impact response is positive and significant in all countries, except in Australia: it is about .5 in the UK and Canada, and above 1 in the US and Germany. The peak effect on GDP is positive and significant in all countries, but larger than 1 only in Germany and the US, while it is about .6 or lower in the other countries.[33]

These results, however, hide a clear difference between the two subperiods: the GDP response is much stronger in S1. As panel E of Table 6 shows, in S1, at 1 year the response is significantly positive in all countries except Australia, although it is large only in the US; at 3 years, it is significantly positive in the US, Canada and Australia. In S2, at 1 year it is significantly positive, but small, only in Germany and Australia; at 3 years, it is significantly positive only in Australia, about 0 in the US, and significantly negative in Germany, the UK and Canada, between -1.2 and -2.2. Thus, except in Australia and Germany at 1 year, where the difference is essentially 0, the cumulative GDP response is always smaller in S2, and always significantly so. Note also that the GDP response estimated for the US tends to be larger - and in most cases considerably so - than in all the other countries.

Are these differences, both across countries and across periods, due to underlying differences in the government spending processes? As we have seen, the government spending response is less persistent in S2 in the US and the UK, two countries with a large drop in the GDP response in S2. The cumulative cyclically adjusted multiplier[34] expresses the cumulative change in GDP per each cumulative change in cyclically adjusted government spending equal to one percentage point of GDP. As panel F of Table 6 shows, it displays much the same pattern across subperiods as cumulative GDP, although the standard errors are somewhat larger.

These differences are also unlikely to be due to underlying differences in the responses of net taxes: as we have seen, in S2 discretionary taxes usually *fall*, or increase less than in S1.

[33]The results for the US in the whole sample are similar to those obtained by Blanchard and Perotti [2002], Burnside, Eichenbaum and Fisher [2003], Canzoneri, Cumby and Diba [2002], Edelberg, Eichenbaum and Fisher [1999], Fatás and Mihov [2001], Galí, López-Salido and Vallés [2003], Ramey and Shapiro [1997], and larger than those obtained by Mountford and Uhlig [2002], although the comparison is not always immediate because the government spending response is hump-shaped in some of these contributions, and because in some of these studies the government spending variable is just defense spending.

[34]The cumulative cyclically adjusted multiplier at quarter t is defined as the ratio of the cumulative response of GDP at quarter t to the cumulative response of cyclically adjusted government spending at the same quarter. Cyclically adjusted government spending at quarter t is computed as the response of government spending less the product of the average elasticity of government spending to the price level and the response of the price level: $\widetilde{g}_t^{CA} = \widetilde{g}_t - \alpha_{gp}\widetilde{p}_t$, where a "tilde" denotes an impulse response.

5.2 Comparison with macroeconometric models

It is interesting to compare the cumulative multipliers estimated so far with the cumulative multipliers typically provided by large scale econometric models. The first panel of Table 7 displays the US cumulative multipliers in S1 and S2, and the averages and extreme values from simulations of the 12 models of the US considered in the surveys by Bryant et al. [1988][35] and by Adams and Klein [1991]. In S1, my point estimate is equal to or below the average multiplier in all cases; in S2, it is below even the lowest estimate of all these models.

Table 7: **Cumulative multipliers, macroeconometric models**

		1 year		2 years	
		S1	S2	S1	S2
USA	Avg. 12 US models[1]	1.27		1.66	
	Extreme values	(0.65 , 2.05)			
	Avg. 5 US models[2]	1.87		2.17	
	Extreme values	(1.10 , 2.40)		(1.40 - 4.40)	
	My estimates, USA	1.29	0.36	1.40	0.28
DEU	Deutsche Bundesbank	1.18		1.12	
	INTERLINK	0.90			
	QUEST	0.65			
	My estimates, DEU	0.53	0.50	-0.27	0.07
GBR	Avg. UK models[3]	0.80		0.50	
	Extreme values	(0.50 , 1.10)		(0.20 , 0.90)	
	My estimates, GBR	0.48	-0.27	0.27	-0.60
EuroZone	AWM, benchmark case	1.04		1.53	
	AWM, lower bound	0.66		0.57	
	My estimates, USA	1.29	0.36	1.40	0.28
	My estimates, avg. DEU and GBR	0.50	0.11	0.00	-0.26

Cumulative multipliers of a government spending shock at 1 and 2 years from several macro econometric models, as reported in Henry, de Cos and Momigliano [2003]. Lines labelled "My estimates" : the two cells in each column display my estimates of the cumulative cyclically adjusted spending multiplier, in S1 and S2 respectively, from panel E Table 6.
1: from Bryant et al.[1988]; 2: from Adams and Klein [1991]; 3: from Church et al. [2000]; 4. "AWM" : "Area Wide Model" .

The next panel displays the multipliers from three models of Germany: again my point estimates in both subsamples are below the lowest multiplier of the three models. The

[35] It should be noted that some models have changed since the Brookings comparison project summarized in Bryant et al. [1988], in particular more models have incorporated forward looking behavior. Also, it is well known that it is difficult to compare the output of simulations across models, because it is difficult to hold "everything else" constant. The use of cumulative multipliers is intended to minimize this problem.

third panel displays the average and extreme values of 5 models of the UK, from Church et al. [2000]: my point estimates in S1 are about equal to the lower bound of these 5 models; in S2, they are far below.

The next panel displays the benchmark and the lower bound of the multipliers from the European Central Bank's Area Wide Model, that encompasses all the EuroZone countries. For comparison, I have included the average of my estimated multipliers for the two European economies in my sample, Germany and the UK, and again my estimated multiplier for the US, a country with comparable size to the Euro area. In S1, my estimated US multipliers are about equal to the baseline multiplier of the ECB Area Wide Model; in S2, they always lower than even the lower bound Area Wide Model. The averages of my estimated UK and German multipliers are always lower than the lower bound multiplier of the Area Wide Model in both subperiods.

5.3 Robustness

Table 8 studies the robustness of the key result so far - the drastic reduction in the effects of government spending shocks on GDP in S2. For each country, it displays the sign of

Table 8: **Cumulative response of GDP to a spending shock: Robustness**

		USA		DEU		GBR		CAN		AUS	
		4	12	4	12	4	12	4	12	4	12
1	Linear Trend	<*	<*	=	<*	<*	<*	<*	<*	>	<*
2	Quadratic Trend	<	<*	>	<*	<*	<*	=	<*	>*	>
3	Levels	<	<*	<*	<*	<*	<*	<*	<*	=	<*
4	Stoch. Trend[1]	<*	<	>	>*	<*	<*	<	<*	>	<*
5	Stoch. Trend, coint.	<*	<	>*	>	<	<*	<	<*	>	<*
6	73:1 - 75:4 excluded	<*	<*	<	<*	<	<	<*	<*	>*	<*
7	S2 starts in 1976	>	<*	>	<*	=	<	<*	<*	>	>
8	Taxes first	<*	<*	>	<*	<*	<*	<*	<*	>*	<*

Each row of this table displays the direction and significance of the difference between the responses of GDP to a spending shock at 4 and 12 quarters in S1 and S2, from the specification of the VAR described in the second column. In each cell, the symbol ”<” indicates that the cumulative GDP response to the government spending shock at the quarter indicated in row 0 in S2 is below the response in S1. The opposite for the symbol ”>”. The symbol ”*” indicates that the difference between the responses in S1 and S2 is significant, i.e. 0 lies outside outside the region between the two one-standard error bands of the difference of the responses in the two periods.
The symbol ”=” means that the difference between the two responses is less than .10 and insignificant.

the difference between the cumulative impulse response of GDP in S2 and S1, at 1 and

3 years, with an asterisk if this difference is significant (if the difference is less than .10 in absolute value and insignificant, a "=" is entered). Rows 1 to 5 display the results of as many different specifications: a linear time trend (the benchmark case displayed in Table 6), linear and quadratic trends, levels, stochastic trend[36], and stochastic trend with cointegration between spending and taxes (as it is well known the latter specification is a way of imposing the intertemporal government budget constraint in the estimation). Under all specifications, the key result remains: the only difference is that in Germany under a stochastic trend and under cointegration the response of GDP is slightly larger in S2 than it S1 at both horizons. On the other hand, the evidence is stronger in a specification in levels: except in Australia at 1 year, now the response in S2 is significantly smaller in all countries and at all horizons.

The pattern of the differences between the two subperiods remains largely unaffected if one omits the 3 years between 1973:1 and 1975:4 (row 6), which were characterized by large swings in GDP growth and government spending; if one assumes a break points between the two subperiods of 1976:1 instead of 1980:1 (line 7); or if government spending is ordered second (line 8). In this last case, typically the point estimates (not shown) of the impulse responses at all horizons change by only a few hundredths of a percentage point, reflecting the small correlation between the structural spending and net tax shocks.

6 The effects of net taxes on GDP

6.1 Benchmark results

Figure 3 displays the effects on GDP of a shock to net taxes equal to -1 percentage point of GDP (a "tax cut" henceforth); the initial shock is negative to facilitate the comparison with spending shocks. In the whole sample, the impact response is positive but very small in the US and Canada, and significantly negative in the other three countries, from -.1 in the UK to -.5 in Germany and Australia. After this, the response builds up in the US, Germany and Canada, to a positive peak of about .6 after 2 years in all three countries. In the UK and Australia, instead, the response stays negative, although close to 0.

Panel A of Table 9 displays the annualized cumulative GDP responses to a tax shock in S1 and S2, and their differences. The US in S1 and Canada in S2 are the only two country-periods where there is evidence of a consistently positive effect of a tax cut on output. Note that once again the effects estimated previously for the US over the whole sample (see e.g. Blanchard and Perotti [2002]) are towards the high end of the spectrum, even in S1.

In S2 the cumulative output response of GDP is persistently *negative* in all countries

[36] Each variable is first differenced, and then a moving average of its past differences is also subtracted to account for low frequency changes in the rate of growth: see Blanchard and Perotti [2002].

except Canada. In fact, there is again evidence of a decline in the effects of a tax cut in S2, though weaker than in the case of spending shocks. Cumulative GDP falls in S2 relative to S1 in the US and UK at 1 and 3 years, and in Germany and Australia at 3 years. Like for spending shocks, the difference between S1 and S2 is large in the US, and small in Australia. Except in Germany, the difference in the response between the two subperiods is statistically significant.

The three countries with the smallest output elasticities of net taxes - Australia, the UK and Germany - also display negative responses in the very first quarter in the whole sample and in both subsamples (see Figure 3). As discussed, there are two reasons for

Table 9: **Cumulative response of GDP to a tax cut**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Cumulative GDP response									
S1	.69*	2.64*	-.19*	.07	.11*	.17*	-.03	-.39*	-.38*	-.71*
S2	-.43*	-2.11*	.03	-.29	-.23*	-.91*	.30*	1.81*	-.36*	-1.16*
S2-S1	-1.12*	-4.77*	.22	-.35	-.34*	-1.08*	.33*	2.20*	.02	-.46*
	B. Cumulative GDP response, higher tax elasticities									
S1	.77*	2.64*	-.07	.02	.14*	.20*	.05	-.29*	-.16	-.44*
S2	-.23*	-1.81*	.24*	-.17	-.20*	-.85*	.37*	1.91*	-.29*	-1.06*
S2-S1	-1.00*	-4.45*	.17*	-.19	-.34*	-1.05*	.32*	2.20*	-.13	-.52*
	C. Cumulative cyclically adjusted tax multiplier									
S1	1.41*	23.87	-.29*	.05	.23*	.21*	-.04	-.22*	-1.50*	-1.69
S2	-.70*	-1.55*	.04	-.59	-.43*	-.70*	.42*	1.59*	-.55*	-.85*
S2-S1	-2.11*	-25.42	.33	-.64	-.66*	-.91*	.46*	1.81*	.95*	.84

Annualized cumulative response of GDP in S1 and S2, at quarters 4 and 12, to a tax shock equal to -1 percentage point of GDP. In Panel B, the GDP elasticities of net taxes are increased by .5. See also Table 6 for the notation.

the small output elasticities of taxes in these countries: the small (or zero, in the case of Australia and the UK) estimated elasticity of employment to GDP and of wages to employment; and the zero contemporaneous elasticity of corporate income taxes to their base. Both these elasticities might be underestimated. In particular, corporations might choose to pay quarterly installments based on expected profits rather than the previous year's assessed tax liability, if the latter differ greatly from the former. For each of these 3 countries panel B of Table 9 displays the cumulative impulse response of GDP under an assumed output elasticity of net taxes equal to the benchmark value augmented by .5. As expected, the GDP response increases, although usually by very small amounts, in year 1; but by year 3 the elasticity makes essentially no difference to the GDP response. Also, the pattern of differences between S1 and S2 remains the same.

The cyclically adjusted cumulative tax multiplier (panel C of Table 9) follows the same pattern, except that now it is larger in S2 in Australia even at 3 years.[37]

6.2 Robustness

Table 10 displays the pattern of differences between S1 and S2 in the cumulative responses of GDP at 1 and 3 years, under the same alternative specifications shown in Table 8. As one can see, with the partial exception of Germany the pattern of the benchmark specification is extremely robust.

Table 10: **Cumulative response of GDP to a tax shock: Robustness**

		USA		DEU		GBR		CAN		AUS	
		4	12	4	12	4	12	4	12	4	12
1	Linear Trend	<*	<*	>	<	<*	<*	>*	>*	=	<
2	Quadratic Trend	<*	<*	>	<	<*	<*	>*	>*	<*	<*
3	Levels	<*	<*	>	>	<*	<*	=	>*	<	=
4	Stoch. Trend[1]	<*	<*	>	>	<*	<*	>	>*	<	<
5	Stoch. Trend, Coint.	<*	<*	<	<	<*	<*	>*	>*	<	<
6	73:1 - 75:4 excluded	<*	<*	>*	>*	<*	<*	>*	>*	<	<*
7	S2 starts in 1976:1	<*	<*	>*	>	<*	<*	>*	>*	>	<
8	Taxes first	<*	<*	>	<	<*	<*	>*	>*	=	<

Each row of this table displays the direction and significance of the difference between the cumulative responses of GDP in S1 and S2, at 4 and 12 quarters, to a net tax shock equal to -1 percentage points of GDP, from the specification of the VAR described in the second column. See also Table 8 for the notation.

7 Comparing spending and tax shocks

Supporters of the use of fiscal policy as a stimulatory tool have always been divided on which is the more effective and faster tool: tax cuts or spending increases? The immediate problem in making such a comparison is that spending increases and tax cuts often do not stimulate output at all. From Tables 6 and 9, in S1 cumulative GDP at 1 year increases in response to a spending shock in all countries except Australia, but only in the US in response to a tax cut. In S2, at the same horizon a spending shock stimulates GDP in the US (although not significantly), Germany and Australia; a tax cut, only in Canada. Thus, there is little evidence that taxes work faster and more strongly, contrary to frequently made claims.

[37] The cyclical component of the net tax response is larger than the cyclical component of the spending response, which does not depend on GDP, and more uncertain because of the uncertainty on the tax elasticities to GDP. Note also the very large multiplier in the US at 3 years, caused by a denominator very close to 0.

With this premise, Table 11 displays the difference between the cumulative GDP response to a spending and tax shock of the same size (panel A), and the difference between the spending and tax multipliers (panel B). There is no evidence that tax cuts

Table 11: **Comparing spending and tax shocks**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Difference of cum. GDP response to spending and tax shocks									
S1	.44	1.02	.61*	-.17	.37*	-.07	.62*	1.13*	.28*	2.21*
S2	.74*	2.21*	.38	-1.10*	.01	-.32	-.58*	-4.06*	.58*	1.93*
	B. Difference of cycl. adj. cum. multipliers of spending and tax shocks									
S1	-.13	-22.20	.90*	-.14	.26*	-.18*	1.02*	.80*	1.36*	3.12
S2	1.14*	1.63*	.42	-.51	.15	-.23	-.74*	-2.74*	.93*	1.53*

Panel A: annualized cumulative response of GDP to a spending shock less annulaized cumulative response of GDP to a tax shock. Panel B: cumulative multiplier of cyclically adjusted spending less cumulative multiplier of cyclically adjusted net taxes. See also Table 6 for the notation.

work faster than government spending. S1 in the US is the only country-subperiod where both shocks have positive effects, and government spending has a stronger effect.

One might argue that the cumulative GDP response to a spending shock is not a pure measure of the effects of government spending, as it might be affected by the underlying change in discretionary taxes; a symmetric argument holds for the response to tax shocks. Panel A of Table 12 displays the cumulative GDP response to a "pure" spending shock, i.e.

Table 12: **Cumulative response of GDP to "pure" fiscal shocks**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Cumul. GDP resp. to a spending shock, constant cycl. adj. taxes									
S1	1.12*	3.48*	.53*	.14	.48*	.02	.55*	.42*	-.12	.90*
S2	.37	1.24*	.49*	-.96*	-.23	-.49	-.29	-2.81*	.19*	.49*
S2-S1	-.75*	-2.24*	-.04	-1.10	-.25*	-.51	-.84*	-3.23*	.31*	-.41
	B. Cumul. GDP resp. to a tax shock, constant cycl. adj. spending									
S1	.68*	2.12*	-.16	-.27	.12*	.15*	-.02	-.34*	-.37*	-.51*
S2	-.43*	-2.27*	.04	-.15	-.23*	-.86*	.30*	1.90*	-.36*	-1.18*
S2-S1	-1.11*	-4.39*	.20	.12	-.35*	-1.01*	.32*	2.24*	.01	-.67*

Panel A: Annualized cumulative response of GDP in S1 and S2, at quarters 4 and 12, to a spending shock equal to 1 percentage point of GDP, holding constant cyclically adjusted taxes. Panel B: Annualized cumulative response of GDP in S1 and S2, at quarters 4 and 12, to a net tax shock equal to -1 percentage point of GDP, holding constant cyclically adjusted spending. See Table 6 for the notation.

the response obtained by holding constant cyclically adjusted taxes, or, in other words, allowing only for the automatic response of taxes to GDP and inflation.[38] Conversely, panel B presents the cumulative GDP response to a "pure" tax cut, i.e. holding constant cyclically adjusted spending. Comparing these response to those in panel E of Table 6 and panel A of Table 9, respectively, it is clear that there is very little difference in the short run, and a slightly larger difference at 3 years; qualitatively, however, the results are very similar. In S2, a spending - induced deficit stimulates output only in the US and in Australia; a tax - induced deficits, only in Canada. In most other cases, both shocks have negative effects. Thus, a general, important lesson of these experiments is that the notion of "deficit shock" has little macroeconomic significance: it matters greatly whether the deficit is caused by a spending increase or a tax cut.

Similar results (not shown) obtain from a slightly different experiment: in response to a spending shock, cyclically adjusted taxes are held constant only over the first 4 quarters, instead than over the whole horizon.

8 Effects on GDP components

Table 13 displays the effects of government spending and tax shocks on private consumption and investment. The responses are derived from a 6 variable VAR, where each component of GDP is added in turn to the benchmark model.

8.1 Government spending

The behavior of private consumption (Panel A of Table 13) largely mimics that of GDP, but usually more muted as one would expect. In S1, at 3 years the response is significantly positive in all countries except Germany; in S2, only in the US. Except in Germany at 1 year, the response is smaller in S2; and with few exceptions, the difference is statistically significant. Like for GDP, the response is much larger in the US than in the other countries.

Panel B of Table 13 displays the cumulative private investment response to a spending shock. In both S1 and S2, it is never significantly positive; in S2, at 3 years it is significantly negative everywhere - between -1.4 and -2.4 - except in Australia.

Exactly like the case of private consumption, the response is always algebraically smaller in S2, except in Germany at 1 year, and again except in this country, the difference at 3 years is significant. In most cases the decline in the response between S1 and S2 at 3 years is similar to or larger than that of private consumption; but since private investment

[38] The experiment can be interpreted in two ways: to compute impulse responses, the reduced form tax equation is changed to $\widetilde{t}_t = \alpha_{ty}\widetilde{y}_t + \alpha_{tp}\widetilde{p}_t$, where a "tilde" denotes an impulse response; or, at each horizon of the response, the structural tax shock e_t^t takes exactly the value that ensures a zero response of cyclically adjusted taxes. Either way to interpret this experiment shows that it violates the Lucas critique, hence it should be interpreted with care, particularly at longer horizons.

is typically at most one third of private consumption in percentage terms the response of private investment falls much more than that of private consumption.[39]

As we have seen, national income accounting rules imply in some cases a mechanical

Table 13: **Cumulative response of private consumption and investment to fiscal shocks**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Cumul. private consumption resp. to a spending shock									
S1	.57*	2.15*	-.26*	-.17	.66*	.48*	.21*	.19*	.24*	.82*
S2	.34*	1.08*	-.08	-2.06*	-.18	.05	-.07	-1.17*	.10*	.03
S2-S1	-.23	-1.07*	.18	-1.89*	-.84*	-.43	-.28*	-1.36*	-.14*	-.79*
	B. Cumul. private investment resp. to a spending shock									
S1	.26	.36	-.24	-.36	-.33*	-.41*	.14	-.72*	-.21	1.49*
S2	-.24	-2.12*	.28	-1.43*	-.54*	-1.70*	-.64*	-2.37*	-.34*	-.21
S2-S1	-.50	-2.48*	.52	-1.07	-.21	-1.29*	-.78*	-1.65*	-.13	-1.70*
	C. Cumul. private investment resp. to a spending shock, no invent.									
S1	.19	1.02*			.11*	.20*	.23*	-.14	.00	1.36*
S2	-.04	-1.15*			-.36*	-1.50*	.10	-1.57*	-.16*	-.24
S2-S1	-.23	-2.27*			-.47*	-1.70*	-.13	-1.43*	-.16	-1.60*
	D. Cumul. private consumption resp. to a tax shock									
S1	.46*	1.39*	-.00	.15*	.15*	.20*	.12*	.24*	-.25*	-.34*
S2	-.31*	-1.53*	-.17*	-.18	-.14*	-.70*	.15*	.81*	-.01	-.18*
S2-S1	-.77*	-2.92*	-.17*	-.33*	-.29*	-.90*	.03	.57*	.24*	.16
	E. Cumul. private investment resp. to a tax shock									
S1	.17*	.86*	-.34*	-.07	.13*	.30*	.03	.15	.01	.10
S2	-.65*	-1.21*	.11	.27*	-.19*	-.83*	-.09	.34*	-.31*	-1.39*
S2-S1	-.82*	-2.07*	.45*	.34	-.32*	-1.13*	-.12	.19	-.32*	-1.49*

Annualized cumulative response of private consumption and private investment, in S1 and S2, at quarters 4 and 12, to a spending and a net atx shock equal to 1 and -1 percentage point of GDP, respectively. See Table 6 for the notation.

negative correlation between government purchases of durable goods and private sector inventories, when the former are recorded under the payment or delivery methods (see

[39]There is a significant dispersion of results in the literature for the whole period in the US. Regarding private consumption, Blanchard and Perotti [2002], Fatás and Mihov [2001], and Galí, López-Salido and Vallés [2003] find a positive effect of government spending shocks; Mountford and Uhlig [2002] and Burnside, Eichenbaum and Fisher [2003] almost no effect; and Edelberg, Eichenbaum and Fisher [1999] a negative effect after 2 years, after a small positive impact effect.

Regarding private investment, Fatás and Mihov [2001], Burnside, Eichenbaum and Fisher [2003] and Edelberg, Eichenbaum and Fisher [1999] find a mostly positive response; Blanchard and Perotti [2002] and Mountford and Uhlig [2002] a negative response.

The negative response of private investment to government spending is consistent with the panel evidence from 20 OECD countries and annual data in Alesina et al. [2002].

section 3, page 9). This could contribute to the small or negative effect on private investment at 1 year (the effect in the very first quarter - not shown in Table 13 - is also negative in all countries and all periods). In addition, in the short run the negative response of private investment might simply reflect the fact that private firms run down inventories to meet an unexpected increase in government demand. Panel C of Table 13 displays the same information as Panel B, except that private inventories are excluded from private investment (Germany does not have separate data for private inventories). The private investment response does indeed increase in general, so that now in S1 it is typically 0 or slightly positive; however, it is still mostly negative in S2. The pattern of the difference between S1 and S2 is also virtually unaffected.

8.2 Net taxes

In S1, the response of cumulative private consumption to a tax cut (panel D of Table 13) is negative in Australia, but positive everywhere else, although usually small - the exception once again is the US, where it reaches 1.4 after 3 years.

There are two countries where the cumulative GDP response to a tax cut falls drastically in S2 relative to S1: the US and the UK. These are also two countries where the response of private consumption in S2 declines dramatically, and becomes both significantly negative in S2 and significantly smaller than in S1. Of the other two countries where the GDP response falls at 3 years between S1 and S2 (although insignificantly) - Germany and Australia - the cumulative consumption response also declines in S2 in the former, while it increases slightly in the latter.

In S1, at 3 years the cumulative response of private investment to a tax cut (panel E of Table 13) is again consistently positive in the US and the UK, at .5 and .3, respectively; it is basically 0 in the other countries. The response of private investment also turns from positive to negative in S2 in the US, the UK and Australia, which also experience a decline in the response of GDP; also, the difference between the two subperiods is statistically significant. In the remaining two countries the response of private investment is essentially the same in the two subperiods.

9 Fiscal policy and interest rates

The impact of fiscal policy on interest rates is among the most debated issues in macroeconomics, and a key policy issue in times of high deficits. The empirical evidence for the US and other OECD countries has always been mixed at best, starting from Plosser [1982] and [1987] and Evans [1987], who, using different methodologies from the present study, could not find evidence of positive effects of debt innovations on interest rates in the US and in 5 OECD countries, respectively.

9.1 Government spending

Figure 4 displays the effects of a spending shock on the 10-year nominal interest rate. In the whole sample, the interest rate increases on impact everywhere, but by little. After this, it falls steadily in the US, to a minimum of -.4 after about 3 years.[40] But once again, this behavior is not typical. In the other countries, the interest rate increases over time, to a significant maximum after 4 to 5 years of about .9 in the UK and between .3 and .4 in the other countries. But this process takes time: after 2 years, the interest rate is .6 in the UK, .2 in Australia, and close to 0 in the other two countries.

Panel A of Table 14 distils the main points by displaying the average responses at 4 and

Table 14: **Average 10-year interest rate response to spending shocks**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Average, nominal interest rate response									
S1	-.00	-.10*	.30*	.06	.32*	.55*	.01	-.09*	-.11*	-.15*
S2	.15	-.19*	.61*	.73*	-.03	.16*	.18	.28*	.11	.11*
S2-S1	.15	-.09	.31	.67*	-.35*	-.39*	.17	.37*	.22*	.26*
	B. Average, *ex-post* real interest rate response									
S1	-.02	-.05	-.00	-.11	-.20	-.47*	.06	.13	.46*	.27*
S2	.29	.10	1.06*	.66*	.16	.51*	.43	.37*	.28*	-.24*
S2-S1	.31	.15	1.06*	.77*	.36	.98*	.37	.24	-.18	-.51*
	C. Average, *ex-ante* real interest rate response									
S1	.12	-.12	.13	.25*	-.86*	-.44*	.36*	-.06	.15	.15*
S2	.47*	.13	.53*	.57*	.38*	.48*	-.32	.52*	-.39*	-.48*
S2-S1	.35	.25*	.40	.32*	1.24*	.92*	-.68*	.58*	-.54*	-.63*

Average interest rate response at 4 and 12 quarters to a spending shock equal to 1 percentage point of GDP. See also Table 6 for the notation.

12 quarters in the two subsamples. In S1, the response at 3 years is significantly positive only in the UK. In S2, at the same horizon it is significantly positive in all countries except the US, between .1 in Australia and .7 in Germany, and essentially 0 in the US.

Panel B of Table 14 displays the response of the average *ex-post* real interest rate[41] at 1 and 3 years. In S1, except in Australia the response is 0 or slightly negative; like for the nominal interest rate, there is evidence of a stronger response in S2, at both 1 and 3 years, except in Australia.

[40]The only other paper that looks at the effects on the long interest rate, Canzoneri, Cumby and Diba [2002], finds a positive effect of spending shocks in the US over the whole sample: the 10-year interest rate increases by about .45 basis points on impact and after 2 years it is still above .5.

[41]The response of the real *ex-post* interest rate is constructed by subtracting from the nominal interest rate response at the change in the response of the log GDP deflator between t-3 and t. The response of the real *ex-ante* interest rate is computed by subtracting from the nominal interest rate response at t the change in the response of the log GDP deflator between t+3 and t.

Panel C of Table 14 displays the results for the *ex-ante* real interest rate. The results at 3 years are very close to those for the *ex-post* real interest rate; at 1 year, there are some minor differences. Again the response is mostly positive in S2, and larger than in S1, in both cases again with the exception of Australia.

9.2 Net taxes

Figure 5 displays the effects of a tax cut on the 10-year nominal interest rate. In the whole sample, on impact the nominal interest rate falls significantly everywhere except in the UK, but by small amounts, between .05 and .15 percentage points. The interest rate then builds up everywhere, but only in the US and Canada does it reach an economically and statistically significant peak, at .4 and .2 respectively; in all the other countries it hovers around 0 throughout.

Panel A of Table 15 displays the average responses at 4 and 12 quarters in the two

Table 15: **Average 10-year interest rate response to tax shocks**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Average, nominal interest rate response									
S1	-.12*	-.11*	.05	-.12*	-.01	.06*	.01	.02	-.01	-.01
S2	-.20*	-.15*	.26*	.25*	.04	.03*	-.09*	-.07*	-.13*	-.19*
S2-S1	-.08	-.04	.22*	.37*	.05	-.03	-.10*	-.09*	-.12*	-.18*
	B. Average, *ex-post* real interest rate response									
S1	.20*	.00	.04	.11*	.11	-.07*	-.26*	-.03	-.21	-.02
S2	-.32*	-.24*	-.08	.18*	-.26*	-.05*	-.18*	.03	-.21*	-.18*
S2-S1	-.52*	-.24*	-.12	.07	-.37*	.02	.08	.00	.00	-.16*
	C. Average, *ex-ante* real interest rate response									
S1	.05	-.19*	.41*	-.05	-.15*	-.19*	-.11	.17*	.27*	.01
S2	-.32*	-.20*	.45*	.26*	-.03	.09*	.11	.09*	-.12*	-.11*
S2-S1	-.37*	-.01	-.04	.31*	.12*	.28*	.22	-.08	-.39*	-.12

Average interest rate response at 4 and 12 quarters to a net tax shock equal to -1 percentage point of GDP. See also Table 6 for the notation.

subsamples. In S1, the average response at 3 years is negative but small in the US and Germany - about -.1 - , and essentially 0 elsewhere. Unlike the case of spending shocks, the response is mostly lower in S2: it is slightly positive in Germany, essentially 0 in the UK, and slightly negative, but significant, in the other countries.

The real interest rate response to a tax cut is displayed in panel B of Table 15. In S1, at 1 year is positive only in the US; at 3 years, it is zero or negative everywhere, except in Germany. In S2, the response is smaller than in S1 in the US, the UK and Australia, and virtually the same in the other countries. Thus, contrary to the case of spending shocks, there is now little evidence that the response of the real rate has increased in S2. The results for the *ex-ante* real rate (panel C) are more difficult to distil: but at 3 years there is evidence of a stronger response in S2 in the UK and Germany, while it changes little in the other countries.

9.3 Comparing spending and tax shock

Table 16 displays the difference between the responses to a spending and to a tax shock

Table 16: **Comparison of effects of spending and tax shocks on interest rates**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Average, nominal interest rate									
S1	.12	.01	.25*	.18*	.33*	.50*	-.01	-.11*	-.09	-.14*
S2	.35	-.04	.35	.48*	-.06	.14*	.27	.36*	.24*	.30*
	B. Average, *ex-post* real interest rate									
S1	-.22	-.05	-.04	-.01	-.31	-.37*	.32	.16	.67*	.29*
S2	.61*	.34*	1.14*	.47*	.41*	.56*	.61*	.34*	.49*	-.05
	C. Average, *ex-ante* real interest rate									
S1	.08	.07	-.28	.30*	-.72*	-.25*	.46*	-.10	-.10	.15
S2	.79*	.33*	.08	.31*	.41*	.39*	-.43*	.43*	-.26*	-.37*

Average interest rate response to a spending shock less average interest rate response to a net tax cut. See also Table 6 for the notation.

of the nominal and real interest rates, respectively. In S2 there is clear evidence that the response to a spending shock, especially of the two real interest rates, is nearly always significantly stronger. The responses to "pure" spending shocks and to "pure" tax shocks (not shown) follow similar patterns. Thus, once again an important lesson is that, in assessing the effects of deficits on interest rates, it matters greatly what is the underlying cause of the deficit.

10 The effects of fiscal policy on inflation

Just as the output elasticity of taxes is a crucial parameter in estimating the effects of taxes on GDP, so is the price elasticity of government spending crucial in estimating the effects of government spending on prices. Consider a simplified version of the relation between the reduced form innovations and the structural shocks

$$u^p = \gamma u^g + e^p \qquad (11)$$

$$u^g = \alpha u^p + e^g \qquad (12)$$

where all inessential variables and superscripts have been omitted. γ is the contemporaneous effect of government spending on prices, α is the automatic elasticity of real government spending to the price level. If not all of government spending is indexed, $\alpha < 0$. Suppose the researcher assumes an elasticity $\widehat{\alpha}$ different from α. Hence, the researcher will estimate $\widehat{e}^g = e^g + (\alpha - \widehat{\alpha})u^p$, and

$$cov(\widehat{e}^g, u^p) = cov(e^g, u^p) + (\alpha - \widehat{\alpha})var(u^p) \tag{13}$$

and solving for $var(u^p)$ and $cov(e^g, u^p)$:

$$cov(\widehat{e}^g, u^p) = \frac{\gamma}{1-\alpha\gamma}\left[1 + \frac{(\alpha - \widehat{\alpha})\gamma}{1-\alpha\gamma}\right] var(e^g) + \frac{(\alpha - \widehat{\alpha})}{(1-\alpha\gamma)^2} var(e^p) \tag{14}$$

Thus, if $\gamma > 0$ (government spending has a positive effect on prices) but the researcher underestimates (in absolute value) the price elasticity of government spending, typically the estimated effect of government spending on prices will be smaller than the true one. Note also that this bias increases with the variance of the price disturbance.

Table 17 shows the response of the GDP deflator inflation rate over the previous year at 1 and 3 years, in S1 and S2. After a spending shock, and under the benchmark value of the spending elasticity of -.5 (panel A), in S1 there is evidence of a positive response of inflation only in the UK and, initially, in Germany. In S2, there is evidence of a positive response only in Germany and Australia at 3 years; in many of the other cases, the response is negative. Notice the large and statistically significant decline in the inflation response relative to S1 in the US and Canada, two countries that also experience a large fall in the GDP response in S2. Conversely, Australia, the only country with positive cumulative GDP response at 3 years in S2, is also the only country with a significantly positive inflation response at the same horizon.

The same general conclusions apply if the CPI inflation rate is included in the VAR instead of the GDP deflator inflation rate (panel B). Now also in Germany at 3 years the response of inflation is smaller in S2, so that the only country with a positive response in S2 is Australia.

Previous VAR investigations on the effects of fiscal policy in the US, like Fatás and Mihov [2001] and Mountford and Uhlig [2002], have often found a negative effect of government spending on prices or inflation.[42] These results are based on orthogonalizations with real governments spending ordered before prices, thus implicitly assuming a zero elasticity of real government spending to the price level. Indeed, when I also assume a zero elasticity (panel C of Table 17), as expected the inflation response at 1 year falls algebraically everywhere. However, the elasticity makes essentially no difference at 3 years.

[42] Canzoneri, Cumby and Diba [2002] also find a negative impact effect, followed by a gradual increase. Edelberg, Eichenbaum and Fisher [1999] find a negative effect after an initial positive effect.

Table 17: **Response of inflation to fiscal shocks**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Response to spending shock, benchmark elasticity									
S1	.02	.05	.68*	-.40*	1.15*	1.23*	.03	-.14	-.31	-.40*
S2	-.23	-.34*	-.67*	.34*	-.06	-.31*	.21	-.70*	-.11	.69*
S2-S1	-.25	-.39*	-1.35*	.74*	-1.21*	-1.54*	.18	-.56*	.20	1.09*
	B. Response to spending shock, benchmark elasticity, CPI									
S1	-.48*	-.09	1.00*	-.33	1.85*	1.18*	.08	-.34*	-.03	-.31*
S2	.09	-.15	.30	-1.11*	-.57*	-.17	-.22	-.64*	.46*	.43*
S2-S1	-.57	-.06	-.70	-.78*	-2.42*	-1.35*	-.30	-.30*	.49*	.74*
	C. Response to spending shock, 0 elasticity									
S1	-.37*	.20*	.39	-.55*	.28	1.06*	-.42	-.09	-1.11*	-.17*
S2	-.43*	-.32*	-.87*	.29*	-.45*	-.15	-.59*	-.65*	-.20*	.70*
S2-S1	-.06	-.52*	-1.26*	.84*	-.73*	-1.21*	-.17	-.56*	.91*	.87*
	D. Response to tax shock									
S1	-.43*	.24*	-.01	-.02	-.21	.45*	.48*	-.33*	.22	.04
S2	.19*	.01	.47*	.32*	.31*	-.14*	-.03	-.21*	.13*	-.13*
S2-S1	.62*	-.23*	.48*	.34*	.52*	-.59*	-.51*	.12	-.09	-.17*
	E. Response to tax shock, CPI									
S1	-.48*	.02	.30*	-.05	-.10	.33*	.05	.02	.59*	.13
S2	.22*	.04	.91*	.25*	.32*	-.05	.02	-.19*	-.01	-.23*
S2-S1	.70*	.02	.61*	.30	.42*	-.38*	-.03	-.21*	-.60*	-.36*

Response of GDP deflator and of CPI, at 4 and 12 quarters, to a spending shock (panels A to C) and to a net tax shock (panels D and E) equal to 1 and -1 percentage point of GDP, respectively. In Panel C, the price elasticity of spending is set to 0. See also Table 6 for the notation.

Like in the case of a spending shock, in S1 at 3 years the response of inflation to a tax cut (panel D) is significantly positive only in the US and UK, the only two countries with a non-zero inflation response to a government spending shock. In S2 at 3 years the inflation response is smaller than in S1 in the US and UK and larger in Germany, exactly like in the case of a government spending shock; but the pattern is different in the other two countries. Again, the same conclusions largely apply to the case of the CPI inflation rate (panel E).

11 Changes in the variance of fiscal policy shocks and GDP

It is well known that the variance of GDP growth has fallen in many OECD countries in the last two decades (see, among many, Mills and Wang [2000], van Dijk, Osborn, and Sensier [2002], and Stock and Watson [2003])). This is also evidenced in column 5 of Table 18, which shows the decline in the four-quarter-ahead forecast variance of GDP between S1 and S2 in all countries except Canada. Columns 1 to 4 of Table 18 show that the standard deviation of government spending shocks (e_t^g in equation (2)) has also fallen everywhere in S2, by about 40 percent in Canada and Germany, 25 percent in the UK, and 10 percent in the US and Australia. The standard deviation of net tax shocks (e_t^t in equation (3)) has also fallen, by between 12 and 50 percent, in the US, the UK and Germany, while it has increased slightly in Canada and Australia.

One interpretation of these findings is that fiscal management improved in the second part of the sample. To provide a term of comparison, the decline in the standard deviation of monetary policy shocks between the pre-1979 period and the post-1983 period[43] estimated by Stock and Watson [2002] for the US is about 25 percent in a VAR à la Christiano, Eichenbaum and Evans [1999] and 25 and 40 percent in two alternative specifications à la Bernanke and Mihov [1998].

Figures 6 and 7 display the rolling standard deviations of e_t^g and e_t^t (estimated over windows of 20 quarters), respectively: in all countries except Australia, there is a clear downward trend over time, and also a rather large discrete decline in the few years around 1980.

We have seen that in S2 the response of GDP to government spending shocks has also become more muted. It is then natural to ask how much, if any, of the decline in the variance of GDP can be attributed to changes in the variance of the fiscal policy shocks and how much to changes in their transmission mechanism. Letting $\Delta\sigma_y^2|e_g$ represent the change in the variance of the 4-quarters-ahead forecast error of GDP between the two

[43] Because of the high volatility of the monetary policy shock during the Volcker period, the results are sensitive to where one allocates the 1979-1983 period.

Table 18: **Contribution of fiscal policy to changes in the variance of 4-quarters-ahead GDP forecast error**

	σ_{e_g}		σ_{e_t}		$\Delta\sigma_y^2$	of which due to			
	S1	S2	S1	S2		$\Delta\sigma_{e_g}^2$	$\Delta\Psi_g$	$\Delta\sigma_{e_t}^2$	$\Delta\Psi_t$
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
USA	.008	.007	.026	.021	-0.43	-0.02	-0.13	-0.10	-0.29
DEU	.010	.006	.019	.010	-0.51	-0.04	-0.02	-0.02	-0.01
GBR	.017	.013	.051	.038	-0.22	-0.05	-0.13	-0.09	0.11
CAN	.013	.008	.028	.030	1.01	-0.08	-0.11	0.02	0.21
AUS	.025	.023	.031	.036	-0.31	0.01	-0.01	0.08	-0.00

Columns (1) and (2): standard deviation of structural government spending shock, in S1 and S2. Columns (3) and (4): standard deviation of structural net tax shock, in S1 and S2; Column (5): change in variance of 4 - quarter - ahead forecast error of GDP between S2 and S1. Column (6): change in variance of 4 - quarter - ahead forecast error of GDP between S2 and S1 due to change in variance of government spending shock; it is equal to the first term on the r.h.s. of eq. 15. Column (7): change in variance of 4 - quarter - ahead forecast error of GDP between S2 and S1 due to change in propgation mechanism of government spending shock; it is equal to the second term on the r.h.s. of eq. 15. Column (8): same as column (6), but net tax shock. Column (9): same as column (7), but net tax shock.

subsamples due to e_g, one can write:

$$\Delta\sigma_y^2|e_g = .5\left(\Psi_{g,S2} + \Psi_{g,S1}\right)\Delta\sigma_{e_g}^2 + .5\left(\sigma_{e_g,S2}^2 + \sigma_{e_g,S1}^2\right)\Delta\Psi_{g,S2} \quad (15)$$

where $\Delta\sigma_{e_g}^2$ is the change in the variance of the government spending shock, and the term $\Psi_{g,J}$ depends on the impulse response up to 1 year ahead, based on the VAR estimated in subsample J (see Hamilton [1994] pp. 323-4). The first term of the sum on the r.h.s. can be interpreted as the contribution of the change in the variance of the spending shock, while the second term can be interpreted as the contribution of the change in the impulse response to a government spending shock, or of the transmission mechanism of government spending. An analogous formula holds for tax shocks. The sum of the r.h.s. of (15) over all the structural shocks of the model gives the change of the 4-quarter-ahead forecast error of GDP.[44]

Column (6) of Table 18 shows that in all countries except Australia, the change in the variance of the government spending shock has contributed to the fall in the variance of the four-quarter-ahead forecast error in GDP, by up to 25 percent in the UK. Column (7) shows that changes in the transmission mechanism of government spending have made an even larger contribution to the decline in the variance of GDP in all countries except in Germany. Overall, changes in the variance of the government spending shock and of its transmission mechanism contribute to about 30 percent of the decrease in the variance of the 4 quarter ahead GDP forecast error in the US, 12 percent in Germany, and 80 percent in the UK; a large decline also occurs in Canada, where however the variance of the 4 quarter ahead GDP forecast error increases.

In the first three countries, changes in the variance of the tax shock (column (8)) also contribute to the decline in the variance of GDP, in two cases by even larger amounts than government spending shocks; the contribution of changes in the transmission mechanism of taxation (column (9)) is mixed.

12 Explaining the facts: an exploration

Two basic facts emerge from the preceding empirical analysis (for brevity, I will focus on government spending):

1) In S1, when government spending has its strongest effects, GDP and private consumption increase after a spending shock, private investment much less so; the real interest rate falls or increases little;

[44] As Boivin and Giannoni [2002] note, there is no unique way of performing this decomposition. In looking at the effect of the change in the propagation mechanism, formula (15) holds the variance of the spending shock constant at its average value over the two subsamples; one could instead hold constant the variance of the shock at either subsample value, for instance.

2) In S2, the government spending process becomes less persistent; GDP, private consumption and private investment decline following a government spending shock, but the real interest rate increases.

In this section, I consider different possible explanations of these findings.

12.1 Theoretical predictions of alternative models

Can neoclassical or neokeynesian models explain result 1)?

The neoclassical model (see e.g. Baxter and King [2003]) can easily accommodate an increase in GDP following a government spending shock: as government spending increases in present discounted value terms, from the government's intertemporal budget constraint taxation must increase by the same amount, and private wealth falls accordingly. This negative wealth effect causes labor supply to shift out, and output and employment to increase.[45] However, the same negative wealth effect implies that private consumption must fall.[46] For the same reason, private investment increases if the shock is sufficiently persistent.[47]

Now introduce price stickiness into this model, as in Linnemann and Schabert [2003]. To ensure uniqueness, assume the short interest rate is determined by a Taylor rule with a coefficient on expected inflation greater than 1. Following a shock to government spending, GDP increases because of the increase in aggregate demand while some firms cannot change their price. Like in the neoclassical model, consumption falls because of the negative wealth effect on forward-looking agents.

To obtain an increase in private consumption, other frictions are needed. Galí, López-Salido and Vallés [2003] assume that a fraction of agents (the "Rule of Thumb" , or "ROT", consumers) cannot save or borrow: hence, they consume their wage period by period. Following a government spending shock, aggregate demand increases because of the presence of sticky prices; labor demand increases, and if the labor supply of ROT consumers is not too elastic, the real wage increases instead of decreasing as in the neoclassical model. With enough ROT consumers, private consumption and GDP also increase. Private investment does fall, but only slightly for reasonable values of the capital adjustment

[45] This statement assumes lump-sum taxation. With sufficient distortions, GDP can fall in the neoclassical model following a spending shock: see Baxter and King [1993].

[46] Intuitively, even in the neoclassical model private consumption can increase following a public consumption shock if the two are complements: see Bouakez and Rebel [2003] for a model with such features.

[47] Consider the case of a permanent government spending shock: as the consumer is poorer, his labor supply shifts out: in the new steady state, the capital labor ratio is unchanged, but employment is higher: hence, the capital stock must be higher; private investment jumps up on impact and then remains positive to reach the new steady state level of capital. Only if the government spending shock is short lived does investment fall. Intuitively, the wealth effect is now small: private consumption falls less, and employment and GDP increase less; but government spending increases as before on impact, hence private investment has to give.

costs.

Instead of relying on price stickiness, Devereux, Head and Lapham [1996] rely on monopolistic competition in the intermediate good sector to obtain demand effects from government spending. An increase in the latter causes entry in the intermediate good sector and raises total factor productivity. With enough monopoly power in the intermediate good sector, the real wage increases even though labor supply shifts out, by the usual negative wealth effect. Private consumption increases; private investment also increases because of the large increase in labor supply due to the increase in the real wage.

In the neoclassical model, usually the real interest rate increases in response to a government spending shock. Intuitively, the marginal product of capital increases as labor supply shifts out; and it increases more, the more persistent is the shock, because the larger is the wealth effect and the accompanying outward shift in labor supply. The real interest rate also increases in the neo-keynesian models of Linnemann and Schabert [2003], Galí, López-Salido and Vallés [2003], and Devereux, Head and Lapham [1996].[48] Note that all these results refer to the short interest rate; if the long interest rate is extrapolated from the sequence of short interest rates, however, it would rise too. Thus, in these models it is difficult to rationalize the small or negative response of the real interest rate observed in S1.

12.2 Explaining the changes between the two subperiods

What could explain result 2), namely the decline in the effects of government spending on GDP and its components in S2, and the larger real interest rate response? This section explores a few possible explanations.

First, all the economies in the sample have become more open over time; however, the increase in the export / GDP ratio is probably too small to account for the large decline in the government spending multipliers. Second, for a large part of the first period the countries of the sample were on a fixed exchange rate regime: a standard Mundell - Fleming model would predict that fiscal policy is less powerful under flexible exchange rates. However, when exports are added to the benchmark VAR (results not shown), there is no evidence of systematic crowding out of exports by fiscal shocks in S2. Third, taxation might have become more distortionary in S2: the neoclassical model would then predict a smaller, or even negative GDP response (see e.g. Baxter and King [1993]). While the intrinsic distortions of a tax system (and in particular of corporate income taxes) are difficult to measure, in general marginal tax rates on individuals have decreased in S2. Fourth, we have seen that in several countries the persistence of the government spending

[48] As Basu and Kimball [2003] note, depending on the assumption one makes about monetary policy, in neo-keynesian models with *only* price stickiness the real interest rate might fall, because the rental rate of capital falls. This is the case for instance if the stock of money is held constant, or if the weight on the output gap in the Taylor rule is large (see Linnemann and Schabert [2003]).

shock falls from S1 to S2. As the wealth effect falls, the neoclassical model can easily explain the decline in the GDP and private investment responses, but it has the opposite prediction for private consumption, since the negative wealth effect on forward-looking consumers also weakens. The real interest rate also increases less. The neo-keynesian model of Galí, López-Salido and Vallés [2003] has similar difficulties in explaining the decline in the response of private consumption, because the non-ROT consumers behave exactly like in the neoclassical model. In addition, note that not only the GDP response, but also the spending multiplier falls in S2, hence the lower persistence of government spending is unlikely to be the whole explanation.

This leaves two more hypotheses, that I explore in turn.

(i) Relaxation of credit constraints

Table 19 displays the evolution over time of the downpayment in housing mortgages

Table 19: **Indicators of credit constraints**

	Down payment ratio			Consumer credit				
	1971-80	1981-90	1991-95	1959-61	1969-71	1979-81	1989-91	1999-01
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
USA	20	11	11	11.3	12.1	12.7	13.9	17.1
DEU	35	35	20					
GBR	19	13	5					
CAN	25	20	20		11.8	13.7	14.4	18.1
AUS	30	20	20			6.6	11.2	14.8

Columns (1) to (3): Down payment in housing mortgages. Columns (4) to (8): ratio of consumer credit to GDP. entry for 1969-71 for Canada is 1971 value. Sources: colums (1) to (3): Chiuri and Jappelli [2003]; columns (4) to (8): see Appendix A.

and the ratio of consumer credit to Net National Income. Lower values of the first index and higher values of the second indicate a relaxation of credit constraints. In all the countries of this sample, both indicators show clear evidence of relaxation of credit constraints over time. In neo-keynesian models with liquidity constrained individuals, like Galí, López-Salido and Vallés [2003], the positive effects of government spending on GDP and private consumption fall as the share of constrained individuals falls, since for non-ROT individuals private consumption is negatively correlated with government spending. On the other hand, these models seem unsuited to explain the decline in the effects of government spending on private investment: the latter is rather insensitive to government spending to start with, and in any case it falls less as the share of ROT individuals falls.

(ii) The stronger real interest rate response

Can the larger response of the real interest rate in S2 help explain the decline of the GDP response in the same period? Panel A of Table 20 displays the cumulative response of GDP to a spending shock in S1 and S2 at 1 and 3 years (the same as in Table 6); Panel B displays the same response, but with the *ex-post* real interest rate response shut

Table 20: **The real interest rate channel**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A. Cumul. GDP resp. to a spending shock									
S1	1.13*	3.68*	.41*	-.11	.48*	.10	.59*	.74*	-.10	1.52*
S2	.31	.10	.40*	-1.38*	-.22	-1.23*	-.28	-2.25*	.21*	.77*
S2-S1	-.82*	-3.77*	-.01	-1.27*	-.70*	-1.33*	-.88*	-2.99*	.31	-.75*
	B. Cumul. GDP resp. to a spending shock, real interest rate shut off									
S1	1.13*	3.54*	.55*	-.41*	.50*	-.55	.64*	.94*	.45*	2.62*
S2	.47	.38	.36*	1.03*	-.21	.12	-.20	-2.00*	.24*	.66*
S2-S1	-.66	-3.16*	-.19	1.44*	-.71*	.77	-.84*	-2.94*	-.21	-1.96*

Panel A: cumulative GDP response to a spending shock, from panel A of Table 6. Panel B: same, but the *ex-post* real interest rate response is forced to be 0 throughout the whole horizon of the impulse response. See also Table 6 for the notation, and the text for further explanations.

off; that is, in each quarter the nominal interest rate response is forced to be equal to the inflation rate response over the last 4 quarters.

Shutting off the real interest rate response makes little difference to the cumulative GDP response at 1 year, but often a large one at 3 years. In the 4 countries with the largest decline in the GDP response is S2 relative to S1, the real interest rate response increases in S2 relative to S1, although significantly so only in Germany and the UK. Shutting off the real interest rate response causes the GDP response to shift up in all these cases, and in particular in Germany and the UK. In fact, now the GDP response in these two countries is *larger* in S2 than in S1.

Still, the real interest rate is an endogenous variable, hence deeper explanations are needed. Two promising candidates come to mind. First, changes in monetary policy. Several studies have documented a more aggressive anti - inflationary stance since the early eighties, in the form of a higher coefficient on expected inflation in the Taylor rule, or a higher coefficient on the output gap. The models of Galí, López-Salido and Vallés [2003] and of Linnemann and Schabert [2003] predict that in this case the positive response of GDP and private consumption to a government spending shock would be attenuated.

A second explanation is that financial markets have become more sophisticated in the last two decades, and react more strongly to fiscal news. Formally, this can be formalized as higher values of β_1 and β_4 in equation (6c); from (9), given $\gamma_2 < 0$, this will decrease the estimated effect of government spending on output. Both explanations await a deeper empirical scrutiny.

Appendix A: The data

The coefficients α_{ty} and α_{tp} in equation (2) are weighted averages of the elasticities of each component of net taxes. I break down total revenues into 5 components, each with a different elasticity: individual income taxes (tyh), corporate income taxes (tyb), indirect taxes (tind), social security taxes (sst), and a residual item, the sum of all other current (ctrr) and capital (ktrr) transfers received by the government, which include all items with zero quarterly elasticity to output.

The data form the national sources follow the classification recommended by the 1993 System of National Accounts (see Commission of the European Communities [1993]), with a few exceptions. To make sure that the five different categories of tax revenues I use have homogeneous elasticities, I have reclassified some of the original items. In particular, I have reclassified in the residual item some components of income taxes or indirect taxes that are likely to be inelastic to output at a quarterly frequency, like property taxes, fines and penalties, inheritance taxes, etc. I have also lumped with indirect taxes items like licenses and fees purchased by households and businesses, on the ground that they, like indirect taxes, are probably close to being unit elastic to GDP. Under the 1993 System of National Accounts, payroll taxes are considered as a tax on production and therefore classified as indirect taxes; whenever the information is available, I have reclassified them as social security taxes.

In what follows I detail the construction of the main budget aggregates (the names in parentheses are the names used in the files [countryname].prg, [countryname].xls and in all the program files to indicate these aggregates): government consumption (cg), government investment (ig), revenues (rev) and transfers (tran), government spending (gcn, the sum cg+ig), and net taxes (tax, the difference rev-tran).

The names on the right hand side of each equality below and in the legend are the names used in the countries' datasets data1_[countryname]_background.xls (see also Perotti [2003]). All these files can be downloaded from my website at http://www.igier.uni-bocconi.it/perotti.

Legend:
fce: government consumption
ctrp: other current transfers paid
ctrp_dom: other current transfers paid to domestic sources
ctrr: other current transfers received
ctrr_dom: other current transfers received from domestic sources
gfkf: government gross fixed capital formation
invnt: govenrment inventories
kca: capital consumption allowances
ktrp: other capital transfers paid

ktrr: other capital transfers received
ktrr_dom: other capital transfers received from domestic sources
sales: government sales
sst: social security contributions
subs: subsidies to firms
tind: indirect taxes
ty_row: direct taxes from rest of the world
tyb: direct taxes on business
tyh: direct taxes on households
tranh: transfers to households

AUSTRALIA:
rev = tind + tyh + tyb + ty_row + sst + ctrr
tran = tranh + subs
cg = fce
ig = gfkf + invnt
Long interest rate: Assessed secondary market yield on non-rebate bonds with maturity to 15 years, *IMF International Financial Statistics*, series 19361...ZF
CPI: CPI all items, *OECD Main Economic Indicators*, series 545241k
Consumer credit: "Other personal credit", *Reserve Bank of Australia Bulletin*, Table 2D, series DLCACOPISS, http://www.rba.gov.au/Statistics/Bulletin/D02hist.xls

CANADA
rev = (tind - sales)+ tyh + tyb + ty_row + sst + ctrr_dom + ktrr_dom
tran = tranh + subs
cg = fce - sales
ig = gfkf + invnt
Long interest rate: Government bonds yield at 10 years ("Average yield to maturity: reflects issues with original maturity 10 years and more"), *IMF International Financial Statistics*, series 15661..ZF...
CPI: CPI all items, *OECD Main Economic Indicators*, series 445241k
Consumer Credit: "Consumer credit, outstanding balances of selected holders" CANSIM database, Table 176-0027, series v122707, http://cansim2.statcan.ca

GERMANY
rev = tind + ty + sst + ctrr
tran = tranh + subs
cg = fce
ig = gkf

Long interest rate: Interest rate on 9-10 year public sector bonds, *OECD Economic Outlook* database

CPI: CPI all items, *OECD Main Economic Indicators*, series a135241JSA

UNITED KINGDOM

rev = tind + ty + sst + ctrr_dom + ktrr

tran = tranh + subs + ctrp_dom + ktrp

cg = fce - kca - imputed social security contributions

ig = gfkf + invnt + nav

Long interest rate: Yield, 10 year government bond, *OECD Main Economic Indicators*, series 266261D

CPI: CPI all items, *IMF International Financial Statistics*, series 265241K

USA

rev = tind + tyh + tyb + ty_row + sst + ctrr + ktrr_dom

tran = tranh + subs

cg = fce - wage accruals less disbursements - supplemental medical insurance premiums

ig = gfkf

Long interest rate: yield, 10-Year Treasury Constant Maturity Rate Averages of Business Days, saries GS10, *H.15 Release, Federal Reserve Board of Governors*

CPI: CPI all items, *IMF International Financial Statistics,* series 265241K

Consumer credit: "Consumer credit outstanding", *Economic Report of the President*, 2004, Table B-77.

Appendix B: Constructing the output and price elasticities

Output elasticity of revenues

(i) Income taxes on individuals

Consider first income taxes on individuals, typically the largest component of tax revenues. One can write

$$H_t = S(W_tP_t)W_t(E_t)E_t(Y_t) \qquad \text{(B. 1)}$$

where H_t is total real direct taxes on individuals, S is the tax rate, W_t is the real wage, P_t is the GDP deflator, E_t is employment, and Y_t is output. Thus, W_tE_t is the tax base (ignoring non-labor income). Letting lower-case letters denote logs, and totally differentiating, one obtains:

$$dh_t = \frac{\partial s}{\partial w_t}dw_t + \frac{\partial w_t}{\partial e_t}de_t + \frac{\partial e_t}{\partial y_t}dy_t + \frac{\partial s}{\partial p_t}dp_t \quad \text{(B. 2)}$$

$$= \left[\left(\frac{\partial s}{\partial w_t} + 1\right)\frac{\partial w_t}{\partial e_t} + 1\right]\frac{\partial e_t}{\partial y_t}dy_t + \frac{\partial s}{\partial p_t}dp_t \quad \text{(B. 3)}$$

Thus, the term multiplying dy_t in (B. 3) is the equivalent of α_{ty} in equation (2) for this particular tax revenue, and the term $\partial s/\partial p_t$ is the equivalent of α_{tp}.

For most member countries, the OECD computes the elasticity of tax revenues per person to average real earnings, the term $\partial s/\partial w_t + 1$ in (B. 3), using information on the tax code of each country and the distribution of taxpayers in each bracket, at intervals of a few years.[49] I then obtain the output elasticity of individual income and of social security taxes from formula (B. 3), after estimating the terms $\partial e_t/\partial y_t$ and $\partial w_t/\partial e_t$. The first is obtained as the coefficient on lag 0 of log GDP in a regression of log employment on lags 4 to -1 of log GDP; the latter from a similar regression of the log real wage on lags 4 to -1 of log employment.

Whenever the self-employed pay income taxes based on past income rather than their current quarterly income (as in all countries except the US), I reduce the elasticity of personal income taxes in proportion to the share of self-employment income in total personal income, if this breakdown is available.

(ii) Social security taxes

The construction of the output elasticity of social security taxes is conceptually identical to that of individual income taxes.

(iii) Corporate income taxes

Corporate income taxes are proportional to profits in all countries in the sample; the output elasticity of corporate income taxes is then equal to the estimate of the quarterly contemporaneous elasticity of profits to GDP. When there are no collection lags, the latter elasticity is estimated as the coefficient on lag 0 of log GDP in a regression of log corporate profits on lags 4 to -1 of log GDP. However, whenever corporate income taxes are collected with a lag longer than a quarter (as in Germany, the UK and Australia), I set their contemporaneous output elasticity to 0.

(iv) Indirect taxes

The output elasticity of indirect taxes is assumed equal to 1.

Output elasticity of transfers

Items like old age, disability and invalidity pensions – the bulk of transfers to households – do not have built-in mechanisms that make them respond automatically to changes in employment or output contemporaneously. Unemployment benefits obviously do, but

[49]Data on $\partial s/\partial w_t + 1$ are obtained from Giorno et al. [1995] until 1992, and from van den Noord [2002] after 1992.

they typically account for a small part of government spending: if all active and passive measures are included, the largest spender was West Germany, with 3.03 percent of GDP (see OECD [1996]). In all cases the sum of spending on passive and active measures was less than 10 percent of total government expenditure. Hence, I assume an output elasticity of transfers of -.2 (see also Giorno et al. [1995]); this is rather generous, and allows for spillover effects in other programs: for instance, some anti-poverty programs like AFDC in the US might display some within-quarter elasticity to unemployment and output.

The weighted average of all the elasticities of revenues and transfers gives the output elasticity of net taxes, the coefficient α_{ty} in equation (2).

Output elasticity of government spending

There is no evidence of any substantial automatic response of government spending to GDP within a quarter: hence, the benchmark output elasticity of spending α_{gy} in equation (3) is assumed to be 0.

Price elasticity of revenues

A methodological innovation of this paper is the construction of the price elasticities of net taxes - $\alpha_{t\pi}$ in equation (2) - and of government spending - $\alpha_{g\pi}$ in equation (3).

(i) Income taxes on individuals

The elasticity of real revenues to the price level, holding constant employment, output and the real wage, is equal to $\partial s_t / \partial w_t$, which can be obtained by subtracting 1 from the OECD estimate of the elasticity of tax revenues per person to average real earnings. As mentioned in the text, the elasticity of real corporate income taxes and indirect taxes to the GDP deflator is assumed to be 0.

(ii) Social security taxes

The construction of the price elasticity of social security taxes is conceptually identical to that of individual income taxes.

(iii) Corporate income taxes

It is well known that inflation has many and complex effects on corporate income tax revenues, in both directions. Any attempt to quantify these effects in all of the countries studied in this work would deliver extremely unreliable results. Hence I assume a 0 price elasticity of real corporate income taxes.[50]

(iv) Indirect taxes

I assume a 0 price elasticity for indirect tax revenues in real terms (i.e., a unitary elasticity for nominal revenues).

[50] In a detailed study on the effects of inflation on government revenues and expenditure in Sweden, Persson, Persson and Svensson [1998] conclude that it is impossible to quantify credibly the effects of inflation on corporate income taxes. They also assume a zero inflation elasticity of corporate income taxes.

Price elasticity of transfers

Many transfer programs are indexed to the CPI; however, indexation typically occurs with a substantial lag. A review of indexation clauses in OECD countries in the postwar period did not uncover any government spending program that was or is indexed to inflation contemporaneously at quarterly frequency. Hence, I set the quarterly price elasticity of real government transfers to -1.

The weighted average of all the elasticities of revenues and transfers gives the price elasticity of net taxes, the coefficient $\alpha_{t\pi}$ in equation (2).

Price elasticity of government spending

Consider first the wage component of current spending on goods and services (typically, slightly less than half the total spending). While government wages were indexed to the CPI during part of the sample in some countries, in all cases indexation occurred with a considerable lag, well above one quarter. Hence, *real* government spending on wages has an approximate elasticity to the GDP deflator of -1.

Consider next the non-wage component of government spending on goods and services. Some of it might be approximately fixed in nominal terms within the quarter, implying a price elasticity of real spending equal to -1. Other parts, like spending on drugs in nationalized health services, might be effectively indexed to the price level within the quarter, implying an elasticity of 0. Overall, a price elasticity of real total government spending ($\alpha_{g\pi}$ in equation (3)) well below 0 seems justified. In my benchmark specifications, I assume $\alpha_{g\pi}$ = -.5. I study the sensitivity of my results to alternative values for this coefficient.

Interest rate elasticities

Because both revenues and expenditures exclude property income, I set the interest rate semi-elasticity of both net taxes and government spending to 0: $\alpha_{gi} = \alpha_{ti} = 0$. This is probably a safe assumption for government spending; it is slightly more uncertain for net taxes[51].

The rest of this Appendix reports the contemporaneous tax elasticities, collection lags, and quarter dependence for cash tax revenues. For true accrual measures of tax revenues, the tax elasticity would always be the statutory tax elasticity, as measured by the OECD.

[51] One could argue that the individual income tax base includes interest income, which would imply a positive interest rate semi-elasticity of individual income taxes. Yet it also includes dividend income, which might covary negatively with the interest rate. Like for the effects of prices, the effects of interest rates on corporate income tax revenues are extremely complex. Canzoneri, Cumby and Diba [2002] conduct a careful exercise to quantify the interest semi-elasticity of net taxes in the US.

United States

Individual income tax. (i) Income from employment: withholding system. Contemporaneous elasticity to real earnings per person: OECD elasticity. Collection lags: none. (ii) Income from self-employment and business: quarterly installments of income tax based on expected income. Contemporaneous elasticity to real earnings per person: OECD elasticity. Collection lags: none.

Corporate income tax. 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 tax final tax liability. No penalty was applied if the estimated tax liability is based on previous year's tax liability; this exception has been gradually phased out from 1980 on. Contemporaneous elasticity to tax base: 1, although it could be lower at the beginning of the sample until the mid eighties, when a company could base its estimated tax liability on the previous year's tax liability. Collection lags: none.

West Germany

Individual income tax. (i) Income from employment: withholding system. Contemporaneous elasticity to real earnings per person: OECD elasticity. Collection lags: none. (ii) Income from self-employment and business: quarterly installments of income tax based on previous year's assessed tax liability. Contemporaneous elasticity: 0.

Corporate income tax. Quarterly installments, based on previous year's assessment Contemporaneous elasticity to tax base: 0.

United Kingdom

Individual income tax. (i) Income from employment and pensions: weekly withholding during entire sample. Contemporaneous elasticity to real earnings per person: OECD elasticity. Collection lags: none. (ii) Income from self-employment: same tax rates as for income from employment (with proportional surcharge). For tax year ending April 1 of year t, two lump sum payments on January 1 and July 1 of year t, based on assessment for fiscal year ending April t-1. Contemporaneous elasticity: 0.

Corporate income tax: For companies started before 1965: If the company's accounting period ends before March 31st of year t, the tax is due January 1 of year t+1. If the company's accounting period ends after March 31st of year t, the tax is due January 1st of year t+2. Hence, the lag in the payment is between 9 and 21 months. For companies started after 1965: the tax is due 9 months after the end of the accounting period. Contemporaneous elasticity: to tax base: 0.

Canada

Individual income tax. (i) Income from employment: withholding system. Contemporaneous elasticity to real earnings per person: OECD elasticity. Collection lags: none. Quarter dependence: none. (ii) Income from self-employment and business: If an individual has less than 25% of his income from dependent employment, required to pay

quarterly installments of income tax on expected income. Expected income is mostly based on previous year's income. Contemporaneous elasticity: 0.
Corporate income tax. Each corporation has its own fiscal year. The taxation year is Jan. 1 to Dec 31, and covers corporations whose fiscal year ends within this calendar year. Corporations must pay quarterly installments on expected income. Contemporaneous elasticity to tax base: 1.

Australia
Individual income tax. (i) Income from employment: withholding system. Contemporaneous elasticity to real earnings per person: OECD elasticity. Collection lags: none. (ii) Income from self-employment and business: installments of income tax based on previous year's assessed tax liability. Contemporaneous elasticity: 0.
Corporate income tax. Quarterly installments, based on previous year's assessment. Contemporaneous elasticity to tax base: 0.

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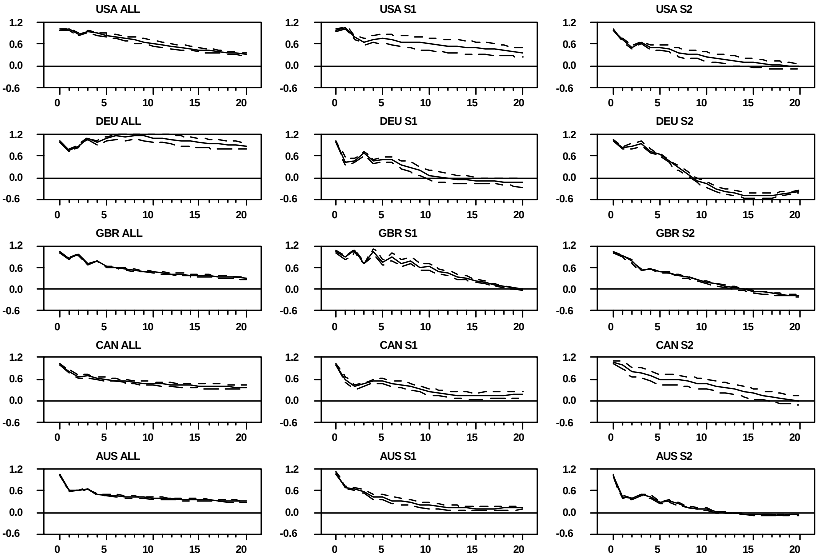

Figure 1: **Response of spending to a spending shock**

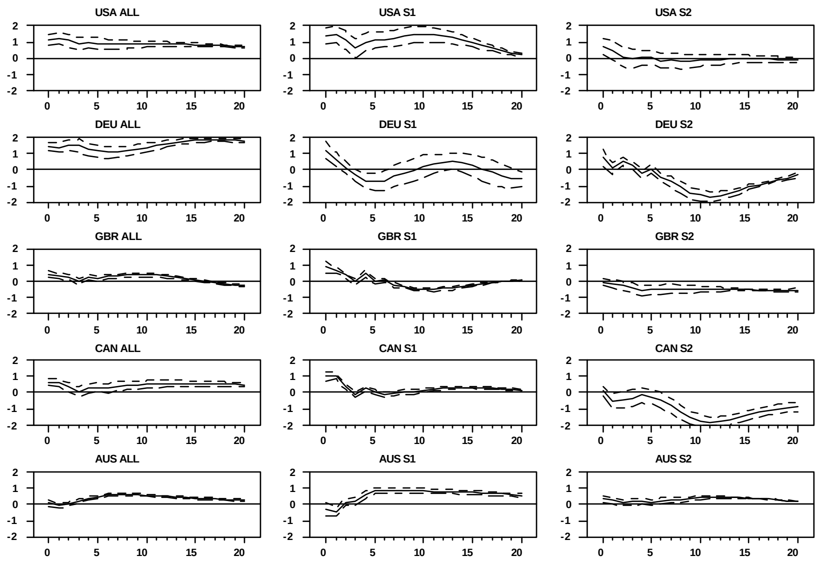

Figure 2: **Response of GDP to a spending shock**

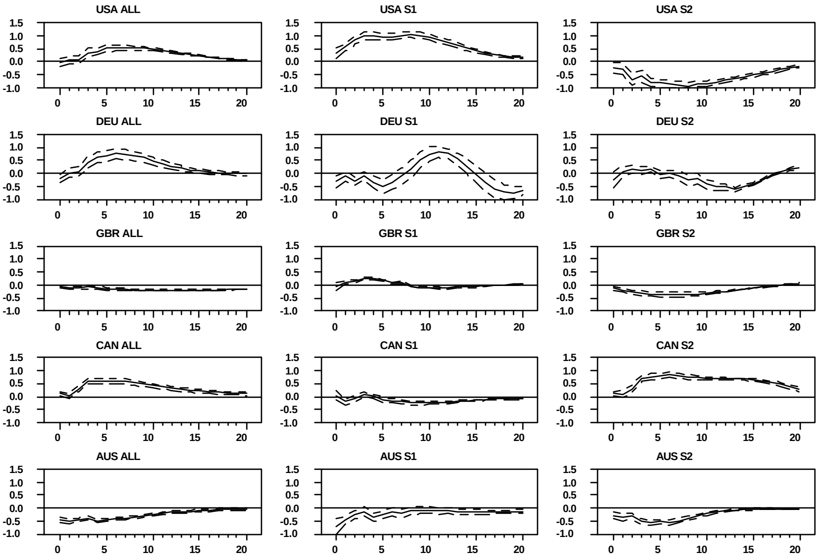

Figure 3: **Response of GDP to a tax shock**

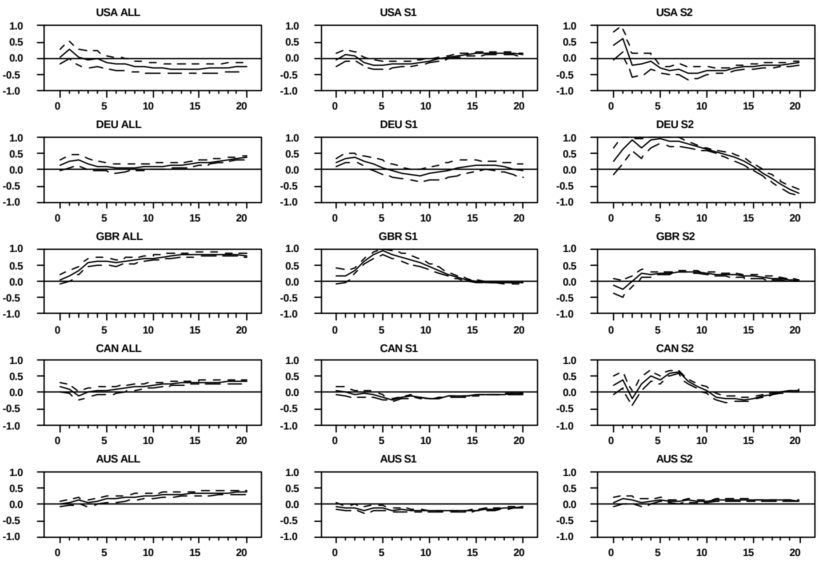

Figure 4: **Response of 10-year interest rate to a spending shock**

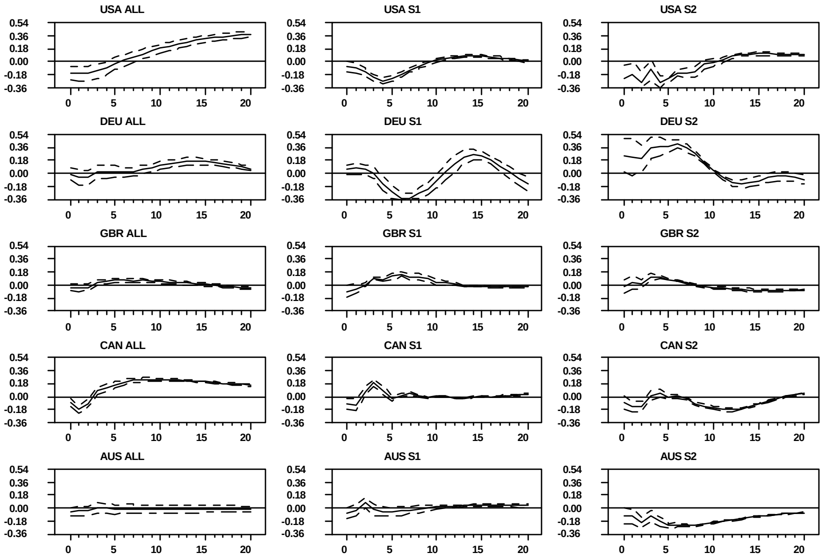

Figure 5: **Response of 10-year interest rate to a tax shock**

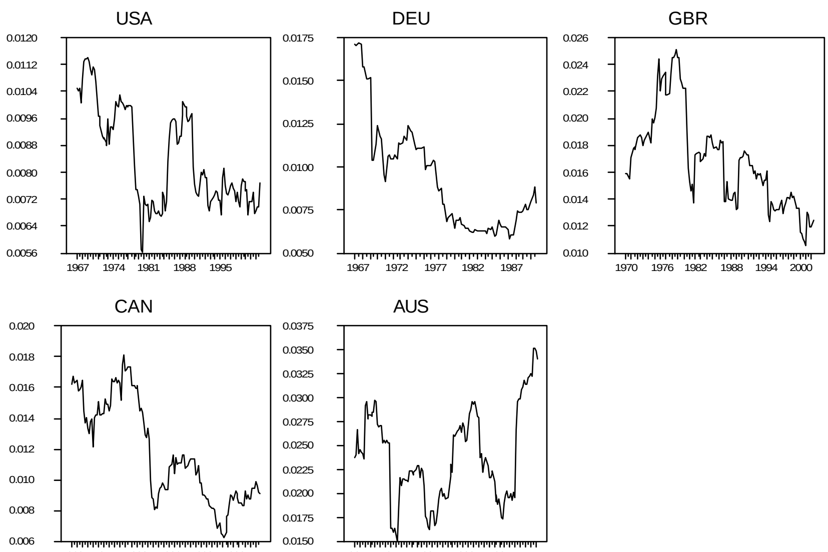

Figure 6: **Rolling standard deviation of spending shock**

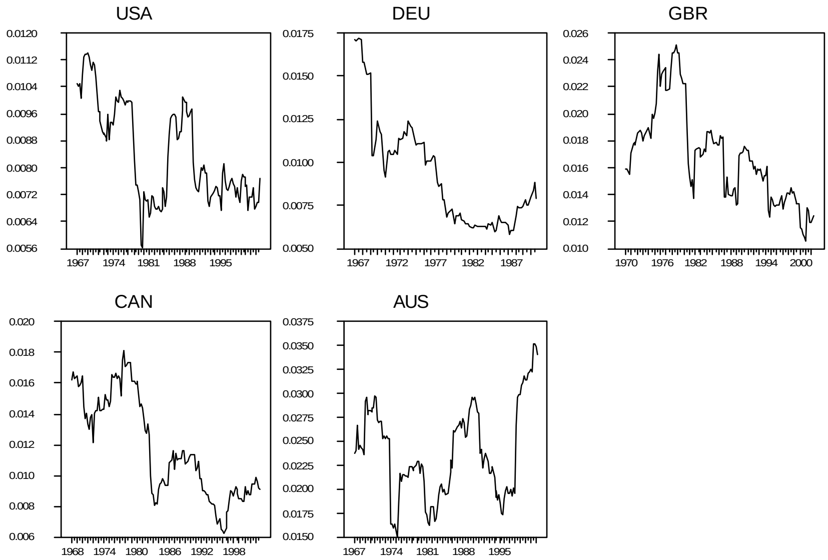

Figure 7: **Rolling standard deviation of net tax shock**