Public investment: another (different) look

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This version: December 2004

Abstract

Using a structural Vector Autoregression approach, this paper compares the macroeconomic effects of the three main government spending tools: government investment, consumption, and transfers to households, both in terms of the size and the speed of their effects on GDP and its components. Contrary to a common opinion, there is no evidence that government investment shocks are more effective than government consumption shocks in boosting GDP: this is true both in the short and, perhaps more surprisingly, in the long run. In fact, government investment appears to crowd out private investment, especially in dwelling and in machinery and equipment. There is no evidence that government investment "pays for itself" in the long run, as proponents of the "Golden Rule" implicitly or explicitly argue. The positive effects of government consumption itself are rather limited, and defense purchases have even smaller (or negative) effects on GDP and private investment. There is also no evidence that government transfers are more effective than government consumption in stimulating demand.

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1 Introduction

It is widely believed that governments no longer engage in the kind of fiscal activism of the fifties and the sixties.[1] Yet, most policymakers still nurture a deep-seated belief that government spending is a useful tool in boosting demand in the short run, should the need arise: it would be difficult to explain otherwise why government spending often increases before elections[2], or why governments budgets around the world are routinely packed with spending provisions for "depressed" areas or for sector experiencing cyclical downturns.

The effectiveness of government spending as a demand management tool depends on the speed and size of its impact on GDP and its components.[3] But government spending is an aggregate of very different tools - chiefly, government consumption, government investment, and transfers to households, which together made up about 96 percent of total non-interest spending of the typical OECD country during the nineties. One often hears the argument that transfers are the fastest and most effective tool, loosely speaking because they "put money directly and quickly in the hands of individuals with a high propensity to spend". For others, government purchases are more effective, because they "create production and income directly" (Hansen [1969], p. 16). And among purchases, some consider public investment the superior instrument, because it combines the attractions of purchases of goods as a countercyclical tool in the short run with the long run virtues of a supply policy tool (it is presumably for these reasons that Keynes was of the opinion that public investment should be the countercyclical tool of choice - see Skidelsky [2001]). Yet, there is very little hard comparative evidence on the macroeconomic properties of the different types of government spending. The first goal of this paper is precisely to evaluate empirically the short-to-medium run properties of alternative types of government spending, along the two dimensions of speed and size of their effects.

In the long run, the superiority of public investment seems hard to refute on theoretical grounds. For instance, in the standard neoclassical model of Baxter and King [1993] public capital is typically introduced as an unpaid factor with a positive marginal product in the private sector production function: hence, it has all the effects of government consumption, plus a positive externality on the productivity of private inputs.

Even at the policy level, in Europe it is almost an article of faith that, abstracting from distributional issues, public investment is a superior type of spending: for instance, the

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[1] For a detailed descritpion of stabilization policies in seven OECD countries during the 1955-1965 period, see Hansen [1969].

[2] Persson and Tabellini [2003, chapter 8] and Shi and Svensson [2002] find evidence that spending increases systematically in election years, by as much as .4 percentage points of GDP, in a panel of developing and developed countries.

[3] The statement obviously abstracts entirely from distributional issues; one might prefer an instrument that is inferior in terms of speed and size of its effects on GDP, but that benefits disproportionately a specific group.

recent official review of public finances in Europe by the European Commission writes: "For the countries with high deficits, the budgetary consolidation strategy, based on expenditure restraint, should not be achieved at the expenses of the most 'productive' components of public spending (such as public investment, education and research expenditures)." (European Commission [2004], p. 28). As a consequence, proposals to shield public investment from the strictures of the Stability and Growth Pact have become increasingly popular.[4]

These proposals are typically associated with the recent revival of interest in the "Golden Rule", whereby current government spending should be fully financed by taxation, while capital spending can be financed with debt.[5] The Golden Rule is based on the notion that public investment "pays for itself": when the public capital stock increases by 1 dollar, the present value of the extra tax revenues generated by the higher GDP at the given tax rates (less the present value of the depreciation expenses on the extra dollar of government capital) is at least 1 dollar. Hence, if the intertemporal government budget constraint is satisfied before the extra dollar of public investment, it will also be satisfied afterwards, *at unchanged tax rates*. The attraction of the Golden Rule is precisely that it allows for potentially socially worthwhile investment opportunities to be undertaken, without violating the "sustainability" of public finances.

But reality can be very different from theory. As I discuss in more detail in section 12, in practice there can be a host of reasons why public investment could have a very low, or even negative, social return. Even in the longer run, the comparative properties of alternative government spending instruments are therefore a matter of empirical investigation. Assessing these long-run properties of the various spending tools is the second goal of this paper; in particular, I investigate whether indeed the long-run returns of public investment are so high that it pays for itself.

There is by now a considerable literature (which I review briefly and selectively in

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[4] See for instance a recent public appeal by a group of European and non-European economists, including two recent Nobel prize winners (Modigliani et al. [1998]).

The Stability and Growth Pact, which took effect in 1998, stipulates that member states of the European Union cannot run budget deficits larger than 3 percent of GDP. The Pact envisions sanctions of various severity, up to a monetary fine, in serious cases of non-compliance. Following a highly publicized debate over a break of the 3 percent rule by Germany and France in late 2003, the operation of the Pact has been *de facto* suspended until further notice.

[5] See e.g. Blanchard and Giavazzi [2004]. An early – but not necessarily the first – mention of the Golden Rule is in Musgrave [1939]. The Golden Rule was followed in the nineteenth century by Great Britain and the US, and is still in effect in some US states. Bassetto and Sargent [2004] show that the Golden Rule can improve the efficiency of the allocation of resources under majority rule and in some demographic conditions, and use the model to explain why in the US the Golden Rule was abandoned by the federal government but not by many states. Currently, among European countries some version of the Golden Rule is formally in operation in the UK and in Germany (one important difference is that the budget deficit cannot exceed net investment in the former and gross investment in the latter). In the 50s and 60s it was adopted by Belgium, the Netherlands, and Sweden, and later abandoned.

the next section) on the effects of public capital and government consumption, based on estimates of production and cost functions of the private sector. In this paper, I take a different approach, based on quarterly VARs, which as I argue below circumvents several problems of the production and cost function approaches. The sample includes 5 OECD countries (Australia, Canada, West Germany, the United Kingdom, and the United States) for which I was able to assemble non-interpolated quarterly data for the general government, directly from national sources.

Several conclusions from this analysis run counter to received wisdom. To preview the main results, there is no evidence that government investment shocks are more effective than government consumption shocks in boosting GDP: this is true both in the short and, perhaps more surprisingly, in the long run. In fact, government investment appears to crowd out private investment, especially in dwelling and in machinery and equipment. There is no evidence that government investment "pays for itself" in the long run, as proponents of the "Golden Rule" implicitly or explicitly argue. There is also no evidence that government transfers are more effective than government consumption in stimulating demand, even in the short run. The multiplier of government consumption is itself not large. When I disaggregate government purchases further, I find that defense government consumption has a consistently lower multiplier than civilian government consumption. These findings appear to be robust along several dimensions.

The plan of the paper is as follows. The next section reviews briefly and selectively the recent literature on the macroeconomic effects of government investment and consumption. Section 3 discusses the specification of the VAR model I use and the identification strategy. Section 4 describes the data. Section 5 discusses the responses of government consumption and investment to shocks to the same two variables. Section 6 discusses the effects of shocks to government investment and consumption on GDP. Section 7 presents the responses of private investment and consumption to fiscal shocks, and briefly reviews the results in the light of the main macroeconomic models of private consumption and investment. Section 8 discusses the robustness and stability of the results. Section 9 distinguishes further between defense and non-defense government purchases. Section 10 studies the long-run properties of government spending, in particular whether there is any indication in the data that public investment pays for itself. Section 11 introduces government transfers to households as a third spending instrument. Section 12 advances some tentative explanations for the main results and concludes.

2 Literature

The macroeconomic effects of government purchases have been studied in a large literature based on estimates of aggregate production or cost functions. Most of this literature focuses on the effects of public capital (the integral of capital purchases by the government), but some of it also studies the effects of current government purchases. In a seminal contribution, Aschauer [1989] calculated that, holding constant private inputs, private US GDP would increase permanently by more than one to one for every additional unit of non-military public capital - in other words, that the annual marginal product of public capital is in excess of 100 percent. Aschauer's results were based on a static production function estimated with yearly US data in levels. Subsequent research estimating production functions using pooled US state data in levels (Munnell [1990]), disaggregating public capital into its main components (Finn [1993]), or using industry data (Fernald [1993]) also found similar effects, particularly for roads and highway capital.

Time series estimates in levels might simply capture common trends; pooled state data in levels might simply capture underlying persistent state characteristics - richer states invest more in public capital. In fact, when the production function is estimated with aggregate US data in differences, or with state data with fixed effects, zero or even negative marginal products of public capital become typical (see Tatom [1991] and Hulten and Schwab [1991] for estimates in differences; Evans and Karras [1994], Hotz-Eakin [1994], Garcia-Milà, McGuire, and Porter [1996] for estimates with fixed effects).

A well known limitation of the production function approach is the joint endogeneity of private inputs and outputs. Besides using instruments of dubious validity in estimating production functions, a frequent response has been to use a cost function approach, which takes as given private input prices instead of quantities.[6] This is hardly a solution, though: at the typical level of aggregation of these studies (US states or industries) private input prices are also likely to be jointly determined with input and output quantities (see Houghwout [2002]).

Both the production function and the cost function approaches can be adapted to study the effects of some types of government consumption as well: one can think of several reasons why items like spending on health and education would enter the production or cost functions of the private sector. However, a first problem common to both the production and cost function approaches is that they are limited in the types of effects of fiscal policy they can capture: many government consumption or transfer items can have important macroeconomic effects even if they have no noticeable impact on the private sector production or cost functions. This is an implication not only of neo-keynesian models of fiscal policy like Galí, López-Salido and Vallés [2003], but also of neoclassical models like Baxter and King [1993].

In the latter, in general equilibrium government spending generates wealth and substitution effects on private agents, both intra- and inter-temporal. In the former, government spending can also have demand effects in the short run, which might pollute the estimate

[6] Based on aggregate US industry data, Nadiri and Mamouneas [1994] estimate marginal products of public capital of about 7 percent (in the cost function approach, the marginal product of capital is equal to the shadow value of capital, or the cost reduction in private production from an extra unit of public capital). based on state data, Morrison and Schwartz [1996] find higher values, ranging from 21 percent in the North-East to 34 percent in the South in 1987, although much lower in previous years.

of the marginal effect of public capital on the productivity of private factors. All these effects depend on the shape of the whole path of government spending over time. For both reasons, what is needed is a specification with a much richer dynamic structure than usually present in the existing literature.[7]

A second problem common to both approaches is that not only private inputs, but also publicly provided inputs can be endogenous: government spending can be higher in years of high growth, as the state and federal governments have more resources to spend; or it can be higher in years of low growth, if the state and federal governments engage in countercyclical policies. Either way, the government spending variables on the right hand side of production and cost function regressions cannot be treated as predetermined.[8]

A third problem of the existing approaches is that the general equilibrium effects of public spending are likely to depend on a number of concomitant variables. This is a standard omitted variable problem, which however is not solved by just adding a set of plausible variables on the right hand side, if their dynamics is also misspecified.

Related to this problem is a fourth one: the production and cost function approaches impose strong restrictions on the functional form of the interaction between government spending and output.

A Vector Autoregression approach in principle can address all these problems. It treats all types of government spending symmetrically, allowing a comparison of their effects in the short and long run; as I show below, if based on data of sufficiently high frequency it can address the second problem, the endogeneity of government spending; it allows for dynamic feedbacks with several endogenous variables; and it only imposes the constraint of linearity of the reduced form equations.

A recent small but growing VAR literature, briefly reviewed in Perotti [2004], uses quarterly data and concentrates on developing alternative identification schemes to isolate shocks to government spending. However, government spending in this literature is almost invariably total government purchases - government investment plus government consumption; there is no distinction between the two, or between the defense and civilian components of government purchases, nor is there a specific analysis of the effects of government transfers.[9]

[7] In the context of the production function approach, Demetriades and Mamuneas [2000] develop a richer dynamic model based on intertemporal profit maximization. They distinguish between a short run, when private investment is fixed, an intermediate run; and a long run, when private factors fully adjust to changes in public investment. The model is estimated using annual data from 12 OECD countries; for the US, the authors find long-run marginal products of public capital comparable to those obtained by Aschauer.

[8] Note that state fixed effects in yearly panel regressions would not take care of the problem. While they partial out persistent state specific determinants of public capital, they do nothing against endogeneity arising from states spending systematically more (or less) when state GDP or growth are high.

[9] Using annual US state data, Pappa [2004] studies the different effects of government investment, government consumption, and government employment.

A different VAR literature focuses specifically on the effects of public investment: Kamps [2004] lists 20 such studies. Identification issues are not the primary focus of this literature, which accordingly relies mostly on simple Choleski ordering to identify the shocks. Also, with the four exceptions noted below, all these studies use annual data, thereby making it difficult to separate true exogenous shocks to public investment from the endogenous response of public investment to other macroeconomic shocks. Finally, and again with one exception also noted below, these studies focus exclusively on public investment and do not include other types of government spending.

All four VAR studies of public investment based on quarterly data identify the fiscal policy shocks via Choleski ordering. Otto and Voss [1996] study the effects of public capital shocks in Australia. Voss [2002] studies the impact of public investment on private investment in the US and Canada, and finds some evidence of crowding out. Mittnik and Neumann [2001] estimate a 4-variable VAR in public investment, government consumption, private investment, and GDP using quarterly data from 6 OECD countries: Canada, Great Britain, West Germany, France, Japan, and the Netherlands.[10] They usually find some positive effect of public investment on GDP both in the short run and in the long run, although in the latter case the effect is significant only in West Germany. Kamps [2004] estimates a similar VAR for the US only, and also finds a small positive effect on GDP.

My approach is based on a different specification of the VAR and on a different identification scheme, and includes only countries with true non-interpolated quarterly data on fiscal policy. In addition to studying the effects of government investment on GDP, I also study the effects of government consumption and transfers, and I conduct several other exercises.

3 Specification and identification

The benchmark specification is a variant of that discussed in Blanchard and Perotti [2002], extended to include inflation and interest rates. Initially, I focus on a comparison of government consumption and government investment[11]; later, I will add government transfers as a separate spending item. Let Z_t, G_t, T_t and Y_t indicate the nominal values of government investment, government consumption, net taxes,[12] and GDP, respectively; let the corresponding lowercase letters indicate the logs of their real, per capita (based on the GDP deflator) values. Let P_t indicate the GDP deflator, p_t its logarithm and π_t the first difference of the latter; finally, r_t denotes the 10-year nominal interest rate. The bench-

[10] Note, however, that the quarterly data for the last three countries are largely interpolated from annual data: see Perotti [2003].

[11] The sum of government consumption and government investment is total purchases of goods and services by the government, a component of GDP.

[12] Net taxes are defined as tax revenues less trasnfers to households and businesses.

mark VAR includes six variables: z_t, g_t, t_t, y_t, π_t, and r_t. The benchmark specification also includes a constant, quarterly dummies, and a linear time trend.

Let W_t and U_t denote the vector of endogenous variables and of reduced form residuals, respectively. Ignoring constants, dummy variables and time trends for simplicity, the reduced form VAR can be written as:

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

where $W_t \equiv [z_t \quad g_t \quad t_t \quad y_t \quad \pi_t \quad r_t]'$ and $U_t \equiv [u_t^z \quad u_t^g \quad u_t^t \quad u_t^y \quad u_t^\pi \quad u_t^r]'$.

The reduced from residuals of the three policy variables, z, g and t, are linear combination of three components. First, the *structural* policy shocks, which are uncorrelated with each other and with all other structural shocks in the economy; this is the component one is interested in for the purpose of estimating meaningful impulse responses. Second, the *automatic* response of net taxes and government spending to innovations in output, prices and interest rates. Third, the *systematic discretionary* response of policymakers to output, price and interest rate innovations.[13] Formally, one can write

$$u_t^t = \alpha_{ty}u_t^y + \alpha_{t\pi}u_t^\pi + \alpha_{tr}u_t^r + \beta_{tg}e_t^g + \beta_{tz}e_t^z + e_t^t \tag{2a}$$
$$u_t^g = \alpha_{gy}u_t^y + \alpha_{g\pi}u_t^\pi + \alpha_{gr}u_t^r + \beta_{gt}e_t^t + \beta_{gz}e_t^z + e_t^g \tag{2b}$$
$$u_t^z = \alpha_{zy}u_t^y + \alpha_{z\pi}u_t^\pi + \alpha_{zr}u_t^r + \beta_{zt}e_t^t + \beta_{zg}e_t^g + e_t^z \tag{2c}$$

where e_t^g, e_t^z and e_t^t are the structural shocks to the three policy variables. The first three terms on the right hand side of each equation in (2) capture the *automatic* and *systematic discretionary* responses of fiscal policy. However, note that in quarterly data the latter response is absent: because of decision and implementation lags, it typically takes longer than a quarter for taxes or government spending to be changed in reaction to news about the economy. Hence, at this frequency the coefficient α_{ty} captures only the *automatic* response of net taxes. Still, the system is not identified as it is: an OLS regression of, say, u_t^t on u_t^y, u_t^π and u_t^r in equation (2a) would not estimate α_{ty} consistently, because u_t^y is correlated with the structural shocks e_t^g, e_t^z and e_t^t. More information is needed.

In fact, we do have external information that allows us to impute values to the various α's. I present here a sketch of the construction of these α's: Appendix A focuses on the construction of the elasticities of the two budget variables of interest in this paper, government purchases and transfers.[14]

The OECD computes the annual output and, implicitly, the price elasticity of the main components of tax revenues for each member country, at intervals of about three years, from data on the tax codes and the distribution of taxpayers (see Giorno et al. [1995] and

[13] For instance, in the case of taxes the second component captures the automatic increase in revenues that occurs when output increases, even at unchanged tax rates. The third component captures instead the systematic changes in tax rates enacted by policymakers in response to changes in output.

[14] Perotti [2004] presents the full details, including the construction of the tax elasticties.

Van den Noord [2002]). With these, and after suitable manipulation to convert them to quarterly elasticities, I construct the coefficients α_{ty} and $\alpha_{t\pi}$ for each country - essentially, as a time-varying weighted average of the elasticities of each component of total tax revenues and of transfers. For government consumption and investment, it is difficult to think of any mechanism by which they should respond to GDP contemporaneously within a quarter: hence I set $\alpha_{gy} = \alpha_{zy} = 0$. In quarterly data, some components of *nominal* government purchases are likely to increase contemporaneously with the GDP deflator, others are likely to be independent of it, at least contemporaneously; hence, in the benchmark case I set $\alpha_{g\pi} = \alpha_{z\pi} = -.5$ (recall that these represent the price elasticities of *real* government purchases). All fiscal variables are net of interest payments and receipts, hence they are largely independent contemporaneously of the interest rate: hence, I set $\alpha_{gr} = \alpha_{zr} = \alpha_{tr} = 0$.[15]

With these elasticities, one can define the cyclically adjusted fiscal shocks as:

$$u_t^{t,CA} \equiv u_t^t - (\alpha_{ty} u_t^y + \alpha_{t\pi} u_t^\pi + \alpha_{tr} u_t^r) = \beta_{tg} e_t^g + \beta_{tz} e_t^z + e_t^t \quad (3a)$$

$$u_t^{g,CA} \equiv u_t^g - (\alpha_{gy} u_t^y + \alpha_{g\pi} u_t^\pi + \alpha_{gr} u_t^r) = \beta_{gt} e_t^t + \beta_{gz} e_t^z + e_t^g \quad (3b)$$

$$u_t^{z,CA} \equiv u_t^z - (\alpha_{zy} u_t^y + \alpha_{z\pi} u_t^\pi + \alpha_{zr} u_t^r) = \beta_{zt} e_t^t + \beta_{zz} e_t^z + e_t^z \quad (3c)$$

There is no plausible *a priori* information on the various β's. I estimate the structural shocks e_t^g, e_t^z, and e_t^t by ordering them.[16] It is hard to think of plausible reasons for selecting one ordering over another. Of the six possible orderings, I will consider three: each of the two government spending variables first and net taxes third (i.e., the benchmark ordering Z, G and T, and the ordering G, Z, T), and net taxes first and then government investment and consumption (i.e., T, Z, G). As it turns out, the correlation between the three reduced form fiscal shocks is low enough that their ordering is immaterial to the key results.

Because in this paper I am only interested in estimating the effects of fiscal policy shocks, it is not necessary to identify the other structural shocks. In other words, one can adopt any ordering of the other three variables and their impulse responses to the fiscal shocks will not be affected. To illustrate, suppose one assumes output comes before inflation and interest rates. Then one would estimate the subsystem

$$u_t^y = \gamma_{yt} u_t^t + \gamma_{yg} u_t^g + \gamma_{yz} u_t^z + e_t^y \quad (4a)$$

$$u_t^\pi = \gamma_{\pi t} u_t^t + \gamma_{\pi g} u_t^g + \gamma_{\pi z} u_t^z + \gamma_{\pi y} u_t^y + e_t^\pi \quad (4b)$$

$$u_t^r = \gamma_{rt} u_t^t + \gamma_{rg} u_t^g + \gamma_{rz} u_t^z + \gamma_{ry} u_t^y + \gamma_{r\pi} u_t^\pi + e_t^r \quad (4c)$$

[15] This might not be an accurate approximation in the case of taxes, which can depend on the interest rate through several channels. However, this relation can go in opposite directions, and is extremely difficult to quantify: see Canzoneri, Cumby and Diba [2002] for such an attempt.

[16] In doing this, I rule out any rotation that is different from an orthogonalization. This is standard practice, but a simplification. See Uhlig [1998], Canova and Denicolò [2000], and Mountford and Uhlig [2002] for an alternative approach.

By construction, e_t^g, e_t^z and e_t^t are orthogonal to all other structural shocks; therefore, they can be used as instruments for u^z, u^g and u^t in estimating (4a).[17]

4 The data

This study includes five countries (samples in parentheses): 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). These are the only countries with long enough series of non-interpolated quarterly government budget data.

The government budget data cover the general government, i.e. the central (or federal), state, local and provincial governments, plus social security institutions. They are net of most inter-governmental flows. All the data are from primary, national sources.[18]

Government investment includes gross fixed capital formation, changes in inventories (except in the US, where they are included in government consumption and not available separately), and net acquisition of valuables (a very small item). It does not include net acquisitions of non-produced assets like land, again a minor item. It is gross of depreciation, and it does not include investment by government enterprises, hence it is largely unaffected by the process of privatization in the last two decades.[19]

According to the 1993 System of National Accounts (see Commission of the European Communities et al. [1993]), purchases of weapons and weapon delivery systems like warships, submarines, military aircraft, tanks, and missiles carriers and launchers should be recorded as government consumption. All countries in the sample follow this approach, except the US where these purchases are classified as government investment.

Table 1 displays the average share in GDP of government consumption, investment, and transfers to households. On average, government consumption ranges from 16.6 percent of GDP in the US to 20.2 in Canada. Of this, almost one third is defense spending in the US, and a much smaller share (around 2 percent of GDP) in Canada and Aus-

[17] Perotti [2004] discusses extensively the interpretation of the fiscal policy innovations, in particular the role of anticipated fiscal policy in polluting the identification of the fiscal shocks, and the effects of alternative methods to estimate government consumption and investment in national income accounts.

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

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

tralia (separate quarterly data on defense government consumption are not available for Germany and the UK).

Government investment is also remarkably similar across countries, with an average share that ranges from 3.0 percent of GDP in the UK to 3.9 in the US. Again, in the US almost one third is defense spending, most of which is machinery and equipment; of this, about half is spending on weapons and weapon delivery systems. The only other country with data on defense investment is Australia, which unlike the US classifies most of defense expenditure on machinery and equipment as government consumption; hence, defense government investment is quite small, about .3 percent of GDP.

There is much more dispersion in the share of government transfers to households in GDP, between 6.4 in Australia and 15.3 in Germany.

Table 1: **Shares of government expenditures in GDP**

	USA	DEU	GBR	CAN	AUS
Govt. consumption	16.6	17.9	18.9	20.2	17.1
Defense	4.8			1.8	2.2
Govt. investment	3.9	3.5	3.0	3.3	3.4
Defense	1.1				0.3
Mach. & Equipm.	1.0				
Weapons	0.5				
Transfers to individuals	9.5	15.3	11.8	8.8	6.4

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

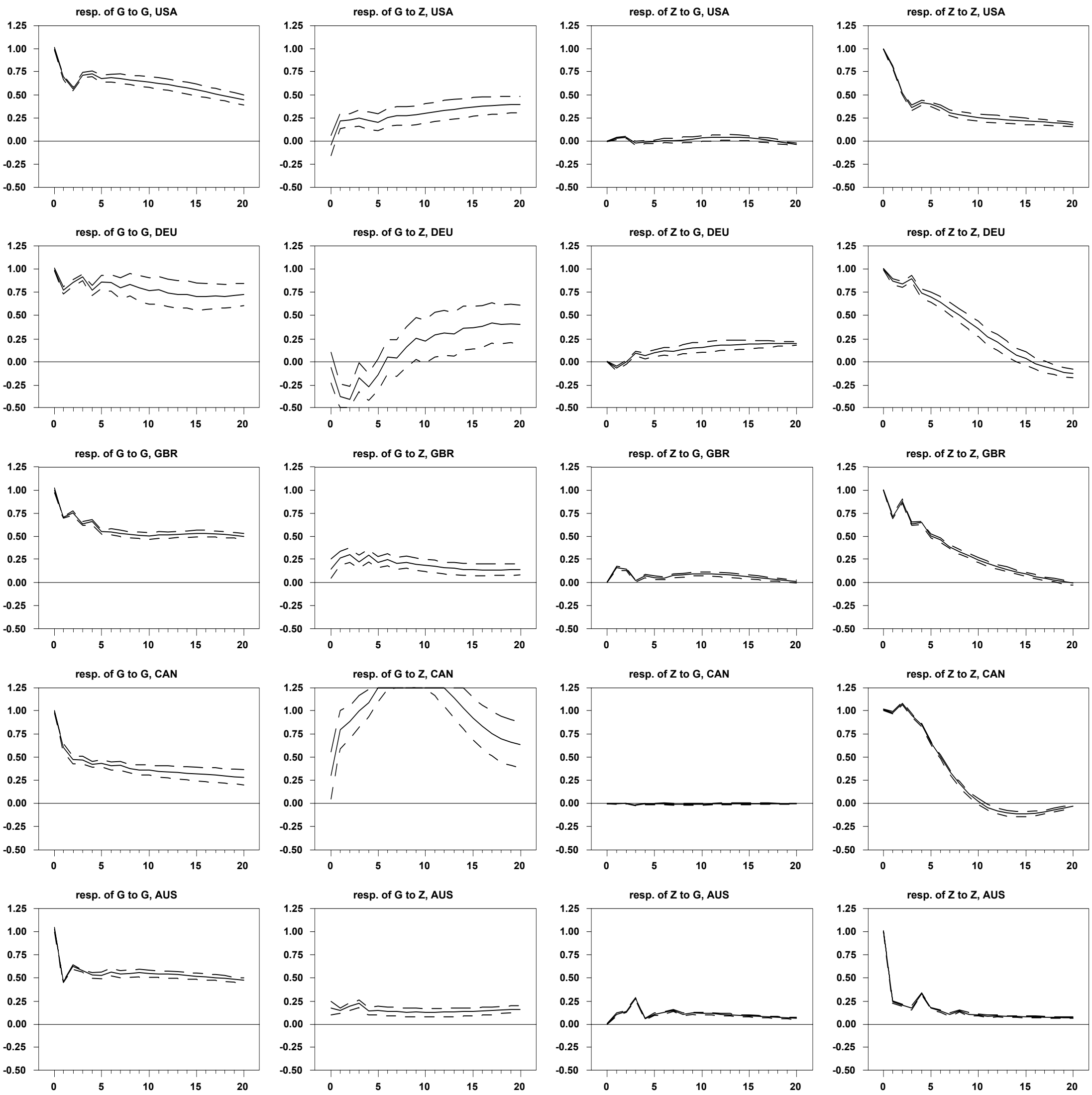
Appendix B provides more details on how the variables used in this paper are constructed; the full details, including the precise definition and coverage of each variable, are in Perotti [2003]. All the data on GDP and its components, including government budget variables, are from National Income Accounts. All real variables are deflated using the GDP deflator. All variables except the interest rate have been seasonally adjusted by the original sources.

5 Fiscal shocks and fiscal policy

Figure 1 displays the responses of government investment (Z) and government consumption (G) to shocks to Z and G, from the benchmark specification. The responses of G and Z are expressed as shares of GDP, obtained by multiplying the responses in logs by the average ratio of G and Z to GDP, respectively; the initial shock is normalized to 1 percent of quarterly GDP for 1 quarter.[20]. The figure also displays one standard error bands on

[20]The actual change of the shocked variable on impact might be slightly different from 1 as it also includes the contemporaneous feedback from the change in inflation.

Figure 1: **Response of G and Z to G and Z shocks**



the two sides of the response. Table 2 displays the annualized[21] cumulative responses of Z and G to the same shocks at selected horizons. An asterisk "*" in the table indicates that 0 is on the same side of both standard error bands. [22]

The figure and the table make two important points. First, in general the responses of Z are smaller and shorter lived than the responses of G. With the exception of Canada up to 3 years, the response of Z to Z shocks is less persistent than the response of G to G shocks, although the difference is large only in the US and Australia. The response of Z to G shocks is extremely small, almost negligible; by contrast the response of G to Z shocks is large, and in the long run comparable to the response of Z to its own shock.

The second conclusion falls from the patterns highlighted above. Except in Canada, the cumulative response of total government purchases (the sum of Z and G) to the two shocks is similar (see panels E and F of Table 2); however, the "Z-content" of total government purchases - the ratio of the cumulative response of Z to the cumulative response of total government purchases - is much higher for Z than for G shocks at any given horizon (see panels G and H). For instance, at quarter 8 the average Z-content of total cumulative government purchases is .71 (median .58) in response to Z shocks, and .07 (median .06) in response to G shocks. Hence, I shall refer to the Z shock as the "Z-intensive" shock.

The similarity of the cumulative response of total government purchases to the two shocks is useful because it implies that the direct wealth effect from the government budget is similar for the two shocks. Differences in the effects of the two shocks are therefore likely to be due to differences in their Z-content.

6 The response of GDP to fiscal shocks

6.1 Effects on output

Figure 2 displays the response of total GDP to G and Z shocks, while Table 3 displays the annualized cumulative response of GDP to a G shock (panel A), to a Z shock (panel B), and the latter less the former (henceforth, the "difference" between GDP responses to Z and G shocks, in panel C) at selected horizons. As before, the structural shock is equal to 1 percentage point of quarterly GDP for a quarter (i.e., .25 percentage points of GDP

[21] The cumulative responses are expressed at yearly rates by dividing the cumulative sums of the quarterly responses by 4.

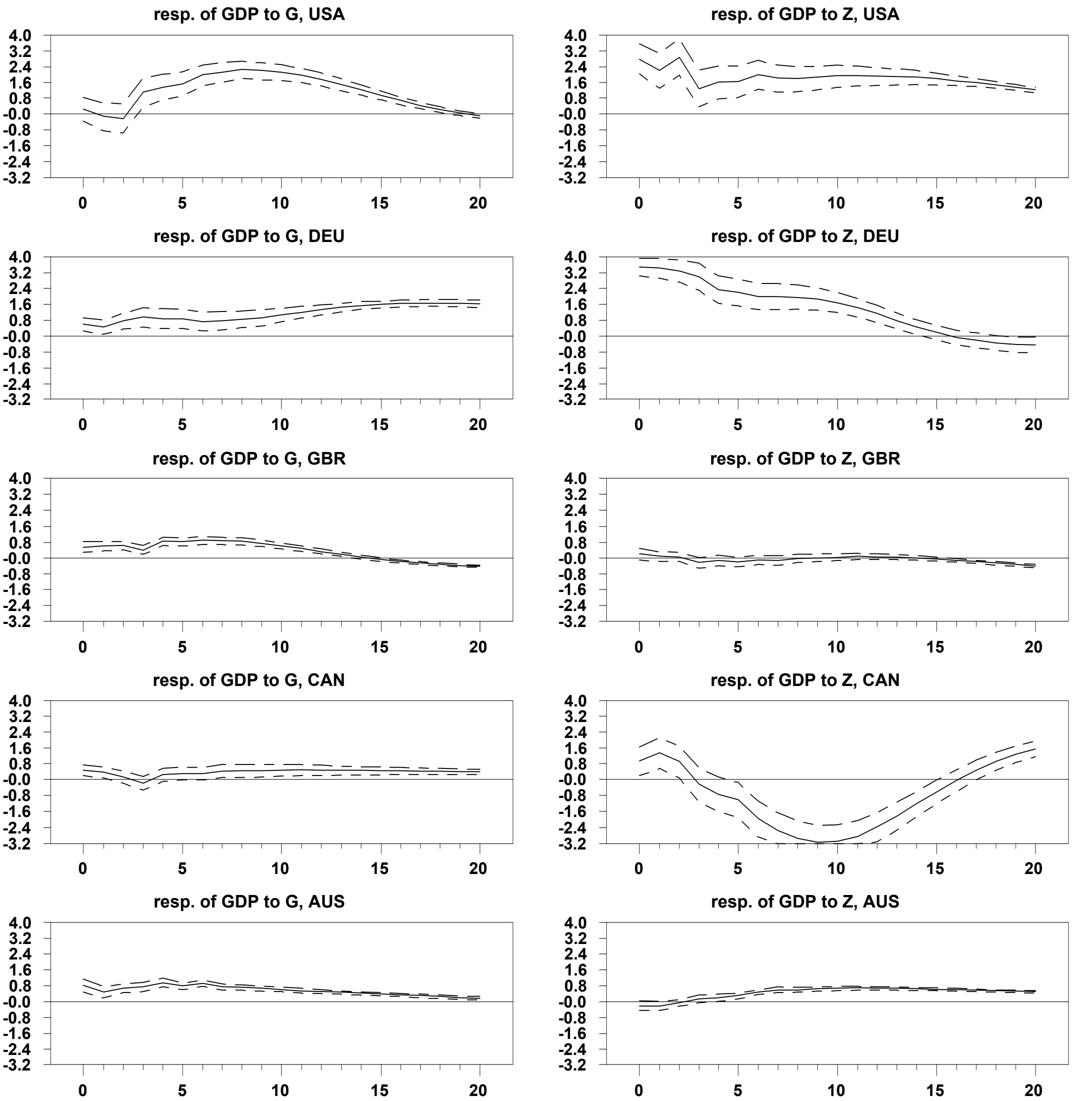
[22] Thus, under normality an asterisk would indicate significance at the 68 percent confidence level. I calculate standard errors from 500 simulations, assuming normality. Specifically, I take 500 draws from the distribution of reduced form residuals. Corresponding to each draw, a new synthetic series 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 asterik indicates that the impulse response plus (minus) one standard error is below (above) zero at that horizon.

Table 2: **Cumulative responses of G and Z to G and Z shocks**

	quarter				quarter			
	4	8	12	20	4	8	12	20
	A Cum. resp. of G to G				**B Cum. resp. of G to Z**			
USA	0.90*	1.69*	2.36*	3.31*	0.34*	0.83*	1.31*	2.04*
DEU	0.88*	1.71*	2.50*	3.94*	-0.25*	-0.33*	-0.10	0.65
GBR	0.78*	1.35*	1.87*	2.92*	0.23*	0.48*	0.67*	0.96*
CAN	0.65*	1.09*	1.48*	2.15*	0.85*	2.32*	3.84*	5.54*
AUS	0.64*	1.08*	1.51*	2.25*	0.25*	0.47*	0.65*	1.02*
	C Cum. resp. of Z to G				**D Cum. resp. of Z to Z**			
USA	0.05*	0.05*	0.02	-0.16*	0.68*	1.16*	1.48*	1.83*
DEU	0.01	0.11*	0.26*	0.64*	0.90*	1.57*	1.96*	2.01*
GBR	0.08*	0.14*	0.23*	0.34*	0.81*	1.31*	1.58*	1.75*
CAN	-0.01*	-0.02*	-0.03*	-0.04*	1.01*	1.59*	1.66*	1.47*
AUS	0.13*	0.23*	0.32*	0.45*	0.39*	0.56*	0.67*	0.84*
	E Cum. resp. of Z+G to G				**F Cum. resp. of Z+G to Z**			
USA	0.95*	1.74*	2.38*	3.15*	1.02*	1.99*	2.79*	3.87*
DEU	0.89*	1.81*	2.76*	4.58*	0.65*	1.24*	1.86*	2.66*
GBR	0.86*	1.49*	2.10*	3.26*	1.04*	1.79*	2.25*	2.70*
CAN	0.64*	1.08*	1.45*	2.11*	1.86*	3.91*	5.51*	7.01*
AUS	0.77*	1.31*	1.83*	2.70*	0.64*	1.03*	1.32*	1.86*
	G Z-content of G shocks				**H Z-content of Z shocks**			
USA	0.05*	0.03*	0.01	-0.05*	0.67*	0.58*	0.53*	0.47*
DEU	0.01	0.06*	0.09*	0.14*	1.39*	1.27*	1.05*	0.76*
GBR	0.09*	0.10*	0.11*	0.11*	0.78*	0.73*	0.70*	0.65*
CAN	-0.01*	-0.02*	-0.02*	-0.00	0.54*	0.41*	0.30*	0.21*
AUS	0.17*	0.18*	0.17*	0.18*	0.61*	0.54*	0.50*	0.45*

Panels A and B: cumulative responses of G to G and Z shocks; Panels C and D: cumulative responses of Z to G and Z shocks; Panels E and F: sum of cumulative responses of G and Z to G and Z shocks; Panels G and H: Z-content of G and Z shocks (cumulative response of Z divided by sum of cumulative responses of G and Z to same shock).
The shocks equal 1 percentage point of quarterly GDP for 1 quarter, from benchmark model described in the text. Entries in the table are expressed at yearly rates, i.e. the cumulative sums of the quarterly responses are divided by 4. A "*" indicates that 0 is outside the regions between the two one-standard error bands.

Figure 2: **Response of GDP to G and Z shocks**



at yearly rates). Also as before, an asterisk indicates that the response (or the difference of the responses in panel C) differs from 0 by more than one standard deviation.[23]

Table 3: **Cumulative response of GDP to G and Z shocks**

	quarter					max	min
	2	4	8	12	20		
	A Cumulative response of GDP to G						
USA	0.48*	1.30*	3.33*	5.14*	7.30*	7.30* (20)	0.19* (1)
DEU	0.26*	0.69*	1.50*	2.52*	5.65*	5.65* (20)	0.15* (1)
GBR	0.29*	0.55*	1.41*	2.08*	1.90*	2.22* (15)	0.14* (1)
CAN	0.27*	0.36*	0.79*	1.35*	2.35*	2.35* (20)	0.15* (1)
AUS	0.19*	0.43*	1.13*	1.62*	2.13*	2.13* (20)	0.12* (1)
	B Cumulative response of GDP to Z						
USA	0.83*	1.19*	1.03	0.58	1.44	1.44 (20)	0.45* (1)
DEU	1.72*	3.29*	5.42*	7.15*	7.52*	7.79* (16)	0.87* (1)
GBR	0.06	0.01	-0.14	-0.13	-0.36	0.07 (3)	-0.36 (20)
CAN	0.57*	0.70	-0.95	-4.02*	-5.17*	0.78* (3)	-5.70* (17)
AUS	-0.13*	-0.19	0.02	0.66*	1.99*	1.99* (20)	-0.20 (5)
	C Cum. resp. of GDP to Z - cum. resp. of GDP to G						
USA	0.35	-0.10	-2.31*	-4.57*	-5.86*	-5.86*	0.26*
DEU	1.46*	2.60*	3.91*	4.49*	1.87	2.14	0.72*
GBR	-0.22*	-0.54*	-1.55*	-2.21*	-2.26*	-2.14*	-0.50
CAN	0.30	0.34	-1.75	-5.37*	-7.52*	-1.57*	-5.86*
AUS	-0.32*	-0.62*	-1.11*	-0.96*	-0.15	-0.15	-0.32*

Cumulative response of GDP to a G shock (panel A), to Z shock (panel B) and cumulative response of GDP to Z shock less cumulative response of GDP to G shock (panel C), from benchmark model described in the text. The shocks equal 1 percentage point of quarterly GDP for 1 quarter. Entries in the table are expressed at yearly rates, i.e. the cumulative sums of the quarterly responses are divided by 4. A "*" indicates that 0 is outside the regions between the two one-standard error bands. In parentheses besides the max and min responses are the quarters at which they occur.

After 1 year, the cumulative response of GDP to a G shock is positive everywhere, and quite similar in all countries - between .4 and .7 percentage points - except in the US, where it is much higher at 1.3. After 3 years, again it is quite similar, between 1.3 and 2.5 percentage points, except again in the US, where it is much larger at about 5 percentage points. In all these cases the cumulative response of GDP is highly significant.

The response of GDP to a Z shock is significantly positive after 2 quarters in the US, Germany and Canada, ranging from .6 in Canada to 1.7 in Germany; then it declines in

[23] To compute the standard deviation of the difference between the responses of Z and G in panel C, I take the i-th draws of the responses to Z and G shocks, compute their difference, and then the standard deviation of the latter.

the US, Canada and the UK, and by year 2 it is significantly positive only in Germany (later also in Australia). Note the large negative response at long horizons in Canada.

As a result, the response of GDP to a Z shock is significantly larger than that to a G shock only in Germany; and by years 2 and 3, it is significantly *smaller* in all countries except Germany.

6.2 Multipliers

To evaluate rigorously the dynamic properties of alternative fiscal policy instruments the responses of GDP displayed in Table 3, though suggestive, are not enough: what matters is the response of GDP per unit of government spending, in other words, the multipliers of government spending.

Table 4 displays the cumulative GDP multipliers of total government purchases in response to G and Z shocks (henceforth, I will drop the qualifiers "cumulative" and "GDP" and will refer simply to the "G-multiplier" as the GDP cumulative multiplier of total government spending in response to a shock to G, and similarly for the "Z-multiplier").[24] The G-multiplier (panel A) is always positive, and surprisingly similar in all countries except the US: at 1 year, it ranges from .6 to .8; then it increases, and ranges between .9 and 1 after 3 years; the maxima are also surprisingly similar, between .9 and 1.3. In the US the G-multiplier is larger - at each horizon, typically about double the largest G-multiplier in the other four countries.

The Z-multiplier starts out higher than the G-multiplier in the US, Germany and Canada, but then it declines in all countries except Australia; by year 2 it is essentially 0 in all countries except Germany (later it increases again in Australia, to a maximum of about 1.0). Note that it is positive and large (perhaps implausibly so) only in Germany, where it is at or above 4 during the first 3 years, then declining to about 3.

As a result, except in Germany the G-multiplier is larger than the Z-multiplier at all horizons after the impact horizon, and almost always significantly so (see panel C). For instance, at 2 years typically the G-multiplier is larger than the Z-multiplier by about 1 percentage point.[25]

[24] Thus, the G- (Z-) multiplier is defined as the cumulative response of GDP to a shock to G (Z) divided by the sum of the cumulative responses of G and Z to the same shock.

[25] The conclusions from the cyclically adjusted multipliers (not shown) are similar, except than now the G-multiplier tends to be slightly smaller in all countries.

The cyclically adjusted Z- (G-) multiplier is defined as the cumulative response of GDP to a Z (G) shock divided by the sum of the cyclically adjusted cumulative responses of G and Z to a Z (G) shock.

The responses of Z and G are cyclically adjusted by subtracting the response of the price level times the price level elasticity of government purchases. The quarterly contemporaneous automatic elasticity of government spending to GDP and to ther interest rate is zero (see section 3). The cyclically adjusted figures should be taken with some caution after the first few quarters, because the long-run elasticities of government purchases, transfers and taxes can be different from the short-run elasticities that are used here.

Thus, Table 4 does not support the notion that government investment is a more effective countercyclical tool than government consumption.[26] At the relevant horizons

Table 4: **Multipliers**

	quarter					max	min
	2	4	8	12	20		
	A G-multiplier						
USA	1.00*	1.37*	1.91*	2.16*	2.32*	2.32* (20)	0.79* (1)
DEU	0.62*	0.77*	0.83*	0.91*	1.23*	1.23* (20)	0.59* (1)
GBR	0.61*	0.64*	0.94*	0.99*	0.58*	1.01* (11)	0.54* (1)
CAN	0.67*	0.55*	0.74*	0.93*	1.11*	1.11* (20)	0.55* (4)
AUS	0.44*	0.56*	0.86*	0.88*	0.79*	0.89* (11)	0.44* (2)
	B Z-multiplier						
USA	1.47*	1.17*	0.52	0.21	0.37	1.68* (1)	0.17 (14)
DEU	4.81*	5.07*	4.38*	3.84*	2.83	5.46* (3)	2.83 (20)
GBR	0.12	0.01	-0.08	-0.06	-0.14	0.16 (1)	-0.13 (20)
CAN	0.71*	0.38	-0.24	-0.73*	-0.74*	0.74* (1)	-0.88* (16)
AUS	-0.32*	-0.29	0.02	0.50*	1.07*	1.07* (20)	-0.33* (3)
	C Z-multiplier - G-multiplier						
USA	0.47	-0.19	-1.40*	-1.95*	-1.94*	-0.64*	-0.62
DEU	4.19*	4.29*	3.55*	2.93*	1.59	4.23*	2.23
GBR	-0.49*	-0.63*	-1.02*	-1.05*	-0.72*	-0.85*	-0.68*
CAN	0.04	-0.18	-0.98*	-1.66*	-1.85*	-0.37	-1.43*
AUS	-0.76*	-0.85*	-0.84*	-0.39*	0.28	0.18	-0.77*

The G-multiplier is defined as the cumulative response of GDP to a G shock divided by the sum of the cumulative responses of G and Z to the same shock. Similarly for the Z-multiplier. See also notes to Table 3.

for countercyclical policies - say between 2 and 8 quarters - except in Germany and initially in the US, the Z-multiplier is virtually 0, and it is consistently and significantly smaller than the G-multiplier. The G-multiplier itself, although positive, is not large, typically below 1 except in the US.

The common wisdom is that public investment should have at least stronger effects over time, as its externalities presumably take time to work through the economy. This notion too is not supported by the data. The Z-multiplier declines over time, except in Australia, and even after 5 years it is significantly smaller than the G-multiplier in three countries, essentially the same in Australia, and larger only in Germany, where the difference is however not significant.

[26] In addition, one should consider that government investment has probably longer decision and implementation lags.

6.3 "Pure" spending shocks

To infer the effects of government investment more directly, ideally one would like to estimate the response of GDP to a shock to Z, holding constant G throughout all the horizon of the impulse response exercise; similarly, when estimating the effects of government consumption one would like to hold constant Z in computing the impulse response to the shock to G. I refer to shocks to Z and G with these features as "pure" Z and G shocks. The data do not offer examples of such shocks. One can still simulate the re-

Table 5: **"Pure"multipliers**

country	quarter					max	min
	2	4	8	12	20		
	A "Pure" G-multiplier						
USA	1.03*	1.48*	2.10*	2.25*	2.06*	2.25* (13)	0.78* (1)
DEU	0.59*	0.77*	0.91*	1.00*	1.18*	1.18* (20)	0.59* (1)
GBR	0.67*	0.74*	1.11*	1.21*	0.74*	1.22* (11)	0.54* (1)
CAN	0.67*	0.55*	0.71*	0.87*	1.02*	1.02* (20)	0.55* (4)
AUS	0.49*	0.70*	1.13*	1.07*	0.64*	1.15* (9)	0.47* (1)
	B "Pure" Z-multiplier						
USA	1.93*	1.65*	0.20	-0.88*	-1.29*	2.09* (3)	-1.39* (17)
DEU	3.69*	3.66*	3.54*	3.76*	3.74*	3.86* (15)	3.48* (1)
GBR	0.14	-0.03	-0.27	-0.37	-0.43*	0.19 (1)	-0.43* (20)
CAN	1.17*	0.94*	0.06	-1.53*	-3.53*	1.17* (2)	-3.53* (20)
AUS	-0.42*	-0.57*	-0.42	0.43	2.10*	2.10* (20)	-0.63* (6)
	C "Pure" Z-multiplier - "Pure" G-multiplier						
USA	0.89*	0.16	-1.90*	-3.13*	-3.35*	-0.16	-2.17*
DEU	3.09*	2.89*	2.63*	2.76*	2.56*	2.67*	2.88*
GBR	-0.53*	-0.76*	-1.39*	-1.58*	-1.18*	-1.03*	-0.97*
CAN	0.50	0.39	-0.65	-2.40*	-4.56*	0.15	-4.08*
AUS	-0.88*	-1.27*	-1.55*	-0.64	1.45*	0.95*	-1.10*

The "pure"G-multiplier is defined as the cumulative response of GDP to a "pure"shock to G divided by the sum of the cumulative responses of G and Z to the same shock. Similarly for the "pure"Z-multiplier. See also notes to Table 3.

sponse of the system to Z shocks, after setting to zero all coefficients in the reduced form G equation; equivalently, each period of the horizon of the impulse response exercise, the government consumption shock e_t^g takes exactly the value that ensures a zero response of G at all horizons. Either way to interpret this experiment shows that it violates the Lucas critique, hence it should be interpreted with care, particularly at longer horizons; still, it could provide a useful approximation to the effects of "pure" Z shocks. A similar exercise can be performed to approximate the effects of "pure" G shocks.

Table 5 displays the cumulative GDP multipliers in response to "pure" fiscal shocks. In all countries, the "pure" G-multipliers (panel A) are very close to the G-multipliers displayed in the same panel of Table 4; this was to be expected, based on the negligible response of Z to G shocks in Table 3. The "pure" Z-multipliers (panel B) are also very similar to the Z-multipliers, with two exceptions: in the US, the "pure" Z-multiplier turns significantly negative after 3 years, against a value of about 0 for the Z-multiplier; and in Canada it becomes even more negative, falling to -3.5 at five years against a Z-multiplier of -.7 at the same horizon.

Panel C displays the difference between the "pure" Z-multiplier less the "pure" G-multiplier. Like in the corresponding panel of Table 4, and again with the exception of Germany, this difference is largely negative and significant.

7 GDP components

7.1 Private consumption and investment

Table 6 displays impulse responses from a 7-variable VAR, in which private investment and private consumption are added in turn to the benchmark specification. For compactness, only the multipliers at 4 and 12 quarters are displayed. The table shows that much of the difference between the GDP Z-multiplier and the GDP G-multiplier is explained by the response of private investment.

With the exception of the US, the private consumption multiplier of government consumption (henceforth, the "government consumption G-multiplier"[27], panel A, columns 1 and 2) is positive but small, never exceeding .4; in the US it is larger, around 1. The private consumption Z-multiplier (panel A, columns 3 and 4) is even smaller, usually about 0 except in the US, where it oscillates around .5. The difference between the private consumption Z- and G-multipliers (panel A, columns 5 and 6) is thus usually significantly negative in the US and Australia, and essentially zero elsewhere.

Like the private consumption G-multiplier, the private investment G-multiplier (panel B, columns 1 and 2) is typically positive (except in Germany), although not large - at 3 years, it ranges between essentially 0 in Australia and .9 in the UK. In contrast, the private investment Z-multiplier (panel B, columns 3 and 4) is, again with the exception of Germany, negative and significant at all horizons, ranging at 3 years from -.5 in Australia to -1.4 in the US. Thus, the private investment G-multiplier is larger than the private investment Z-multiplier everywhere (except in Germany) and at all horizons (panel B, columns 5 and 6). At 3 years, the difference ranges from -.6 percentage points in Australia to -2 percentage points in the US, and it is nearly always significant. Note that the

[27] To be precise, the private consumption G-multiplier is defined as the cumulative response of private consumption to a shock to G divided by the sum of the cumulative responses of G and Z to the same shock.

difference in the private investment multipliers is very close to or exceeds (in absolute value) the difference in the GDP multipliers in panel C of Table 4.[28]

Table 6: **Private investment and consumption**

	(1)	(2)	(3)	(4)	(5)	(6)
	G-mult.		**Z-mult.**		**G-mult. - Z-mult.**	
	4	12	4	12	4	12
	A Private consumption multipliers					
USA	0.75*	1.26*	0.60*	0.45*	-0.14	-0.81*
DEU	0.10	0.35*	0.48	-0.42	0.37	-0.77
GBR	0.37*	0.06	0.11	0.14	-0.26	0.08
CAN	0.16	-0.02	0.04	0.04	-0.12	0.06
AUS	0.37*	0.37*	0.02	0.09	-0.36*	-0.28*
	B Private investment multipliers					
USA	0.32	0.60*	-0.53*	-1.43*	-0.85*	-2.03*
DEU	-0.34	-0.48*	2.79*	2.45*	3.13*	2.85*
GBR	0.22*	0.91*	-0.38*	-0.60*	-0.60*	-1.51*
CAN	0.22	0.56*	0.14	-1.07*	-0.08	-1.64*
AUS	-0.22	0.16	-1.02*	-0.46*	-0.80*	-0.62*

The private consumption G-multiplier is defined as the cumulative response of private consumption to a G shock, divided by the sum of the cumulative responses of G and Z to the same shock, from the 7-variable model that adds private consumption to the benchmark 6-variable specification. Similarly for the other multipliers. See also notes to Table 3. The numbers in the third row indicate the quarter after the initial shock.

For all countries except Germany it is possible to disaggregate private investment into dwellings and non-dwellings. Columns 1 to 4 of Table 7 display the Z-multipliers for these two components. In three countries out of four, the effect of government investment on dwellings at 3 years is significantly negative and between one third and one fourth of the effect on non-dwellings. Disaggregated data on government investment exist only for the US, where the share of government investment in dwellings is minimal, about .1 percentage point of GDP. Hence, at least for this country the results above seem to indicate that the negative effect on private dwellings is unlikely to be due to substitutability between private and government investment.

Still, the bulk of the decline in private investment following a Z shock is due to non-dwellings. In three countries (the US, Canada and Australia) it is also possible to disaggregate non-dwellings into machinery and equipment and other structures: at 1 year, most of the decline in non-dwellings is due to machinery and equipment; in the US, this

[28]When calculated from the 7-variable specification that includes private investment, the GDP multipliers are virtually identical to those of Table 4.

is still true at 3 years, while in the other two countries the responses of machinery and equipment and of other structures at this horizon are more similar.[29] In the US, the average GDP shares of government investment in other structures and in machinery and equipment are about 2.3 and 1.6 percentage points, respectively. The share of machinery

Table 7: **Private investment components**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Private investment Z-multipliers, components							
	dwellings		**Non-dwellings**		**non-dwellings**			
					M&E		**Other**	
	4	12	4	12	4	12	4	12
USA	-0.12	-0.33*	-0.36*	-0.99*	-0.22*	-0.57*	-0.06	-0.38*
GBR	-0.08*	-0.11*	-0.02	-0.44*				
CAN	0.04	0.01	-0.19*	-1.09*	-0.19*	-0.57*	0.04	-0.49*
AUS	-0.02	-0.06*	-0.48*	-0.24*	-0.15*	-0.06	-0.15*	-0.24*

The dwellings Z-multiplier is defined as the cumulative response of private investment in dwellings to a Z shock, divided by the sum of the cumulative responses of G and Z to the same shock, from the 7-variable model that adds private investment in dwellings to the benchmark 6-variable specification. Similarly for the other multpliers. See also notes to Table 3. The numbers in the third row indicate the quarter after the initial shock.

and equipment would be even smaller if military expenditure on aircraft, missiles and ships were reclassified as government consumption, as in the other countries. Thus, again substitutability is unlikely to be the key reason for the negative response of private investment to a government investment shock. This conclusion is strengthened by another consideration: in the US, about 40 percent of government investment in machinery and equipment is defense expenditure, whose substitutability with private sector investment is likely to be close to 0. Yet, as I show in Table 17, government defense spending in machinery and equipment has a large negative effect on all types of private investment, including machinery and equipment.

7.2 National income accounting and the response of private investment

A closer look at national income accounting practices suggests a possible, mechanical explanation for the strong negative effect of government investment on private investment.

[29] Note that the sum of the Z-multipliers on Dwellings and Non-Dwellings is very close to the aggregate Z private investment multiplier in panel E of Table 6; similarly the sum of the Z-multipliers on Machinery and Equipment and on Other Structures in panels C and D of Table 7 is close to the Z-multiplier on Non-Dwellings in panel B of the same Table.

Most goods purchased by the government and classified as government investment take more than one quarter (the accounting period) to be produced. National account systems record government purchases of goods with long production processes with two different methodologies. According to the first (called *work put in place* method under accrual accounting, and *progress payment* method under cash accounting), each quarter the addition to the value of the unfinished good by a private contractor is recorded directly as government investment in the government accounts. According to the second method (called *delivery* method under accrual accounting, and *payment* method under cash accounting), each quarter the addition to the value of the good by the private contractor is recorded as work in progress in the inventories of the private sector. When the good is completed and delivered to the government, the whole value of the final good is recorded at once as government investment, while private inventories are decreased by the same amount.

It is clear that the delivery and payment methods generate a mechanical contemporaneous negative correlation between government investment and private inventories, a component of private investment; in turn, this could conceivably explain the strong contemporaneous negative effect of government investment on private investment displayed in Table 6. It is then important to understand how widespread these methods are in compiling national income account statistics. Table 8 describes the methods used by the countries in this study (more details can be found in Perotti [2003])[30]. The table shows

Table 8: **Method of recording of government investment**

	AUS[1]	CAN	DEU	GBR	USA
Machinery and Equipment	P, PP	PP	PP	PP, WPIPA[2]	PP, WPIP, P, D
Structures	P, PP	PP	WPIPA	PP, WPIPA[2]	PP, P

Legend: A: "Accrual" D: "Delivery" ; P: "Payment" ; 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: "Speculative construction" : P.
Source: Perotti [2003].

that the progress payment and the *work put in place approximation*[31] are the two most

[30] Government consumption is usually recorded on a cash basis or on a time-adjusted cash basis. In the latter, the cash data are lagged by a fixed number of weeks to approximate accruals (see again Perotti [2003] for details). The difference between cash and accrual data is thus small.

[31] The work-put-in-place method is the method recommended by the 1993 System of National Accounts for government purchases of most goods with long production processes. However, a literal application of this method is difficult because it requires data on private sector inventories and because government budget data are usually derived from Treasury accounts, which are in cash terms. Thus, in practice

widely used methods, and that the delivery and payment methods seem in practice quite rare. The one partial exception is some components of government defense investment in machinery and equipment, mostly battleships, aircraft, and missiles (see BEA-DOC [1988] Table II-8), whose role I investigate further in in Table 17. The sample average of total spending on these three items is 0.44 percent of GDP, of which probably about half is recorded with the delivery method.[32] For the US, one can 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.[33]

Table 9: **Private investment, net of inventories**

	(1)	(2)	(3)	(4)
	Private investment Z-multiplier			
	Benchmark		**No Inventories**	
	4	12	4	12
USA	-0.53	-1.43*	-0.62*	-1.14*
GBR	-0.38*	-0.60*	-0.29*	-0.51*
CAN	0.14	-1.07*	-0.14	-1.01*
AUS	-1.02*	-0.46*	-0.49*	-0.18

Panel A: private investment Z-multipliers, from panel E of Table 6. Panel B: private investment Z-multiplier, with private investment net of inventories. See also notes to Tables 3 and 6.

Table 9 displays private investment Z-multipliers, both in the benchmark case (columns 1 and 2, the same as panel E of Table 6) and with private investment net of private inventories (columns 3 and 4).[34] In general, in the second case the multiplier is indeed larger algebraically, although the difference is appreciable only in Australia. More importantly, the private investment Z-multiplier is still significantly negative everywhere, and still smaller than the private investment G-multiplier.

statistical agencies approximate work-put-in-place data by either progress payment data based on quarterly cash disbursements, or by assessing the share of the final payment accruing to each quarter - the "work-put-in-place approximation".

[32]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).

[33]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.

[34]Data on private inventories for Germany are not available.

7.3 Government consumption and investment in neo-classical and neo-keynesian models

A positive response of private consumption to a government consumption shock is inconsistent with the neoclassical model (see e.g. Baxter and King [1993]). As government consumption increases, from the intertemporal government budget constraint taxes must increase by the same amount; private wealth falls, and so does the consumption of forward-looking individuals.[35] A positive response of private consumption to government consumption is instead consistent with neo-keynesian models such as Galí, López-Salido and Vallés [2003] or Devereux, Head and Lapham [1996]. In the former model, a portion of the population (the "Rule - of - Thumb" consumers) does not have access to credit markets, hence their consumption equals disposable income, and depends positively on the real wage. Due to nominal rigidities, government consumption increases aggregate demand and the real wage, hence the consumption of ROT consumers; if these are a large enough fraction of the population, aggregate consumption can increase. In the latter model, the presence of monopolistic competition in the intermediate goods sector ensures that an increase in government consumption has a positive aggregate demand effect, thereby causing also an increase in private consumption and employment.

In contrast, a positive response of private investment to a government consumption shock is consistent with the neoclassical model, where the negative wealth shock shifts out labor supply, thereby increasing the marginal product of capital and stimulating investment.[36] It is inconsistent with neo-keynesian models, although it can be consistent with the more stripped-down textbook keynesian model with an investment accelerator (see e.g. Blanchard [2002]).

The result that is difficult to reconcile with *any* model is the smaller response of GDP, private consumption and private investment to government investment than to government consumption shocks.

For our purposes, government investment differs from government consumption in two respects: it increases output directly for any level of the private inputs; and by doing so, it reduces (and possibly reverses) the negative wealth effect on forward-looking individuals via the government budget constraint.

If the productivity of public capital is large enough the wealth effect is positive, and private consumption increases following a government investment shock. Otherwise, private consumption falls, but certainly less than in the case of a government consumption

[35] Quite intuititively, a positive response of private consumption to a government consumption shock could occur in the neoclassical model if there are strong complementarities between government and private consumption: see Bouakez and Rebei [2003].

[36] This mechanism assumes lump-sum taxation: the effect on private investment can still be negative if taxation is sufficiently distortionary. Also, for private investment to respond positively to a government consumption shock, the latter must be sufficiently persistent, so that private consumption falls enough for private investment to increase.

shock of the same size (see Finn [1998]).

In principle, in the neoclassical model government investment could have a smaller *impact* effect than government consumption on GDP and private investment. Because under a government investment shock the wealth effect is less negative, or even positive, labor supply increases less or even decreases; with predetermined private and public capital, initially GDP increases less, or even falls; so does private investment, which is also crowded out by the increase in private consumption. However in the long run, as the public capital stock builds up, the productivity of private capital increases; hence, private investment also increases.

Can the GDP response to a government investment shock still be below the response to a government consumption shock in the long run? If this were the case, the wealth effect would be more negative under a government investment shock. But then labor supply would shift out more; with a higher public and private capital stock, GDP also would increase more under a government investment shock - a contradiction.

The only formal neo-keynesian model of public investment that I know of is Pappa [2004]. For the same specification of the production function as the neoclassical model, and rather intuitively, it has the same implications regarding the difference between the effects of government investment and government consumption shocks.

Hence the findings of Tables 4, 5, and 6 do indeed constitute a puzzle: in section 12 I offer some tentative explanations.

8 Robustness and stability

8.1 Alternative detrending methods

Table 10 displays results from alternative assumptions about the statistical properties of the data: the benchmark case of a linear trend in panel A; a linear and quadratic trend in panel B; first differences in panel C[37], and levels in panel D. In each panel, columns 1 and 2 display the cumulative G-multiplier at 1 and 3 years; columns 3 and 4 the Z-multiplier at the same horizons; and columns 5 and 6 the difference between the two.

Relative to the benchmark case of a linear trend, the results are very similar in the specification with a quadratic trend. The G-multiplier tends to be smaller in the specification in differences; as a consequence, the difference between the Z- and G-multipliers becomes larger algebraically, although it remains negative in all countries except Germany (where it was already positive in the benchmark case). In contrast, the Z-multiplier tends

[37] More precisely, the variables are first differenced, and then a moving geometric average of their past differences is subtracted, with decay parameter equal to 2.5 percent per quarter, to take into account slowly changing trends in the rate of change.

to be smaller in the specification in levels; as a consequence, the difference between the Z- and G-multipliers is now even more negative (or less positive, in the case of Germany) than in the benchmark case.

Table 10: **Alternative detrending methods**

	(1)	(2)	(3)	(4)	(5)	(6)
	G-mult.		**Z-mult.**		**Z-mult. - G-mult.**	
	4	12	4	12	4	12
	A Linear trend					
USA	1.37*	2.16*	1.17*	0.21	-0.20	-1.95*
DEU	0.78*	0.93*	5.23*	3.94*	4.45*	3.02*
GBR	0.64*	0.99*	0.01	-0.06	-0.63*	-1.05*
CAN	0.55*	0.93*	0.38	-0.73*	-0.18	-1.66*
AUS	0.56*	0.88*	-0.29	0.50*	-0.85*	-0.39*
	B Quadratic trend					
USA	1.42*	1.73*	1.27*	0.23	-0.16	-1.50*
DEU	0.48*	0.26	5.41	5.05	4.92	4.79
GBR	0.56*	1.11*	-0.03	-0.10	-0.59*	-1.21*
CAN	0.26	0.29	0.19	-1.38*	-0.07	-1.67*
AUS	0.44*	0.59*	-0.37*	0.39*	-0.81*	-0.20
	C Differences					
USA	1.10*	1.09*	1.04*	0.36	-0.06	-0.74*
DEU	0.50*	0.14	3.68*	1.80*	3.18*	1.66*
GBR	0.08	-0.19	0.03	-0.39*	-0.04	-0.20
CAN	0.24	0.16	0.60*	0.08	0.36	-0.09
AUS	0.27	0.44*	-0.16	-0.09	-0.43*	-0.53*
	D Levels					
USA	0.84*	0.46	0.62*	-0.78*	-0.22	-1.24*
DEU	0.22	0.09	4.15*	1.48*	3.93*	1.39*
GBR	0.65*	1.67*	-0.02	-0.60*	-0.67*	-2.27*
CAN	0.61*	0.68*	0.41	-0.65*	-0.20	-1.32*
AUS	0.70*	1.26*	-0.62*	-0.74*	-1.32*	-2.00*

G- and Z-multipliers and their difference, at 1 and 3 years, under alternative detrending methods. See also notes to Table 3.

8.2 Alternative orderings of fiscal variables

Table 11 has a similar structure to Table 10, except that it displays the results under alternative orderings of the three fiscal variables. Panel A presents the benchmark ordering, with Z first, G second, and T third, as in Table 4; panel B presents the ordering

G-Z-T; and panel C the ordering T-Z-G. In all cases the differences with the benchmark specification of panel A are minimal.

Table 11: **Alternative orderings**

	(1)	(2)	(3)	(4)	(5)	(6)
	G-mult.		**Z-mult.**		**Z-mult. - G-mult.**	
	4	12	4	12	4	12
	A Benchmark ordering: Z, G, T					
USA	1.37*	2.16*	1.17*	0.21	-0.20	-1.95*
DEU	0.78*	0.93*	5.23*	3.94*	4.45*	3.02*
GBR	0.64*	0.99*	0.01	-0.06	-0.63*	-1.05*
CAN	0.55*	0.93*	0.38	-0.73*	-0.18	-1.66*
AUS	0.56*	0.88*	-0.29	0.50*	-0.85*	-0.39*
	B Ordering: G, Z, T					
USA	1.36*	2.07*	1.16*	0.08	-0.20	-1.98*
DEU	0.69*	0.87*	4.86*	3.67*	4.16*	2.80*
GBR	0.55*	0.86*	-0.07	-0.22	-0.63*	-1.08*
CAN	0.54*	0.78*	0.36	-0.83*	-0.18	-1.62*
AUS	0.42*	0.83*	-0.57*	0.35	-0.98*	-0.48*
	C Ordering: T, Z, G					
USA	1.37*	2.16*	1.18*	0.25	-0.19	-1.91*
DEU	0.69*	1.16*	5.38*	4.30*	4.69*	3.14*
GBR	0.59*	0.87*	0.01	-0.06	-0.58*	-0.93*
CAN	0.44*	0.68*	0.40	-0.70*	-0.05	-1.38*
AUS	0.37*	0.69*	-0.40*	0.38*	-0.77*	-0.31*

G- and Z-multipliers and their difference, at 1 and 3 years, under alternative orderings of the fiscal variables. See also notes to Table 3.

8.3 Interpolated items

Some components of government consumption and government investment in the UK and the US are interpolated from annual data without indicators as guidelines. As Table 12 shows, in the UK the interpolated items are all local government purchases except wages; in the US, all state and local government purchases plus civilian federal government wages and salaries and their supplements.

Panel B of Table 13 displays the cumulative multipliers from a VAR where government consumption and investment do not include the interpolated items, as described in Table 12 (in the UK, all local government purchases are excluded, because wages are not separately available); panel A displays the benchmark multipliers, from Table 4. The only case of substantial difference is the decline in the G-multiplier in the US, by about 1 percentage point at 3 years. The key qualitative results however are unchanged.

Table 12: **Interpolated items**

GBR[1]	LG: all except wages and Council Tax receipts
USA[2]	FG military wages and salaries: Interpolated with military employment as indicator
	FG supplements to military wages and salaries: computed as quarterly wages and salaries times the tax rate
	FG civilian wages and salaries: interpolated without indicator
	FG supplements to civilian wages and salaries: largely interpolated without indicator
	SLG wages and salaries: interpolated without indicators
	SLG supplements to wages and salaries: interpolated without indicators
	SLG all purchases of goods: interpolated without indicator
	SLG government sales (subtracted from purchases, mostly tuition fees and hospital charges): interpolated without indicators

Legend: LG: "Local Government" ; SLG: "State and Local Government" FG: "Federal Government".
1: see Office for National Statistics [2001] p. 371. 2: see Bureau of Economic Analysis and U.S. Department of Commerce [1988], Tables II-5 and III-4.
Source: Perotti [2003].

Table 13: **Excluding interpolated items**

	(1)	(2)	(3)	(4)	(5)	(6)
	G-mult.		**Z-mult.**		**Z-mult. - G-mult.**	
	4	12	4	12	4	12
	A Cumulative multiplier, benchmark					
USA	1.37*	2.16*	1.17*	0.21	-0.19	-1.95*
GBR	0.64*	0.99*	0.01	-0.06	-0.63*	-1.05*
	B Cumulative multiplier, excluding interpolated items					
USA	0.83*	1.17*	1.23*	-0.08	-0.40	-1.25*
GBR	0.44	1.18*	-0.35	-0.53	-0.53	-1.71*

G- and Z-multipliers and their difference, at 1 and 3 years, in benchmark case (panel A) and with interpolated items excluded from government consumption and investment (panel B). See also notes to Table 3.

Note that the excluded interpolated items are predominantly civilian spending; hence, the decline in the G-multiplier in the US is consistent with the results of Table 17, where defense spending is shown to have a lower multiplier than civilian spending.

8.4 Alternative elasticities

Table 14 displays the G- and Z-multipliers and their difference in the benchmark case and under two alternative sets of elasticities. In the first case (second line of each panel) the price elasticity of the two real government spending variables is set to 0. As one can see, the difference with the benchmark case is minimal.

Table 14: **Alternative elasticities**

	USA		DEU		GBR		CAN		AUS	
	4	12	4	12	4	12	4	12	4	12
	A G-multiplier									
benchmark	1.37*	2.16*	0.77*	0.91*	0.64*	0.99*	0.55*	0.93*	0.56*	0.88*
$\alpha_{g\pi} = \alpha_{z\pi} = 0.0$	1.43*	2.27*	0.73*	0.84*	0.69*	0.99*	0.58*	1.08*	0.67*	1.12*
$\alpha_{gy} = \alpha_{zy} =$ -0.5	3.35*	3.03*	1.46*	1.18*	1.50*	1.57*	1.64*	2.07*	1.26*	1.30*
	B Z-multiplier									
benchmark	1.17*	0.21*	5.07*	3.84*	0.01	-0.06	0.38	-0.73*	-0.29	0.50*
$\alpha_{g\pi} = \alpha_{z\pi} = 0.0$	1.20*	0.29	5.03*	3.86*	0.02	-0.06	0.40	-0.60*	-0.26*	0.55*
$\alpha_{gy} = \alpha_{zy} =$ -0.5	1.93*	0.71*	5.30*	3.66*	0.14	0.07	0.97*	-0.13	-0.13	0.62*
	C **Z-multiplier - G-multiplier**									
benchmark	-0.19*	-1.95*	4.29*	2.93*	-0.63*	-1.05*	-0.18	-1.66*	-0.85*	-0.38*
$\alpha_{g\pi} = \alpha_{z\pi} = 0.0$	-.23	-1.98*	4.30*	3.01	-0.67*	-1.05*	-0.18	-1.68*	-0.93*	-0.57*
$\alpha_{gy} = \alpha_{zy} =$ -0.5	-1.42*	-2.32*	3.85*	2.47*	-1.36*	-1.50*	-0.68*	-2.20*	-1.39*	-0.68*

In each panel, the first line displays the benchmark multiplier, from Table 4. The second line displays the multiplier obtained when the price elasticity of government spending is set to 0, against a benchmark value of -.5. The third line displays the multiplier obtained when the GDP elasticity of government spending is set to -.5, against a bednchmark value of 0.0

In the second case (third line of each panel) the output elasticity of government spending is set to -.5. A negative elasticity would occur if there were some automatic mechanism ensuring an *automatic* and *immediate* increase in government purchases in response to a decline in output. As argued in section 3, it is difficult to think of such mechanism; and in any case an elasticity of -.5 is implausibly large. In fact, the G- and Z- multipliers are uniformly higher, as one would expect, and particularly the G-multipliers; as a consequence, the difference between the Z- and G- multiplier is now uniformly even smaller in an algebraic sense.

8.5 Subsample stability

Perotti [2004] documents that the response of GDP to total government purchases has become weaker in the last 20 years. Table 15 displays the G and Z-multipliers and their

Table 15: **Subsample stability, I**

	USA	DEU	GBR	CAN	AUS
	A G-multiplier, linear trend				
1960-79	1.09*	-0.49	0.18	-0.60	1.32*
1980-01	-1.49 <	-0.01 +	0.55 +	-0.15 +	0.84* -
	B Z-multiplier, linear trend				
1960-79	1.74	1.19	0.58*	0.72*	0.44*
1980-01	1.05* -	-1.00 -	-1.25* <	-2.17 <	-0.53 -
	C Z-multiplier - G. multiplier, linear trend				
1960-79	0.65	1.68	0.40	1.33*	-0.87
1980-01	2.54 +	-0.99 -	-1.80* <	-2.02 <	-1.37 -
	D G-multiplier, levels				
1960-79	0.18	0.75	1.61*	1.32*	1.55*
1980-01	-0.79 -	-0.96*<	0.53 <	-0.52 <	0.85*-
	E Z-multiplier, levels				
1960-79	-0.11	-1.93	0.54*	1.76*	0.26
1980-01	-2.34*-	-5.05 -	-1.28*<	-1.76*<	-1.56*<
	F. Z-multiplier - G. multiplier, levels				
1960-79	-0.30	-2.68	-1.07*	0.45	-1.29*
1980-01	-1.56 -	-4.09 -	-1.81* -	1.24* <	-2.41* -

In each panel, the first line displays the multiplier at 8 quarters from a system estimated from the beginning of the sample in each country to 1979:4 (1974:4 in the case of Germany). The second line displays the multiplier at 8 quarters from a system estimated from 1980:1 (1976:1 in the case of Germany) to the end of the sample in each country.
“+”(“-”) : the multiplier in the second subsample is larger (smaller) than the multiplier in the first subsample at the same horizon, but the difference is statistically insignificant;
“>”(“<”) : the multiplier in the second subsample is larger (smaller) than the multiplier in the first subsample at the same horizon, and the difference is statistically significant.
See also notes to Table 3.

differences at 8 quarters (for compactness, an horizon intermediate between the 4 and 12 quarters displayed in the preceding tables) estimated over the first part of the sample up to 1979:4 (first line in each panel), and over the second part of the sample from 1980:1

(second line).[38] The table displays these multipliers for both the benchmark specification with a linear trend (panels A to C), and the alternative specification in levels (panels D to F).

Table 16: **Subsample stability, II**

		(1)	(2)	(3)	(4)	(5)	(6)
	Z-multiplier - G-multiplier, linear trend						
		4 qrts.		12 qrts.		20 qrts.	
	full sample	-0.19		-1.95*		-1.94*	
USA	min	-0.80*	(75-79)	-2.79*	(65-69)	-0.82*	(60-64)
	max	0.93*	(95-01)	-0.90*	(95-01)	-2.94*	(65-69)
	full sample	4.29*		2.93*		1.59	
DEU	min	4.02	(60-64)	1.23	(70-74)	-0.62	(70-74)
	max	5.28*	(80-84)	5.17	(65-69)	4.13	(65-69)
	full sample	-0.63*		-1.05*		-0.72*	
GBR	min	-1.07*	(75-79)	-2.04*	(70-74)	-2.35*	(70-74)
	max	-0.15	(85–89)	-0.14	(90-94)	0.30	(90-94)
	full sample	-0.18		-1.66*		-1.85*	
CAN	min	-0.78*	(65-69)	-3.76*	(65-69)	-4.91	(65-69)
	max	0.66	(95-01)	0.24	(95-01)	0.16	(95-01)
	full sample	-0.85*		-0.38*		0.28	
AUS	min	-1.05*	(60-64)	-0.63*	(80-84)	-0.45*	(80-84)
	max	-0.61*	(80-84)	0.11	(90-94)	0.70*	(95-01)

For each country, the first line displays the difference between the Z- and G-multipliers at 4, 12 and 20 quarters in the benchmark case with the system estimated over the whole sample. The second line displays the minimum of the same difference at the same horizons, among all the estimates obtained by excluding 5 years of the sample, starting from the 1960:1 - 1964:4 period. Besides each minimum is the five year period whose exclusion generates that minimum. Similarly for the maxima displayed in the third line. See also notes to Table 3.

In the benchmark specification, the G-multiplier is larger in the second subsample than in the first in three countries out of five, although the difference is not significant; the exception is the US, where the G-multiplier is significantly (both economically and statistically) smaller in the second subsample.[39] The decline in the effects of fiscal policy in the second subsample is thus due mostly to a decline in the Z-multiplier, which occurs in all five countries[40] and is statistically significant in the UK and Canada. This decline is

[38] For Germany, whose data ends in 1989:4, the break-point is 1974:4.

[39] With at most 20 years of data in each subsample, the standard error bands in the two subsamples tend to be larger than in the whole sample. 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.

[40] However, in Germany the Z-multiplier is negative in the second subsample because the denominator

consistent with the notion that, as public capital accumulates, its productivity declines; it is also consistent with similar findings of Fernald [1993], based on panel evidence on highway capital in US states. As a consequence of this pattern, except in the US the Z-multiplier at 8 quarters is larger than the G-multiplier in the first subsample, but smaller in the second (panel C).

In the specification in levels, both the Z- *and* the G-multipliers are smaller in the second than in the first subsample (panels D and E). Except in Canada, the difference between the Z and G-multipliers is also negative in both the first and the second subsamples, including now in the US, and larger in absolute value in the second.

Table 16 provides a different check on the stability of the results. In the benchmark specification, I routinely exclude 5 years of data, starting with the 1960:1 to 1964:4 period. For each country, the table reports in the first line the difference between the G and Z-multipliers at 4, 12 and 20 quarters as estimated in Table 4; the second line displays the minimum of the same difference, and the five-year period whose exclusion generates that minimum at each of the three horizons; and the same for the maximum in the third line.

In about half of the cases (excluding Germany, where the benchmark case is already positive) the maximum difference between the two multipliers is positive, but usually very small; and only in two cases (the US at 4 quarters and Australia at 20 quarters) is the maximum of the difference positive and statistically significant.

9 Defense

According to the 1993 System of National Accounts (see Commission of the European Communities et al. [1993], sections 10.65 to 10.68), weapons like bombs and missiles and weapons delivery systems like aircraft, battleships, and missile launchers should be classified as government consumption; the US, however, classifies them as government investment. Conceptually, it is unclear to which category one would want to assign these items. In this section, I explore the sensitivity of the results to alternative classifications of government spending on defense. This exercise is also important, because much of the literature on the social returns to public capital (starting with Aschauer [1989]) refers to non-defense public capital.

The first panel of Table 17 displays the benchmark GDP multipliers at 8 quarters for the US, Canada and Australia (the three countries with quarterly data on government spending on defense). In the second line, in the US government investment in machinery and equipment (of which about half is aircraft, missiles, battleships, and vehicles - see Table 1) is allocated to government consumption and subtracted from government investment, as in the other countries; the G-multiplier falls considerably, and the Z-multiplier increases by a similar amount, so that the two multipliers are now essentially equal. In

- the cumulative change in total government spending - is negative in the second subsample.

the other countries, defense spending on machinery and equipment is already classified as government consumption, hence the second line is the same as the first line. The third line

Table 17: **Defense spending**

	GDP multipliers								
	USA			CAN			AUS		
	G	**Z**	**Z-G**	**G**	**Z**	**Z-G**	**G**	**Z**	**Z-G**
benchmark	1.91*	.52	-1.40*	.74*	-.24	-.98*	.86*	.02	-.84*
M&E in govt cons	1.08*	1.14*	.05	.74*	-.24	-.98*	.86*	.02	-.84*
civ. spending only	1.38*	2.81*	1.43*	.51	-.23	-.74*	1.10*	.25	-.85*
3 spending variables	2.31*	1.95*	-.36	.19	.11	-.08	1.20*	-.42*	-1.62*
3 spending variables	1.37*	1.95*	.58	-.08	.11	.19	.29	-.42*	-.71*
	Private consumption and investment multipliers, USA								
	private consumption			**private investment**			**dwellings**		
	G	Z	Z-G	G	Z	Z-G	G	Z	Z-G
benchmark	1.11*	.45*	-.66*	-.54*	-1.10*	-1.64*	.26*	-.26*	-.52*
M&E in govt cons	.72*	.88*	.17	-.27	-.68*	-.41	-.04	-.02	.02
civ. spending only	1.25*	1.69*	.44	.26	-.36	-.53	.31*	.09	-.22
3 spending variables	1.97*	1.12*	-.85*	.74	-.22	-.97	.53	.10	-.43
3 spending variables	.74*	1.12*	.38	-.08	-.22	-.14	.03	.10	.06
	non-dwellings			**mach. & equipm.**			**other structures**		
	G	Z	Z-G	G	Z	Z-G	G	Z	Z-G
benchmark	-.21*	-.71*	-.50*	.12	-.42*	-.46*	-.10	-.24*	-.14
M&E in govt cons	-.52*	-.53*	-.01	-.19*	-.33*	-.14	-.19*	-.18*	.01
civ. spending only	.11	-.17	-.28	.24*	-.15	-.39*	-.13	-.03	.10
3 spending variables	.23	-.30	-.53	.42*	-.18*	-.61*	-.19	-.13	.06
3 spending variables	-.67*	-.30	.37	-.27*	-.18*	.08	-.12	-.13	-.01

The first panel displays the G-multiplier, Z-multiplier, and their differences, at 8 quarters, for the following cases: line 1: benchmark VAR, as in Table 4; line 2: government defense investment in Machinery and Equipment is added to government consumption and subtracted from government investment; line 3 defense government consumption is subtracted from government consumption and defense government investment is subtracted from government investment; line 4: from a VAR with 3 government spending variables instead of 2, in this order: civilian government investment, civilian government consumption, and defense government spending; the multiplier in the G column is the multiplier of civilian government consumption; the multiplier in the the Z column is the multiplier of civilian government investment; line 5: from the same specification, now the multiplier in the G column is the multiplier of defense spending; the multiplier in the Z column is still the multiplier of civilian government investment.

displays GDP multipliers from a specification where both government consumption and government investment are net of defense spending.[41] Relative to the second line, both

[41] In Canada and Australia, in quarterly data all defense spending is allocated to government consumption.

multipliers increase in the US and Australia, and remain essentially the same in Canada, indicating that both types of defense spending, current and capital, tend to have a lower multiplier than the civilian components.

The next two lines display multipliers from a specification with three government spending variables, civilian government investment, civilian government consumption, and defense spending, in this order.[42] In line 4 the columns labelled G and Z display the GDP multipliers of civilian government consumption and of civilian government investment, respectively; the former is still slightly larger than the latter, although significantly so only in Australia. In line 5, the columns labelled G and Z display the GDP multipliers of defense spending and again of civilian government investment, respectively: now defense spending has a lower multiplier than civilian government investment in the US and Canada, although again the difference is not significant.

The next two panels investigate the private consumption and investment multipliers in the US, the country where the distinction between civilian and defense spending makes the largest difference to the results. The private consumption G- and Z-multipliers follow the same pattern as the GDP G- and Z-multipliers in the previous panel: they increase if defense spending is excluded. The difference between the two is still negative or at most around 0, depending on the specification.

The same pattern - higher multipliers for civilian spending - applies to the private investment G- and Z-multipliers. In particular, when government investment in machinery and equipment is attributed to government consumption, the private investment G-multiplier decreases and the private investment Z-multiplier increases, whether the VAR includes total private investment or any of its components. Note that the Z-multiplier increases less for machinery and equipment than for dwellings, suggesting once again that substitution between private and government investment is not the main cause of these results. The private investment Z-multiplier tends to remain negative throughout all these specifications, and smaller than (or at most statistically equal to) the G-multiplier.

Finally, note that in the 3 spending variables specification (lines 4 and 5 of each panel) the private investment multiplier of defense spending (line 5, column "G" in each panel) is always smaller than the private investment multiplier of civilian government consumption (line 4, column "G" in each panel). For all components of private investment the difference between the two multipliers is often large.

Government defense investment in machinery and equipment consists largely of goods with very long production processes, such as aircraft and missiles, which are often budgeted with a method close to the delivery method (see Table 8). Hence, the estimated multiplier might be particularly open to the problem of the mechanical negative correlation between government investment and private investment in machinery and equipment (see the discussion on page **??**). In fact, when private inventories are excluded from private investment, the private investment Z-multiplier at 8 quarters increases from -.94 and

[42] Results with alternative orderings of these three variables are virtually identical.

significant when government spending on machinery and equipment is included in government investment to -.22 and insignificant when it is included in government consumption (results not shown).

10 Does public investment pay for itself?

Regardless of its stabilizing properties (or lack thereof) in the short run, a frequent argument in favor of public investment is that it "pays for itself" in the long run: one extra dollar of public capital at time 0 generates an increase in output over time such that, at unchanged tax rates, the present value of tax revenues increases by at least one dollar (plus the present value of the depreciation spending on the extra dollar of capital). Formally:

$$\sum_{t=0}^{\infty} \frac{\tau_t \left(dY_t/dK_0\right)}{(1+r)^t} \geq 1 + \sum_{t=1}^{\infty} \frac{\delta}{(1+r)^t} \tag{5}$$

where K_0 is public capital at time 0, τ_t is the average tax rate and δ is the rate of depreciation. r is some measure of the interest rate paid by the government, assumed to be constant for simplicity. dY_t/dK_0 is the *total* change in GDP at time t from the extra unit of public capital at time 0, hence it takes into account the optimal changes in private inputs in response to the change in public capital. Note also that the expression assumes that no cost is recovered directly through user fees, a plausible approximation in the case of public investment by the general government.

Implicitly or explicitly, condition (5) is at the heart of the "Golden Rule", the notion that current government spending should be financed by taxation but capital government spending can be financed by debt.

In its pure form, condition (5) is difficult to test: in computing the impulse responses from a VAR, when government investment is shocked one cannot hold constant the other types of government spending. Nor is it clear that one would want to do so. Self-amortization is not necessarily an exclusive property of capital goods as defined in the national income accounts; it could apply also to some current purchases with positive externalities of various types.[43] Hence, the definition of "self-amortizing government spending" I adopt is slightly different from that embedded in (5): a given sequence of *total* government purchases following a shock to Z is self-amortizing if the following inequality

[43] Perhaps the clearest – though indirect – statement of the Golden Rule is in Sargent [1986], pp 388-89: "Capital account expenditures are defined as expenditures that lead to the accumulation of assets that yield a competitive rate of return to the government. Examples of capital account expenditures are government purchases of private capital, government expenditure on welfare and public education that increases the receipients' productivity by enough to increase the present value of subsequent tax collections by an amount equal to government expenditure, and government loans to the private sector at the market rate of interest. Capital account expenditures are, by definition, self-amortizing and do not require current or subsequent taxation in order to finance them."

is realized:

$$\sum_{t=0}^{\infty} \frac{\tau_t \widetilde{Y_t(Z)}}{(1+r)^t} \geq \sum_{t=1}^{\infty} \frac{\left[\widetilde{Z_t(Z)} + \widetilde{G_t(Z)}\right]}{(1+r)^t} \tag{6}$$

where the expression $\widetilde{X_t(Z)}$ denotes the impulse response at horizon t of the variable X following a shock to the variable Z. In words, a given sequence of government purchases following a shock to Z is self-amortizing if the present discounted value of the implied response of tax revenues generated by the GDP response at unchanged tax rates is at least as large as the present discounted value of the response of total government purchases. Note that because government investment is gross of depreciation, this formula automatically takes into account depreciation costs.

Table 18: **Discounted multipliers**

	shock to G			**shock to Z**			$\mathbf{1/\overline{\tau}}$
	20 qrts	40 qrts	80 qrts	20 qrts	40 qrts	80 qrts	
USA	2.29*	2.47*	2.28*	0.38*	0.90*	0.88*	3.63
DEU	1.21*	1.33*	1.39*	2.92*	2.27*	2.02*	2.52
GBR	0.61*	0.08*	-0.08*	-0.12*	-0.84*	-0.93*	2.70
CAN	1.09*	1.20*	1.29*	-0.72*	-0.01*	0.29*	3.27
AUS	0.79*	0.47*	-0.03*	1.00*	1.13*	0.85*	3.78

Discounted multipliers, defined in the left-hand-side of equation 7. The last column displays the inverse of the average tax revenue to GDP ratio, as in the right-hand-side of equation 7. See also notes to Table 3.

In practice, I replace τ_t with the average revenue/GDP ratio over the sample, $\overline{\tau}$, and I truncate the summation in (6) at some finite horizon T: I present results for T equal to 20, 40 and 80 quarters. Hence, a given sequence of total government purchases is self-amortizing if

$$\sum_{t=0}^{T} \frac{\widetilde{Y_t(Z)}}{(1+r)^t} / \sum_{t=1}^{T} \frac{\left[\widetilde{Z_t(Z)} + \widetilde{G_t(Z)}\right]}{(1+r)^t} \geq 1/\overline{\tau} \tag{7}$$

Thus, in this definition government purchases following a Z shock are self-amortizing if the (discounted) Z-multiplier is at least as large as the inverse of the average tax/GDP ratio. Of course, a similar definition applies to G shocks.

Table 18 displays the discounted Z- and G-multipliers at 5, 10 and 20 years assuming a quarterly interest rate of 1 percent; an asterisk indicates that the difference of the discounted multiplier from the inverse of the average revenues to GDP ratio (displayed in the last column) is significant at the 95 percent level. Only in Germany after 5 years one cannot reject the hypothesis that the flow of total government purchases following the initial Z shock is self-amortizing. There are no cases of self-amortizing spending after a G shock.

Even when US government investment in machinery and equipment is reallocated to government consumption, as expected given the results of the previous section the discounted multiplier of government investment (not shown) increases, but it is still short of the inverse of the average tax ratio.

11 Transfers

Perhaps even more than government purchases, transfers to households are typically regarded by policymakers as the quickest and most effective spending instrument for demand management. In this section, I decompose net taxes into revenues and transfers to individuals; I then estimate the same VARs as in the previous sections, except that now the first block consists of 4 fiscal policy variables: government investment Z, government consumption G, transfers to households S, and revenues R.[44] In the benchmark case, this is also the order of the variables in the first block of the VAR. I use a benchmark GDP elasticity of real transfers to GDP of -.2 (as in Giorno et al. [1995]), and a transfer elasticity to inflation of -1 (that is, I assume no transfer programs are indexed to contemporaneous inflation, which is indeed the case in the countries and periods covered here).

Table 19: **Transfers**

	(1)	(2)	(3)	(4)	(5)	(6)
	4	12	4	12	4	12
	G-mult.		**Z-mult.**		**S-mult.**	
USA	1.14*	1.62*	1.09*	-0.84	0.81*	0.99*
DEU	0.61*	0.80*	9.26	4.50	0.02	0.96*
GBR	0.57*	1.10*	-0.05	-0.15	0.56*	0.37
CAN	0.37	0.52*	0.25	-0.83*	0.80*	1.79*
AUS	0.68*	1.01*	-0.40*	0.26	-1.07*	-0.94*
	Z-mult. - G-mult.		**G-mult. - S-mult.**		**Z-mult. - S-mult.**	
USA	-0.05	-2.45*	0.33	0.63*	0.28	-1.82
DEU	8.66	3.69	0.59	-0.16	9.25	3.53
GBR	-0.61*	-1.25*	0.00	0.73*	-0.61*	-0.52*
CAN	-0.12	-1.36*	-0.43	-1.26	-0.55	-2.62*
AUS	-1.08*	-0.75*	1.75*	1.95*	0.67	1.19*

The G multiplier is defined as the cumulative response of GDP to a G shock divided by the sum of the cumulative response of G, Z and S to the same shock, from the 7-variable model described in the text. See also notes to Table 3.

[44] Revenues are net of the residual transfer items, namely transfers to businesses (subsidies) and other current and capital transfers, such as transfers to universities or capital grants not included in subsidies to businesses. Note that the elasticities of revenues to prices and GDP are different from the elasticities of net taxes to the same variables.

Panels A and B of Table 19 display the G- and Z-multipliers from this specification, at the horizons of 4 and 12 quarters[45] As one can see, these are very similar to the corresponding G-multipliers from the 6-variable VAR in panels A and B of Table 4; they are only slightly smaller because the denominator now includes also the response of transfers. The only noticeable exception is the Z-multiplier in Germany, which takes very large values because the denominator is now close to 0 (in fact, the multiplier is insignificant because the denominator switches sign easily in each simulation). Panel C displays the S-multiplier, from the same 7-variable VAR. It is negative in Australia, at about -1; but it is positive and mostly significant in the other countries, although never above 1 except in Canada at 3 years.

The next set of panels display the differences between these multipliers. The difference between the Z- and G-multipliers in panel D displays much the same pattern as in Table 4. Panels E and F display the difference between the G- and S-multipliers, and between the Z- and S-multipliers, respectively. At 1 year, the G-multiplier is essentially the same as the S-multiplier, except in Australia where the former is much larger. At 3 years, the G-multiplier is significantly larger in 3 countries, the same in Germany, and smaller only in Canada (although not significantly so). The comparison with the Z-multiplier is more mixed.

Thus, transfers do not appear to have an obvious advantage over government consumption in stimulating GDP in the short run, and even less so in the long run.

12 Explanations

Although a full explanation of the evidence presented here is beyond the scope of this paper, it is important to lay down a few hypotheses, and to be aware of what one can and cannot legitimately conclude from the results of this paper.

One might think of several reasons for the negative effects of government investment on GDP and private investment. A country might have *too much* public capital relative to its optimal level, so that public investment could have a very low, or negative, marginal product. For instance, Fernald [1993] shows that the in the US the social marginal product of the first wave of interstate highway construction in the sixties was extremely high, but successive waves had a social marginal product close to 0 or even negative. The results in Table 15, showing a decline in the Z-multipliers in the second half of the sample, are also consistent with this argument. In this sense, the results of this paper might not extend to countries with low GDP and, presumably, low public capital per capita.

More mundanely, public investment might be particularly prone to political pressure,

[45] In all the multipliers displayed in this table, the denominator is the cumulative response of all government spending, i.e. the sum of the cumulative responses of government consumption, government investment, *and* transfers.

and loaded with pork-barrel projects with no economic rationale; if it crowds out more productive private investment, it can show up as having a negative multiplier after the general equilibrium effects are played out. In more extreme cases, it can foster downright corruption and rent-seeking activities.

These arguments also might explain why government consumption can have a higher multiplier than government investment. Other explanations for this result are also possible. Some types of transfers and government consumption also have important, if less obvious, positive externalities in the long run; for instance, some models of growth imply that under some conditions transfers might release credit constraints and therefore promote investment in education and growth (see e.g. Perotti [1993]). Another possibility is the distortionary effects of the taxation, current and future, that accompanies an increase in public investment, as shown for instance in the neoclassical model of Baxter and King [1993]. Note, however, that for similar effects on the present discounted value of total government spending, government consumption shocks tend to have higher effects on GDP. Hence, this explanation would require government investment shocks to be accompanied systematically by more distortionary taxation - a hypothesis that appears far-fetched.

This paper has provided evidence that the popularity of public investment as an engine of growth is probably undeserved. An important, if obvious, caveat is that a low or negative multiplier of aggregate government investment is perfectly compatible with a very high social rate of return of specific projects. As always, macroeconomic evidence can only go so far: perhaps a conservative way to interpret the results of this paper is as a warning against a blind acceptance of popular and superficially compelling theoretical arguments on the macroeconomic properties of public investment.

Appendix A: Output and price elasticities of government spending

Output elasticity of government purchases

There is no evidence of any substantial automatic response of government spending to GDP within a quarter: hence, the benchmark output elasticity of government consumption and investment is assumed to be 0.

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 they typically account for a small part of government spending: in all countries the sum of spending on passive and active measures never exceeds 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.

Price elasticity of government purchases

Consider first the wage component of government spending on goods and services (typically, slightly less than half the total spending). While government wages were or are indexed to the CPI during part of the sample in some countries, in all cases indexation occurs 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 consumption well below 0 seems justified. In my benchmark specifications, I assume a price elasticity of government consumption and investment of -.5.

Price elasticity of transfers

Some 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.

Appendix B: The data

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). Revenues are broken down 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 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

Defense Government Consumption: constructed as the product of "Final consumption expenditure, general government, national, defense: chain volume measure" (National Income and Product Accounts, Publication No. 5206, Australian Bureau of Statistics, Table 5, at http://www.abs.gov.au) and "Final consumption expenditure, general government, national, defense: implicit price deflator" (same, Table 9)

Defense Government Investment: constructed as the product of "gross fixed capital formation, general government, national, defense: chain volume measure" (same, Table 5) and "Gross fixed capital formation, general government, national, defense: implicit price deflator" (same, Table 9)

Private Investment: dwellings, non-dwellings, machinery and equipment, other structures: Table 22

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...

Defense Government Consumption: series v499764, Table 380-0034, CANSIM database

Private Investment: dwellings: series v498096; non-dwellings: series v498095 - series v498096, machinery and equipment: series v498099; other structures: series v498098; all in Table 380-0002, CANSIM database

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

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

Private Investment: dwellings: series GGAG, United Kingdom Economic Accounts, Table A8; non-dwellings: series NPEK, Table A8

USA

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

tran = 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, series GS10, *H.15 Release, Federal Reserve Board of Governors*

Defense Government Consumption: "Federal National Defense Consumption Expenditure", Table 3.7, Bureau of Economic Analysis, National Accounts

Defense Government Investment: "Federal National Defense Gross Investment Expenditure", Table 3.7

Defense Government Investment, machinery and equipment: "Federal National Defense Gross Investment Expenditure on machinery and equipment", Table 3.7

Private Investment: dwellings, non-dwellings, machinery and equipment, other structures: Table 1.1.

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