Public investment and the Golden Rule: another (different) look

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Abstract

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1 Introduction

It is widely believed that governments no longer engage in the kind of fiscal activism that was typical 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,

[1] For a detailed description 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.

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 side 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]). The first goal of this paper is to evaluate empirically the short-to-medium run properties of government consumption and government investment, 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 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.

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, a 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

[4]See for instance a 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 was *de facto* suspended for a long period.

[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.

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 jeopardizing the "sustainability" of public finances.

But reality can be different from theory. Assessing the 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 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 4 OECD countries (Australia, Canada, the United Kingdom, and the United States) for which I was able to assemble non-interpolated quarterly data for the general government for a long enough period, directly from national sources.[6]

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 in the short run. Section 7 discusses the] same effects, but in the] long run, and in so doing investigates the empircal content of the] Golden Rule. Section 8 presents the responses of private investment and consumption

[6]For a fifth country, West Germany, data are available from 1960:1 to 1989:4, the date of the reunification. However, the available documentation was not sufficient to understand the construction of the government budget data.

to fiscal shocks, and briefly reviews the results in the light of the main macroeconomic models of private consumption and investment. Section 9 discusses the robustness of the results. Section 11 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-defense 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.[7] 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

[7]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.

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 [2007], 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 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.[8]

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.[9]

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 [2007], uses quarterly data and concentrates on developing alternative identification schemes to isolate shocks to government spending. However, government spending in this literature is

[8] 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.

[9] 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.

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.[10]

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. Kamps [2004] estimates a similar VAR for the US only, and also finds a small positive effect on GDP. Mittnik and Neumann [2001] is the closest antecedent to this paper. They 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.[11] 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. 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. More importantly, the focus of the present paper is a comparison of the effects of the two types of government purchases - government investment and government consumption -, and a quantitative evaluation of the Golden Rule. I also study in depth issues related to the construction of the data, and the role of defense spending.

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. 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 values. Let P_t indicate the GDP deflator, p_t its logarithm and π_t the first difference of the

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

[11] Note, however, that the quarterly data for the last three countries are largely interpolated from annual data.

[12] The sum of government consumption and government investment is total purchases of goods and services by the government, a component of GDP. Net taxes are defined as tax revenues less trasnfers to households and businesses.

latter; finally, r_t denotes the 10-year nominal interest rate. The benchmark 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. 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 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.[14] For government consumption and investment, it is difficult

[13] For instance, in the case of taxes the second component captures the automatic increase in revenues that occurs when output increases, 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 of the construction of the tax elasticities.

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).[15] All fiscal variables are net of interest payments and receipts, hence they are largely independent contemporaneously of the interest rate: hence, I set $\alpha_{gr} = \alpha_{zr} = \alpha_{tr} = 0$.[16]

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

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

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

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

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.[17] 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] 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 the benchmark specifications, I assume a price elasticity of government consumption and investment of -.5.

[16] 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.

[17] 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).

The VAR approach employed here does not come for free. While decision lags help identify fiscal policy shocks with quarterly data, implementation lags imply that the shocks estimated by the econometrician might in fact be anticipated by the public sector. Perotti [2007] discusses extensively this and other aspects of the identification scheme, and concludes that, empirically, this is not likely to constitute a major problem.

In the context of this paper, there is an additional reason why this problem might not be too serious empirically. Government consumption and government investment shocks will be shown to have significantly different effects on GDP and its components. Even if the shocks were in part anticipated, they would bias the impulse responses to government consumption and govenrment investment, but it is not clear why this bias whould be drastically different for the two spending components.

4 The data

This study includes four countries (samples in parentheses): Australia (1960:1 - 2006:3), Canada (1961:1 - 2006:3), United Kingdom (1963:1 - 2006:2), and United States (1960:1 - 2006:1).[18]

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. Except for the interest rate in the UK and Canada, all the data are from primary, national sources.[19]

Government investment is defined as gross fixed capital formation; thus it excludes changes in inventories, net acquisition of valuables (a very small item), and net acquisitions of non-produced assets like land (again a minor item). It does not include investment by government enterprises, hence it is largely unaffected by the process of privatization in the last two decades.[20]

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

[18] For the US, the sample goes back to 1947:1. As discussed in Blanchard and Perotti [2002] and Perotti [2007], the period until the end of the Korean War was characterized by a few large short lived discretionary changes in government spending and taxation, which have a considerable influence on the results. Thus, as in Blanchard and Perotti [2002], I start the US sample in 1960:1; results over the sample starting in 1954:1 (as in Galí, Lopez-Salido and Vallés [2007]) are very similar.

[19] 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 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).

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

recorded as government consumption. All countries in the sample follow this approach, except the US where some of 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 Australia (separate quarterly data on defense government consumption are not available for Germany and the UK).

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

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

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

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 11.8 in the UK.

5 Fiscal shocks and fiscal policy

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, 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.[21] The figure also displays one standard error bands on the two sides of the response. Table 2 displays the annualized[22] discounted cumulative responses of Z and G to

[21] 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.

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

the same shocks at selected horizons, assuming a quarterly discount rate of 1 percent. An asterisk "*" in the table indicates that 0 is on the same side of both standard error bands. [23]

The figure and the table make two important points. First, except in Canada the response of Z to Z shocks is very similar to the response of G to G shocks. However, 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 the UK, the cumulative response of total government purchases (the sum of Z and G) is larger in the case of Z shocks; as we have seen above, the difference is mostly due to the response of Z. In fact, 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 shocks than for G shocks at any given horizon (see panels G and H). For instance, at 12 quarters the average Z-content of total cumulative government purchases is .59 in response to Z shocks, and .06 in response to G shocks. Hence, I shall refer to the Z shock as the "Z-intensive" shock.

In the neoclassical model with separable preferences, government consumption has just a negative wealth effect on the private sector. Government investment has a negative wealth effect like government consuption, because it requires an equivalent amount of taxation in present value terms; but it could also have a positive wealth effect through various externalities on the private factors of production. Hence, the fact that the cumulative response of G to the two shocks is similar is useful because it implies that the direct negative 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 short-run response of GDP to fiscal shocks

In this section, I consider the short-run behavior of output, up to 3 years, after a fiscal shock.

6.1 Effects on output

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

[23] 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	12	20	4	12	20
	A Cum. resp. of G to G			**B Cum. resp. of G to Z**		
USA	0.88*	2.10*	2.75*	0.39*	1.67*	2.50*
GBR	0.68*	1.75*	2.51*	0.14*	0.46*	0.67*
CAN	0.61*	1.29*	1.71*	0.37*	1.75*	1.97*
AUS	0.54*	1.22*	1.69*	0.47*	1.36*	1.90*
	C Cum. resp. of Z to G			**D Cum. resp. of Z to Z**		
USA	0.09*	0.22*	0.06*	0.78*	2.10*	2.98*
GBR	0.07*	0.21*	0.20*	0.76*	1.56*	1.86*
CAN	0.01*	-0.02*	-0.09*	1.05*	2.57*	3.14*
AUS	0.03*	0.05*	-0.01*	0.59*	1.19*	1.57*
	E Cum. resp. of Z+G to G			**F Cum. resp. of Z+G to Z**		
USA	0.97*	2.32*	2.81*	1.17*	3.77*	5.49*
GBR	0.75*	1.96*	2.71*	0.91*	2.02*	2.52*
CAN	0.62*	1.27*	1.62*	1.43*	4.32*	5.10*
AUS	0.58*	1.27*	1.68*	1.06*	2.55*	3.47*
	G Z-content of G shocks			**H Z-content of Z shocks**		
USA	0.09*	0.09*	0.02*	0.67*	0.56*	0.54*
GBR	0.09*	0.11*	0.07*	0.84*	0.77*	0.74*
CAN	0.01*	-0.01*	-0.06*	0.74*	0.59*	0.61*
AUS	0.06*	0.04*	-0.01*	0.55*	0.47*	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 cumulative responses are computed assuming a quarterly discount rate of 1 percent.

The shocks equal 1 percentage point of quarterly GDP for 1 quarter, from the 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.

shock is equal to 1 percentage point of quarterly GDP for a quarter (i.e., .25 percentage points of GDP 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.[24]

After 1 year, the cumulative response of GDP to a G shock is positive everywhere, ranging from .2 in the UK and Canada to .8 in the US. After 3 years, the cumulative response ranges from .7 in Canada to 3.2 in the US. In all these cases the cumulative response of GDP is significant.

Table 3: **Cum. resp. of GDP**

	quarter			
	2	4	8	12
	A Cum. resp. of GDP to G			
USA	0.26*	0.76*	2.04*	3.19*
GBR	0.11*	0.21*	0.67*	1.05*
CAN	0.11*	0.17*	0.42*	0.74*
AUS	0.18*	0.75*	1.86*	2.49*
	B Cum. resp. of GDP to Z			
USA	0.99*	1.72*	2.34*	2.50*
GBR	0.05	-0.12	-0.43*	-0.52*
CAN	0.25	0.58	-1.17	-5.36*
AUS	-0.10	-0.16	0.49	2.19*
	C Cum. resp. of GDP to Z - Cum. resp. of GDP to G			
USA	0.73*	0.97*	0.30*	-0.69*
GBR	-0.05*	-0.33*	-1.10*	-1.57*
CAN	0.14*	0.41*	-1.58*	-6.09*
AUS	-0.28*	-0.91*	-1.37*	-0.30*

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.

[24]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 response of GDP to a Z shock is significantly positive initially in the US and Canada, and larger than the response to a G shock; it is 0 or negative in the UK and Australia. At 3 years, it is positive in the US and Australia, negative in the other two countries. Note the large (perhaps implausibly so) negative response at long horizons in Canada.

After 1 year, the cumulative response of GDP to a Z shock is significantly larger than that to a G shock in the US and Canada; but then the difference declines everywhere, and after 3 years the respons to a Z shock is significantly smaller than that to a G shock in all countries.

6.2 Multipliers

To evaluate 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"). 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. Thus, if $\widetilde{Y_t(Z)}$ is the impulse response of Y_t at time t to a shock to Z at time 0, and similarly for $\widetilde{Z_t(Z)}$ and $\widetilde{G_t(Z)}$, then the Z-multiplier is defined as

$$\sum_{t=0}^{T} \frac{\widetilde{Y_t(Z)}}{(1+r)^t} / \sum_{t=1}^{T} \frac{\left[\widetilde{Z_t(Z)} + \widetilde{G_t(Z)}\right]}{(1+r)^t} \tag{5}$$

and similarly for the G-multiplier. I assume a value of $r = .01$, corresponding to a quarterly discount rate of 1 percent.

The G-multiplier (panel A) is always positive: at 1 year, it ranges from .3 in Canada and the UK to 1.3 in Australia; then it increases, and after 3 years it ranges between .6 in the UK and Canada to 2 in Australia.

The Z-multiplier starts out higher than the G-multiplier in the US and Canada, but then it declines in all countries except Australia; by year 3 it is everywhere significantly smaller than the G-multiplier; at this horizon, typically the G-multiplier is larger than the Z-multiplier by more than 1 percentage point.

Thus, Table 4 does not support the notion that government investment is a more effective countercyclical tool than government consumption.[25] At the relevant horizons for

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

Table 4: **Multipliers**

	quarter			
	2	4	8	12
	A G-multiplier			
USA	0.53*	0.78*	1.15*	1.38*
GBR	0.27*	0.28*	0.47*	0.54*
CAN	0.28*	0.27*	0.42*	0.58*
AUS	0.53*	1.30*	1.94*	1.96*
	B Z-multiplier			
USA	1.70*	1.47*	0.93*	0.66*
GBR	0.11	-0.13	-0.27*	-0.25
CAN	0.41	0.41	-0.39	-1.24*
AUS	-0.19	-0.15	0.26	0.86*
	C Z-mult. - G-mult.			
USA	1.16*	0.70*	-0.22*	-0.71*
GBR	-0.15*	-0.41*	-0.74*	-0.79*
CAN	0.12*	0.14*	-0.80*	-1.82*
AUS	-0.72*	-1.45*	-1.68*	-1.10*

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.

countercyclical policies except in the US, the Z-multiplier is virtually 0, and (again with the initial exception of the US) it is consistently and significantly smaller than the G-multiplier.

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 response 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 of interpreting this experiment shows that it violates the Lucas critique, hence it should be interpreted with care, particularly at longer horizons. 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 similar to the Z-multipliers, with the exception of Australia at longer horizons.

Panel C displays the difference between the "pure" Z-multiplier less the "pure" G-multiplier. Like in the corresponding panel of Table 4, after two year na dmore the difference is largely negative and significant.

7 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:

$$\sum_{t=0}^{\infty} \frac{\tau_t \left(dY_t/dK_0\right)}{(1+r)^t} \geq 1 + \sum_{t=1}^{\infty} \frac{\delta}{(1+r)^t} \tag{6}$$

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

Table 5: **"Pure" multipliers**

country	quarter			
	2	4	8	12
	A "Pure" G-multiplier			
USA	0.56*	0.88*	1.52*	1.80*
GBR	0.29*	0.33*	0.60*	0.69*
CAN	0.28*	0.27*	0.43*	0.61*
AUS	0.54*	1.42*	2.15*	2.07*
	B "Pure" Z-multiplier			
USA	2.27*	2.25*	1.41*	0.71*
GBR	0.12	-0.16	-0.39*	-0.41*
CAN	0.51	0.67	-0.27	-1.67*
AUS	-0.32	-0.62	-0.79*	-0.03
	C "Pure" Z-multiplier - "Pure" G-multiplier			
USA	1.71*	1.37*	-0.11*	-1.09*
GBR	-0.16*	-0.50*	-0.99*	-1.10*
CAN	0.23*	0.40*	-0.70*	-2.28*
AUS	-0.86*	-2.04*	-2.93*	-2.10*

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.

cost is recovered directly through user fees, a plausible approximation in the case of public investment by the general government.

Implicitly or explicitly, condition (6) 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 (6) 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.[26] Hence, the definition of "self-amortizing government spending" I adopt is slightly different from that embedded in (6): a given sequence of *total* government purchases following a shock to Z is self-amortizing if the following inequality is realized:

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

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 6: **Long-run multipliers**

	shock to G			**shock to Z**			$\mathbf{1}/\overline{\tau}$
	20 qrts	40 qrts	80 qrts	20 qrts	40 qrts	80 qrts	
USA	1.75*	2.83	5.17	0.58*	0.64*	0.54*	3.64
GBR	0.44*	-0.13*	-1.01*	-0.10*	-0.19*	-0.51*	2.68
CAN	0.80*	1.11*	1.22*	-2.56*	-6.04	-8.15	3.25
AUS	1.73*	0.99*	-0.17*	1.75*	2.23*	2.08*	3.81

Discounted multipliers, defined in the left-hand-side of equation 8. The last column displays the inverse of the average tax revenue to GDP ratio, as in the right-hand-side of equation 8. See also notes to Table 3.

[26] 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."

In practice, I replace τ_t with the average revenue/GDP ratio over the sample, $\overline{\tau}$, and I truncate the summation in (7) 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

$$\sum_{t=0}^{T} \frac{\widetilde{Y_t(Z)}}{(1+r)^t} / \sum_{t=1}^{T} \frac{\left[\widetilde{Z_t(Z)} + \widetilde{G_t(Z)}\right]}{(1+r)^t} \geq 1/\overline{\tau} \tag{8}$$

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 6 displays the cumulative Z- and G-multipliers at 5, 10 and 20 years, as usual assuming a quarterly interest rate of 1 percent; an asterisk indicates that the difference between the multiplier and the inverse of the average revenues to GDP ratio (displayed in the last column) is significant at the 95 percent level. Even at these horizons, the Z-multiplier is negative, except in the US where however it is significantly lower than the inverse of the average revenue to GDP ratio. In fact, there are no cases of self-amortizing spending shocks of either type at any horizon.

8 GDP components

8.1 Private consumption and investment

Table 7 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 both the consumpotion and the investment multipliers are lower in the case of Z-shocks.

The private consumption multiplier of government consumption (henceforth, the "private consumption G-multiplier"[27], panel A, columns 1 and 2) is positive in all countries at all horizons. The private consumption Z-multiplier (panel A, columns 3 and 4) is instead 0 or negative. The difference between the private consumption Z- and G-multipliers (panel A, columns 5 and 6) is thus significantly negative in all countries at all horizons.

With a few differences, a similar picture holds for private investment. The private investment G- multiplier (panel B, columns 1 and 2) is 0 or positive, although small, except in the US whhere it is negative. The private investment Z- multiplier is negative or zero, except in Canata at 1 year. As a consequence, the difference between the G- and Z-private investment multipliers (panel B, columns 5 and 6) is negative except in Canada at 1 year.

[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.

Table 7: **Private consumption and investment**

	(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	.66*	1.18*	.19	-.10	-.47*	-1.28*
GBR	.50*	.03*	-.05	-.42*	-.55*	-.45*
CAN	.27*	.67*	.10	-.37	-.17*	-1.04*
AUS	.44*	.79*	-.27*	-.26*	-.71*	-1.05*
	B Private investment multipliers					
USA	-.41*	-.27*	-.03	-.43*	.38*	-.16*
GBR	.06*	.06*	-.23*	-.41*	-.29*	-.47*
CAN	.02*	.16*	.93*	-.20*	.92*	-.35*
AUS	.86*	.80*	-.09	.15	-.95*	-.64*

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.

8.2 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.[28]

A positive response of private consumption to government consumption can instead occur in neo-keyenesian models where laboir demand shifts out in response to a government consumption shock, either because of counter-cyclical mark-ups, as in Rotemberg and Woodford [1992], Ravn, Schmitt-Grohé and Uríbe [2006], or Linnemann and Schabert [2003]; or because of increasing returns, as in Devereux, Head and Lapham [1996] and Bilbiie, Ghironi and Melitz [2005]. If the outward shift in labor demand is strong enough, the real wage increases; there are then two ways to get a rise in consumption. First, the higher real wage induces individuals to substitute from leisure into consumption, thereby generating an increase in the latter: this is the route taken by Ravn, Schmitt-Grohé and Uríbe [2006] and Devereux, Head and Lapham [1996]. In models with nominal rigidities, in general, the increase in the real wage will not be sufficient, by itself, to generate an increase in consumption. The second route, taken by Galí, Lopez-Salido and Vallés [2006], is then to appeal to credit constraints: a share of the population cannot borrow or lend, and must consume all their labor income in each period. As the real wage increases, their consumption increases too. With enough of these individuals, the model can generate a positive response of total private consumption to a government spending shock.

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.[29] 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,

[28] 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]. Alternatively, if consumption and leisure are non-separable, as in Basu and Kimball (2002) and Linnemann (2005), private consumption also can increase in response to a government consumption shock.

[29] 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.

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 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 7 do indeed constitute a puzzle.

8.3 A digression: national income accounting and the response of private investment

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 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.[30]. The table shows that the progress payment and the *work put in place approximation*[31] are the two most widely used methods, and that the delivery and payment methods seem in practice quite rare. The one partial exception is some components of

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

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

government defense investment in machinery and equipment, mostly battleships, aircraft, and missiles (see BEA-DOC [1988] Table II-8). The sample average of total spending on these three items is 0.44 percent of GDP, 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.

It is clear that the delivery and payment methods generate a mechanical contemporaneous negative correlation between government investment and private inventories; in turn, this could conceivably explain the contemporaneous negative effect of government investment on private investment displayed in Table 7. However, private investment in this table is net of inventories. In fact, when private inventories are added, the response of private invesment (not shown) in general becomes even more negative.

[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. 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 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).

9 Robustness

9.1 Alternative detrending methods

Table 9 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, 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.

Table 9: **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	.78*	1.38*	1.47*	.66*	.69*	-.71*
GBR	.28*	.54*	-.13	-.25	-.41*	-.79*
CAN	.27*	.58*	.41	-1.24*	.14*	-1.82*
AUS	1.22*	1.73*	-.18	.80*	-1.45*	-1.10*
	B Quadratic trend					
USA	.79*	1.41*	1.44*	.65*	.65*	-.76*
GBR	.55*	.75*	-.06	-.13	-.61*	-.88*
CAN	.26*	.62*	.47	-1.37*	.21*	-1.99*
AUS	1.49*	2.33*	-.18	.81*	-1.71*	-1.56*
	D Levels					
USA	.57*	.56*	1.24*	.25	.67*	-.32*
GBR	.24*	.71*	-.29	-1.00*	-.54*	-1.71*
CAN	.16*	-.16*	.37	-1.35*	.21*	-1.19*
AUS	1.38*	2.23*	-.32	.31	-1.69*	-1.91*
	C Differences					
USA	.69*	.61*	1.79*	1.13*	1.11*	.52*
GBR	-.07*	-.17*	-.09	-.43*	-.02*	-.26*
CAN	.27*	.12*	.56	.35	.28*	.23*
AUS	1.05*	1.33*	-.08	.54*	-1.13*	-.78*

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

Relative to the benchmark case of a linear trend, the results are very similar in the specification with a quadratic trend. In the specification in levels, at 1 year there is not much difference with the benchmark specification; predictably, the difference becomes larger at 3 year, but it is still true that the Z-multiplier is still smaller than the G-multiplier in all countries.

The one case where there is some substantial departure from the qualitative results so far is in the specification in first differences. Now the G-multiplier tends to be smaller; as a

consequence, the difference between the Z- and G-multipliers becomes larger algebraically, and becomes positive even at three years in the US and Canada, although the difference is small.

9.2 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 10 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 11 displays the cumulative multipliers from a VAR where government consumption and investment do not include the interpolated items, as described in Table 10 (in the UK, all local government purchases are excluded, because wages are not separately available); panel A displays the benchmark multipliers, from Table 4. All the multipliers

Table 10: **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].

fall when the interpolated items are excluded: but the difference between the G- and Z-multipliers remain virtually unchanged.

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 12, where defense spending is shown to have a lower multiplier than civilian spending.

Table 11: **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	0.78*	1.38*	1.47*	0.66*	-0.70	-0.71*
GBR	0.28*	0.54*	-0.13	-0.25	-0.41*	-0.79*
	B Cumulative multiplier, excluding interpolated items					
USA	0.40*	0.50*	0.66*	–0.33*	0.26*	-0.83*
GBR	-0.15*	-0.47*	-0.45	-1.13*	-0.30*	-0.67*

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.

9.3 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 some of 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.

Table 12 displays GDP multipliers at 12 quarters from a specification with three government spending variables, civilian government investment, civilian government consumption, and defense spending, in this order.[33] The columns labelled $\mathbf{G}_{civ}$ and $\mathbf{Z}_{civ}$ display the GDP multipliers of civilian government consumption and of civilian government investment, respectively; the former is still always larger than the latter, although significantly so only in Australia. The defense spending multplier (column 3) is smaller than (in the US) or equal to the civilian investment multiplier

10 Conclusions

Although a full explanation of the evidence presented here is beyond the scope 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

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

Table 12: **Defense spending**

	GDP multipliers, 3 spending variables					
	G_{civ}	**Z_{civ}**	**DEF**	**Z_{civ}-G_{civ}**	**Z_{civ}-DEF**	**G_{civ}-DEF**
USA	3.75	1.57*	.62*	-2.18	.95*	3.13
CAN	.05	-.40	-.52	-.44	.12	.56
AUS	2.65*	.72*	.77*	-1.93*	-.05	1.89*

The table displays the GDP multipliers, at 12 quarters, of civilian government investment, civilian government consumption, and defense government purchases, and their differences.

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. In fact, there is evidence that the Z-multipliers decline in the second half of the sample, which is 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, 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, public investment can foster downright corruption and rent-seeking activities.

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.

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