Estimating the Impact of Public Investment for the United Kingdom: Has the Golden Rule of Public Finance Made a Difference?

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ESTIMATING THE IMPACT OF PUBLIC INVESTMENT FOR THE UNITED KINGDOM: HAS THE GOLDEN RULE OF PUBLIC FINANCE MADE A DIFFERENCE?

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This paper uses a SVAR methodology to investigate the effects of public investment on growth, and more specifically, the effects of the introduction of a golden rule. We extend the existing literature by estimating a model of the British economy that takes into account long run factors. This seems necessary when dealing with a multi annual variable like public investment, and its long term effects on public finances through debt accumulation. We find that in such a long run framework investment has significant and permanent positive effects on GDP growth; this result runs counter to most recent literature on the topic, that was limited to a short run specification. We further find, by comparing different subsamples, that the introduction of the golden rule in 1997 strengthened this positive effect of public investment.

1. Introduction

This paper develops a comparative method to analyze the regime change experienced in the UK with the introduction of the "golden rule" in 1997. We build on the increasingly popular literature on structural VAR that originally developed in the field of monetary theory, and has been applied to fiscal policy since the seminal paper of Blanchard and Perotti (2002).

The golden rule remains a controversial subject; its adoption in the UK stirred a debate, not settled yet, on whether the fiscal framework for the Euro area should somehow be amended to take into account the particularity of public investment. This debate has proceeded on the double track of whether public investment is beneficial for economic growth, and of whether the golden rule would be able to ensure a sufficient level of public investment without hampering the sustainability of public finances.

On both accounts the theoretical literature is quite inconclusive, as the results depend on the relative weight of contrasting factors as crowding out, externalities, strategic interaction with monetary policy and so on. The empirical literature does not help in disentangling the issue, as its results are mixed.

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Our exercise uses as a benchmark the specification by Blanchard and Perotti (2002), and we use constraints on elasticities in order to endogenize or exogenize public investment (the latter case being the typical setting of the golden rule). Interestingly enough, this benchmark gives no relationship between investment and growth, a result consistent with recent work (e.g. by Perotti, 2004).

Our paper adds to the existing literature in that we extend the model in order to take into account a longer time horizon. This seems a natural and necessary extension when discussing a typically long run phenomenon like investment. In a longer time horizon debt has to be explicitly accounted for when dealing with public finances, so that we find it convenient to borrow the framework we developed for different purposes in Creel, Monperrus-Veroni and Saraceno (2005). The change in the results, with respect to the benchmark, is quite dramatic, with a positive and persistent effect of investment on growth that emerges in new specification. We further find that this effect became more robust since the introduction of the golden rule in 1997, thus giving arguments in favor of a positive role of such a framework.

The paper is structured as follows: Section 2 briefly reviews the debate on the golden rule sketching the arguments in favor and against it; we also give a short summary of the recent literature on the effects of public investment on growth. Then, Section 3 details the SVAR model we build, describing our identification procedure in the benchmark and in the long run models. We also map the different identification procedures to the different institutional settings. Section 4 gives the results of our estimations, showing how the effect of investment emerges when we shift from the benchmark to the long run model. Finally, Section 5 concludes.

2. The "golden rule of public finances"

Since 1997 the United Kingdom has adopted a double budget approach, according to which the budget is split into a balanced current account and a deficit-financed capital account. More explicitly, the golden rule states that, over the cycle, government borrowing should not exceed net government capital formation; hence, current expenditures should be financed by current receipts. Indeed, the UK budget incorporates a medium-run target for the net-of-public investment deficit, where the medium-run corresponds to a cycle. Over this cycle, this deficit should be balanced. The ensuing "golden rule" is associated with a "sustainable investment rule" (HM Treasury, 2002)[1] in order to prevent any overstatement for public investment and to limit net public debt below 40 per cent of GDP.

The distinction between current and capital spending aims at removing the bias against capital spending thus shifting attention from a mere quantitative target (one of the most controversial characteristics of the Stability and Growth Pact) to the quality of public finance (recent contributions include Fitoussi and Creel, 2002; Le Cacheux, 2002; Blanchard and Giavazzi, 2003).

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[1] See also Buiter (2001).

A number of reasons may be given in favor of the golden rule. First, it allows countries to spread the cost of durables over all the financial years in which they will be in use, and the burden of capital formation over the generations of taxpayers benefiting from it.[2] Further reasons derive from the current fiscal setup of the European Union. In fact, as documented in Balassone and Franco (2000),[3] there has been a close relationship between fiscal consolidation and cuts in capital spending in Europe during the eighties and nineties, and the strong constraints on public finances imposed by the Maastricht and Amsterdam Treaties have certainly played a role in this consolidation. The example of Portugal, that reduced investment substantially after breaching the Pact in 2001, shows that the problem is still present Adopting a golden rule would put an end to this negative bias. Moreover the golden rule implies debt-to-GDP convergence to the ratio of public capital to GDP, rather than to the unwarranted level of zero implied by the Stability Pact.

Two additional advantages of a golden rule should be mentioned. First, as European countries aim at "creating the most innovative area in the world" (Lisbon summit recommendation), there should be budgetary scope for improving infrastructures and human capital for which *public* capital (considered quite widely and loosely) may play an important role through two channels: first, public investment provides public goods like transport infrastructures which benefit users and directly or indirectly improve total factor productivity; second, public investment also raises overall welfare when it participates in the protection of environment or enhance the fairness in resource distribution.

On the other hand, many critical arguments against the golden rule are advanced in the literature. The main one is that such a rule would risk to hamper public finance sustainability. As discussed in EC (2003, part III), a golden rule of public finance in the EU would stop the reduction in public debts. Part of the rationale for slowing down public debt to GDP ratios in the euro area has been related to monetary policy. High public debts are seen as a threat to price stability and to the independence of the ECB. Though the latter is prevented by statute to monetize public debts, high debts might increase the risk of default which would require ECB intervention as the lender of last resort, and hence cause inflation. In a previous paper (Creel, Monperrus-Veroni and Saraceno, 2005) we discussed the strategic interaction of monetary and fiscal authorities. This tendency of debt to explode could be easily contrasted though, by adopting a debt ceiling as done by the UK. In fact, it may be proven that this is not even necessary, as two intrinsic features of the golden rule, endogenously limit the debt explosion. The first is that under the golden rule the debt ratio converges to the ratio of public capital to GDP (Blanchard

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[2] Though the welfare benefits of boosting public investment may be unevenly distributed across generations – public investment should increase private capital formation and wages, but the latter rise only gradually whereas the former is in the hands of the "elderly" –, Heijdra and Meijdam (2002) show that financing some part of public investment with public bonds increases equality across generations. A golden rule is thus theoretically welfare-improving.

[3] See also EC (2003) and notably, table III.3 which shows that fiscal consolidation induced by high debt levels and the need to satisfy the Maastricht criteria coincided with relatively larger cuts in public investment.

and Giavazzi, 2003). We already argued that this seems more coherent than a zero debt ratio as implied by the SGP. Second, the rule contains built-in mechanisms that prevent endless growth of investment and deficit. Creel (2003) shows how the interest payment expansion generated by public capital accumulation and debt would impose a constraint to current expenditure growth, and hence at a certain point prevent further capital accumulation. We can conclude from these counter arguments that the fear of debt explosion is overemphasized, and that the "Debt arm" of the UK golden rule may be considered as redundant.

The endogenous limit to public investment incorporated in the golden rule also answers the concerns raised by Buti, Eijffinger and Franco (2003) that "the possibility of borrowing without strict limits in order to finance investments can lower the attention paid when evaluating the costs and benefits of each project". (p. 18). In fact one may argue that as the growth in public investment is limited by the necessity to pay interests on public debt, it is in the interest of government to implement investments whose cost/benefits ratio is the lowest.

Besides public debt's growth or the cost/benefits analysis, other criticisms to the adoption of a "golden rule" in the euro area are worth mentioning. Balassone and Franco (2000) consider that the "golden rule", as it is promoting public investment, will result in a bias in favor of physical assets, at the expense of health and education expenditures. Hence, the definition of "public investment" in national account statistics includes transactions that lead to changes in the stock of physical capital (like the construction of infrastructures or the purchase of computer hardware), but excludes large amounts of expenditures related to the accumulation of human capital, like training or R&D. More in general, the vagueness of the concept of "public investment" may lead to dangerous practices of creative accounting, aimed at covering lack of fiscal discipline. This is a serious argument, and an eventual adoption of the rule should be accompanied by a precise enunciation of what is "public investment" (to account for immaterial spending like human capital formation, and to exclude creative accounting) furthermore, it would be advisable to update these definitions at regular and predictable intervals, in order to prevent opportunistic behavior by governments.

Another criticism of the "golden rule" is that it promotes public capital, though it is overall capital from the public and private sectors that should be incentivated (Balassone and Franco, 2000). Thus, it is argued that as long as public capital crowds out private investment, no positive expect is to be expected. The weakness of this criticism is that empirical evidence in favor of it is scant at best: Estimates of the direct effect of public investment on private investment have been performed by the EC (2003, Table III.2) and are inconclusive, except for Spain and Portugal (for which positive "crowding-in" effects are found) and the UK (for which a negative "crowding out" effect is found).[4] Such a weak evidence is theoretically all

[4] According to the EC, the negative relationship between public and private investment in the UK might result from a coincidence: the privatization process would have decreased public investment while increasing "to a certain extent" investment in the private sector.

but surprising, as traditional crowding out effects may be compensated by complementarities between public and private investment (think of infrastructures for example), and thus improve total factor productivity.[5]

The empirical literature on "public capital productivity" is extremely vast. Table 1 overleaf reports the major contributions on the impact of public investment on economic growth, using different methods. It appears clearly how the evidence is mixed. In particular, the VAR literature seems to find no or little effect of public investment on growth.

3. Specifications and identifications

3.1 Elaborating on Blanchard and Perotti (2002)

The benchmark specification of the model is a variant of that elaborated by Blanchard and Perotti (2002), extended to distinguish between government consumption and government investment (excluding interest payments). Let g_c, g_i, τ and y denote respectively the real values of government consumption (hereafter current outlays), government investment (hereafter public investment), net taxes (tax revenues less transfers to households and businesses), and GDP, all stated in logs.

Let Y_t and U_t denote the vector of endogenous variables and of reduced-form residuals of the VAR, respectively. The reduced form VAR can be written:

$$Y_t = A(L)Y_{t-1} + U_t$$

where $Y_t = [g_{c,t}\ g_{i,t}\ \tau_t\ y_t]'$ and $U_t = [u_{gc,t}\ u_{gi,t}\ u_{\tau t}\ u_{yt}]'$. A(L) is the L-quarter lag operator.

The identification methodology consists in isolating structural shocks by a three-step procedure, like in Blanchard and Perotti (2002). The residuals of the canonical VAR are uninformative on the response of endogenous variables to shocks; to obtain response functions meaningful for the analysis of economic policy we need to isolate structural shocks. Thus, while the canonical residual of, say, the tax rate collects information on all the unexpected movements of the variable, the corresponding structural residual is obtained by eliminating all feedback mechanism (automatic or discretionary) triggered by changes in the other variables. Thus, the structural residual will be interpreted as an autonomous, discretionary shock, whose effects on the other variables can be examined by means of the impulse response functions (IRF).

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[5] Aschauer (1989b) shows that the productivity slowdown in the US private sector during the Seventies and Eighties was the consequence of a shortage of investment in public infrastructure.

Table 1a

A Parsimonious Survey on the Contribution of Public Capital to Economic Growth

Methodology	**Contribution of public capital to economic growth**
Production-function approach	**Elasticity**
Ratner (1983)	= 0.056 (US data)
Aschauer (1989a)	= [0.29, 0.56] depending on assumptions regarding productivity (US data)
Ram and Ramsey (1989)	= 0.24 (US data)
Garcia-Mila and McGuire (1992)	= 0.05 (48 US states)
Eisner (1994)	= 0.27 (US data)
Sturm and De Haan (1995)	= 0.41 (US data)
Vijverberg *et al.* (1997)	= 0.48 (US data)
Evans and Karras (1994)	estimates are fragile and generally not significant (7 OECD countries)
Dessus and Herrera (1996)	= 0.26 (panel, 28 countries)
Merriman (1990)	= 0.58 (9 Japanese regions)
Berndt and Hansson (1991)	= 0.68 (Swedish data)
Bajo-Rubio *et al.* (1993)	= 0.19 (Spanish data)
Otto and Voss (1994)	= 0.38 (Australian data)
Wylie (1996)	= 0.51 (Canadian data)
Gong *et al.* (2004)	= 0.50 (US data) = 0.29 (German data)
Estimations including the budget composition	
Kneller, Bleaney and Gemmel (1999) Bleaney, Gemmel and Kneller (2001)	a 1-point increase in productive public expenditures increases per capita growth by 0.29 points; and a 1-point increase in distortionary taxation decreases per capita growth by 0.45 points

Table 1b

VAR Studies

Study	Data	Variables	Conclusions
Clarida (1993)	USA, France, Germany, United Kingdom: 1964-89	Multifactor productivity, public capital stock	MFP and public capital are cointegrated but direction of causality is unclear
McMillin and Smyth (1994)	USA: 1952-90	Hours of work per unit of capital; relative price of energy; ratio public capital to private capital; inflation	No significant effect of public capital
Otto and Voss (1996)	Australia: 1959-82	Private sector GDP; private capital stock; public capital stock; number of working hours	No significant relation between public capital and output
Sturm, Jacobs and Groote (1999)	Netherlands: 1863-1913	Private sector GDP; private capital stock; public capital stock; private labor	Public infrastructure Granger-causes output
Ligthart (2000)	Portugal : 1965-95	GDP; private capital stock; public capital stock; private labor	Public capital Granger-causes output
Otto and Voss (2002)	USA: 1951-97 Canada:1951-96	GDP, relative price of public and private investment goods, real interest rate and shares of private and public investment in output	Public investment crowds out private investment in both countries

The reduced form residuals of the three policy variables are linear combination of these three components (structural, automatic and discretionary) and can be written:

$$\begin{aligned} u_{gc,t} &= \alpha_{gc,y} u_{y,t} + \beta_{gc,gi} e_{gi,t} + \beta_{gc,\tau} e_{\tau,t} + e_{gc,t} \\ u_{gi,t} &= \alpha_{gi,y} u_{y,t} + \beta_{gi,gc} e_{gc,t} + \beta_{gi,\tau} e_{\tau,t} + e_{gi,t} \\ u_{\tau,t} &= \alpha_{\tau,y} u_{y,t} + \beta_{\tau,gi} e_{gi,t} + \beta_{\tau,gc} e_{gc,t} + e_{\tau,t} \end{aligned} \quad (1)$$

where $e_{gc,t}$, $e_{gi,t}$ and $e_{\tau,t}$ are the structural shocks to the three policy variables. The first term on the RHS of each equation in block (1) captures the automatic response of fiscal policy to a change in GDP. The second and third terms capture the discretionary responses to a structural shock on another policy variable, whereas the last term captures the structural policy shock.

The identification, following Blanchard and Perotti (2002), is based on restrictions in the contemporaneous correlation matrix. In particular, Blanchard and Perotti use the institutional features of the American tax system to impose constraints to the matrix. After including a relationship between the canonical residual on *y* and the structural shock on *y* in the system (1), and if we write the relationship between canonical (u_t) and structural (e_t) residuals as $M_1 u_t = M_2 e_t$, the identification procedure consists in imposing constraints on the elements of the two matrices that allow writing $e_t = M_2^{-1} M_1 u_t$.

The constraints are of three economic kinds. First, we rely on institutional information about tax, transfer and spending programs to construct the parameters $\alpha_{i,y}, \forall i = gc, gi, \tau$. For instance, regarding taxes, some do depend on immediate GDP (VAT is an example) whereas some others do not as their base is time-delayed (the UK corporation tax return needs to be paid with the Inland Revenue, now HM Revenue and Customs, 12 months after the end of the period of account in which the accounting period falls). Taking this into account, one can compute immediate elasticities for those policy variables that may change with quarterly GDP.

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

$$\begin{aligned} u^{CA}_{gc,t} &\equiv u_{gc,t} - \alpha_{gc,y} u_{y,t} = \beta_{gc,gi} e_{gi,t} + \beta_{gc,\tau} e_{\tau,t} + e_{gc,t} \\ u^{CA}_{gi,t} &\equiv u_{gi,t} - \alpha_{gi,y} u_{y,t} = \beta_{gi,gc} e_{gc,t} + \beta_{gi,\tau} e_{\tau,t} + e_{gi,t} \\ u^{CA}_{\tau,t} &\equiv u_{\tau,t} - \alpha_{\tau,y} u_{y,t} = \beta_{\tau,gi} e_{gi,t} + \beta_{\tau,gc} e_{gc,t} + e_{\tau,t} \end{aligned} \quad (2)$$

The second type of constraint is related to the ordering of the different policy variables in the VAR model. There is no *a priori* reason to favor one ordering over the others. However, one can rely on economic theories and empirical findings to gauge the relationships between the three policy variables under study. As for the causality between taxes and spending at large, two theories compete: on the one hand, spending may cause taxation; on the other hand, taxation may cause spending.

These two are respectively named the "spend & tax" (*argument 1*) and "tax & spend" *(argument 2*) public finance frameworks (see Musgrave, 1966). In the first case, public expenditures appear first and second in the VAR model, taxes, third; in the second case, taxes appear first, expenditures, second and third.

Yet, the ordering of the two different kinds of public expenditures has not been cleared. Among the two of them, which one is the most likely to "constrain" the other? Here again, two possible cases arise. First, government consumption may come first, government investment second (*argument 3*). This context describes a situation Balassone and Franco (2000) disclosed during the European transition process towards the euro: compliance with the Maastricht deficit limit was shown to have provoked a sharp reduction in public investment *vis-à-vis* public consumption. Second, government investment may come first, government consumption second (*argument 4*). This situation would resemble that of the Golden Rule of Public Finance: the constraint on public expenditure would hinge on government consumption, hence leaving some margins for manoeuver for public investment.

This leaves us with 4 possible orderings. Because we are mostly interested in the responses of public spending shocks on the economy, we will favor argument 1 and test it with either argument 3 or argument 4. Argument 2 may illustrate the possible robustness of our former results and will be left to further research.

Our first case study (mixing arguments 1 and 3, call it *case A*) will be written:

$$\begin{aligned} u_{gc,t}^{CA} &\equiv u_{gc,t} - \alpha_{gc,y} u_{y,t} = e_{gc,t} \\ u_{gi,t}^{CA} &\equiv u_{gi,t} - \alpha_{gi,y} u_{y,t} = \beta_{gi,gc} e_{gc,t} + e_{gi,t} \\ u_{\tau,t}^{CA} &\equiv u_{\tau,t} - \alpha_{\tau,y} u_{y,t} = \beta_{\tau,gi} e_{gi,t} + \beta_{\tau,gc} e_{gc,t} + e_{\tau,t} \end{aligned} \tag{3}$$

whereas *case B* (mixing arguments 1 and 4) is written:

$$\begin{aligned} u_{gi,t}^{CA} &\equiv u_{gi,t} - \alpha_{gi,y} u_{y,t} = e_{gi,t} \\ u_{gc,t}^{CA} &\equiv u_{gc,t} - \alpha_{gc,y} u_{y,t} = \beta_{gc,gi} e_{gc,t} + e_{gc,t} \\ u_{\tau,t}^{CA} &\equiv u_{\tau,t} - \alpha_{\tau,y} u_{y,t} = \beta_{\tau,gi} e_{gi,t} + \beta_{\tau,gc} e_{gc,t} + e_{\tau,t} \end{aligned} \tag{4}$$

In both cases, the first structural shock is identified with the related cyclically-adjusted canonical shock. Of course, in so far as public investments are considered, it is not legitimate to assume an instantaneous impact of GDP: $\alpha_{gi,y} = 0$. The second structural shock is identified with the residual of the regression of the related cyclically-adjusted canonical shock on the structural shock of the previously ordered policy variable using ordinary-least squares. The third structural shock is obtained in the same way, except that the two first structural shocks are now used in the OLS regression.

The third constraint is related to the estimation of the GDP variable in the VAR model. Estimating the structural shock on GDP is not the heart of our present analysis and we will leave GDP in fourth position of cases A and B:

$$u_{y,t} = \gamma_{y,gc} u_{gc,t} + \gamma_{y,gi} u_{gi,t} + \gamma_{y,\tau} u_{\tau,t} + e_{y,t} \quad (5)$$

By construction, the structural shocks on the three policy variables are respectively orthogonal to all other structural shocks and they can be used as instruments for the canonical residuals in estimating (5).

Above all, cases A and B will be used to perform estimations of GDP responses to a structural shock on public investment. As such, they will not tell much about the incidence of adopting a Golden Rule of Public Finance in the UK since 1998. For data since then are too scarce, we cannot estimate impulse response functions before and after 1998. We will therefore give a first but imperfect assessment of the incidence of this Rule following a three-step procedure. First, we will perform the VAR over the entire dataset[6] and with variables transformed into a *I*(0) process.[7] Second, we will perform the same VAR on a sub-sample excluding the years from 1998 onwards. We will then gauge the difference between the coefficients on public investment in the GDP equation of the VARs. A statistically significant difference will be attributed to a change in the set of fiscal rules, while the direction of the (possible) change will give some information on the (possible) effects of adopting a Golden Rule.

3.2 Elaborating on Creel, Monperrus-Veroni, Saraceno (2005)

One drawback with Blanchard and Perotti's identification is its reliance on short-run dynamics. To cope with the long-run properties of fiscal policies, Creel *et al.* (2005) have extended the specification to include public debt dynamics and they have assumed that some restrictions could be linked to the Fiscal theory of the price level (FTPL).

A macroeconomic version of the underlying model in a closed economy is presented below. The stability conditions are also given. The model hinges on Leith and Wren-Lewis (2000) and Creel and Sterdyniak (2002)'s extensions to a FTPL's framework of the Blanchard (1985)'s perpetual youth model.

The first equation is an aggregate demand relationship (all variables are real; fiscal variables are expressed in percent of GDP):

$$y_t = cy_{t-1} + (1-c)[-\tau_t - \delta r_t + \varphi b_t + g_{c,t} + g_{i,t}] \quad (6)$$

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[6] Until then, we have abstracted from the inclusion of quarterly dummies, constant and a possible time-trend.

[7] With *I*(0) variables, VAR coefficients are statistically consistent.

where y is output, τ tax revenues, r the interest rate, b public debt; real public debt affects demand positively (due to a wealth effect), the real interest rate has a negative influence on demand, and public expenditure is the sum of public investment and current outlays $g_i + g_c$.

Aggregate supply is a standard Lucas-supply curve relating inflation to the level of output:

$$\pi_t = E_{t+1}\pi_t + \nu(y_t - y^*) \tag{7}$$

where E is the expectation operator and starred-variables are steady-state variables.

Real debt cumulates according to the law of motion:

$$b_t = b_{t-1}(1+r_t) - \tau_t + g_{i,t} + g_{c,t} \tag{8}$$

Finally, two last equations define the reaction functions of fiscal and monetary authorities:

$$\tau_t = \tau^* + h(b_t - b^*) \tag{9}$$

and:

$$r_t = r^* + \alpha(\pi_t - \pi^*) \tag{10}$$

Equation (9) states that the fiscal authority reacts to deviations of debt from its steady state value, while equation (10) is a standard Taylor rule relation if α is positive (hence an inflationary shock would provoke a rise in the *real* interest rate).

Transforming the above-mentioned model with the methodology first elaborated by Blanchard and Perotti (2002) gives the cyclically-adjusted components of the primary deficit: public investment, current outlays and tax revenues:

$$\begin{aligned} u^{CA}_{gi,t} &\equiv u_{gi,t} - \alpha_{gi,y}u_{y,t} - \alpha_{gi,\pi}u_{\pi,t} = e_{gi,t}; \\ u^{CA}_{gc,t} &\equiv u_{gc,t} - \alpha_{gc,y}u_{y,t} - \alpha_{gc,\pi}u_{\pi,t} = \beta_{gc,gi}e_{gc,t} + e_{gc,t}; \\ u^{CA}_{\tau,t} &\equiv u_{\tau,t} - \alpha_{\tau,y}u_{y,t} - \alpha_{\tau,\pi}u_{\pi,t} = \beta_{\tau,gi}e_{gi,t} + \beta_{\tau,gc}e_{gc,t} + e_{\tau,t}. \end{aligned} \tag{12}$$

Canonical residuals are corrected for economic growth and inflation variations, in order to extract the respective discretionary parts of fiscal and tax variables. All fiscal and tax variables are net of interest payments and receipts; hence they are independent contemporaneously of the interest rate. In a variant to equation (9), tax revenues are here supposed to react to public expenditures variations rather than to debt variations. This assumption keeps the original structure of fiscal and tax variables that Blanchard and Perotti modeled. The β terms are estimated like in Blanchard and Perotti.

Box 1
Stability conditions

If dx is the time derivative for variable x, *i.e.* $dx(t)/dt$, the full model can be rewritten under matrix algebra form,

$$\begin{bmatrix} db'(t) \\ d\pi'(t) \end{bmatrix} = A \begin{bmatrix} b'(t) \\ \pi'(t) \end{bmatrix} \quad (11)$$

where $A = \begin{bmatrix} \bar{r} - h & \alpha \bar{b} \\ \nu(\varphi - h) & -\alpha\nu\delta \end{bmatrix}$; a primed variable denotes deviations from the steady state and a variable with an upper bar denotes steady state value.

Under rational expectations, the forward-looking Phillips curve requires that $\nu < 0$. A sufficient stability condition of the model is that $\det A < 0$. This is possible under the usual Leeper (1991)'s conditions. The model is locally-stable under two different features of monetary and fiscal policies: either both policies react toughly to respective deviations from their objectives ($h > \frac{\delta\bar{r} + \varphi\bar{b}}{\delta + \bar{b}}$ *and* $\alpha > 0$); or both policies react mildly ($h < \frac{\delta\bar{r} + \varphi\bar{b}}{\delta + \bar{b}}$ *and* $\alpha < 0$), with the real interest rate decreasing after an inflationary shock.

Under adaptive expectations, the backward-looking Phillips curve requires that $\nu > 0$. With two pre-determined variables, stability conditions require that $\det A > 0$ *and* $tr\ A < 0$. If $\alpha > 0$, the condition on the reaction of fiscal policy towards deviations of public debt is: $h > \frac{\delta\bar{r} + \varphi\bar{b}}{\delta + \bar{b}}$ *and* $h > \bar{r} - \alpha\nu\delta$. If $\alpha < 0$, stability requires that the government does not react too much but also not too few to public debt deviations, $h < \frac{\delta\bar{r} + \varphi\bar{b}}{\delta + \bar{b}}$ *and* $h > \bar{r} - \alpha\nu\delta$.

The adjusted component of public debt gives:

$$u_{b,t}^{CA} \equiv u_{b,t} - \alpha_{b,\pi} u_{\pi,t} - \alpha_{b,r} u_{r,t} = \beta_{b,gi} e_{gi,t} + \beta_{b,gc} e_{gc,t} + \beta_{b,\tau} e_{\tau,t} + e_{b,t}. \quad (13)$$

Public debt is corrected for the presence of indexed bonds and for the part of debt with flexible rates. This debt component is then supposed to react to unexpected shocks on tax revenues and expenditures.

The system of canonical residuals for output, inflation and interest rates follows:

$$\begin{aligned} u_{y,t} &= \gamma_{y,gi} u_{gi,t} + \gamma_{y,gc} u_{gc,t} + \gamma_{y,\tau} u_{\tau,t} + \gamma_{y,b} u_{b,t} + \gamma_{y,\pi} u_{\pi,t} + \gamma_{y,r} u_{r,t} + e_{y,t} \\ u_{\pi,t} &= \gamma_{\pi,y} u_{y,t} + e_{\pi,t} \\ u_{r,t} &= \gamma_{r,y} u_{y,t} + \gamma_{r,\pi} u_{\pi,t} + e_{r,t} \end{aligned} \quad (14)$$

The first equation in system (14) is estimated in a two-step procedure. By construction, $e_{gi,t}$, $e_{gc,t}$, $e_{\tau,t}$ and $e_{b,t}$ are orthogonal to all other structural shocks; they can thus be used as instruments for $u_{gi,t}$, $u_{gc,t}$, $u_{\tau,t}$ and $u_{b,t}$ to estimate the first four parameters of this equation where the terms in inflation and interest rate are not taken into account; then, $\gamma_{y\pi}$ *and* γ_{yr} are estimated by OLS in the following equation:

$$u_{y,t}^{CA} \equiv u_{y,t} - (\gamma_{y,gi} u_{gi,t} + \gamma_{y,gc} u_{gc,t} + \gamma_{y,\tau} u_{\tau,t} + \gamma_{y,b} u_{b,t}) = \gamma_{y,\pi} u_{\pi,t} + \gamma_{y,r} u_{r,t} + e_{y,t}$$

As already mentioned, the correction of public investment for economic growth is irrelevant contemporaneously; hence, the discretionary part of public investment – the structural shock on public investment – is the canonical residual of public investment corrected for shocks on inflation: the real value of public investment is supposed to be reduced by shocks on inflation.

3.3 Data and elasticities

The source of UK data has been the OECD. Series are seasonally adjusted, a feature absent from the data available at the UK Central Statistical Office. Real series (GDP, tax revenues, current outlays, public investment, public debt) have been deflated by the GDP deflator. Inflation is based on the consumer price index. Public debt is end-of-year net financial government liabilities.

The variable "tax revenues" is the difference between government's total receipts and transfers. Transfers are defined as the sum of social benefits other than in kind, interest payments, property income paid by government and other current and capital transfers paid including acquisitions less disposals of non-produced non-financial assets which are excluded from investment.

The variable "public investment" is government gross fixed capital formation.

The variable "current outlays" corresponds to total public expenditures in goods and services, excluding GFCF; it thus corresponds to total government final

consumption, *i.e.* the sum of wage consumption expenditure, social transfers in kind and subsidies.

The values of elasticities are:

- $\alpha_{gc,y}$ = –0.73411; $\alpha_{\tau,y}$ = –0.30100: these two elasticities state that current outlays and tax revenues increase at a slower pace than GDP's (recall that "g_c" and "τ " are expressed in percent of GDP);
- $\alpha_{gi,\pi}$ = 0.00134; $\alpha_{gc,\pi}$ = –5.71959e–05; $\alpha_{\tau,\pi}$ = 3.48482e–04: inflation contemporaneously increases the public investment to GDP ratio, meaning that GDP's reaction to inflation is higher in absolute value than public investment's; current outlays and tax revenues are contemporaneously as reactive to inflation as GDP, so that their respective ratios to GDP remain constant;
- $\alpha_{b,\pi}$ = –0.26987; $\alpha_{b,r}$ = 0.07101: these two elasticities are fully consistent respectively with the share of indexed public sector debt (it was equal to 23.3 per cent of total public sector debt at the end of 2004) and with the share of public sector debt issued at a variable interest rate (HM Treasury bills represented 6.8 per cent of total public sector debt at the end of 2004).

4. Results

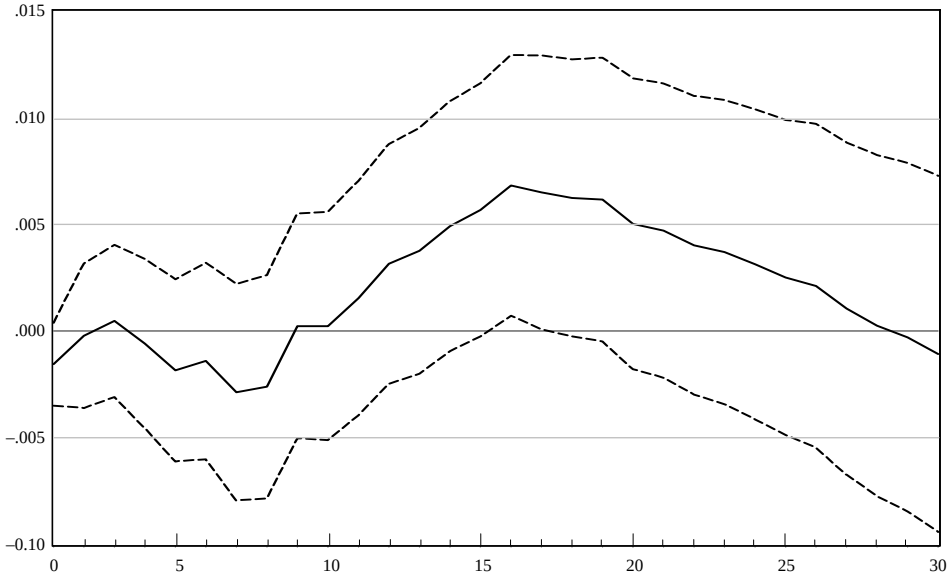
4.1 A canonical VAR

As reported in the first part of the paper, empirical VAR results on the impact of public investment on GDP are generally inconclusive. Before turning to SVAR, we have computed the responses of GDP (in log) to shocks respectively on public investment and current outlays. Responses are shown in Figure 1. With a canonical VAR, over what we will call "full sample" (1972:1-2004:4), the response of GDP to public investment would be statistically significant only 4 years after the shock, and significance would vanish afterwards. The response of GDP to current outlays is never significant.

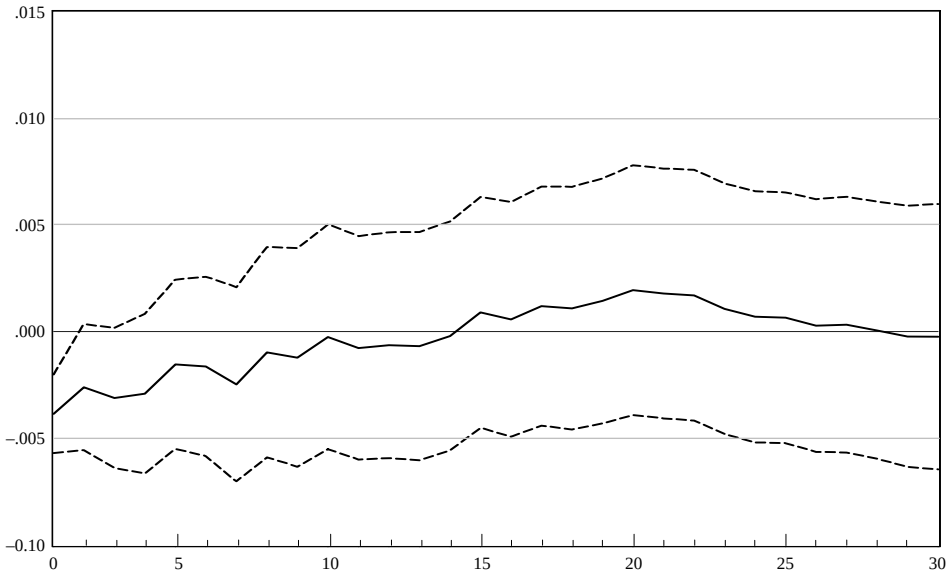
This result could mark the end of our investigation, eliminating public investment from the variables capable of enhancing growth; nevertheless, such a result shows a puzzling inconsistency with both theoretical and empirical results. Theoretically, standard textbook analysis emphasizes the positive role of public spending on economic growth, at least in the short run. The development of endogenous growth theory has also given considerable importance to public aid and productive government services in fostering innovation, the production of human capital and economic growth (Barro and Sala-i-Martín, 1995; Aghion and Howitt, 1998). Empirically, we saw above that various studies have pointed to the positive incidence of public investment on economic growth, although generally not with a VAR methodology.

Figure 1

Canonical VAR of the Full Model, First Ordering, Full Sample, UK
Response of LPIB to GIPIB



Response of LPIB to GCPIB



Reconciling this body of evidence with VAR analysis clearly requires that the variables at stake – public investment, current outlays and tax revenues – are corrected for their feedback effects: as was recalled earlier, current outlays may be crowding out public investment when the public deficit is considered to be too high by political authorities. Thus, reliance on Blanchard and Perotti's methodology can be justified on the ground that it helps to distinguish between automatic stabilizers, feedback reactions to other fiscal or tax variables, and discretionary actions.

4.2 SVAR with Blanchard and Perotti's identification

Figure 2 reports the dynamic responses of public investment, current outlays, tax receipts and GDP to structural shocks on respectively public investment and current outlays (*case B*, as a benchmark). Estimations were based on Blanchard and Perotti's methodology extended to a decomposition of public expenditures, following the steps described in the section above. Estimations were implemented with variables expressed in first difference, hence stationary variables. Unit root tests were performed using the Augmented Dickey-Fuller test. Results are reported in Table 2.

Table 2

Unit Root Tests[1]

	Δ**GDP**	Δg_c	Δg_i	$\Delta\tau$
ADF test stat.[2]	–7.11	–12.73	–12.62	–13.50

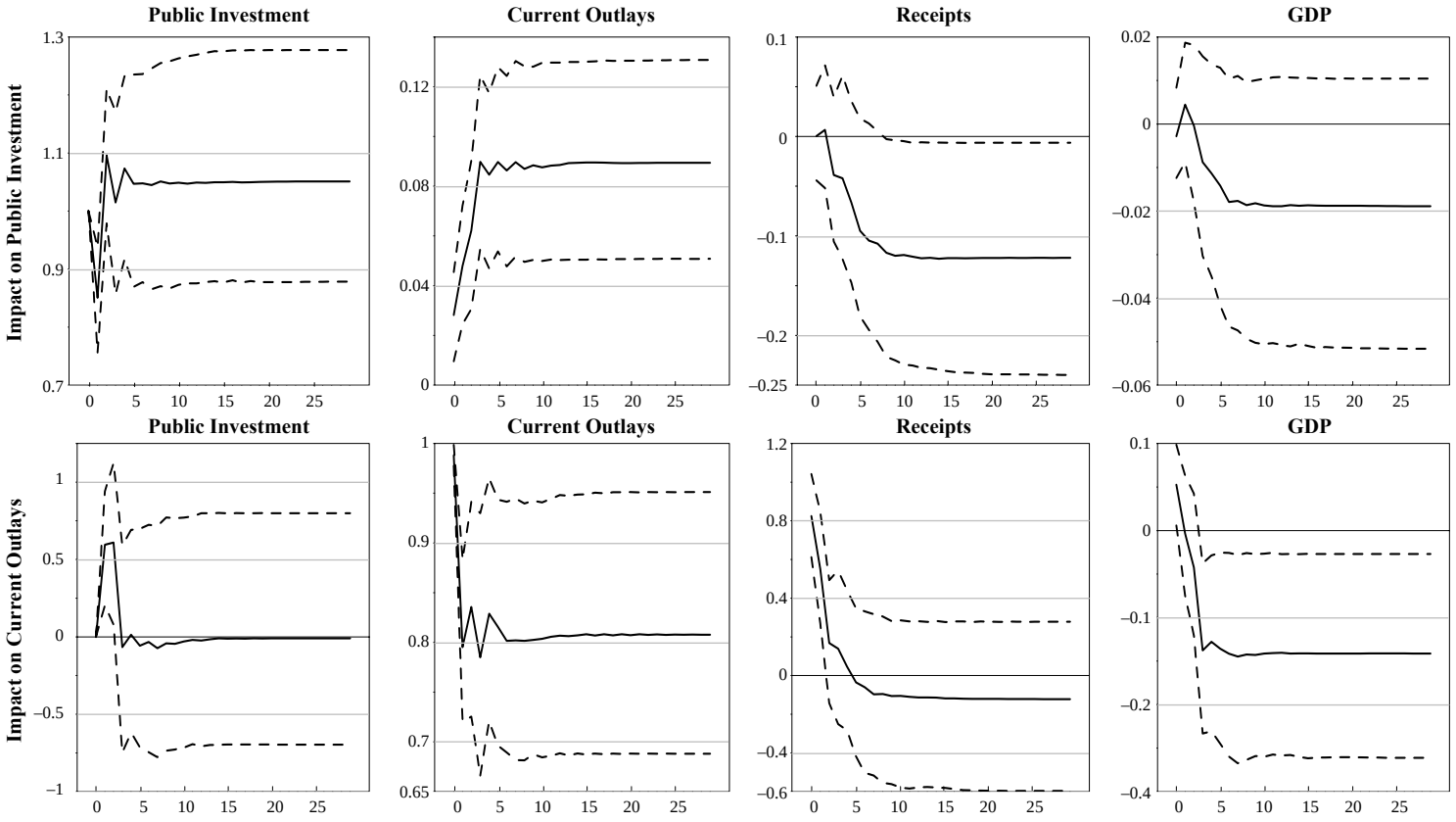
[1] Test critical value at 1 per cent: –4.02.
[2] ADF test with a constant and a linear trend.

Impulse response functions reported on Figure 2 are cumulated impulse responses and are therefore expressed in percentage points or percentage variations of, on the one hand, fiscal and tax variables, and, on the other hand, GDP.

The results are consistent with the canonical VAR, and even more counterintuitive. They substantially replicate Perotti's (2004) estimations for the UK, although he also introduced inflation and interest rates in his model. First, public investment would have no discretionary impact on GDP: responses are not statistically significant. Since public investment is fully discretionary by definition when it is ordered first, expect the possible impact of inflation on it, this means that public investment has no impact at all on UK GDP. Public investment would only impinge on other fiscal and tax variables: with growing public investment, civil servants would negotiate higher wages and/or higher public employment whereas

Figure 2

Blanchard and Perotti's Framework with a Decomposition of Government Outlays, UK
Impulse Response Functions



public enterprises would ask for higher subsidies;[8] meanwhile, tax receipts would be decreasing.

The sharp increase in primary deficit that emerges from our estimation can be compared with the actual figures for the UK (see Figure 3). The UK has only undergone two episodes of sharp increase in their primary deficit since 1972: between 1989 and 1993, and between 2000 and 2003. Do these periods fit the empirical outcomes? Two opposite answers can be suggested: On the one hand, 9 years out of 33 for the full sample and their alleged incidence on empirical results should not be overstated; because there is no clear evidence of a long lasting decline in government primary deficit, empirical results should be taken with caution. On the other hand, the second period almost exactly corresponds to the years over which the Code for Fiscal Stability has been implemented, so that the results reported in Figure 2 testify for the suboptimality and unsustainability of the Golden Rule of Public Finance in the UK. Fortunately, the unsustainability of UK public finances can be ruled out thanks to the "sustainable investment rule" over the economic cycle that limits the ratio of net public sector debt to GDP to a "stable and prudent level" of no more than 40 per cent of GDP. As for suboptimality, Figure 3 clearly shows that both episodes of steep increase in UK primary deficit have been concomitant with an increase in government gross capital formation and the efficiency of this fiscal variable therefore seems at stake. It is worth noticing however that the respective increases in UK public investment between 1988 and 1994 and between 1996 and 2004 have never exceeded 1 percentage point; basing upon the responses reported in Figure 2, a shock of this level for public investment would increase the primary deficit by 1.4 percentage point in the long run, quite at odds with the 10 percentage points increase in the primary deficits between 1989 and 1993, and between 2000 and 2003.

We thus argue that relying on these responses and on an apparent correlation between GFCF and the primary deficit to minimize the impact of public investment on economic growth in the UK would not be prudent. A quotation of an IFS Briefing Note (Emmerson, Frayne and Love, 2004) can be interestingly put forward: "During the economic cycle running from 1986-87 to 1996-97, the golden rule was far from met, with the deficit on current budget averaging over 4 per cent of GDP between 1991-92 and 1996-97. This was due to high levels of public borrowing combined with low levels of public investment" (p. 3). At the beginning of this period, the GFCF was close to 2 per cent of GDP; in the fourth quarter of 1996, it had plunged to 0.75 per cent of GDP. After the implementation of the Code for Fiscal Stability, public investment has finally been retrieved but it is still below the level it had reached at the beginning of the Nineties. Compared with current outlays, it is still negligible and cannot be seriously considered responsible for the long lasting increase in current outlays, as Figure 2 would show.

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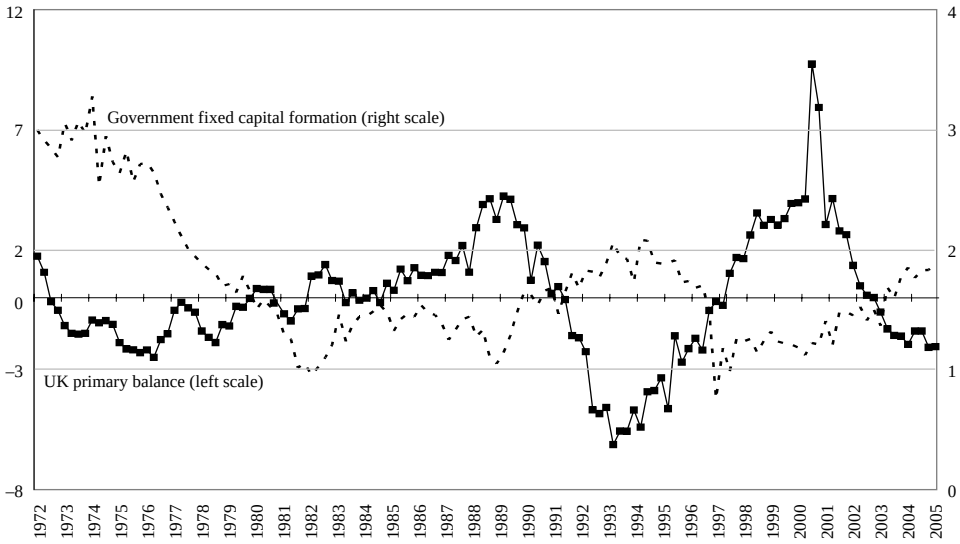
[8] This is generally called "hijacking of expenditure for the specific benefit of special pressure groups" (see Afonso, Schuknecht and Tanzi, 2006, for a survey on conceptual issues related to the efficiency of public expenditures).

Figure 3

UK Government Primary Balance and Government Gross Capital forMation
(percent of GDP)



Source: OECD.

Another result stemming from the dynamic responses reported on Figure 2 is the negative impact of current outlays on GDP, except in the very short run. The negative impact comes so early as to contradict textbook analyses.

Both results – total ineffectiveness of public investment and negative effects of current outlays – are counterintuitive so that they ask, to say the least, for robustness tests.

Two direct tests for robustness checks were performed with Blanchard and Perotti's methodology: First, a change in the ordering; second, a change in the sample. Changing the ordering – with current outlays coming first and public investment second, *case A* – or removing the "Golden Rule years" (1998 onwards) from the sample would not change the impulse response functions.[9] Thus our results appear to be robust and consistent with the existing literature following similar approaches. We need then to look in a different direction to explain this puzzling set of results. Recognizing the inherent long term characteristics of investment behavior we extend the model to take into account long run factors. This requires the explicit consideration of debt among the variables to track, in the line of Creel, Monperrus-Veroni and Saraceno (2005).

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[9] The corresponding figures are available from the authors upon request.

4.3 A long term SVAR: Introducing debt

In the remainder, the model made of the systems of equations (12) and (14) and equation (13) is tested and discussed. Variables are no longer in first difference. We follow Sims' (1980) recommendation against differencing even if the variables contain unit roots because the goal of a VAR analysis is to determine the inter-relationships among the variables, not to determine estimates. As reported in Sims, Stock and Watson (1990), VARs with non stationary variables incur some loss in estimators' efficiency without any costs in terms of estimators' consistency.

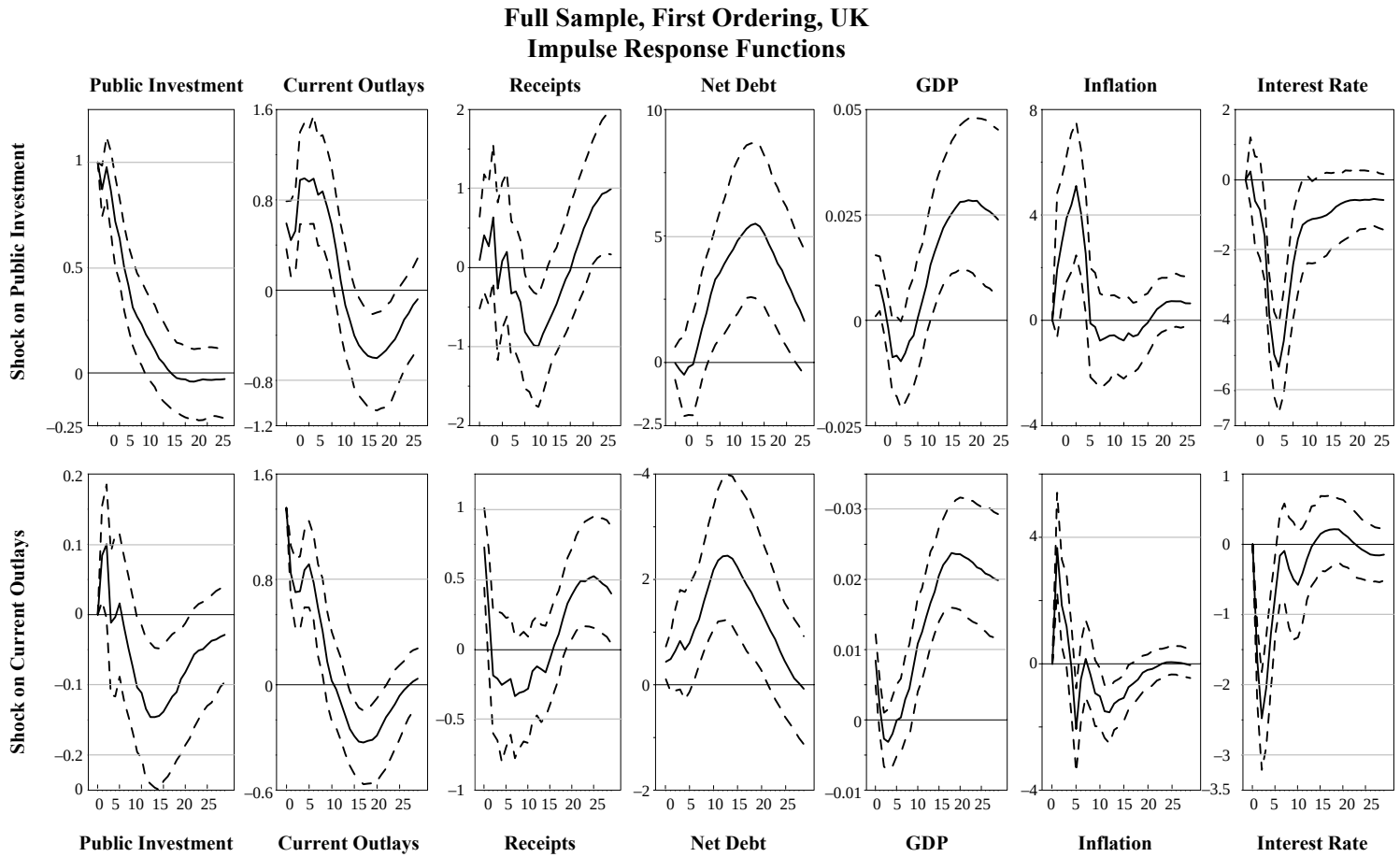
After performing a VAR lag exclusion Wald test, 5 lags were chosen. Figures 4 to 7 display the responses of the 7 endogenous variables to two different shocks on two different samples: first a shock to public investment; second a shock to current outlays, each equal to 1 percent of GDP. The figures also display the two symmetric one-standard error bands computed by bootstrapping, as in Stock and Watson (2001). The two samples are 1972:1-2004:4 and 1972:1-1997:4, the latter excluding the years over which the Code for Fiscal Stability has been implemented

Results displayed on Figure 4 are at odds with previous ones as regards the impact of public investment on GDP. The shock immediately produces an increase in GDP that may be related to growth accounting. After one year, GDP is decreasing and then, after one more year, GDP increases again, persistently this time. Although the decrease in GDP may be attributed to organization delays, it may also be due to higher inflation, through disturbances to households and firms' behaviors. Nevertheless, one important thing here is definitely the positive impact of public investment on GDP in the long run. Recall that this positive effect was also obtained temporarily with a simple VAR; in this new setting, however, the whole evolution of GDP after the shock is statistically significant and the positive impact is long-lasting.

Outcomes of the shock on public investment do produce the same response function for current outlays as with Blanchard and Perotti's identification until the mid-run. In this new setting, however, the response of current outlays finally returns towards the initial steady state in the long run. With the progressive decrease in public investment (the shock is temporary), public debt stops increasing 4 years after the shock. It then returns towards its initial steady state ratio on GDP. Inflation and interest rates are also back to their respective steady states. The shock on public investment does not produce imbalances but only higher economic growth.

In contrast with the results obtained so far, the shock on current outlays is not shown to be detrimental to economic growth. The main difference with the previous shock is that the fiscal variable which is not hit by the shock (public investment, here) is rapidly reduced; hence, public debt does not increase by as much as after the shock on public investment. The relationship between public investment and current outlays gives credit to the following analysis that many economists, mostly political economists, have endorsed: it is easier to reduce investment than current outlays and, in case where investment increases, policymakers are eager to open the Pandora

Figure 4


Full Sample, First Ordering, UK
Impulse Response Functions
Public Investment
Current Outlays
Receipts
Net Debt
GDP
Inflation
Interest Rate
Shock on Public Investment
Shock on Current Outlays

box, satisfying the claims for higher current expenditures. Anyway, the resulting increase in the public debt to GDP ratio is only temporary.

In the following, we assess the robustness of our results: public investment efficiency; to a lesser extent, current outlays efficiency; and the asymmetry in the interactions between fiscal variables depending on which one underwent a positive shock.

First, the ordering of fiscal variables has been changed: it has now been assumed that current outlays do not respond immediately to the structural shock on public investment, whereas the reverse is now true for public investment. Results are reported in Figure 5. In this setting, public investment is less efficient (as far as real GDP is concerned) than in the previous ordering: the immediate rise in output is no longer significant (which is not completely unlikely) and its long-run rise is no longer statistically significant over the entire time span. The short run response of GDP may have been influenced by the reaction of the interest rate: it is now increasing in the short run, and significantly so. Note nevertheless that public investment has still a positive impact on real GDP around 5 years after the shock occurred. All in all, the significant positive impacts of public investment on economic growth on the entire time span are higher than their significant negative impacts (they are scarce).

As for the relative efficiency of current outlays in boosting economic growth, on the one hand, and the asymmetry between both fiscal variables on the other hand, they seem to be robust to the change in the ordering.

Second, excluding the years over which the Code for Fiscal Stability has been implemented shows very interesting results, reported in Figure 6 and Figure 7 depending on the ordering. Focusing on a shock on public investment, it is shown that within the most favorable ordering (public investment, first), public investment has a significant impact on real GDP on very short periods: over two quarters in the short run and 2 to 3 years after the shock occurred. Significant responses of real GDP when the ordering is changed are even scarcer.

We interpret this result – the lower efficiency of public investment on output when the Code for Fiscal Stability is removed from the sample – as a first – though rough – evidence of the positive impact on the UK economy of the application of the Golden Rule of Public Finance at the national level.

Now focusing on the shock on current outlays, it is shown that they have lost their positive and significant impact on real GDP in the short run, in comparison with the IRFs obtained on the full sample. In the mid- and long run however, current outlays still positively impinge on economic growth; responses are significant.

Finally, the asymmetry between fiscal variables seems fairly robust to the sample and ordering changes, although to a lesser extent with the second ordering on the subsample excluding the Code for Fiscal Stability. In this situation, the immediate and short-run increases in current outlays following a structural shock on public investment are no longer significant.

Figure 5

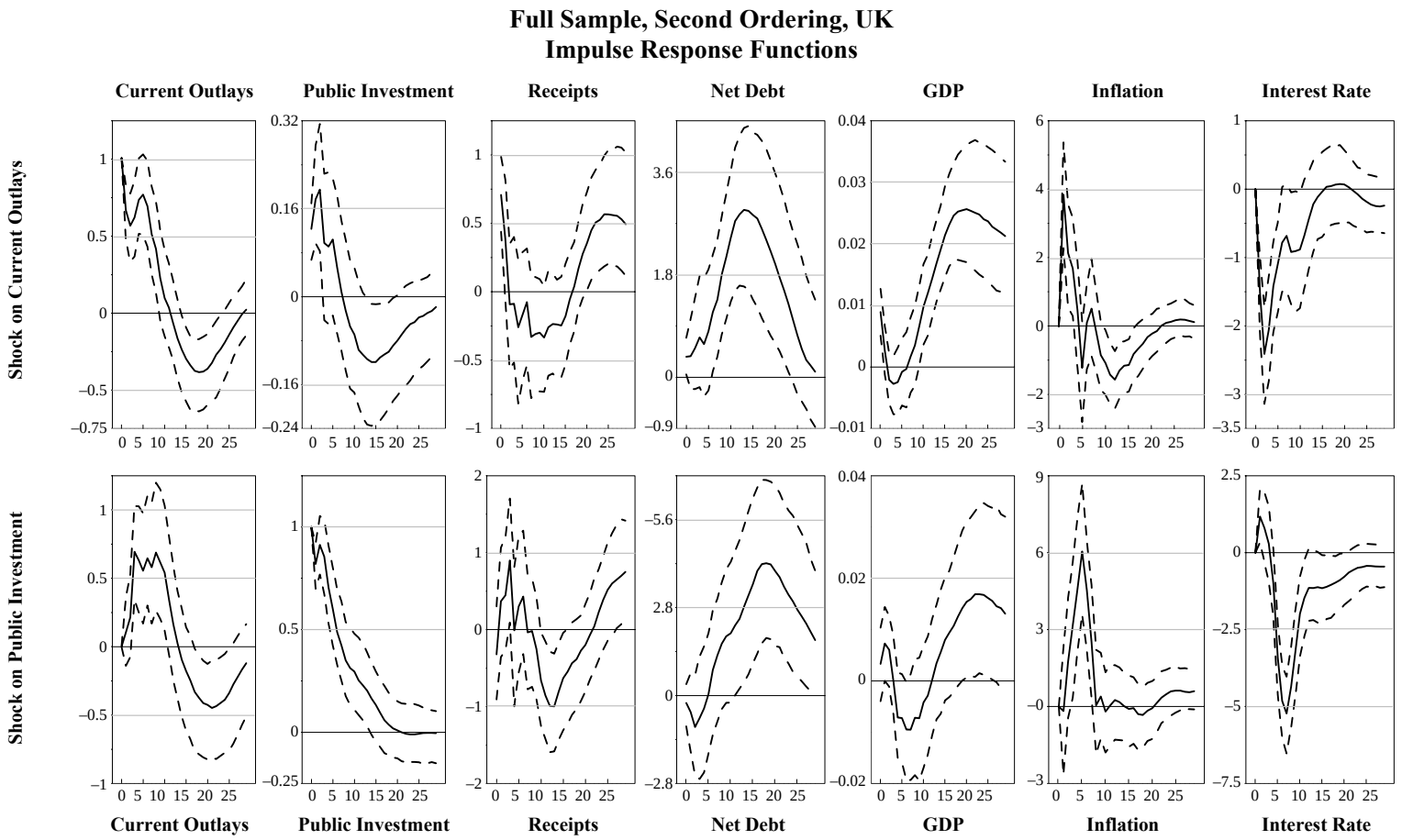

Full Sample, Second Ordering, UK
Impulse Response Functions
Current Outlays
Public Investment
Receipts
Net Debt
GDP
Inflation
Interest Rate
Shock on Current Outlays
Shock on Public Investment

Figure 6

Short Sample, Excluding the Years of the Code for Fiscal Stability, First Ordering, UK
Impulse Response Functions

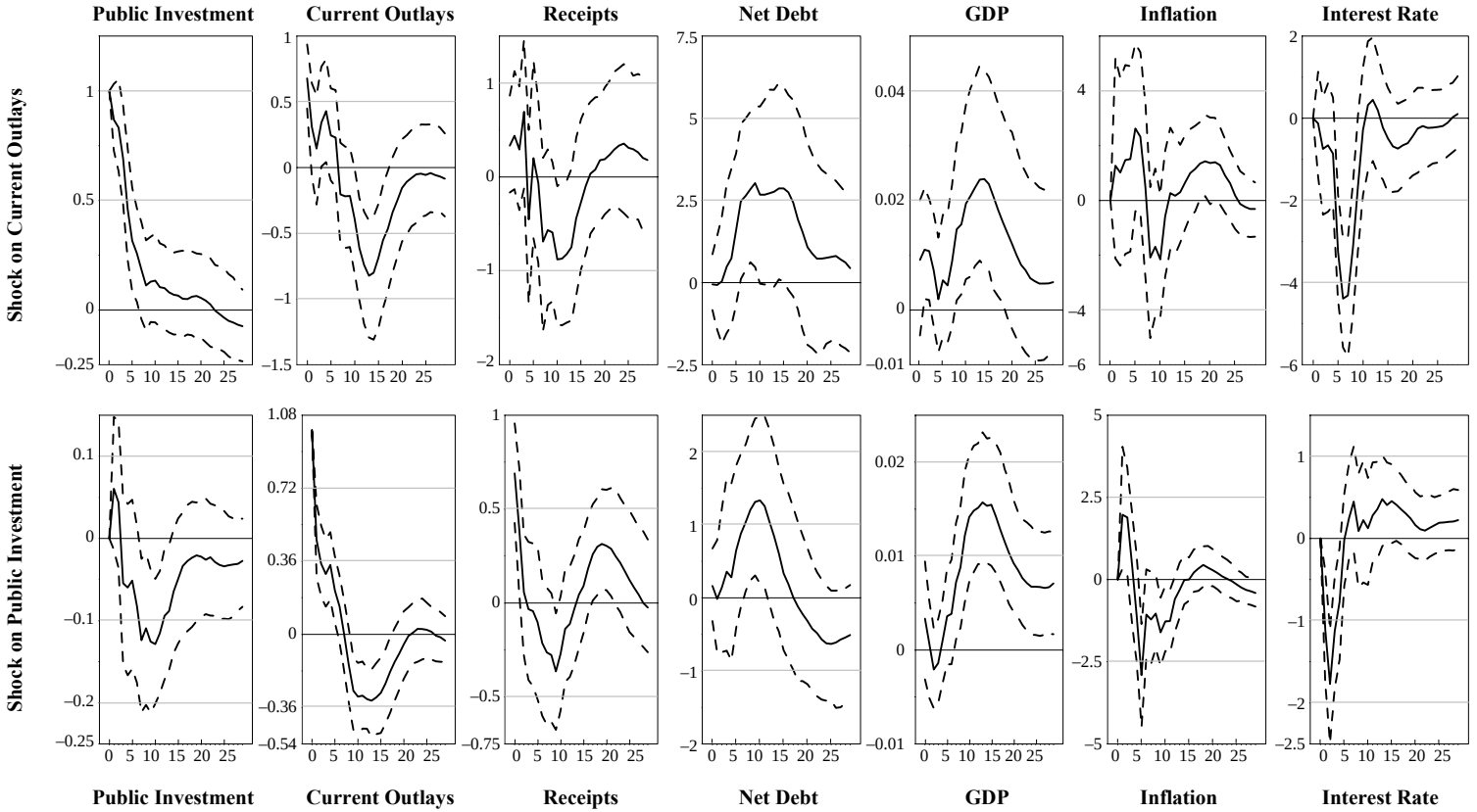
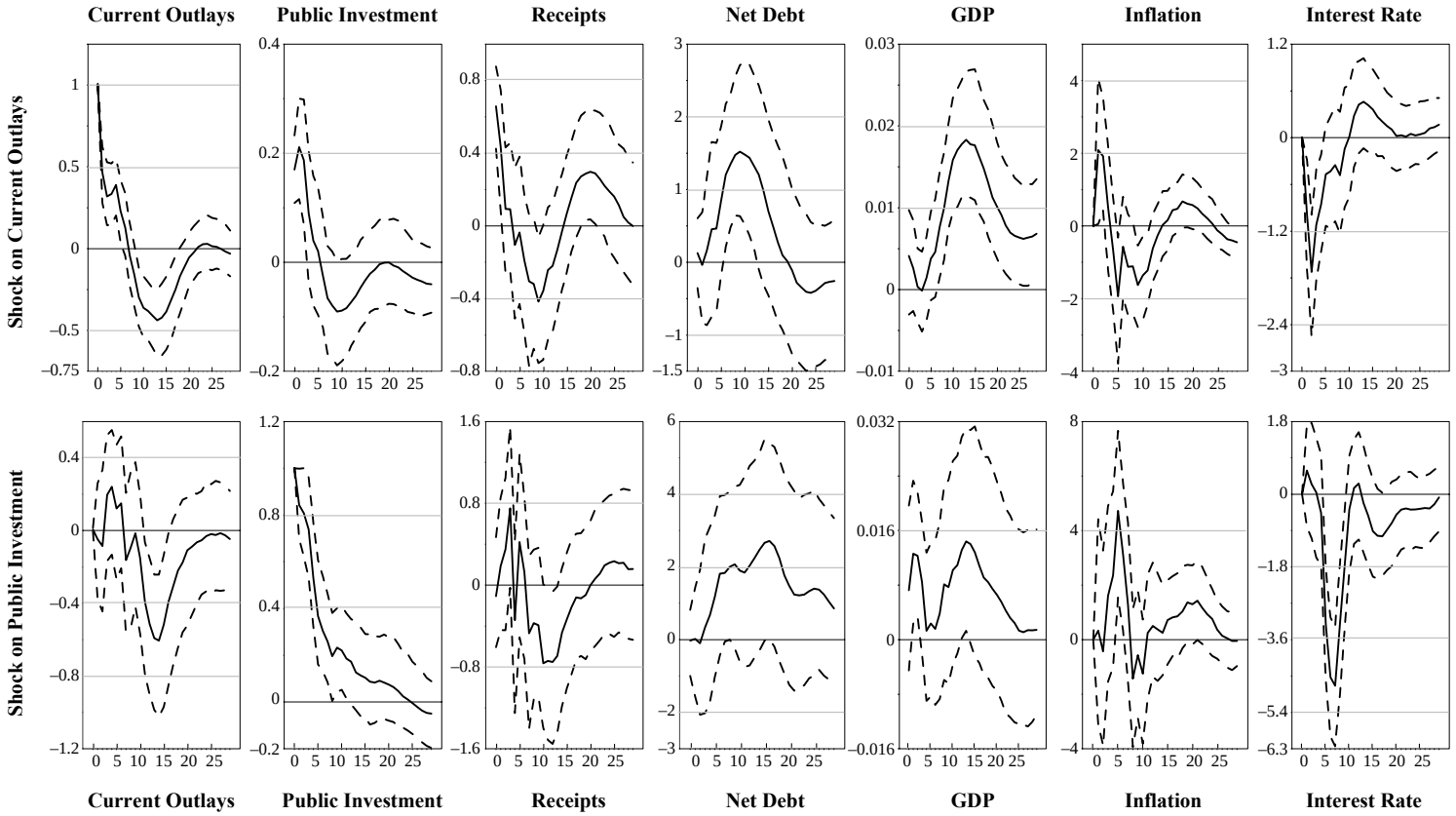


Figure 7

Short Sample, Excluding the Years of the Code on Fiscal Stability, Second Ordering, UK
Impulse Response Functions



5. Conclusion

Different tests have been performed to assess the incidence of public investment on key macroeconomic variables: fiscal and tax variables, public debt, inflation rate, interest rate, and real GDP. The introduction of debt is coherent with the long term model structure that we deem necessary to study the effects of investment. We argue that in the UK context, as well as in the more general context of studying the application of the Golden Rule of Public Finance, public debt cannot be ruled out. Without it, we substantially replicate Perotti's (2004) results on the UK economy, in spite of a slightly different specification. On the other hand we showed that incorporating public debt in the empirical analysis had a major influence on the results. Four important findings have emerged from a study incorporating public debt:

- Public investment in the UK has positive and permanent effects on real GDP, *i.e.* public investment is productive;
- Current outlays are also productive, thus eliminating the puzzle that emerged from the benchmark specification.
- There is evidence that a change has occurred since the Code for Fiscal Stability has been implemented: public investment was less efficient before that period;
- There is evidence that there still exists a asymmetry in the interactions between current outlays and public investment, depending on which one has undergone a positive shock.

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