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FISCAL POLICY AND CONSUMPTION: NEW EVIDENCE FROM THE UNITED STATES

Julia Darby
Jim Malley

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Center for Economic Studies
University of Munich
Schackstr. 4
80539 Munich
Germany
Telephone & Telefax:
++49-89-2180-3112

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Abstract

In this paper we estimate the marginal rate of substitution between aggregate per-capita consumption and per-capita government expenditure on goods and services using U.S. quarterly data over the period 1953 to 1993. This estimate is an important input to any attempt to assess the overall effectiveness of fiscal policy. Other recent consumption studies which incorporate the effects of government expenditure have failed to establish a stable estimate of the marginal rate of substitution. We argue that this failure results from imposing the unrealistic assumption that this parameter is constant. In contrast, we allow the marginal rate of substitution to depend on both the level and composition of government spending and provide strong econometric evidence in support of this claim.

Julia Darby
Jim Malley
University of Stirling
Department of Economics
Stirling, FK9 4LA
Scotland

1. Introduction

In assessing the overall effectiveness of fiscal policy it is fundamentally important to gauge the impact of changes in government expenditure on private sector consumption. It is theoretically possible that government provision can substitute perfectly, imperfectly or not at all, for private consumption. Ultimately, establishing the appropriate size of the marginal rate of substitution is a task which requires empirical analysis. To this end, we estimate the marginal rate of substitution between aggregate per-capita consumption and per-capita government spending on goods and services, using U.S. quarterly data.

Previous attempts to address this question, see for example, Feldstein, (1982), Kormendi, (1983), Aschauer (1985, 1993) and Graham (1993), have assumed that the marginal rate of substitution, θ, is a fixed parameter despite ample evidence to the contrary. Instead, we propose a more general formulation, in which aggregate θ_t is not constant but responds to changes in government expenditure. We show that this approach yields plausible and robust estimates of the aggregate marginal rate of substitution.

More specifically, we model θ_t as a function of the ratio of government expenditure to GDP, where the ratio is further decomposed into its defence, federal non-defence and state and local components. This formulation allows for the possibility of a change in the marginal rate of substitution between per-capita consumption and per-capita government spending when (i) the level of government purchases change as a share of GDP, and (ii) the composition of a given level of government expenditure changes.

An argument predicated on the changing level of government expenditure has previously been suggested by Barro (1993) who states, "It is plausible that the parameter

[θ] would decline as the quantity of government purchases rises. That is, as the amount of public services increase, the marginal unit substitutes less closely for private spending''. Emphasising that this argument applies to changes in the marginal rate of substitution and not to marginal utility, he adds "...the value of the parameter [θ] does not necessarily indicate how valuable an extra unit of public consumption is. People might like these services a lot even if they do not substitute much for private spending" (p 314).

Our second argument is a compositional one, we would expect the marginal rate of substitution to increase if, for a given ratio of government expenditure to GDP, there is an increase in state and local spending. This argument is predicated on the widely held view that defence and federal non-defence expenditure substitute less well for private consumption than does state and local spending. We maintain that this view is sensible, since the latter category includes expenditure on public provision of education, health care and social services. In contrast, some 80% of federal non-defence and 70% of defence spending consists of the wage bill of federal and military employees and the provision of specialised services which, though providing utility, are less relevant to consumers own purchasing decisions. Our econometric results presented in Section 3 are consistent with this interpretation.

The structure of the remainder of the paper is as follows. In Section 2 we develop the theoretical framework, emphasising the importance of government expenditure, public debt and personal sector net financial wealth in determining consumption. In Section 3 we present our econometric estimates which provide evidence for effects on θ_t from both the level and composition of government expenditure. Finally, we present our conclusions in Section 4.

2. The Model

In this section, we make use of the theoretical model developed by Aschauer (1985) which we have extended to incorporate our more general treatment of θ_t[1]. This model, with the assumption of a quadratic utility function, allows us to derive a closed-form solution for consumption. In keeping with virtually all macroeconomic studies, we assume that the government buys final goods and services on the commodity market (see Bailey, 1971 and Barro, 1981), and that government spending on goods and services provides utility directly to households (see Barro, *op.cit.*). The model developed below focuses exclusively on how government expenditure affects private consumption and therefore is partial equilibrium in nature[2].

For simplicity, and conforming with the existing literature, we further assume that (i) the infinitely lived representative agent obtains utility from private consumption, C_t,

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[1] Aschauer estimated a single marginal rate of substitution between consumption and aggregate government expenditure. Besides our different treatment of θ, our derived consumption function excludes tax payments, T, which are in fact eliminated during the derivation. Aschauer reintroduces T in his empirical work to address the issue of the equivalence of debt versus tax financing of government deficits. He interpreted the lack of significance of the tax term as one factor supporting Ricardian Equivalence. In contrast, we impose full Ricardian Equivalence, given our assumptions that (i) all government debt is treated as a liability by consumers, and (ii) we do not introduce any *ad hoc* tax effects. It is also worth noting that we adopt a different approach to the specification of the estimated equation; one consequence of which is that income is included in our estimated consumption function, another is that we consistently allow the rate of time preference, δ, to differ from the personal sector discount rate, r .

[2] Note that examining the partial equilibrium effects on output, Y, is only valid when the aggregate price level is fixed. Under these circumstances, *ceteris paribus*, $\partial Y/\partial G = 1 + \partial C/\partial G$. This expression implies that government spending is fully effective in increasing output when $\partial C/\partial G.=0$, full fiscal neutrality occurs when $\partial C/\partial G=-1$ and finally, "crowding-in" arises when $\partial C/\partial G>0$. Related research which also aims to assess the effectiveness of fiscal policy includes: (i) partial equilibrium studies concentrating on estimating the marginal product of public services, $\partial Y/\partial G$ (see Ahmed, 1986 and Aschauer, 1989a,b) and (ii) reduced-form studies which allow for utility and productivity effects from the public provision of services (see Barro, 1981 and Baxter and King, 1993).

and from goods and services provided by the government sector, G_t[3]; (ii) the individual offers one unit of labour inelastically and (iii) the agent's momentary utility function, V_t, is intertemporally separable, concave and at least twice continuously differentiable, e.g.

$$V_t = \sum_{j=0}^{\infty} u(C^*_{t+j})\,(1+\delta)^{-j} \tag{1}$$

where *effective* consumption is given by

$$C^*_t = C_t + \theta_t G_t \tag{2}$$

and $\delta \geq 0$ is the subjective rate of time preference. The marginal rate of substitution between *actual* consumption and government expenditure, $\theta_t = -\partial C_t/\partial G_t$ is given by

$$\theta_t = \gamma_1 \frac{G^d_t}{Y_t} + \gamma_2 \frac{G^{nd}_t}{Y_t} + \gamma_3 \frac{G^{sl}_t}{Y_t} \tag{3}$$

where, $0 \leq \theta_t \leq 1$, Y is GDP and G^d, G^{nd} and G^{sl} refer to government defence, federal non-defence and state and local spending respectively. The γ_i represent the change in the marginal rate of substitution, resulting from a change in the ratio of a particular component of government expenditure to GDP, holding all remaining components constant.

Note that each component change implies simultaneous effects from the level and composition of government expenditure. For example, *ceteris paribus* an increase in state and local expenditure raises G^{sl}/Y and hence G/Y (the level effect) whilst also raising G^{sl}/G and by definition reducing G^{nd}/G and G^d/G (the composition effect). It should be

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[3] All variables are expressed in per-capita terms in this Section and in the empirical analysis.

clear from this example, in conjunction with the assumption that defence and federal non-defence spending are relatively poor substitutes for private sector expenditure, that we expect γ_1 and γ_2 to be negative. Accordingly, an increase in either of these components, with the implication of an increase in the relative share of poor substitute goods, would lead to a fall in the marginal rate of substitution. On the other hand, a shift in the composition of government expenditure towards closer substitutes, via an increase in state and local spending, would be expected to raise the marginal rate of substitution implying that γ_3 is positive.

The representative agent's period t flow budget constraint is given by

$$C_t = (N_t - T_t) + W_t - \frac{W_{t+1}}{1+r} \tag{4}$$

where, N_t is non-property income, T_t are tax payments, W_t is the net stock of financial wealth at end t-1, valued at t prices and r is the real discount rate. Equation (4) states consumption in period t is equal to net labour income in period t plus the change in the present discount value (pdv) of asset holdings. Forward substitution in equation (4) and imposition of the private sector solvency condition, as $k \to \infty$ $W_{t+k}(1+r)^{-k} = 0$, gives

$$\sum_{j=0}^{\infty} \frac{C_{t+j}}{(1+r)^j} = \sum_{j=0}^{\infty} \frac{(N_{t+j} - T_{t+j})}{(1+r)^j} + W_t. \tag{5}$$

The government's period t flow budget constraint in this model is given by

$$T_t = G_t + B_t - \frac{B_{t+1}}{(1+r)} \tag{6}$$

where, B_t is government debt. Equation (6) implies that government spending in period t can be financed either through taxation or by issuing debt. Again, forward substitution in equation (6) and imposition of the government's solvency condition, as $k \to \infty$ $B_{t+k}(1+r)^{-k} = 0$

gives

$$\sum_{j=0}^{\infty}\frac{T_{t+j}}{(1+r)^{j}}=\sum_{j=0}^{\infty}\frac{G_{t+j}}{(1+r)^{j}}+B_{t}. \tag{7}$$

Assuming that the representative agent in this model is forward looking with respect to the actions of the government, and takes into account the benefits derived from government expenditure on goods and services, we substitute (7) into (5), which yields the consolidated private and government sector budget constraint

$$\sum_{j=0}^{\infty}\frac{C^{*}_{t+j}}{(1+r)^{j}}=(W_{t}-B_{t})+\sum_{j=0}^{\infty}\frac{(N_{t+j}+(\theta_{t+j}-1)\,G_{t+j})}{(1+r)^{j}}. \tag{8}$$

The consolidated budget constraint for the representative individual states that the pdv of effective consumption is equal to the stock of aggregate net wealth (W_t-B_t) plus the pdv of labour income plus (θ_t-1) of the pdv of government expenditure.

Assuming quadratic utility and maximising (1) subject to the consolidated budget constraint (8) yields

$$C_{t}=\beta_{0}+\beta_{1}\left[N_{t}+(W_{t}-B_{t})+\left[\frac{\beta_{1}(\theta_{t}-1)-\theta_{t}}{\beta_{1}}\right]G_{t}+E_{t}\sum_{j=1}^{\infty}\frac{(N_{t+j}+(\theta_{t+j}-1)\,G_{t+j})}{(1+r)^{j}}\right]+\varepsilon_{t}. \tag{9}$$

where, $\beta_0=C^{**}(\delta-r)/r(1+r)$, $\beta_1=(r^2+2r-\delta)/(1+r)^2$, C^{**} is bliss consumption, E_t is the expectations operator conditional on information up to period t and $\varepsilon_t\sim N(0,\sigma^2)$ is a white noise error term. A detailed algebraic derivation is provided in Appendix 1.

3. Econometric Method and Results

One problem apparent in attempting to estimate equation (9) in its present form is that the terms in the infinite summation are unobservable. A number of alternative

approaches are available to make this problem tractable. For example, Hansen and Sargent (1980) proposed estimating an autoregressive system by maximum likelihood. A weakness in this approach is that the order of the autoregressive expectations generating processes is assumed to be finite, known *a priori* and stable. Generally little is known about actual expectation formation and, since maximum likelihood estimation is highly sensitive to specification errors (see for example Pesaran, 1987), we are reluctant to follow this approach (for a related discussion see Nickell, 1986).

More recently, Gregory, Pagan and Smith (1993) have suggested that the processes generating the forcing variables (in our case N and G) could be data determined. This approach holds some attraction, however, Gregory *et al.* have only considered the possibilities of AR(1) and AR(2) generating processes which are rather restrictive. In addition, we have few reasons to believe that actual expectations generating processes should be stable, this is particularly relevant in the case of a policy variable such as government expenditure. Gregory *et al.*'s approach would effectively entail assuming that the forcing variables, including policy variables, could be characterised by fixed parameter autoregressive rules for our entire sample period 1953 to 1993.

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An alternative approach has been to estimate equations such as (9) by including the forward summation (or convolution) terms explicitly but truncating the convolutions at some arbitrary point. Typically four leads are used with quarterly data, see for example and Hall, Henry and Wren-Lewis (1986) and Cuthbertson and Gasparro (1993). The lead terms in such equations are then instrumented, following McCallum (1976), with instruments drawn from the assumed information set I_{t-1}. One problem with this type of equation specified in levels is that the regressors tend to be non-stationary, another concern is that the lead terms also tend to be highly collinear, both problems suggest that inference is not straightforward. Whilst stationarity and collinearity problems can be circumvented by reparameterising the equation to include a convolution of forward differences, (e.g. Callen, Hall and Henry, 1990 and Cuthbertson and Gasparro, *op. cit.*), the arbitrary nature of the truncation and the need to instrument each lead term remain.

Our approach follows Hayashi (1982), who argued that the unobservable terms in future non-property income and future government expenditure could be eliminated by exploiting the present discounted value formulae through quasi-differencing. Quasi-differencing involves applying the operator $\Delta^q=(1-(1+r)L)$ to equation (9), where r is the personal sector real discount rate and L is the lag operator. Applying this transformation to equation (9) gives

$$\Delta^q C_t=\beta_0+(1+r)[(1-\beta_1)\theta_{t-1}+\beta_1]G_{t-1}-\theta_t G_t+\beta_1[\Delta^q(W_t-B_t)-(1+r)N_{t-1}]+e_t \quad \textbf{(10)}$$

where, $e_t = \varepsilon_t + (1+r)\varepsilon_{t-1} + v_t$

The composite error, e_t, now includes a "surprise" term, v_t, which represents revisions to expectations made between t-1 and t. Under the assumption of rational expectations, this term is orthogonal to information available in t-1 and is serially uncorrelated. A further bi-product of quasi-differencing is the appearance of the MA term in ε_t, which we return to below.

Clearly equation (10) is non-linear. For a number of reasons estimation by non-linear least squares (NLS) is inappropriate. Firstly, consistency is hampered by standard simultaneity considerations in consumption and wealth. Secondly, whilst the assumption of rational expectations implies orthogonality of v_t with I_{t-1}, it does not preclude the potentially problematic correlation of v_t with current dated variables. As a result, we require a set of instruments Z_{t-1} that are in I_{t-1} and so by definition are uncorrelated with v_t.

Adopting Hayashi's approach to the specification and estimation of (10) has several advantages over the other methods outlined above. Firstly, it involves fewer parameters than the autoregressive approach. Secondly, we do not have to specify all the variables that influence expectations of future income and government expenditure, so the set of instruments does not have to include variables influencing policy rules. Thirdly, whilst we ultimately adopt a limited information approach to estimation, which by definition is less efficient than the full information approaches suggested by Hansen and Sargent, this approach is likely to be more robust (see Gregory *et al.* (*op. cit.*) for recent simulation evidence).

We employ Hansen's (1982) Generalised Methods of Moments estimator, GMM, in estimating (10). Whilst non-linear instrumental variables, NLIV would be a consistent estimator, the presence of the MA error term referred to above means that NLIV is not efficient. This inefficiency arises because NLIV ignores the MA process in constructing the estimated covariance matrix and consequently the estimated standard errors are incorrect. GMM applies a correction to the standard covariance matrix and should achieve asymptotic efficiency.

Nevertheless, there are some disadvantages involved in estimating (10) by GMM. Taking the MA(1) process seriously imposes a restriction on the choice of legitimate instruments in that regressors should be lagged at least twice to ensure that the instruments are uncorrelated with e_t. Our basic instrument set consists of second, third and fourth lags of each variable (following the suggestion of Campbell and Mankiw, 1989 and 1991). Using this restricted set is potentially counterproductive, leading to inefficiency (see Hendry, 1991) and possible bias, if the MA parameter is not in fact statistically significant (see Bowden and Turkington, 1984 and Nelson and Startz, 1987). Furthermore, Hayashi suggests that the theoretical MA parameter induced by quasi-differencing is likely to be small and may not need to be taken into account in estimation. Finally the MA coefficient may deviate from its theoretical value due to the inclusion of durable expenditure in the measure of consumption, the presence measurement errors, seasonality and time averaging of data, see Mankiw (1982), Ermini (1989) and Campbell and Mankiw (*op. cit.*). Given the above considerations we have examined both GMM and NLIV estimates of equation (10).

Prior to estimation we take one final precaution, scaling both sides of the equation by the exponential trend in per-capita consumption[4]. The unscaled errors may be expected to be heteroscedastic in so far as the mean change and the variance of consumption tend to grow with the levels of consumption. Hayashi (*op. cit.*) and Campbell and Mankiw (1989) have suggested that such scaling is potentially useful in inducing homoscedasticity in the transformed error terms.

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[4] This trend was obtained as the exponent of the fitted values from a regression of the log of real per-capita consumption on a constant and time trend.

Table 1 - Estimation Results - Equation (10)

$$\Delta^q C_t = \beta_0 + (1+r)[(1-\beta_1)\theta_{t-1}+\beta_1]G_{t-1} - \theta_t G_t + \beta_1[\Delta^q(W_t - B_t) - (1+r)N_{t-1}] + e_t$$
$$\text{where, } \Delta^q = (1-(1+r)L) \text{ and } \theta_t = (\gamma_1 G_t^{d} + \gamma_2 G_t^{nd} + \gamma_3 G_t^{sl})Y^{-1}$$

Sample Period:- 1953:3 to 1993:3	Parameter Estimates (with t-statistics in parentheses)
β_0	-122.01 (-10.2)
β_1	0.035 (25.1)
γ_1	-0.898 (-2.6)
γ_2	-3.077 (-4.3)
γ_3	5.474 (6.8)
Minimised Criterion Function	0.119
% Standard Error	1.012
Test of Over-Identifying Restrictions	$\chi^2(27)=19.13$

We report GMM estimates in Table 1[5]. The MA correction does appear to be

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[5] We used TSP 4.2 in estimation. The GMM estimates use a Bartlett kernel with four lags, this ensures that the covariance matrix is positive semi-definite. Throughout the estimation we assume a fixed real discount rate of 5%, this is a common approach (see Kennan (1979), Dolado, Galbraith and Banerjee (1991) and Gregory *et al.* (1993)). The estimation start date is determined by the availability

necessary, in that GMM estimation of (10) proved to be more efficient than NLIV, providing consistently smaller standard errors on the individual parameters. All the estimated parameters are statistically significant at the 95% level or above. Hansen's test of over-identifying restrictions, which can be interpreted as a joint test of instrument validity and general specification, detects no problems (and this is further supported by Sargan's test for instrument validity ($\chi^2(27)=32.8$) based on the NLIV estimates).

Figure 1 provides informal evidence on the stability of the key parameter estimates. The figure shows the estimated parameters, with a band of one standard error either side, plotted against the sample end date. These estimates were obtained by successively dropping one year from the end of the sample, the final bar represents the full sample results. This evidence is encouraging in the sense that none of the parameters show systematic trended behaviour, the standard error bands are similar in size throughout and all the estimated parameters lie within one standard error of the full sample estimates.

[Figure 1 here]

In interpreting the parameter estimates in Table 1, note that the negative intercept, β_0, is consistent with the discount rate exceeding the rate of time preference ($r > \delta$, see equation (9)). The value of β_1, can be interpreted as the proportion of (broadly defined) lifetime income consumed in each quarter. The signs of the estimated γ_i conform with our *a priori* reasoning set out in Section 2 and are consistent with the view that state and local spending is a closer substitute for private sector consumption than either defence or federal non-defence expenditure.

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of quarterly government debt data.

In estimating (10), we employ Hansen's (1982) Generalised Methods of Moments estimator, GMM. Whilst non-linear instrumental variables, NLIV would be a consistent estimator, the presence of the MA error term referred to above means that NLIV is not efficient. This inefficiency arises because NLIV ignores the MA process in constructing the estimated covariance matrix and consequently the estimated standard errors are incorrect. GMM applies a correction to the standard covariance matrix and should achieve asymptotic efficiency.

Table 2 - Elasticities of θ, with respect to expenditure to GDP ratios.

Defence	-0.152
Federal Non-Defence	-0.153
State and Local	1.309
Aggregate Government Expenditure	0.604

In Table 2, as an aid to the interpretation of the relative sizes of the γ_i, we report elasticities evaluated at the sample means and the mean of the estimated marginal rate of substitution. Whilst these partial elasticities relate to changes in the individual components of government expenditure, we also report their weighted average which shows the mean percentage change in consumption for a given percentage change in aggregate government spending leaving its composition unaltered. From these partial elasticities it is clear that a shift in the composition of government spending, towards either defence or federal non-defence expenditure, leads to a decline in the marginal rate of substitution of a similar magnitude. In contrast, any shift toward state and local expenditure results in a more than proportionate increase in the aggregate marginal rate of substitution.

[Figures 2 and 3 here]

The estimated values of the aggregate marginal rate of substitution, θ_t, are shown in Figure 2. The estimates cover a range from 0.25 to 0.56 over the period 1953 to 1993. The main movements in this series largely reflect changes in the absolute and relative levels of G^d/Y and G^{sl}/Y since, although the federal non-defence parameter is statistically significant, G^{nd}/Y has remained virtually constant at 2.3%, see Figure 3. Estimated θ_t climbs through the 1950s and 60s following the Korean war. During this period G^{sl}/Y grew on trend with G^d/Y and aggregate government spending declining on trend (with the exception of the defence build up in the later years of the Vietnam war, 1967-71). From the late 1970s until 1983, θ_t declines slightly, but returns to the levels of the early 1970s by the end of the sample. This movement can largely be attributed to the Reagan rearmament and the levelling off of the state and local expenditure to GDP ratio.

Table 3 - Comparison of Results

	Range	Sample Period
Aggregate θ_t		
	0.25 to 0.56	1953-1993
Estimates of a fixed aggregate θ		
Feldstein (1982)	ns[1]	1930-1977
Kormendi (1983)	0.17 to 0.24	1930-1976 (maximum sample)
Aschauer (1985)	0.23 to 0.42	1948-1981 (varying dynamics)
Graham (1993)	0.22[2] or ns[3]	1948-1981 (varying base year of data)
	ns[3]	1948-1990 (varying sample)
Federal Non-Defence θ[4]		
Graham (1993)	0.80	1948-1981
	ns	1953-1990 (varying sample)

Notes:

1 ns - insignificant at the 5% level
2 using 1972 base data (as Aschauer)
3 using 1982 base data
4 state and local expenditure and defence not significant over any sample period

Table 3 provides a summary of related results in the literature to put our findings into context. First, although our approach is quite different, representing the only attempt to provide a time varying estimate, it is notable that our range for θ_t, 0.25 to 0.56, is very similar to the range of statistically significant fixed estimates spanned by the other studies, 0.17 to 0.42. This similarity is particularly striking when allowance is made for the inclusion of more of the war years early in their samples, which assuming our argument is correct, would clearly place a downward bias on their estimates. The variability of θ within each of the other studies was generated through changing the sample period, the base year of the data and the dynamic specification. This lack of robustness in itself provides ample evidence that it is inappropriate to treat the aggregate marginal rate of substitution as a fixed parameter. In recognition of this instability, and in contrast to the other studies, Graham attempted to identify separate but still constant marginal rates of substitution for defence, federal non-defence and state and local spending. Notably, he had some success with this approach over a sample ending in 1981. In particular, he found a significant substitution effect between private consumption and federal non-defence spending. On the basis of these results he claims to have improved upon the more basic specification employed by Aschauer (op cit.). However, Graham reported that this result was not robust to extensions of the estimation period through to 1990 and he found no clear relationship (over any period) between either defence or state and local government expenditure and consumption. Graham himself notes that these results are "unconventional" in their implication of a zero marginal rate of substitution for state and local spending, but a strongly significant degree of substitutability between consumption and federal non-defence expenditure. In contrast, our results provide a plausible and robust estimate for aggregate θ_t, whilst also incorporating significant and credible effects from the individual components of government expenditure.

4. Conclusions

In this paper we have provided an estimate of the marginal rate of substitution between aggregate consumption and government expenditure for the United States. An assessment of the appropriate marginal rate of substitution is of crucial importance in assessing the overall effectiveness of fiscal policy. Whilst other recent studies have addressed this issue they have failed to provide a stable estimate, this feature has persisted despite dissaggregation. We have provided strong evidence to suggest that this failure results from imposing an inappropriate assumption of parameter constancy. Instead we have proposed and estimated a more general formulation in which θ_t is specified as a function of the ratio of government expenditure to GDP, where this ratio is further decomposed into its defence, federal non-defence and state and local components. This formulation has allowed us to identify plausible and significant effects from both the level and composition of government spending. We therefore argue that this constitutes a significant contribution to the work in this area.

Appendix 1 - Model Derivation

In this model, the representative agent's intertemporally separable momentary utility function, V_t, is given by

$$V_t = \sum_{j=0}^{\infty} u(C^*_{t+j})\,(1+\delta)^{-j} \tag{A1}$$

where $\delta \geq 0$ is the subjective rate of time preference.

Effective consumption is defined as

$$C^*{}_t = C_t + \left[\gamma_1 \frac{G^d_t}{Y_t} + \gamma_2 \frac{G^{nd}_t}{Y_t} + \gamma_3 \frac{G^{sl}_t}{Y_t}\right] G_t . \tag{A2}$$

The marginal rate of substitution between *actual* consumption, and government expenditure, is given by

$$\theta_t = -\frac{\partial C_t}{\partial G_t} = \gamma_1 \frac{G^d_t}{Y_t} + \gamma_2 \frac{G^{nd}_t}{Y_t} + \gamma_3 \frac{G^{sl}_t}{Y_t} \tag{A3}$$

where, $0 \leq \theta_t \leq 1$, Y is GDP and G^d, G^{nd} and G^{sl} refer to government defence, federal non-defence and state and local spending respectively.

The representative agent's period t flow budget constraint is given by

$$C_t = (N_t - T_t) + W_t - \frac{W_{t+1}}{1+r} \tag{A4}$$

where, N_t is non-property income, T_t are tax payments, W_t is net financial wealth and r is the real discount rate. Forward substitution in equation (A4) and imposition of the private sector solvency condition, as $k \rightarrow \infty$ $W_{t+k}(1+r)^{-k} = 0$, which requires that r is greater than the growth in asset holdings, gives

$$\sum_{j=0}^{\infty} \frac{C_{t+j}}{(1+r)^j} = \sum_{j=0}^{\infty} \frac{(N_{t+j} - T_{t+j})}{(1+r)^j} + W_t . \tag{A5}$$

The government's period t flow budget constraint in this model is given by

$$T_t = G_t + B_t - \frac{B_{t+1}}{(1+r)} \tag{A6}$$

where, B_t is government debt. Again, forward substitution in equation (A6) and imposition of the government's solvency condition, as $k \rightarrow \infty$ $B_{t+k}(1+r)^{-k} = 0$, which again requires that the real rate of return be greater than the growth in government debt, gives

$$\sum_{j=0}^{\infty} \frac{T_{t+j}}{(1+r)^j} = \sum_{j=0}^{\infty} \frac{G_{t+j}}{(1+r)^j} + B_t . \tag{A7}$$

Assuming that the representative agent in this model is forward looking with respect to the actions of the government, and takes into account the benefits derived from government expenditure on goods and services, we can substitute (A7) into (A5), and rearrange for effective consumption C^*, e.g.

$$\sum_{j=0}^{\infty} \frac{C^*_{t+j}}{(1+r)^j} = (W_t - B_t) + \sum_{j=0}^{\infty} \frac{(N_{t+j} + (\theta_{t+j} - 1)\, G_{t+j})}{(1+r)^j} . \tag{A8}$$

Maximizing (A1) subject to (A8) gives the familiar Euler-equation for adjacent periods,

$$u'(C^*_{t+j}) = \left[\frac{1+\delta}{1+r}\right]^j u'(C^*_t) . \tag{A9}$$

In order to obtain a closed form solution for consumption we employ the standard assumption that utility is quadratic. Note that while the assumption of a quadratic utility function may appear somewhat restrictive, Hall (1978) and Hayashi (1982) have shown, for the Euler equation, that a number of different functional forms are locally well approximated by a quadratic form. Accordingly, equation (A9) can be rewritten for periods t+1 and t as

$$C^*_{t+1} = \alpha_0 + \alpha_1 C^*_t , \tag{A10}$$

where, $\alpha_0 = C^{**}(r-\delta)/(1+r)$, $\alpha_1 = (1+\delta)/(1+r)$ and C^{**} is bliss consumption.

Substituting out C^*_{t+j} (j=1, 2,...) in (A8) and taking the finite sum of the resulting geometric series yields

$$C^*_{t+j} = \frac{\alpha_0}{1-\alpha_1} - \frac{\alpha_0 \alpha_1^j}{1-\alpha_1} + \alpha_1^j C^*_t . \tag{A11}$$

Substituting (A11) into (A8) gives

$$\sum_{j=0}^{\infty}\left(\frac{1}{(1+r)^{j}}\left[\frac{\alpha_0}{1-\alpha_1}-\frac{\alpha_0\alpha_1^{j}}{1-\alpha_1}+\alpha_1^{j}C_t^{*}\right]\right)=(W_t-B_t)+\sum_{j=0}^{\infty}\frac{(N_{t+j}+(\theta_{t+j}-1)G_{t+j})}{(1+r)^{j}} \quad \text{(A12)}$$

Taking the infinite sum of the three geometric series on the left hand side of (A12), solving for C^{*}_{t}, and substituting for α_0 and α_1 from equation (A10), gives effective consumption

$$C_t^{*}=\left[\frac{(\delta-r)}{r(1+r)}\right]\overline{C}^{*}+\left[\frac{r^{2}+2r-\delta}{(1+r)^{2}}\right]\left[(W_t-B_t)+\sum_{j=0}^{\infty}\frac{(N_{t+j}+(\theta_{t+j}-1)G_{t+j})}{(1+r)^{j}}\right] \quad \text{(A13)}$$

Note that equation (A13) is equivalent to Aschauer's equation (9) but that we have corrected a typographical error in Aschauer's intercept term. In order to solve (A13) for actual consumption, C_t, we substitute for C^{*}_{t} from (A2), separate out the period t levels from the summation and convert to an explicitly stochastic environment, i.e.

$$C_t=\beta_0+\beta_1\left[N_t+(W_t-B_t)+\left[\frac{\beta_1(\theta_t-1)-\theta_t}{\beta_1}\right]G_t+E_t\sum_{j=1}^{\infty}\frac{(N_{t+j}+(\theta_{t+j}-1)G_{t+j})}{(1+r)^{j}}\right]+\varepsilon_t \quad \text{(A14)}$$

where, $\beta_0=C^{**}(\delta-r)/r(1+r)$ and $\beta_1=(r^2+2r-\delta)/(1+r)^2$ and E_t is the expectations operator conditional on information up to period t and $\varepsilon_t \sim N(0,\sigma^2)$ is a white noise error term. In the closed-form consumption function (A14), which is equation (9) in the main text, actual consumption depends on contemporaneous non-property income, private sector net financial wealth less government debt, current government expenditure and the present discounted value of expected future non-property income and government expenditure.

Appendix 2 - Data Sources and Definitions

The data are quarterly, seasonally adjusted and divided by the population (in millions). All nominal variables (current $bn) have the prefix v. Unless otherwise stated data are from the National Income and Product Accounts (NIPA)

C Total Consumption, 1987 $bn.

N Non-Property Income, 1987 $bn.

N = 100.(vy + vtr - vpsi)/pc

Labour Income:
vy = vpi - vri -vdiv - vpii
vpi : Personal income
vri : Rental income of persons
vdiv : Personal dividend income
vpii : Personal interest income

Other Non-Property Income (assumed to be tax free):
vtr : Transfer payments to persons
vpsi : Personal contributions for social ins.
pc : Implicit deflator for consumers expenditure, 1987=100.

W Personal Sector Net Financial Wealth, 1987 $bn
(from Flow of Funds: Assets and Liabilities of Individuals, previous period-end outstanding).

W = 100.vnwi(-1)/pc
vnwi = vtfai - vtli
vtfai : Individuals Total Financial Assets
vtli : Individuals Total Liabilities

B Government Debt, 1987 $bn.
(from IMF Financial Statistics - Government Finance)

B = 100.(vbt - vbma)/pc
vbt : Total Government Debt (Treasury Issues)
vbma : Government Debt held by Monetary Authorities (Treasury Issues)

G Government Expenditure on Goods and Services, 1987 $bn

G^{d} : Defence
G^{nd} : Federal Non-Defence
G^{sl} : State and Local
G^{f} : Federal

Note: Implicit deflators were used where available, however, no constant price series for G^{d} and G^{nd} were available prior to 1972:1. The series used for G^{nd} prior to this date the current price federal non-defence series is deflated by the G^{sl} deflator, G^{d} was then defined as G^{f} - G^{nd}.

Y Gross Domestic Product, 1987 $bn.

POP Total Population (millions) mid period, includes armed forces overseas.

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Figure 1: Stability of key parameters: estimate and +/-1s.e. band against sample end date

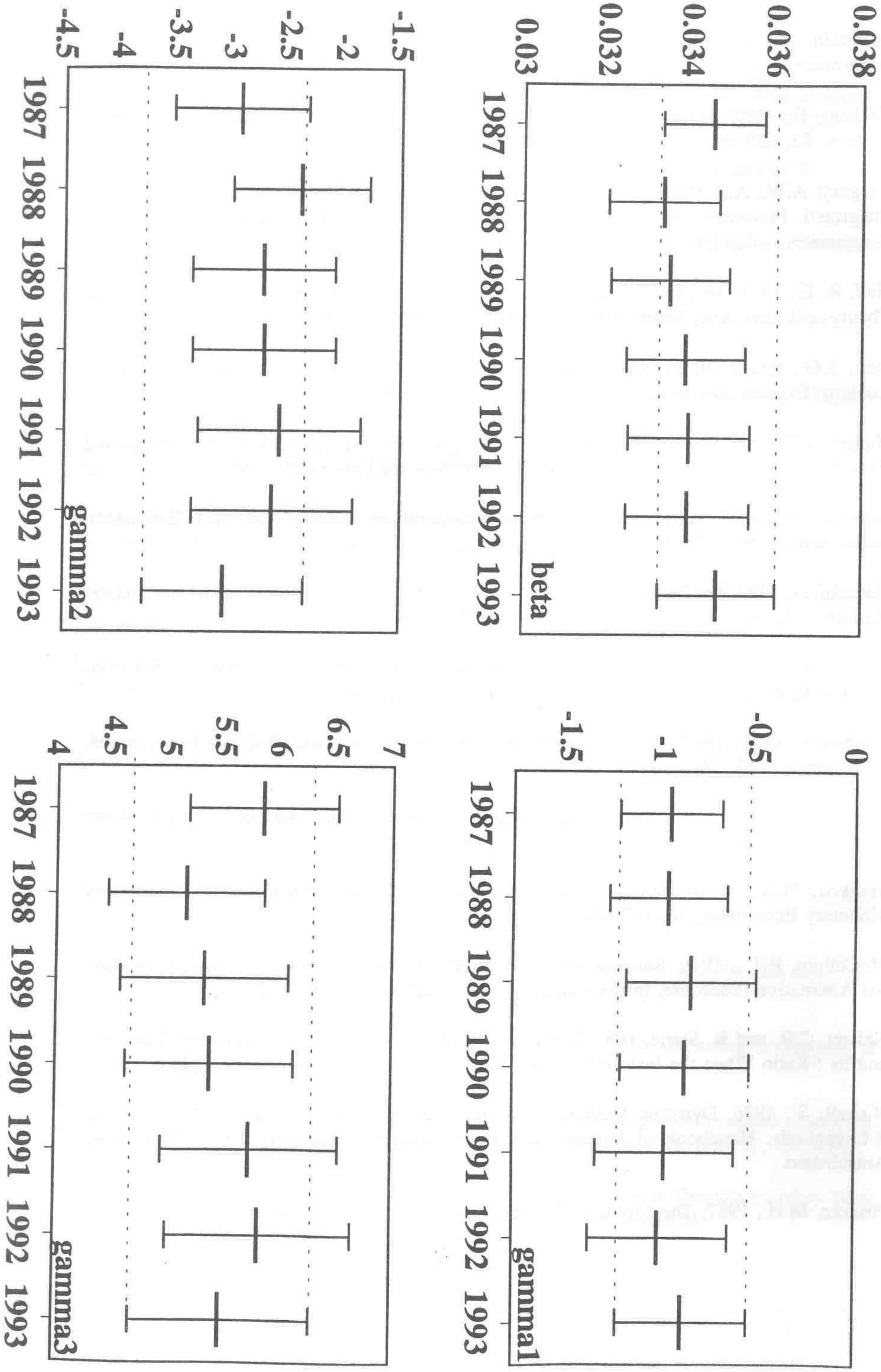


Figure 2: The Marginal Rate of Substitution 1953-1993

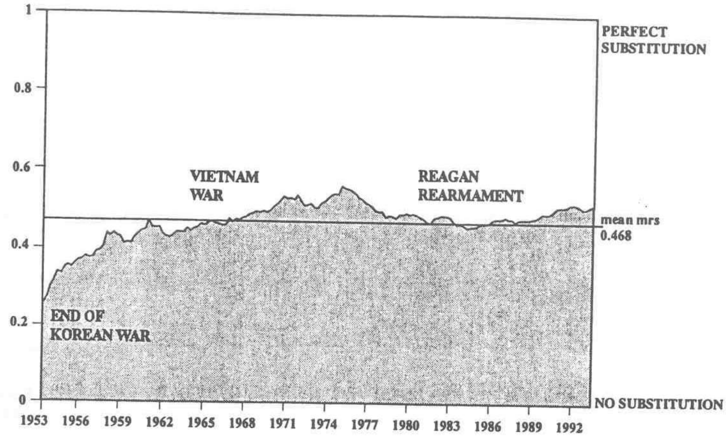
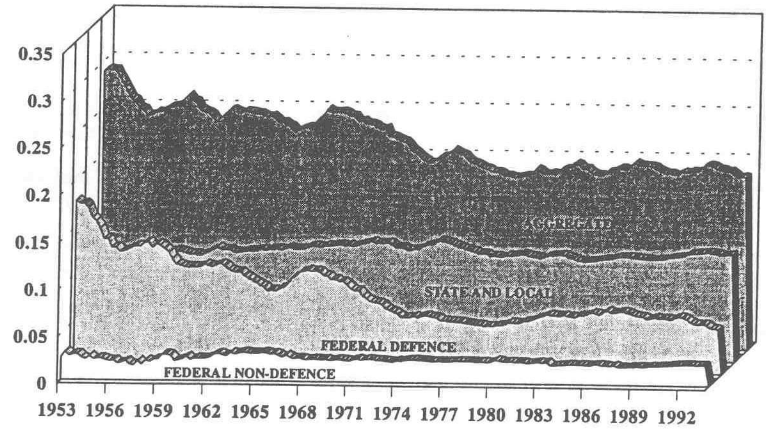


Figure 3: U.S. Government Expenditure as a share of GDP 1953-1993



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