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Fiscal Policy in a Depressed Economy:
Was There a 'Free Lunch' in 1930s' Britain?

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Abstract

We report estimates of the fiscal multiplier for interwar Britain based on quarterly data and time-series econometrics. We find that the government-expenditure multiplier was in the range 0.3 to 0.9 even during the period that interest rates were at the lower bound. The scope for a 'Keynesian solution' to recession was much less than is generally supposed. In the later 1930s but not before Britain's exit from the gold standard, there was a 'fiscal free lunch' in that deficit-financed government spending would have improved public finances enough to pay for the interest on the extra debt.

Keywords: defence news; Keynesian solution; multiplier; public works; self-defeating austerity

JEL Classification: E62; N14

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The weak recovery from the post-2008 crisis has reawakened interest in the appropriate role for fiscal policy in a depressed economy. Competing claims of 'expansionary fiscal consolidation' and 'self-defeating austerity' are being investigated and empirical research into the fiscal multiplier has become a hot topic. In this paper, we present an analysis for 1930s' Britain, an economy in which interest rates were at the zero lower bound (ZLB) and unemployment remained at high levels for a prolonged period. Moreover, there was a good deal of variation in fiscal policy, which went through successive phases in which, first, expenditure cuts and tax increases were imposed in an attempt to return to budget balance in the face of adverse shocks from the world economic crisis and, second, rearmament accompanied by deficit finance comprised a large expansionary fiscal shock in the context of facing up to the threat from Nazi Germany. Interestingly, the public debt to GDP ratio rose during the former and fell during the latter phase. An outline of the fiscal landscape is provided in Table 1.

It has been widely noted in recent papers that, in some circumstances, fiscal consolidation can worsen standard fiscal indicators such as the ratio of public debt to GDP (*P*), at least initially (Boussard et al., 2012; Cottarelli and Jaramillo, 2012). In particular, it has been suggested that this is quite probable at the ZLB, when some models predict the fiscal multiplier will be large; Holland and Portes (2012) develop simulations in which current fiscal consolidation moves in European countries will lead to higher values of *P* in almost all countries in 2013.

It is well known that the condition for deficit-financed government expenditure to be self-financing, in the sense that government debt does not increase, is that $\mu > 1/\tau$, where μ is the government expenditure multiplier and τ is the marginal tax and transfer rate. In this case the additional tax revenue and lower transfer payments will cover the extra borrowing. Even in economies with quite a large welfare state this will probably require a multiplier in excess of 2. The discussion in Keynes (1933) shows that he was well aware of this condition and that he did not believe it to be satisfied at the time.

The concept of self-defeating austerity used by Holland and Portes (2012) is that reductions in government borrowing increase *P*. The condition for this to happen initially is that $\mu > 1/(P+\tau)$, which might be satisfied more easily, especially when the debt ratio is high, as was the case in the 1930s. However, this outcome will typically be reversed quite soon once the impact on GDP of the temporary boost to government expenditure dies away while the stock of debt has been permanently increased (Boussard et al., 2012).

A more interesting focal point for this discussion has been provided by DeLong and Summers and, in particular, their argument that "policies of austerity may well be counter-productive even by the yardstick of reducing the burden of financing the national debt in the future. Austerity in a depressed economy can erode the long-run fiscal balance. Stimulus can improve it" (DeLong and Summers, 2012, p. 234). Their criterion is that a fiscal expansion is self-financing if it generates enough future tax revenue and/or reductions in outlays to cover the interest payments on the additional stock of debt that the initial borrowing entails. This requires the following condition to be satisfied.

$$R \leq \dot{Y} + \frac{\eta\mu\tau}{(1-\mu\tau)} \tag{1}$$

where R is the real rate of interest at which the government can borrow, $\dot{Y}$ is the trend rate of growth of real GDP, and η is a hysteresis parameter defined as the per cent reduction in the flow of potential future output per per centage-point-year of the present-period output gap (DeLong and Summers, 2012, p. 238). The idea here is that, if depressed levels of output today have large enough permanent costs in terms of GDP lost, for reasons such as reductions in labour force skills or the capital stock, then, if these costs can be avoided by deficit-financed temporary government spending, this will be self-financing – a fiscal 'free lunch'. It should be noted that this formula assumes that government borrowing costs are unaffected and takes no account of any adverse effects on growth from the increase in P. DeLong and Summers argue that in depressed-economy conditions (though not in normal times) the inequality in equation (1) is almost certainly satisfied in the United States.

All three of these conditions turn on the value of the fiscal multiplier and the belief that it is large when interest rates are at the ZLB and when there is spare capacity. It is widely accepted that the value of the multiplier depends heavily on circumstances but there is relatively little evidence from ZLB conditions. This makes 1930s' Britain an interesting case to study. At the same time, taking the approach championed by DeLong and Summers to the idea of a 'Keynesian solution' to the 1930s' unemployment problem is an interesting permutation on a prominent debate in interwar British economic history.[1]

Existing estimates of fiscal multipliers for interwar Britain are quite old. The methods they employed to obtain estimates of the multiplier are open to challenge and are not those which would be used by macroeconomists today. They do, however, suggest that the multiplier may have been much higher than would be assumed nowadays in 'normal conditions'. If they are reliable, a fiscal free lunch might well have been on offer. Thus, estimates of the government-expenditure multiplier of 0.98 in the short-run and 1.44 in the long-run were obtained by Thomas (1981) based on a simulation of a Keynesian macro-econometric model, and estimation of an IS-LM model gave a value of 1.22 for the fiscal multiplier in Broadberry (1986). Thomas (1983) looked at the impact of rearmament using an approach based on an input-output table and a social accounting matrix which assumes no crowding out and concluded that the government expenditure multiplier was 1.64 in 1935 and 1.60 in 1938. Hatton (1987) surveyed this literature and concluded that it was appropriate to think in terms of a range of values between 1.25 and 1.75 for the multiplier. Finally, Dimsdale and Horsewood (1995), who incorporated aggregate supply with a high degree of nominal inertia as well as aggregate demand into a macro-econometric model for the interwar period, concluded that the short run multiplier was about 1.5 and the long run as much as 2.5.

The models that these papers rely upon basically embody Keynesian ideas in their specification with a traditional consumption function and may not adequately reflect crowding out, with the implication that the estimated multipliers are too large. None of these papers is based on models in either the neoclassical or new-Keynesian traditions which embody optimizing behaviour by forward-looking households. These are models which typically expect consumer expenditure to fall rather than rise in response to an increase in government expenditure and envisage that the multiplier may be less than 1.[2]

[1] For a recent overview of this debate, see Middleton (2011).

[2] For a convenient summary of predictions from a variety of macroeconomic models, see Hebous (2011).

Nor does the literature on multipliers in interwar Britain use any of the modern econometric techniques to estimate the multiplier from time-series data listed in Ramey (2012). A major reason for this has been the unavailability of quarterly national accounts data until very recently. This gap has now been partly filled with the development of a series for real GDP on a quarterly basis (Mitchell et al., 2011). Estimates for components of national expenditure such as consumption and investment are not available but it is possible to construct a series on a quarterly basis for government expenditure and thus to obtain by subtraction total private expenditure. Moreover, it is also possible to divide government expenditure into defence and non-defence components and to create a quarterly series for 'defence news', defined as changes in the present value of expected future defence spending, the concept suggested by Ramey (2011) as a way to address the issues of exogeneity and anticipation that plague attempts to estimate the fiscal multiplier using time-series econometrics.

Given that theoretical predictions about multipliers are model-dependent it is important to let the data speak; as there is also no consensus on the best empirical strategy to follow, it is clearly valuable to compare the results from using different estimation techniques. We follow this approach here. We obtain estimates of the government expenditure multiplier using single equation models and VARs to ascertain the relationship between changes in government spending (in total and defence spending in particular) and changes in GDP, variants of these models using defence news, and, finally, a more general specification in which both direct and indirect effects of defence news are taken into account.

This provides a range of estimates and an upper bound on the value of the government-expenditure multiplier which we use to inform an assessment of the general plausibility of a 'Keynesian solution' to the macroeconomic difficulties of the 1930s and the issue of self-defeating austerity or a fiscal free lunch in particular. We also provide an ex-post accounting analysis of changes in *P* during the 1930s in order to check on the role that budgetary policy played in its ultimate reduction.

1. Defence News

The data required for our econometric modelling are provided in the Data Appendix. The only series which requires discussion and explanation is that for 'defence news', the aim of which is to reflect changes to planned government defence expenditure previously unanticipated by the public. This variable can be thought of as capturing exogenous shocks to a key component of government spending. The series for changes in the expected present value of government expenditure on defence for the United Kingdom in the interwar period has been constructed using a method similar to that employed by Ramey (2009). The key place from which information was taken is *The Economist* magazine, which was published weekly throughout the interwar period. This source gives details of defence estimates, which were usually published in government papers in February and March each year, but there were sometimes also supplementary estimates. *The Economist* gave a detailed yearly account of actual spending at the time of the annual budget in April and published quarterly running totals at the beginning of January, April, July and October each year, and it also regularly commented on the prospects for defence spending in editorials and in featured news items.

The statistical information obtained from *The Economist* has been cross-checked against the detailed descriptions of British budgets provided by Mallet and George (1929, 1933) and by Sabine (1970). Interpretation of the commentary of *The Economist* has been facilitated by the accounts in the major historical studies of military policy, such as those of Ferris (1989) and Peden (1979). The general pattern of the news is quite clear but, of course, there is a margin of error in the details. At times there was considerable uncertainty, not simply for agents in the private sector but also among policymakers, as to what would happen both with regard to magnitudes and timing, especially in the early 1920s and the late 1930s, and judgment calls are unavoidable. Expected values have been calculated at 1938 prices for a horizon of five years using a discount rate of 5.1 per cent.[3] Estimates of 'defence news' are reported in Table 2 and a full discussion of how this variable was constructed can be found elsewhere (Crafts, 2012).

2. Econometric Estimation of Fiscal Multipliers

Over the years a variety of econometric methods have been used to estimate fiscal multipliers and we examine several approaches here: single equation modelling of levels variables; a variety of vector autoregressions (VARs) in which impulse responses are recast as multipliers; and a recent approach in which the relationship between GDP growth and defence news is examined.

2.1. *Single equation dynamic modelling*

The traditional econometric approach to calculating a long-run multiplier/elasticity is to estimate a single equation autoregressive distributed lag (ARDL) model between GDP and government spending with a vector of control variables included. On denoting y_t and g_t as the logarithms of GDP and government spending respectively, such a model can take the general form

$$y_t = \alpha_0 + \sum\nolimits_{i=1}^{p} \alpha_i y_{t-i} + \sum\nolimits_{i=0}^{p} \beta_i g_{t-i} + \sum\nolimits_{i=0}^{p} \mathbf{c}_i \mathbf{z}_{t-i} + u_t \qquad (2)$$

where $\mathbf{z}_t$ is the vector of control variables, $\mathbf{c}_i$ the accompanying vector of coefficients for lag *i* and u_t is a zero mean independent and identically distributed (i.i.d.) error with constant variance σ_u^2. Estimating (2) over the sample 1922q1 to 1938q4 with $p=4$ (set at this value to model any seasonality present in the seasonally unadjusted data) obtains, after some experimentation with a general-to-specific modelling strategy, the following equation.[4]

$$\hat{y}_t = \underset{(0.082)}{1.273} y_{t-1} - \underset{(0.135)}{0.777} y_{t-2} + \underset{(0.088)}{0.505} y_{t-3} - \underset{(0.008)}{0.015} g_{t-2} + \underset{(0.008)}{0.014} g_{t-4} + \sum\nolimits_{i=0}^{4} \hat{\mathbf{c}}_i \mathbf{z}_{t-i}$$

Standard errors are shown in parentheses and the vector of controls $\mathbf{z}_t$ contains export growth and changes in the money multiplier, the unemployment rate, consol yields and the tax rate. This equation passes tests for residual autocorrelation, heteroskedasticity and non-normality but is

[3] Figures in current prices have been converted to constant 1938 prices using the monthly retail price index in Capie and Collins (1983, Table 2.13) and the discount rate is 1.25% per quarter.

[4] This choice of sample avoids the volatility of the aftermath of World War 1, which is known to have produced a shift in the process generating GDP (see, for example, Mills, 1991).

dynamically unstable since $\hat{\alpha}_1+\hat{\alpha}_2+\hat{\alpha}_3=1.001>1$. This is a consequence of the non-stationarity of both y_t and g_t, as shown in Figure 1 (note also that $\hat{\beta}_2+\hat{\beta}_4\approx 0$, thus implying that ∇g_t is the appropriate form for government spending). Using first differences of these variables (in other words, quarterly growth rates: e.g., $\nabla y_t=\log\left(GDP_t/GDP_{t-1}\right)$), which precludes conventional multiplier analysis, obtains

$$\nabla\hat{y}_t=\underset{(0.001)}{0.008}+\underset{(0.100)}{0.152}\nabla y_{t-1}-\underset{(0.148)}{0.442}\nabla y_{t-2}-\underset{(0.107)}{0.218}\nabla y_{t-3}-\underset{(0.010)}{0.027}\nabla g_{t-2}-\underset{(0.009)}{0.020}\nabla g_{t-3}+\sum\nolimits_{i=0}^{4}\hat{\mathbf{c}}_i\mathbf{z}_{t-i}$$

While this equation is obviously dynamically stable, the negative coefficients on lagged government spending growth imply a *negative* relationship between ∇y and ∇g, the long-run growth rate elasticity being of the order –0.03.

This analysis was repeated with the logarithm of defence spending, d_t, replacing g_t, obtaining the analogous equations

$$\hat{y}_t=\underset{(0.075)}{1.317}y_{t-1}-\underset{(0.108)}{0.803}y_{t-2}+\underset{(0.061)}{0.487}y_{t-3}-\underset{(0.007)}{0.014}d_{t-1}+\underset{(0.008)}{0.013}d_{t-3}+\sum\nolimits_{i=0}^{4}\hat{\mathbf{c}}_i\mathbf{z}_{t-i}$$

$$\nabla\hat{y}_t=\underset{(0.135)}{0.823}+\underset{(0.077)}{0.254}\nabla y_{t-1}-\underset{(0.066)}{0.542}\nabla y_{t-2}-\underset{(00447)}{0.106}\nabla y_{t-3}+\underset{(0.059)}{0.017}\nabla d_{t-4}+\sum\nolimits_{i=0}^{4}\hat{\mathbf{c}}_i\mathbf{z}_{t-i}$$

The levels specification is again bedevilled by dynamic instability and, although the differenced equation yields a positive long-run growth elasticity, it is extremely small at 0.012. We thus conclude that this traditional ARDL approach is a rather unsatisfactory method of computing fiscal multipliers.

2.2. *VAR analyses*

Following the framework outlined by Ramey (2012), we consider computing multipliers using the VAR system

$$\mathbf{x}_t=\mathbf{A}_0\mathbf{d}_t+\sum\nolimits_{i=1}^{4}\mathbf{A}_i\mathbf{x}_{t-i}+\mathbf{u}_t \tag{3}$$

with $\mathbf{x}_t=\left(z_t,g_t,y_t,tax_t,r_t\right)'$: z_t is a variable that distinguishes the alternative systems introduced below, tax_t is the tax rate and r_t an interest rate; $\mathbf{d}_t$ contains a quadratic trend and seasonal dummies and is thus consistent with the exercises reported in Ramey (2011, 2012). This ordering of the variables in $\mathbf{x}_t$ is used in the Choleski decomposition leading to the calculation of impulse responses and hence multipliers from three choices of $\mathbf{x}_t$:

1. **Blanchard-Perotti structural VAR (SVAR)**: Blanchard and Perotti (2002) omit z_t entirely and identify the shock to government spending as the innovation to g_t, now ordered first in the Choleski decomposition.

2. **Perotti SVAR**: Perotti (2011) sets $z_t = d_t$, the logarithm of defence spending. The government spending shock is then the innovation to d_t
3. **Ramey News Expectational VAR (EVAR)**: Ramey (2011) sets $z_t = news_t$, where $news_t = DEF\_NEWS_t / GDP_{t-1}$ is her 'defence news' variable defined as the ratio of defence news (*DEF_NEWS*), and which is shown in Table 1, to lagged GDP (this series is shown in Figure 2). The innovation to this variable is thus identified as the government spending shock.

Figure 3 shows the sequence of multipliers up to T = 80 quarters obtained from the three variants of the VAR (3) computed for the sample 1922q1 to 1938q4. The Blanchard-Perotti SVAR multiplier is negative whereas the Perroti SVAR and Ramey EVAR multipliers are both in the region of 0.7 (interestingly, Ramey (2012) also found that these two multipliers were essentially the same for her U.S. application). Unfortunately, the precision with which these multipliers can be estimated is rather poor, the standard error to be attached to the Ramey EVAR multiplier being in the region of 0.65 while that for the Perotti SVAR multiplier being over 2.8.[5]

2.3. *Incorporating defence news*

The defence news variable defined above may be incorporated into an approach that is similar to that followed by Barro and Redlick (2011), which has the following general specification:

$$\nabla y_t = \alpha_0 + \sum_{i=1}^{4} \beta_{1i} news_{t-i} + \sum_{i=1}^{4} \beta_{2i} \nabla D_{t-i} / GDP_{t-1-i} + \sum_{i=1}^{4} \mathbf{c}_i \mathbf{z}_{t-i} + u_t \tag{4}$$

where D_t is the level of defence spending. The control variables included are lags of export growth, changes in the money multiplier, consol yields and the tax rate, and the unemployment rate. Growth rates and changes were used to ameliorate problems caused by the non-stationarity of many of the variables when expressed as levels, as found in the analysis of (1) above. The error term u_t is specified as the ARCH(1) process $u_t^2 = \delta_0 + \delta_1 u_{t-1}^2$, which effectively models the volatility of GDP growth during 1926 and 1927 (see Figure 4) and precludes the need for lagged values of GDP growth to be introduced as regressors: including such lags with u_t assumed to be homoskedastic leads to a significant deterioration of fit. Note that contemporaneous (lag 0) values of the regressors are omitted to avoid possible simultaneity problems that have complicated instrumental variable estimation of similar models using annual data.

Estimates of the finally chosen specification, in which insignificant variables have been deleted, are shown as Table 3 (the estimated coefficients of the included control variables are shown in the Statistical Appendix as column (1) of Table A1). Using standard errors robust to possible residual autocorrelation and heteroskedasticity, all included variables are significant and the reported equation passes a variety of standard tests for misspecification. The *news* variable is significantly positive at a lag of two quarters with a coefficient estimated to be, with one-standard error bound, 0.0416 ± 0.0025.

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[5] Attempts to compute multipliers for sub-samples were consequently unsuccessful.

Noting that Barro and Redlick's multiplier definition is based on using annual data with single lags of the regressors, its (dynamic and annualised) quarterly counterpart here would be $16\sum_{i=1}^{4}\beta_{1i}+\sum_{i=1}^{4}\beta_{2i}$. The estimate of this multiplier obtained from the estimates shown in Table 3 is 0.52 ± 0.06.[6]

An attempt was then made to investigate how this multiplier might change within the sample period. Attempts to re-estimate equation (4) for the post-1932 sub-period in order to investigate whether the multiplier is higher for the era where interest rates were close to the ZLB were unsuccessful, but truncating the sample period at 1932q2 yielded a multiplier of 0.8, which seems contrary to this hypothesis.

Since the fit of this equation is not particularly good, with an R^2 of just 0.19, it was thought that we might do better by moving to a more general model. To this end a specification was developed which relates ∇y_t again to lags of $news_t$, but now to lags of government spending growth disaggregated into defence and non-defence spending, ∇d_t and $\nabla non-d_t$, and lags of private spending growth, ∇n_t, all growth variables again being defined as one-quarter changes in the logarithms:

$$\nabla y_t=\alpha_0+\sum_{i=1}^{4}\beta_{1i}news_{t-i}+\sum_{i=1}^{4}\beta_{2i}\nabla d_{t-i}+\sum_{i=1}^{4}\beta_{3i}\nabla non-d_{t-i}+\sum_{i=1}^{4}\beta_{4i}\nabla n_{t-i} \qquad (5)$$
$$+\sum_{i=1}^{4}\mathbf{c}_i\mathbf{z}_{t-i}+u_t$$

Estimates of the finally chosen specification, in which insignificant variables have been deleted through a general-to-specific modelling strategy, are shown as column (1) of Table 4 (the estimated coefficients of the included control variables are shown in the Statistical Appendix as column (2) of Table A1). Again using standard errors robust to possible residual autocorrelation and heteroskedasticity, all included variables are highly significant and the reported equation passes a variety of standard tests for misspecification. The *news* variable is significantly positive at a lag of two quarters with a coefficient estimated to be 0.0430 ± 0.0083. This coefficient may be regarded as an estimate of the 'direct' multiplier of defence news on GDP, which on an annualised basis is 0.172 ± 0.033.[7] The chosen specification of (5) offers a superior fit to the Barro and Redlick model, with a much improved R^2 of 0.51 and a regression standard error some 20% lower.[8]

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[6] Ramey's (2012) alternative specification of (4), where the dependent variable is the ratio of private spending to lagged GDP and the ratio of the change in government spending to lagged GDP is used as a regressor, was also investigated. The defence news variable was imprecisely estimated and the implied multiplier turned out to be negative, albeit insignificant.

[7] The reasoning behind this statement is as follows. Noting that $news_t=DEF\_NEWS_t/GDP_{t-1}$ and the long-run relationship between GDP growth and *news* is

$$\nabla y_t=\log\left(GDP_t/GDP_{t-1}\right)\approx\nabla GDP_t/GDP_{t-1}=0.0430DEF\_NEWS_t/GDP_{t-1}$$

$\nabla GDP=0.0430DEF\_NEWS$ is then the long-run relationship.

[8] Again an ARCH(1) error specification was employed to model the volatility of GDP growth during 1926 and early 1927, as shown in Figure 4. Attempts to deal with this episode by using lagged values of ∇y_t rather than an ARCH error led to a severe deterioration of fit: for example, the log-likelihood of the specification fell from

2.4. *Defence news multipliers*

However, as well as this direct multiplier, there may also be 'indirect' effects present via the possible impact of *news* on the various categories of spending that also influence GDP growth. Regressions of the form

$$\nabla x_t = \gamma_0 + \sum_{i=1}^{4} \gamma_i \nabla x_{t-i} + \sum_{i=1}^{4} \theta_i news_{t-i} + v_t$$

were therefore estimated with *x* being, successively, ∇d, $\nabla non-d$ and ∇n, these being reported in columns (2)-(4) of Table 4.

The deterministic parts of these relationships may be written generically as

$$w_{i,t} = \frac{\theta_i(B)}{\phi_i(B)} news_t$$

where $\theta_i(B) = \theta_{i,0} + \theta_{i,1}B + \ldots + \theta_{i,4}B^4$, etc., where *B* is the lag operator. For example, for $w_{i,t} = \nabla n_t$, $\theta_i(B) = -0.195B^4$ and $\phi_i(B) = 1 + 0.538B + 0.243B^2$. Equation (5) can similarly be written as (on ignoring the control variables)

$$\nabla y_t = \alpha(B) news_t + \sum_{j=1}^{3} \beta_j(B) w_{j,t}$$

$$= \left(\alpha(B) + \sum_{j=1}^{3} \frac{\beta_j(B)\theta_j(B)}{\phi_j(B)} \right) news_t$$

$$= \left(\alpha(B) + \sum_{j=1}^{3} \xi_j(B) \right) news_t$$

The long-run 'total' multiplier is then given by

$$\mu(1) = \alpha(1) + \sum_{j=1}^{3} \xi_j(1)$$

where $\alpha(1)$ is the 'direct' multiplier and the $\xi_j(1)$ are the 'indirect' multipliers. *k*-period interim multipliers can be computed by solving for the implied coefficient at lag *k* in, for example, $\alpha(B) + \xi_1(B) + \xi_2(B) + \xi_3(B)$. The various direct and indirect interim multipliers are shown in Figure 5, along with the long-run total multiplier $\mu(1) = 0.132 \pm 0.062$ (which is 0.53 ± 0.25 on an

259.14 for the model above to 188.58 on replacing the ARCH specification with a lagged dependent variable, with the coefficient on *news* also becoming much less significant (0.0814 with a standard error of 0.0481).

annualised basis: these multipliers have had any seasonality smoothed out to enhance interpretability).[9]

The overall multiplier time path may be used to compute the monetary impact on GDP of defence news shocks. Figure 6 shows the overall monetary impact of such shocks from 1925 onwards using a five-year horizon.[10] By the end of 1938, defence news shocks had produced an increase in GDP of £95 million, the rapid increase since 1934 being clearly seen.

To ascertain how the multiplier may have altered throughout the sample period, the specifications of Table 4 was re-estimated using samples ending in 1932q2 and 1934q4, with the multipliers being recalculated. These produced annualised total overall multipliers of 0.82 and 0.67, respectively. Again, this offers no support to the proposition that the fiscal multiplier increased during the cheap-money period.

The equations in columns (2) and (4) of Table 4 are also informative in other respects. The former shows that defence news does predict subsequent actual defence spending. The latter shows that defence news has a negative effect on non-government spending, which is indicative of crowding out. There are no quarterly data on components of national expenditure but from 1932 there are estimates of retail sales, which can be used as a proxy for consumer expenditure. The estimates of an equation relating defence news to retail sales are shown in Table A2 of the Statistical Appendix. The results suggest that consumer expenditure was reduced by expectations of future defence spending, which would be consistent with neoclassical predictions based on negative wealth effects.

3. Results

The results of our econometric modelling are that the government expenditure multiplier in interwar Britain was probably well below 1. This was found using the SVAR and EVAR methods, the Barro and Redlick formulation, and also our preferred specification. Moreover, we did not find any evidence of a higher value for the multiplier during the 'cheap-money' period of very low nominal interest rates. A reasonable conclusion from our preferred econometric modelling is that a point estimate of the government expenditure multiplier is between 0.5 and 0.7 and, allowing for the standard errors of these estimates, probably between 0.3 and 0.9. This is much lower than the estimates in the historiography reviewed earlier; these ranged between 1.2 and 2.5. As we noted, however, those multipliers were not obtained using modern methods and are clearly questionable.

In terms of a 'Keynesian solution' to the interwar unemployment problem, much of the historiography focuses on the issue of the possible impact of public expenditure proposals made by Keynes and Henderson (1929) with a view to reducing unemployment, which were taken up by the Liberal Party under David Lloyd George at the general election of that year.[11] The optimism of Keynes and Henderson over the impact of a late-1920s public works programme on unemployment

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[9] The standard error accompanying the total multiplier has been calculated using the 'delta' method: see the Statistical Appendix for details. As this is an asymptotic technique, this standard error should be treated with the usual caveats that accompany such calculations for limited sample sizes.

[10] These impacts were computed in the following way. If μ_i is the k-th period overall multiplier, then Figure 6 shows the five-year (20-quarter) impact computed as $\sum_{k=0}^{20} \mu_i DEF\_NEWS_{t-k}$

[11] The Liberal Party did not win the election and the proposals were not implemented.

has not been shared by quantitative economic historians, who have regarded their claim that a £100 million programme for three years would have cut unemployment by 500,000 as implausible. In particular, as Middleton (2010) noted, this is mainly because estimates of the multiplier have been lower than those of early Keynesians like Kahn (1931), whose best guess was 1.88, and Keynes himself, who favoured a range of 2 to 3. For example, Thomas (1981), whose estimate of the long-run multiplier was 1.44, concluded that by the third year real GDP would be increased by £120 million and unemployment reduced by 329,000. Dimsdale and Horsewood (1995) did support the idea of a relatively large multiplier but their more detailed treatment of the labour market led them to conclude that, even though the Keynes-Henderson stimulus would have raised real GDP by £182-£202 million by year 3, unemployment would have been reduced only by 302,000-333,000. Given that restoring 'normal' unemployment in 1932 would have entailed cutting it by close to 3 million, there is a consensus that at that point there was no possibility of a Keynesian solution to unemployment.

Even our highest point estimate of 0.8 after about three years for the pre-1932 government expenditure multiplier means that we would be considerably more pessimistic about the impact of the Keynes-Henderson program; Lloyd George would have been hard pressed to cut unemployment by much more than 200,000. So we share the consensus view that it would be unwise to have expected too much from fiscal stimulus in the early 1930s. Moreover, insofar as there were risks that a fiscal stimulus might trigger a rise in risk premia in interest rates, our results suggest that this gamble was less worth taking than has hitherto been believed.[12]

Table 5 sets out in more detail the estimated impact of defence news on GDP during the recovery period, already shown in Figure 6 based on our preferred specification. Using the total multiplier (including the direct and indirect components), this impact averaged 7.1 per cent of GDP in 1938 and amounted to £347.8 million (at 1938 prices) for the four quarters. However, our results suggest that the reason rearmament had a big impact was because the future spending plans were massive rather than because there was a large fiscal multiplier at the ZLB. The large rise in GDP at a time of increased defence expenditure came as armaments manufacturers scrambled to add capacity in anticipation of strong future demand (Robertson, 1983).

Our estimates also imply that is not plausible that deficit-financed government expenditure would not have increased government debt in the 1930s. Middleton (1985, Table 7.2) provides estimates showing that τ, the marginal tax and transfer rate, averaged 0.44 in the early 1930s. This means that the required value of μ was 2.28. On the other hand it is quite possible that the condition that fiscal consolidation raised the debt to GDP ratio in the first year, $\mu > 1/(P+\tau)$, was realized, in particular because P was very high. Given that $P = 1.7$, $\mu > 0.47$ would satisfy this condition.

Nevertheless, it is important to note that the falling values of P after 1933 reported in Table 1 mainly result from continuing (albeit smaller) primary budget surpluses. Using the standard formula $\Delta P = -b + (i - \pi - \dot{Y})P$, where b is the primary budget surplus to GDP ratio, i is the nominal interest rate on government debt, and π is the rate of inflation, we find that 22.8 percentage points of the 35.4 percentage points fall in P from 179.2 per cent of GDP in 1933 to 143.8 per cent of GDP in 1938 came from primary budget surpluses and 10.7 percentage points from the real interest rate being

[12] Middleton (2010) sets up the government's policy options in exactly this way.

lower than the growth rate. Thus the work done by the budget surpluses was augmented by 'financial repression' at a time of capital controls. In this respect, the stark difference from the period prior to leaving the gold standard in September 1931 is clearly seen in Table 6. When the price-deflationary years of the early 1930s had been left behind, the required primary budget surplus fell steeply and, indeed, once the differential between the real interest rate and the real growth rate had turned negative, it would have been possible to run modest primary budget deficits and still have stabilized *P*. Thus, rearmament was consistent with continuing falls in the public debt to GDP ratio.

Was there a fiscal 'free lunch' in the sense of DeLong and Summers? In order to address this question, we also need estimates of the values of $\dot{Y}$, the trend rate of growth of real GDP, and of η, the hysteresis parameter. With regard to the former, our interwar quarterly data set yields an estimate of a trend growth rate with $\dot{Y} = 1.93$ per cent per year.[13] This is, in fact, the same as the trend-stationary rate that was estimated for the pre-World War I period by Mills (1991). For the purposes of the 'free lunch' calculation this is unlikely to be a controversial benchmark to choose.

Obtaining an estimate of η is more difficult. Our approach is based on using IMF (2012, annex 1) as a starting point. Their methodology focuses on hysteresis effects that emerge in the form of a higher NAIRU (U^*) being generated by years when real GDP falls below its potential level (Y^*). More precisely, the empirical estimate on which IMF (2012) relies is that each 1 percentage point widening of the cumulative output gap raises U^* by 0.14 percentage points, with the implication that Y^* falls by 0.1 per cent. This is equivalent to setting $\eta = 0.1$, the central estimate of the hysteresis parameter assumed by DeLong and Summers (2012).

We can check the plausibility of assuming that a similar relationship applied in Britain in the 1930s. On the basis of trend growth at 1.93 per cent per year, the output gap in 1929 averaged -3.7 per cent. Working forward through the 1930s, the cumulative output gap sums to 27.3 per cent of GDP, which would imply that U^* is predicted to have risen by 3.82 percentage points between 1929 and 1937. The best estimates for U^* show an increase of 3.83 percentage points over these years (Dimsdale and Horsewood, 1995). The increase in U^* results from various proximate determinants but is essentially driven by the economy's response to the exogenous demand shock of the world economic crisis. Thus the assumption of $\eta = 0.1$ appears quite reasonable, prima facie.

However, this conclusion must be treated with some caution. On the one hand, there may be other contributions to η which would mean the true value exceeds 0.1. These might include the marked increase in long-term unemployment during the 1930s, which probably also contributed to a higher U^* although the magnitude of such an effect is unclear (Crafts, 1989), and a slowdown in the rate of growth of the capital stock.[14] On the other hand, the rise in U^* partly reflects policy choices, for

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[13] This comes from estimating the following trend stationary model for GDP

$$y_t = 20.54 + 0.00483t + u_t \qquad u_t = 1.295u_{t-1} - 0.425u_{t-2} + \varepsilon_t$$

and annualizing the trend coefficient.

[14] The rate of growth of non-residential capital stock fell from 0.8 to 0.5 per cent per year between the business cycles 1924-9 and 1929-37 (Feinstein, 1972). A growth accounting calculation suggests that if this

example, with regard to the replacement rate. Moreover, it is not clear how far a fiscal stimulus could have averted the rise in *U** or the slowdown in capital stock growth and thus underpinned future tax revenues. Even if 0.1 is a reasonable assumption for the value of η, as we assume in what follows, this is no more than a best guess with quite wide margins of error. That said, it would not seem reasonable to suppose that $\eta = 0$, which means that there will be some values of the multiplier which would deliver the free lunch.

Table 7 uses equation (1) to calculate the critical values of the real interest rate that would permit a fiscal stimulus to have been self-financing for $\dot{Y} = 1.93$ per cent and, as before, $\tau = 0.44$. As might be expected, the outcome is quite sensitive to the value of the government-expenditure multiplier. The likelihood of the criterion being met was obviously much greater after Britain had left the gold standard and had entered financial repression, as the data in Table 6 confirm. *R* in the late 1920s was around 5.7 per cent but ≤ 3 per cent from 1934 onwards.

If the multiplier was ≥ 1.5, as suggested by Dimsdale and Horsewood (1995) and by Thomas (1983), then the fiscal free lunch was very probably available in the late 1920s when Keynes and Henderson (1929) were advocating a substantial public work programme. In the late 1930s, this was also the case, even if the multiplier was only in the range 0.5 to 0.7 that our estimates suggest was most likely. However, on the gold standard in the late 1920s, with this smaller multiplier the real interest rate facing the British government was very possibly too high to meet the criterion. This conclusion is strengthened when it is recognized that interest rates faced significant upward pressure if budgetary policy was viewed as ‘unsound’, as was demonstrated in 1931 (Middleton, 1985, p. 94).

Our estimates for the government expenditure multiplier are considerably lower than has been believed by earlier writers and also are out of line with models which predict that the multiplier will be large in a depressed economy with interest rates at the ZLB. Even so, there is a plausible reason for the multiplier to have been quite modest even in the 1930s, namely that the legacy of World War I meant that there was a high ratio of public debt to GDP. Between the late 1920s and the late 1930s this was never less than 140 per cent and peaked at nearly 180 per cent in 1933 (Table 1).

Empirically, econometric evidence for the recent past finds that, once the level of government debt is over 100 per cent of GDP, the response of output to government spending shocks is very small even in deep recessions (Auerbach and Gordnichenko, 2011; Ilzetski et al., 2010). Theoretically, the reason for this result may be that expectations of large tax increases are raised by the fragility of the public finances when the debt to GDP ratio is high. There seems to be stronger modern evidence for consumption reductions stemming from ‘Ricardian equivalence’ when debt to GDP is above 100 per cent.

4. Conclusions

The main result in this paper is evidence that the government expenditure multiplier was less than 1 in interwar Britain. We find that it was probably in the range 0.3 to 0.9 and that several different estimation techniques give similar results. There is no evidence that the multiplier was larger than

were attributable to the cumulative output gap resulting from a demand shock, then this would add about 0.05 to η.

this when interest rates were at the ZLB after mid-1932. To our knowledge, the estimates in this paper are the first to be obtained using modern time-series methods and quarterly data.

The implication of a multiplier well below 1 is that the so-called Keynesian solution of returning to ‘full employment’ using the fiscal stimulus of a relatively modest public works programme would not have worked, contrary to the claims made by Keynes himself in the late 1920s. This conclusion is in line with the existing economic history literature and simply reinforces the findings of earlier writers who have generally supposed that the multiplier was significantly greater than 1.

There is reason to believe that fiscal consolidation would initially raise the public debt to GDP ratio because, although the multiplier was probably not large, the legacy of World War I was a large outstanding stock of national debt relative to GDP. There was a fiscal free lunch in the later 1930s in the sense that deficit-financed government expenditure would have paid for the interest on the extra stock of national debt, as argued for the case of a depressed economy by DeLong and Summers (2012). These conditions probably did not apply prior to Britain’s exit from the gold standard at the time when Keynes originally proposed the public works programme.

The public debt to GDP ratio fell quite noticeably in the years after 1933 even though fiscal policy was relaxed considerably at this time. An ex-post analysis shows that primary budget surpluses accounted for about two-thirds of the reduction but another third came from the differential between the real growth rate and the real interest rate. Dealing with the debt problem was made much easier at this time by financial repression in an era of capital controls.

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Table 1. Fiscal Indicators for 1930s' Britain, Real GDP and Unemployment

	Government Debt	*Budget Surplus*	*Debt Interest*	*Constant Employment Budget Surplus*	*Real GDP (1929 =100)*	*Unemployment (%)*
1929	158.4	-0.7	7.7	0.4	100.0	8.0
1930	159.2	-1.4	7.6	1.1	99.9	12.3
1931	169.8	-2.2	7.7	2.5	94.4	16.4
1932	173.6	-0.5	7.8	3.0	95.1	17.0
1933	179.2	0.4	7.0	4.2	96.0	15.4
1934	173.1	0.5	6.2	3.2	102.8	12.9
1935	165.0	-0.3	6.0	2.0	106.6	12.0
1936	158.7	-0.7	5.7	0.8	109.9	10.2
1937	147.2	-1.5	5.4	-0.1	114.7	8.5
1938	143.8	-3.7	5.2	-1.5	118.2	10.1

Notes:

All fiscal indicators are as %GDP.

The constant employment budget surplus is for the fiscal year, i.e., the first entry is 1929/30; a bigger positive indicates that fiscal policy has been tightened.

Sources:

Fiscal data: from database for Middleton (2010) generously made available by the author.

Real GDP: Feinstein (1972).

Unemployment: Boyer and Hatton (2002).

Table 2. Defence News: Estimates of Changes in Net Present Value of Expected Defence Expenditure (£ million, 1938 prices).

1920_{Q1}		1927_{Q1}		1934_{Q1}	
1920_{Q2}		1927_{Q2}	+2.2	1934_{Q2}	
1920_{Q3}		1927_{Q3}		1934_{Q3}	+44.3
1920_{Q4}	+36.0	1927_{Q4}		1934_{Q4}	
1921_{Q1}	+112.4	1928_{Q1}		1935_{Q1}	
1921_{Q2}		1928_{Q2}		1935_{Q2}	+178.2
1921_{Q3}	-36.7	1928_{Q3}		1935_{Q3}	
1921_{Q4}		1928_{Q4}		1935_{Q4}	
1922_{Q1}		1929_{Q1}		1936_{Q1}	+160.0
1922_{Q2}		1929_{Q2}		1936_{Q2}	
1922_{Q3}		1929_{Q3}		1936_{Q3}	
1922_{Q4}	-10.9	1929_{Q4}		1936_{Q4}	
1923_{Q1}		1930_{Q1}		1937_{Q1}	+393.0
1923_{Q2}	+72.4	1930_{Q2}		1937_{Q2}	
1923_{Q3}		1930_{Q3}		1937_{Q3}	
1923_{Q4}	-0.9	1930_{Q4}		1937_{Q4}	
1924_{Q1}		1931_{Q1}		1938_{Q1}	
1924_{Q2}	-22.1	1931_{Q2}	+7.0	1938_{Q2}	+98.8
1924_{Q3}		1931_{Q3}		1938_{Q3}	+29.1
1924_{Q4}		1931_{Q4}		1938_{Q4}	
1925_{Q1}		1932_{Q1}			
1925_{Q2}		1932_{Q2}	+52.0		
1925_{Q3}		1932_{Q3}			
1925_{Q4}		1932_{Q4}			
1926_{Q1}		1933_{Q1}			
1926_{Q2}	+0.9	1933_{Q2}			
1926_{Q3}		1933_{Q3}			
1926_{Q4}		1933_{Q4}			

Source: own calculations, see text.

Table 3. Barro and Redlick Specification Estimates

	∇y_t
constant	-0.0081 [6.1]
$news_{t-2}$	0.0416 [16.5]
$\nabla D_{t-2}/GDP_{t-3}$	-0.0787 [2.4]
$\nabla D_{t-3}/GDP_{t-4}$	-0.1607 [5.6]
$\nabla D_{t-4}/GDP_{t-5}$	0.0919 [2.7]
R^2	0.19
SE	0.0172

Note: Sample period is 1922q1 to 1938q4. Figures in parentheses are robust t-ratios. *SE* is the regression standard error. The estimates for the ARCH(1) error specification for equation (1) are $\hat{\delta}_0 = 3.37\times10^{-9}[195.3]$ and $\hat{\delta}_1 = 2.1797[4.6]$.

Table 4. Regression Estimates: Preferred Specifications

	(1) ∇y_t	(2) ∇d_t	(3) $\nabla non-d_t$	(4) ∇n_t
constant	0.0027 [2.3]	–	–	0.0126 [2.3]
$news_{t-2}$	0.0430 [5.2]	–	–	–
$news_{t-4}$	–	1.3880 [4.7]	0.3416 [1.4]	-0.1952 [1.9]
∇d_{t-1}	-0.0077 [4.6]	-0.7720 [8.2]	–	–
∇d_{t-2}	–	-0.4766 [4.4]	–	–
∇d_{t-3}	–	-0.3022 [2.0]	–	–
∇d_{t-4}	0.0114 [3.7]	0.3589 [4.0]	–	–
$\nabla non-d_{t-1}$	0.0203 [9.2]	–	-0.3991 [4.0]	–
$\nabla non-d_{t-2}$	-0.0321 [15.2]	–	-0.2906 [2.8]	–
$\nabla non-d_{t-3}$	-0.0247 [12.2]	–	-0.2678 [2.6]	–
$\nabla non-d_{t-4}$	–	–	0.5359 [5.7]	–
∇n_{t-1}	-0.2224 [32.1]	—	–	-0.5375 [4.6]
∇n_{t-2}	–	–	–	-0.3433 [2.2]
∇n_{t-3}	-0.1696 [21.9]	–	–	–
∇n_{t-4}	-0.0613 [8.5]	–	–	–
R^2	0.51	0.73	0.86	0.28
SE	0.0137	0.1223	0.1056	0.0424

Note: Sample period is 1922q1 to 1938q4. Figures in parentheses are t-ratios. *SE* is the regression standard error. The estimates for the ARCH(1) error specification for equation (5) are $\hat{\delta}_0 = 1.37\times 10^{-9}[209.4]$ and $\hat{\delta}_1 = 2.2023[4.6]$.

Table 5. Estimated Impact of Defence News Shocks on Real GDP (£million, 1938 prices)

	GDP Impact from Defence News (Total Multiplier)	*Impact as % Real GDP*	*Defence Expenditure*
1932_{Q1}	5.73	0.06	27.92
1932_{Q2}	3.01	0.03	28.38
1932_{Q3}	7.13	0.07	28.03
1932_{Q4}	3.04	0.31	26.89
1933_{Q1}	3.01	0.30	30.34
1933_{Q2}	3.07	0.31	28.43
1933_{Q3}	6.38	0.63	28.22
1933_{Q4}	6.86	0.66	27.81
1934_{Q1}	6.55	0.62	34.76
1934_{Q2}	7.05	0.66	28.35
1934_{Q3}	9.10	0.84	29.59
1934_{Q4}	7.49	0.69	31.33
1935_{Q1}	8.86	0.81	36.25
1935_{Q2}	9.13	0.82	30.49
1935_{Q3}	10.82	0.97	32.91
1935_{Q4}	19.66	1.73	39.50
1936_{Q1}	19.93	1.74	44.78
1936_{Q2}	18.96	1.63	40.27
1936_{Q3}	38.04	3.22	43.69
1936_{Q4}	40.75	3.45	49.48
1937_{Q1}	38.56	3.24	61.14
1937_{Q2}	42.72	3.54	47.13
1937_{Q3}	68.24	5.60	58.35
1937_{Q4}	63.88	5.24	66.61
1938_{Q1}	62.51	5.13	89.45
1938_{Q2}	91.91	7.58	65.43
1938_{Q3}	97.89	8.06	92.52
1938_{Q4}	95.48	7.82	80.18

Sources: defence-news impact based on own calculations, see text. Defence expenditure based on *The Economist* and Capie and Collins (1983), see data appendix; GDP from Mitchell et al. (2011).

Table 6. Fiscal Sustainability Data, 1925-1938

	b	*i*	*π*	*g*	*d*	*b**
1925-9 average	6.78	4.72	-0.99	2.22	1.636	5.71
1930	6.15	4.75	-0.40	-3.72	1.592	14.12
1931	5.41	4.51	-2.40	-2.37	1.698	15.76
1932	7.25	4.49	-3.58	0.65	1.736	12.88
1933	7.42	3.90	-1.40	4.74	1.792	1.00
1934	6.76	3.58	-0.68	4.78	1.731	-0.90
1935	5.68	3.64	0.87	4.26	1.650	-2.46
1936	4.95	3.59	0.55	4.15	1.587	-1.76
1937	3.89	3.67	3.73	3.17	1.472	-4.75
1938	1.56	3.62	2.77	0.42	1.438	0.62
1933-8 average	5.04	3.67	1.67	3.59	1.612	-1.38

Note:

*b** is the required primary budget surplus to GDP ratio to satisfy the condition that $\Delta P = 0$, where $\Delta P = -b + \left(i - \pi - \dot{Y}\right)P$.

Sources:

b, primary budget surplus to GDP ratio, i, average nominal interest rate on government debt, and *P*, public debt to GDP ratio from Middleton (2010) database; *π*, rate of inflation based on GDP deflator from Feinstein (1972); $\dot{Y}$, 4th quarter real GDP growth rate, from Mitchell et al. (2011).

Table 7. Critical Values of the Real Interest Rate of Government Borrowing for Fiscal Expansion to be 'Self-Financing' (%)

	μ = 0.5	*μ = 0.7*	*μ = 0.8*	*μ = 1.2*	*μ = 1.5*
Hysteresis η					
0.025	2.64	3.04	3.29	4.73	6.78
0.05	3.34	4.16	4.65	7.52	11.64
0.1	4.75	6.38	7.36	13.12	21.34
0.2	7.57	10.83	12.79	24.30	40.75

Notes:

This is analogous to Table 2 in DeLong and Summers (2012) but with $\dot{Y} = 1.93\%$ per year and $\tau = 0.44$.

Source: own calculations, see text.

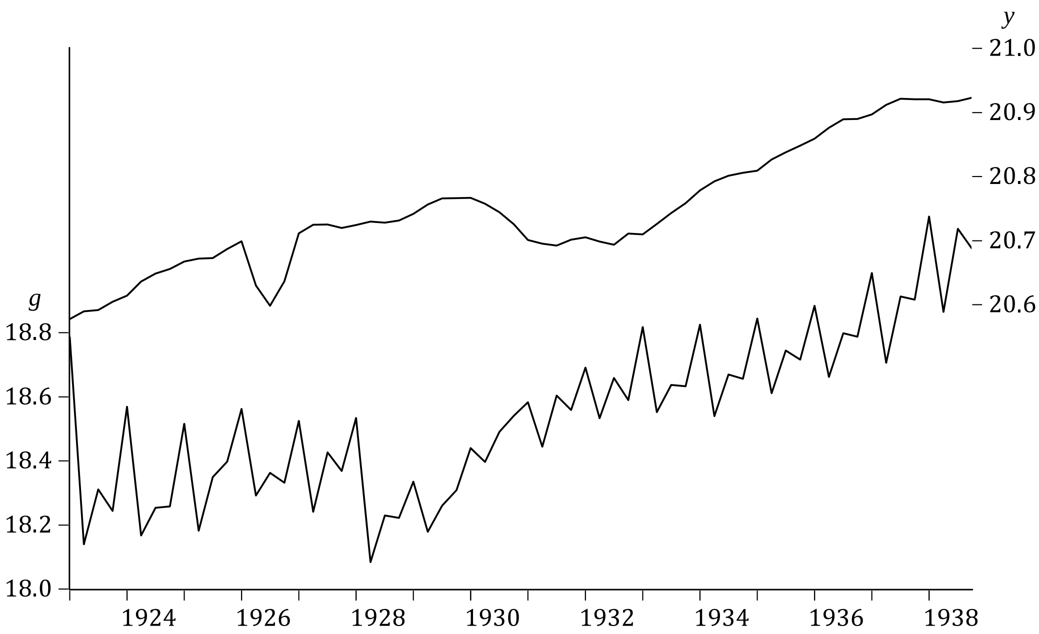

Figure 1 Logarithms of GDP (y) and government expenditure (g): 1923q1 – 1938q4.

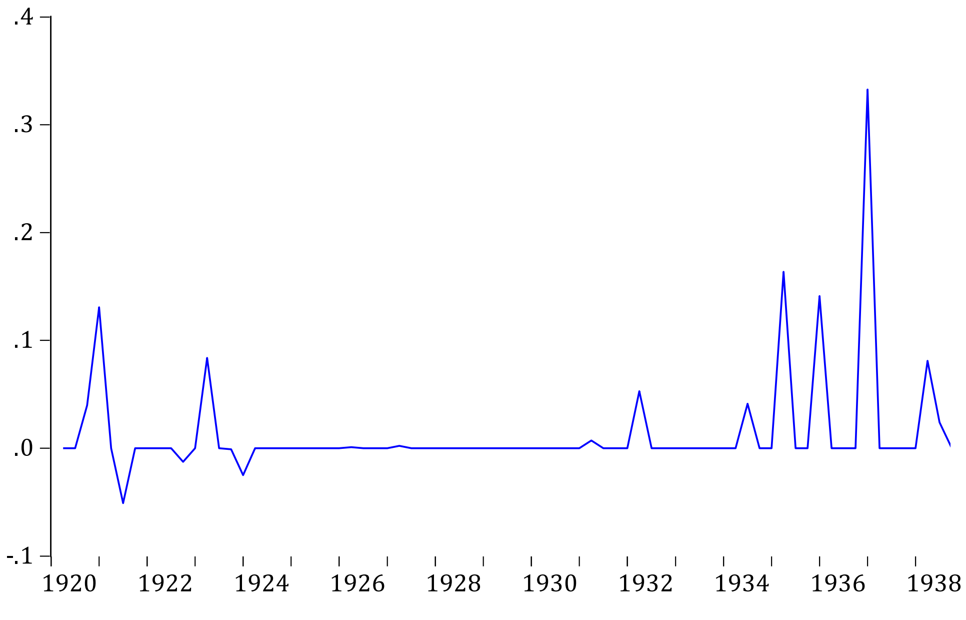

Figure 2 Defence news divided by lagged real GDP: 1920q1-1938q4.

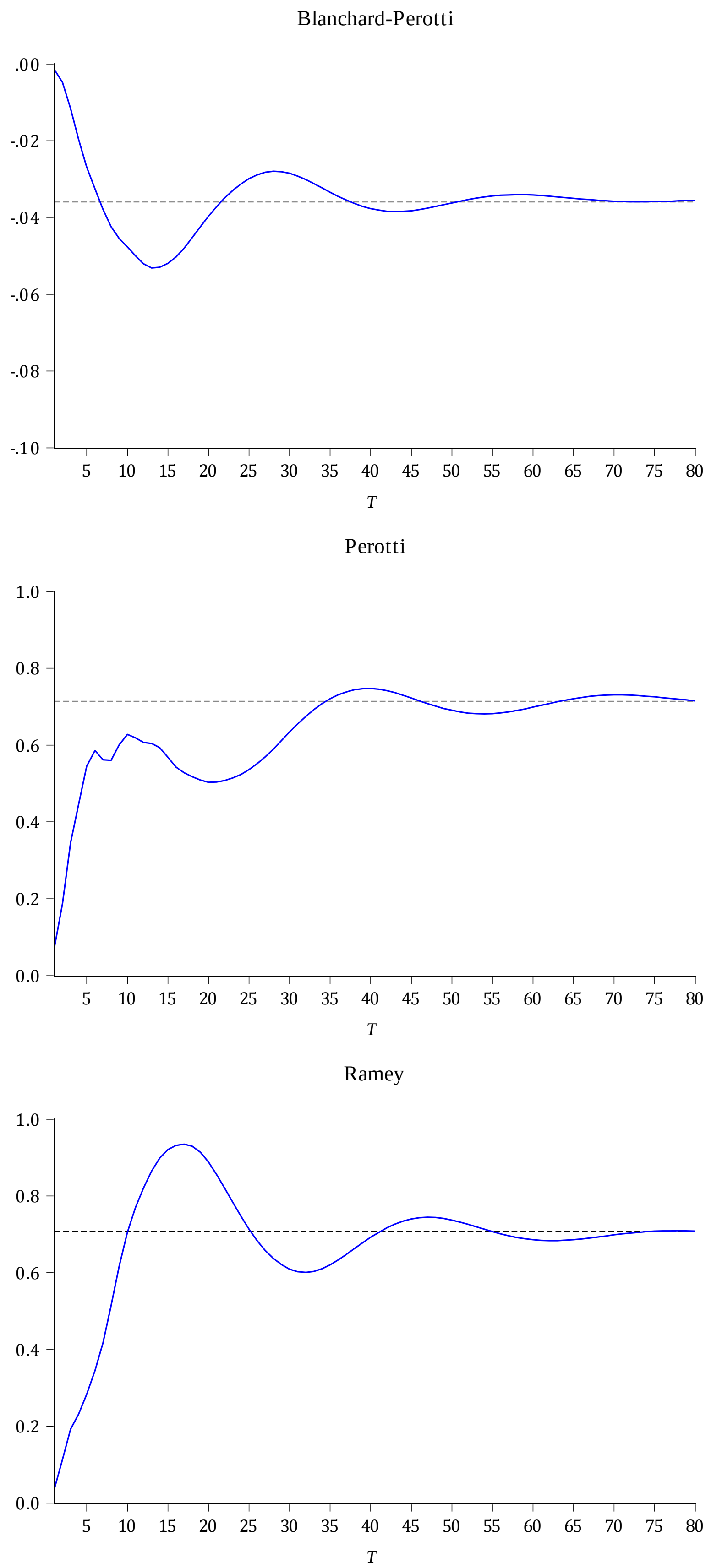

Figure 3 Multipliers computed from alternative VARs.

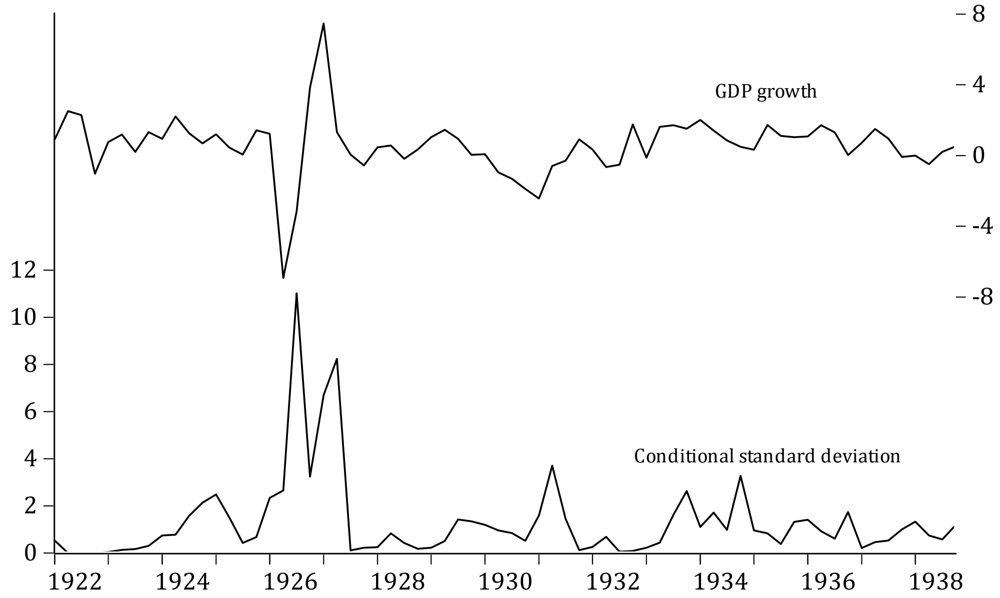

Figure 4 GDP growth and the conditional residual standard deviation from (5).

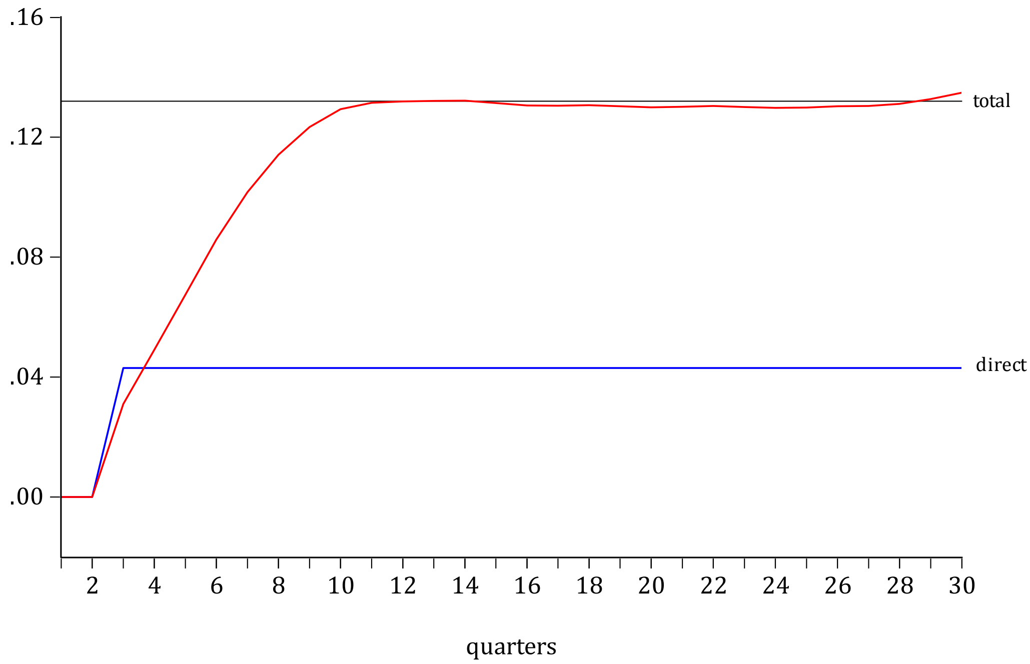

Figure 5 Defence news multipliers (total multiplier smoothed to remove seasonal variability).

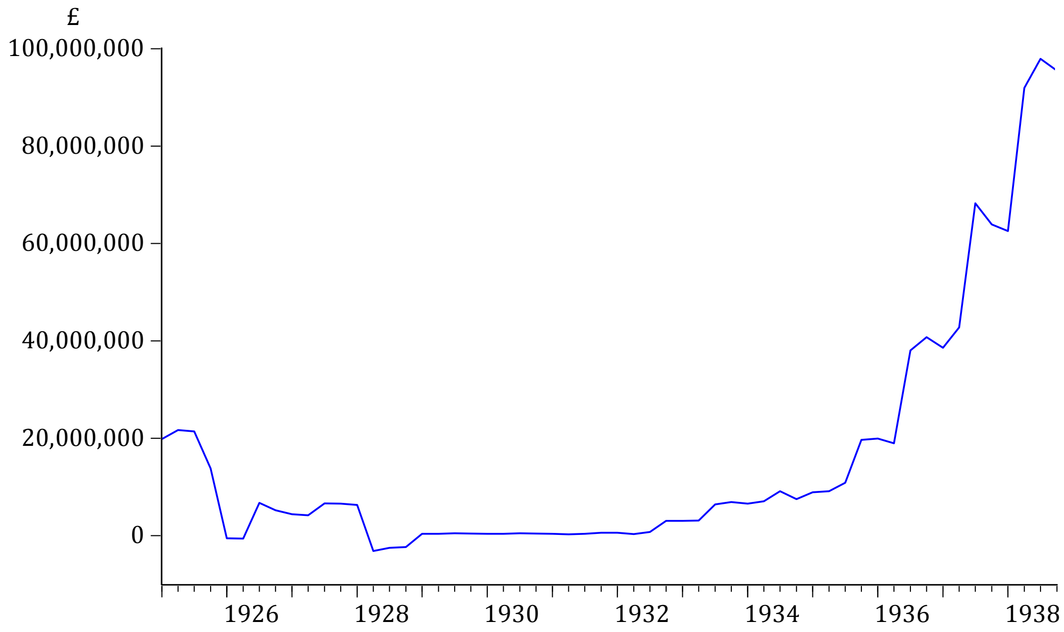

Figure 6 Effect of defence news shocks on GDP using a five-year horizon.

Data Appendix

The data sources for the variables used in the regressions are as follows:

Real GDP at 1938 prices: Mitchell et al. (2011), Table 2b.

Government expenditure on goods and services and on defence: as reported in *The Economist* on a quarterly basis at current prices in the first issue of January, April, July and October each year, converted into 1938 prices using the retail price index from Capie and Collins (1983), Table 2.14. Before 1921_{Q2}, defence expenditure was inferred using the annual total reported in Feinstein (1972), Table 33, allocated to quarters based on army numbers taken from *General Annual Report on the British Army* for years ending 30 September 1920 and 1921.

Defence News: derived as explained in Crafts (2012).

Exports: Capie and Collins (1983), Table 5.8, converted into 1938 prices.

Tax Rate: total tax revenues/GDP from Middleton (1996), Tables AI.1 and AI.2

Unemployment: Capie and Collins (1983) Table 4.5.

Money Multiplier: M1/monetary base from Capie and Webber (1985) , Table I.2. Before 1922_{Q1} M1 was estimated as M3/1.33 from Howson (1975), Appendix 1, Table 1.

Yield on Consols: Capie and Webber (1985), Table III.10.

Retail Sales: Capie and Collins (1983), Table 2.22.

Statistical Appendix

The Delta Method

An asymptotic standard error can be attached to the estimate of the long-run 'total' multiplier $m(1)$ by using the 'Delta Method': see, for example, Davidson and MacKinnon (2004, Chapter 5.6. We begin by gathering together the parameters of (3) in the vector $\boldsymbol{\psi}$:

$$\boldsymbol{\psi} = (\boldsymbol{\alpha}, \boldsymbol{\beta}_1, \boldsymbol{\beta}_2, \boldsymbol{\beta}_3, \boldsymbol{\theta}_1, \boldsymbol{\theta}_2, \boldsymbol{\theta}_3, \boldsymbol{\phi}_1, \boldsymbol{\phi}_2, \boldsymbol{\phi}_3)$$

where, for $j = 1,2,3$,

$$\boldsymbol{\alpha} = (\alpha_1, \ldots, \alpha_k)$$
$$\boldsymbol{\beta}_j = (\beta_{j1}, \ldots, \beta_{jk})$$
$$\boldsymbol{\theta}_j = (\theta_{j1}, \ldots, \theta_{jk})$$
$$\boldsymbol{\phi}_j = (\phi_{j1}, \ldots, \phi_{jk})$$

Attention then focuses on the non-linear transformation $\gamma = \mathbf{g}(\boldsymbol{\psi})$. The estimated covariance matrix of γ is given by

$$\hat{\Sigma}(\gamma) = \hat{\mathbf{G}}\hat{\Sigma}(\boldsymbol{\psi})\hat{\mathbf{G}}'$$

where $\hat{\Sigma}(\boldsymbol{\psi})$ is the estimated covariance matrix of $\boldsymbol{\psi}$ and $\mathbf{G}$ is a matrix of first derivatives with typical element $\partial g_i / \partial \hat{\psi}_j$. Here

$$\gamma = \mu(1) = \sum_{i=1}^{k} \alpha_i + \sum_{j=1}^{3} \left(\frac{\sum_{i=1}^{k} \beta_{ji} \sum_{i=1}^{k} \theta_{ji}}{1 - \sum_{i=1}^{k} \phi_{ji}} \right)$$

Thus

$$\hat{\mathbf{G}} = \left(\frac{\partial g}{\partial \boldsymbol{\alpha}}, \frac{\partial g}{\partial \beta_1}, \frac{\partial g}{\partial \beta_2}, \frac{\partial g}{\partial \beta_3}, \frac{\partial g}{\partial \theta_1}, \frac{\partial g}{\partial \theta_2}, \frac{\partial g}{\partial \theta_3}, \frac{\partial g}{\partial \phi_1}, \frac{\partial g}{\partial \phi_2}, \frac{\partial g}{\partial \phi_3} \right)$$

with, for $j = 1,2,3$ and $i = 1, \ldots, k$

$$\frac{\partial g}{\partial \alpha_i} = 1$$

$$\frac{\partial g}{\partial \beta_{ji}} = \frac{\sum_{i=1}^{k} \theta_{ji}}{1 - \sum_{i=1}^{k} \phi_{ji}}$$

$$\frac{\partial g}{\partial \theta_{ji}} = \frac{\sum_{i=1}^{k} \beta_{ji}}{1 - \sum_{i=1}^{k} \phi_{ji}}$$

$$\frac{\partial g}{\partial \phi_{ji}} = \frac{\sum_{i=1}^{k} \beta_{ji} \sum_{i=1}^{k} \theta_{ji}}{\left(1 - \sum_{i=1}^{k} \phi_{ji}\right)^2}$$

and

$$\hat{\Sigma}(\psi) = \begin{bmatrix} \hat{\Sigma}(\alpha, \beta) & \mathbf{0} & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \hat{\Sigma}(\theta_1, \phi_1) & \mathbf{0} & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \hat{\Sigma}(\theta_2, \phi_2) & \mathbf{0} \\ \mathbf{0} & \mathbf{0} & \mathbf{0} & \hat{\Sigma}(\theta_3, \phi_3) \end{bmatrix}$$

where $\hat{\Sigma}(\mathbf{x}, \mathbf{y})$ is the estimated covariance matrix for the parameter vectors **x** and **y**.

Table A1. Control Variable Estimates from Equations (4) and (5).

	(1)	(2)
∇ex_{t-2}	0.0453 [7.1]	0.0889 [17.4]
∇ex_{t-3}	0.0299 [7.0]	–
∇ex_{t-4}	-0.0249 [6.4]	–
∇mm_{t-3}	0.0331 [6.5]	-0.0402 [7.3]
∇mm_{t-4}	0.0747 [13.8]	0.0514 [8.4]
∇tax_{t-1}	-0.0118 [10.3]	-0.0090 [27.6]
∇R_{t-1}	-0.0066 [3.2]	-0.0077 [6.2]
un_{t-1}	–	-0.0053 [12.7]
un_{t-2}	0.0013 [5.0]	-0.0056 [13.4]
un_{t-3}	-0.0005 [2.0]	–

Note: ∇ex_t is export growth, ∇mm_t is the change in the money multiplier, ∇tax_t is the change in the money multiplier, ∇R_t is the change in the consol yield, and un_t is the unemployment rate. Figure in parentheses are robust t-ratios.

Table A2. Retail sales equation

	∇r_t
constant	0.0109 [3.8]
$news_{t-1}$	-0.0842 [2.1]
∇r_{t-3}	0.3243 [2.7]
R^2	0.33
SE	0.0115

Note: Sample period is 1933q1 to 1938q4. Figures in parentheses are t-ratios. *SE* is the regression standard error.