Online Appendix for 'The Macroeconomic Effects of Income and Consumption Tax Changes'

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Contents

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A Details of the Proxy-SVAR

The starting point is the two moment conditions of our identification scheme, see main text. Then, we can partition the matrix $\mathbf{\Gamma}$ introduced in the Main Text as

$$\mathbf{\Gamma} = \left[\underbrace{\gamma_1}_{n\times m} \quad \underbrace{\gamma_2}_{n\times(n-m)} \right], \quad \gamma_1 = \left[\underbrace{\gamma_{11}'}_{m\times m} \quad \underbrace{\gamma_{21}'}_{m\times(n-m)} \right]', \quad \gamma_2 = \left[\underbrace{\gamma_{12}'}_{(n-m)\times m} \quad \underbrace{\gamma_{22}'}_{(n-m)\times(n-m)} \right]',$$

with the necessary conditions that γ_{11} and γ_{22} are non-singular. From this, it can be shown that

$$\mathbf{\Psi}\gamma_1' = \Sigma_{q\mu'}. \tag{1}$$

This last condition provides extra restrictions. However, (1) is based on the $m \times m$ unknown elements of $\mathbf{\Psi}$. Without any further assumption on $\mathbf{\Psi}$, (1) provides only $(n-m)m$ identification restrictions. Using the partition $\Sigma_{q\mu'} = [\underbrace{\Sigma_{q\mu_1'}}_{m\times m} \quad \underbrace{\Sigma_{q\mu_2'}}_{m\times(n-m)}]$ and (1), we can write

$$\gamma_{11} = \left(\Sigma_{q\mu_1'}^{-1}\Sigma_{q\mu_2'}\right)'\gamma_{21}. \tag{2}$$

Because $\Sigma_{q\mu_1'}^{-1}\Sigma_{q\mu_2'}$ can be estimated, say, with the two-stage least squares method by regressing from $\mu_{2,t}$ on $\mu_{1,t}$, using q_t as instruments for $\mu_{1,t}$, (2) imposes extra covariance restrictions. Altogether, the 'Proxy-SVAR' is estimated using the following steps:

1. Estimate the reduced-form VAR model by OLS.
2. Estimate $\Sigma_{q\mu_1'}^{-1}\Sigma_{q\mu_2'}$ by regressing the residuals of the reduced-form VAR on the proxies q_t.
3. Use (2) to estimate the objects of study.
4. Impose further restrictions when $m > 1$ and the instruments for structural shocks $\epsilon_{1,t}$ are correlated with each other.

B Data Description

When not otherwise mentioned, the data source is the Office for National Statistics, the national statistical institute of the UK. All data are freely available to download.

- **Population** is UK total population, code EBAQ, Source: UK Economic Accounts time series dataset (UKEA), ONS (2016f).
- **Output** is the real GDP, code ABMI, Source: UK Economic Accounts time series dataset (UKEA), ONS (2016f).

- **Consumption** is the real final household consumption expenditure, code ABJR, Source: UK Economic Accounts time series dataset(UKEA), ONS (2016f).
- **Investment** is the real gross fixed capital formation, code NPQT, Source: UK Economic Accounts time series dataset (UKEA), ONS (2016f).
- **Households Consumption Expenditure Deflator** is the implicit deflator for final consumption expenditure by households and NPISH, code YBFS, Source: UK Economic Accounts time series dataset (UKEA), ONS (2016f).
- **Nominal Interest Rate** is the UK three-month treasury bill, Source: FRED (2015).
- **Income Tax Base** is the sum of total compensation of employees (code DTWM), gross operating surplus (code CGBZ) and mixed (self-employed) income (code CGBX), source UK Economic Accounts time series dataset (UKEA), ONS (2016f).
- **Nominal GDP**, code YBHA, UK Economic Accounts time series (UKEA), ONS (2016f).
- **Nominal consumption**, code ABJQ, UK Economic Accounts time series (UKEA), ONS (2016f).
- **GDP deflator** is the implicit price deflator for GDP, code YBGB, UK Economic Accounts time series (UKEA), ONS (2016f).
- **Government Spending** is the central government total managed expenditure calculated as the sum of Government Consumption Expenditures and Gross Investment, divided by GDP deflator, codes (ANLP+(-ANNS)+NSRN))/YBGB, Source: Public sector finances borrowing by sub-sector dataset, ONS (2016d).
- **Taxes on Income** are the receipts of our income tax categories, code NMCU, and National Insurance Contribution, code AIIH, Source: Public sector finances borrowing by sub-sector, ONS (2016f).
- **Total Consumption Tax Receipts** is the sum of:
  - VAT (code NZGF), Tobacco duties (code GTAO, Fuel duties (code CUDG), Vehicle duties, i.e. road tax (code CDDZ + EKED), Alcohol duties available from 1993 (code MF6V), Source: Public sector finances time series, ONS (2016e).
  - Air duties (APD)available from 1995, Source: HM Revenue and Customs, HMRC (2016a). Quarterly data is the sum of monthly data in the quarter.
  - Betting and Gaming duties available from 1986, Source: HM Revenue and Customs, HMRC (2016b). Quarterly data is the sum of monthly data in the quarter.
  - Insurance Premium tax IPT, from 1995, Source: HM Revenue and Customs, HMRC (2016c). Quarterly data is the sum of monthly data in the quarter.

- **Aggregate Tax Receipts** are the Total tax and NI receipts, codes NMBY + NMCU + LIQR + AIIH, Source: Public sector finances time series, ONS (2016e).

- **Narrative Aggregate Tax Changes** are unanticipated narrative tax changes from Cloyne (2013b).

- **Unemployment rate** unemployment rate (Age 16 and over) Claimant count and ILO measure, code MGSX, Source: Labour market statistics time series dataset (LMS), ONS (2016c).

- **NEER** is the nominal effective exchange rate, code NNGB, Source: BIS (2015).

- **Imports** are the real total imports in goods and services, code IKBL, Source: UK Economic Accounts time series dataset (UKEA), ONS (2016f).

- **Exports** are the real total exports in goods and services, code IKBK, Source: UK Economic Accounts time series (UKEA), ONS (2016f).

- **RPI** is the retail price index, code CHAW (for data from 1987Q1), Source: ONS (2016b). The series from 1987Q1 backwards are extrapolated based on the series of percentage change in RPI, code CZBH, Source: ONS (2016a).

- **Term of trade** is the ratio of export deflator (code YBFW) to import deflator (code YBFZ), Source: UK Economic Accounts time series datatset (UKEA), ONS (2016f).

- **Durable consumption** is the household final consumption expenditure for durable goods (code UTID), Source: UK Economic Accounts time series datatset (UKEA), ONS (2016f). ONS only reports the data from 1985Q1, so the series from 1985Q1 backwards are constructed based on the consumer trends data in the national archive using the same code, Source: National Archives (2004).

- **Non-Durable consumption** is the household final consumption expenditure for non-durable goods (code UTIL), Source: UK Economic Accounts time series datatset (UKEA), ONS (2016f). ONS only reports the data from 1985Q1, so the series from 1985Q1 backwards are constructed based on the consumer trends data in the national archive using the same code, Source: National Archives (2004).

Table B.1 – Inside Income and Consumption Taxes

Group	Sub-category
Income	1. Self assessed income tax.
	2. Capital gains tax.
	3. National Insurance Contributions.
	4. Pay As You Earn (PAYE) Income Tax.
	5. Other personal income taxes.
	6. Corporation tax.
	7. Petroleum revenue tax.
	8. Miscellaneous.
Consumption	1. Value Added Tax (VAT).
	2. Fuel Duties.
	3. Alcohol Duties.
	4. Tobacco Duties.
	5. Other Duties.

Notes: The category 'Other personal income taxes' mainly consists of repayments and those tax credits recorded as negative taxes plus company IT and TDSI (tax deduction scheme for interest). The category 'Other duties' includes: Vehicle excise duties (VED), taxes on betting, gaming, lottery, Camelot payments to National Lottery (from 1986 onwards), air passenger duty (from 1995 onwards), insurance premium tax (from 1995 onwards).

Table B.2 – Classification of different tax changes, Cloyne (2012, 2013a).

Group	Sub-category	Explanation and examples
Endogenous	1. Demand Management (**DM**)	1.a Targeting the aggregate level of demand e.g. to boost investment, consumption, growth, or curb inflation. 1.b Specific help to households and individuals by stimulating disposable income. 1.c Dealing with a balance of payments crisis via demand.
	2. Supply Stimulus (**SS**)	2.a Certain help for businesses during a downturn (e.g. NIC cut). 2.b Short term sector support (e.g. targeted tax cuts for a sector).
	3. Deficit Reduction (**DR**)	3.a Direct measures to deal with a budget or external deficit.
	4. Spending Driven (**SD**)	4.a Taxes which fund specific spending commitments contemporaneously caused.
Exogenous	1. Long-Run performance (**LR**)	1.a Measures to improve competitiveness, productivity, efficiency and long-run growth (but not taken to offset a shock). 1.b Simplification and deregulation measures. 1.c Long-term support for business or sectors of the economy.
	2. Ideological (**IL**)	2.a Long-term social or political goals, independent of their effect on performance and not to offset current shocks. 2.b Some anti-avoidance measures (where no other motive is given).
	3. External (**ET**)	3.a Court rulings and enforcement of directives.
	4. Deficit Consolidation (**DC**)	4.a Measures to lower inherited deficit for reasons of economic philosophy or to offset current actions in the future. 4.b Does not include actions forced on the government, or decisions contemporaneously motivated by a current shock.

C Properties of the Narrative Series

The 'exogeneity' of our narrative tax changes is a crucial assumption for the validity of our identification strategy. As shown in the main paper, we found no evidence that lagged macro variables Granger cause our narrative measure of tax changes $\Delta\tau_t^{i,n}$ and $\Delta\tau_t^{c,n}$. As we discuss here, this finding relies crucially on excluding from our narrative account, the tax changes announced in 1979:III and in 1988:II that we, as Cloyne (2012), classify as exogenous.

In the 1979 Budget (FSBR, 12 June 1979), there were major tax measures in both consumption and income taxes, aimed to switch part of the tax burden from earnings to spending. In the 1988 Budget (FSBR, 15 March 1988), there were changes in income taxes, mainly a reduction of basic rate and the abolition of higher rates of income tax. It is important to stress that we cannot precisely pinpoint the reason why these tax changes where predicted by lagged macro variables. However, given that these measures where introduced in the Budgets right after two general elections (3 May 1979 and 11 June 1987), it is likely that they were announced in electoral manifestos and thus expected by economic agents.[1]

In order to identify the incriminated policy measures, we proceed as follows. We run a set of Granger causality tests on each macro variable (GDP, consumption, investments and government spending) and jointly together, by excluding one tax change at a time from our narrative series. For the narrative series of consumption taxes, i.e. $\Delta\tau_t^{c,n}$, the tests reject non-causality in all cases but when the 1979:III tax changes are excluded. We therefore eliminate this consumption tax change from the series and, for consistency, we also exclude the exogenous income tax changes happening in the same budget. We repeat the same exercise for $\Delta\tau_t^{i,n}$ and found that the tests reject non-causality in all cases but when the 1988:II tax changes are excluded.

Table C.1 – Granger Non-Causality Tests for Narrative Consumption Tax Series

	With 1979:III		**Without 1979:III**	
	Test statistic	p-value	Test statistic	p-value
$\Delta ln(Y_t)$	10.76	0.03	0.33	0.99
$\Delta ln(C_t)$	26.79	0.00	0.90	0.92
$\Delta ln(I_t)$	2.97	0.56	0.92	0.92
$\Delta ln(G_t)$	4.71	0.32	7.17	0.13
All	57.58	0.00	10.04	0.86

Notes: The table shows the test statistic and its corresponding p-value of the test that the variable in the first column does not Granger cause narrative income tax series.

For the sake of brevity, Table C.1 and Table C.2 present the results from the Granger tests on each

[1] On the 12 of June 1979, during the presentation of the annual budget, the Chancellor of the Exchequer (Sir Geoffrey Howe) announced: 'We made it clear in our *manifesto* that we intended to switch some of the tax burden from taxes on earnings to taxes on spending. This is the only way that we can restore incentives and make it more worth while to work and, at the same time, increase the freedom of choice of the individual. We must make a start now', HC Deb 12 June 1979 vol 968 cc249-250. Similarly, on the 15 of March 1988, during the presentation of the annual budget, the Chancellor of the Exchequer (Sir Nigel Lawson) announced: 'In our general *election manifesto* last year, we committed ourselves to reducing the basic rate of income tax to 25 pence in the pound as soon as it was prudent to do so. This pledge followed a reduction of twopence in the pound to 27 pence in last year's Budget.' HC Deb 15 March 1988 vol 129 cc1006-13.

narrative variable with and without the mentioned policy measures. As required by the test, we use the first (log) difference for non-stationary variables. The test rejects the null hypothesis that lagged macro variables do not Granger cause our narrative measure of consumption tax changes when the 1979:III episode is included (Table C.1). In particular the consumption tax changes can be predicted by GDP ($p = 0.03$), private consumption ($p \approx 0$) and when we consider all macro variables together ($p \approx 0$). On the other hand, when we exclude the tax changes in 1979:III, the same test cannot reject the null on each macro variable and when they are tested together. Similarly, the test rejects the null hypothesis that lagged macro variables do not Granger cause our narrative measure of income tax changes when the 1988:II episode is included (Table C.2). In this case our narrative account of income tax changes can be predicted by past investments ($p = 0.02$). Once this episode is removed, we find no evidence that lagged macro variables Granger cause our narrative measure of income tax changes.

Table C.2 – Granger Non-Causality Tests for Narrative Income Tax Series

	With 1988:II		**Without 1988:II**	
	Test statistic	p-value	Test statistic	p-value
$\Delta ln(Y_t)$	2.40	0.66	5.61	0.23
$\Delta ln(C_t)$	0.73	0.95	1.36	0.85
$\Delta ln(I_t)$	11.38	0.02	3.56	0.47
$\Delta ln(G_t)$	5.94	0.20	1.04	0.90
All	22.47	0.17	11.55	0.77

Notes: The table shows the test statistic and its corresponding p-value of the test that the variable in the first column does not Granger cause narrative income tax series.

In addition, we find that the correlations between the principal components of the narrative tax changes and the latent tax shocks are 0.28 and 0.80 when the policy measures at 1979:III and 1988:II are included in our narrative account. Also, the R^2 statistics for regressions of the reduced form residuals of ACTR and AITR on non zero observations of the proxies are 0.29 and 0.006, respectively. These numbers are substantially smaller than the corresponding ones of the benchmark specification. This feature remains when using the errors of these narrative changes in 1979:III and 1988:II from estimating narrative measures (including those in 1979 and 1988) on a set of macroeconomic variables. More importantly, as aforementioned, these changes are likely anticipated.

To sum up, we do not include the tax measures legislated at 1979:III and 1988:II into our narrative series in order to comply with 'exogeneity' condition, necessary for our identification strategy. In doing so, we also improve the reliability of the proxy and the correlation between our narrative measures and the latent tax shocks.

D Tax Shocks in a General Equilibrium Model

Here we present a Dynamic Stochastic General Equilibrium (DSGE) closed-economy model with capital accumulation and a fiscal sector, similar to, inter alia, Mertens and Ravn (2011) and Schmitt-Grohé and Uribe (2012). This model is not meant to provide any definitive quantitative answers, but rather serves as intuition for the empirical results in the main text.

Let us begin by giving a brief overview of the model. The agents in our economy are: a continuum of identical households, a representative final good firm and the Government. Markets are perfectly competitive so agents are price takers. The Government provides a uniform public good, set transfers and balances its budget by levying income and consumption taxes and by issuing government bonds. Time is discrete.

Households. There is a continuum of identical households of mass 1, who consume, save and supply labour and capital in order to maximise their utility function given by

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t u\left(x_t, \ell_t\right), \tag{3}$$

where $\mathbb{E}_0$ represents the rational-expectations operator at time 0, $\beta \in (0,1)$ is the discount factor, x_t is the habit-adjusted measure of consumption, i.e. $x_t = c_t - \theta c_{t-1}$, c_t represents private consumption at time t and θ identifies the strength of (internal) habits, while ℓ_t represents leisure at time t; subject to the time constraint

$$h_t + \ell_t = 1, \ \forall t, \tag{4}$$

where h_t represents hours worked, and the flow real budget constraint

$$\left[\left(1+\tau_t^c\right)c_t + i_t\right] + \frac{1}{R_t} b_{t+1} = \left[\left(r_t^k - \delta\right)k_t + w_t h_t\right]\left(1-\tau_t^i\right) + b_t - \tau^{LS}, \ \forall t, \tag{5}$$

where τ_t^c represents the consumption tax rate, i_t is investment, R_t is the nominal short-term interest rate, b_{t+1} is the quantity of risk-less one-period government bonds, paying one unit of account in period $t+1$, k_t is the quantity of capital, r_t^k represents the real rental rate of capital, w_t is the real wage and τ_t^i is the income tax rate, where current income consists of labour income and capital income. Finally, δ is the capital depreciation rate and τ^{LS} represents a steady-state lump-sum taxes or transfers.

Physical capital, k_t, accumulates according to:

$$k_{t+1} = \left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right)\right] i_t + (1-\delta)k_t . \forall t \tag{6}$$

As in Christiano et al. (2005) and many others, the function $\Phi(\bullet)$ measures an investment adjustment cost and satisfies $\Phi(1) = \Phi'(1) = 0$, and $\Phi''(1) = \kappa \geq 0$, i.e. $\Phi\left(\frac{i_t}{i_{t-1}}\right) = \frac{\kappa}{2}\left(\frac{i_t}{i_{t-1}} - 1\right)^2$.

Denoting with λ_t and μ_t the Lagrangean Multipliers on the budget constraint and the accumulation of capital, respectively, and with $u_{z,t}$ the derivative at time t of a function $u(\cdot)$ with respect to the variable

z, the First Order Conditions of the Household problem are:

$$x_t : u_{x,t} - \beta\theta\mathbb{E}_t u_{x,t+1} = (1+\tau_t^c)\lambda_t, \tag{7}$$

$$\ell_t : -u_{(1-\ell),t} = \lambda_t w_t \left(1-\tau_t^i\right), \tag{8}$$

$$b_{t+1} : \lambda_t = \beta\mathbb{E}_t\left(\lambda_{t+1}R_t\right), \tag{9}$$

$$k_{t+1} : \mu_t = \beta\mathbb{E}_t\left[(1-\delta)\mu_{t+1} + \lambda_{t+1}\left(r_{t+1}^k - \delta\right)\left(1-\tau_{t+1}^i\right)\right], \tag{10}$$

$$i_t : \lambda_t = \mu_t\left[1 - \Phi\left(\frac{i_t}{i_{t-1}}\right) - \Phi'\left(\frac{i_t}{i_{t-1}}\right)\frac{i_t}{i_{t-1}}\right] + \beta\mathbb{E}_t\mu_{t+1}\left[\Phi'\left(\frac{i_{t+1}}{i_t}\right)\left(\frac{i_{t+1}}{i_t}\right)^2\right], \tag{11}$$

Firms. There is a representative good producer who operates in a perfectly competitive manner. It has access to a Cobb-Douglas production function technology of the type

$$y_t = k_t^\alpha h_t^{1-\alpha}, \tag{12}$$

where k_t and h_t are the amount of capital and labour hired, respectively, and α represents the capital income share. Optimal behaviour implies that factors are remunerated at their marginal products, i.e.

$$w_t = (1-\alpha)\left(\frac{k_t}{h_t}\right)^\alpha, \tag{13}$$

$$r_t = \alpha\left(\frac{h_t}{k_t}\right)^{1-\alpha}. \tag{14}$$

Fiscal Policy. The fiscal authority finances an exogenously determined level of government spending, g_t, through taxes from various sources and by issuing a one-period discount bond, b_{t+1}. Its budget constraint is

$$g_t + b_t = \frac{1}{R_t}b_{t+1} + tax_t + \tau^{LS}, \tag{15}$$

where tax_t is the total government receipts (in real terms) from distortionary tax components, i.e.

$$tax_t = \tau_t^c c_t + \left[\left(r_t^k - \delta\right)k_t + w_t h_t\right]\tau_t^i. \tag{16}$$

Income and consumption tax rates are assumed to be stochastic and to evolve according to standard AR(1) processes:

$$\tau_t^c = (1-\rho_c)\,\bar{\tau}^c + \rho_c\tau_{t-1}^c + \epsilon_t^c, \tag{17}$$

$$\tau_t^i = (1-\rho_i)\,\bar{\tau}^i + \rho_i\tau_{t-1}^i + \epsilon_t^i. \tag{18}$$

For the aim of this exercise we assume that government spending follows a simple rule that guarantees stationary debt dynamics, i.e.

$$g_t = g\left(\frac{1+b_t}{1+b}\right)^{-\pi_G}, \tag{19}$$

where $\pi_G > 0$ is a policy parameter governing the strength of the response of public spending to movement in public debt.[2]

Aggregation and Equilibrium. Using the structural equations of the model one can construct an aggregate measure of aggregate demand, i.e. the market clearing, as

$$y_t = c_t + g_t + i_t. \tag{20}$$

We are now ready to define the equilibrium.

Definition 1 (Decentralised Equilibrium) *A decentralised equilibrium consists of policies,* $\left\{tax_t, \tau_t^i, \tau_t^c, \tau_t^{LS}, b_{t+1}\right\}_{t=1}^{\infty}$*, prices,* $\left\{R_t, w_t, r_t^k, \lambda_t, \mu_t\right\}_{t=1}^{\infty}$*, and allocations,* $\{x_t, c_t, \ell_t, h_t, i_t, g_t, k_t, y_t\}_{t=1}^{\infty}$*, satisfying,*

(i) the time constraint, (4), the evolution of capital and the household's first order conditions, i.e. (6)-(11);

(ii) the production function and first order conditions of the representative firm, i.e. (12)-(14);

(iii) fiscal policies, i.e. (15)-(19);

(iv) the market clearing condition, i.e.(20),

given the initial conditions on b_0*,* k_0*,* τ_{-1}^i *and* τ_{-1}^c*.*

Solution and Calibration. As it is standard in the literature, we solve the model by taking the first order (log) Taylor expansion of the system of non-linear structural equations around the non-stochastic steady-state. We also need to make a few more assumptions. We specify the utility function to be

$$u(x_t, \ell_t) = \frac{x_t^{1-\sigma}}{1-\sigma} - \alpha_\ell \frac{(1-\ell_t)^{1+1/\varphi}}{1+1/\varphi}, \tag{21}$$

where σ is the CRRA parameter, α_ℓ is the relative weight of leisure in the utility function and φ is the Frisch elasticity of labour supply.

The model is parametrised at a quarterly frequency for the sample under consideration. While we do not intend to give any quantitative guideline, we still want to discipline our model in a sensible manner. We use data are taken from the ONS and Trabandt and Uhlig (2011).[3] The average real annual interest rate over the period is 2.57 percent. We therefore set $\beta = 0.993$. Following the literature, e.g.

[2] As alternative one could derive the same results with zero public debt and a rule adjusting government spending and lump-sum taxes in response to movement in fiscal revenues, e.g. Mertens and Ravn (2011) or with a fiscal rule where government spending is fixed at its steady state level and all movements in fiscal revenues are compensated with lump-sum taxes.

[3] Data can be found at https://sites.google.com/site/mathiastrabandt/home/research.

Kimball and Shapiro (2008), we set the Frisch elasticity to 1 and we fix the utility weight on leisure α_ℓ, such that in the decentralised equilibrium households work 23 percent of their time, as suggested by the data. We follow the literature and set $\sigma = 1$, so that the utility function collapses to the log case. We set the parameter on internal habits, θ to 0.9, as estimated by Zubairy (2014). The capital income share, α, and the capital depreciation rate, δ, are calibrated so that the model matches the capital income share and the ratio of private investment to GDP ($\alpha = 0.41$ and $\delta = 0.018$). The steady state level of consumption and income tax rates are set as average of these two tax components over the sample, i.e. $\bar{\tau}^c = 0.173$ and $\bar{\tau}^i = 0.216$. The steady-state level of public debt ($\bar{b}$) is set to 48 percent of GDP and the steady state level of government spending to GDP is set to 0.23, see Trabandt and Uhlig (2011). Finally transfers are set such that in the steady-state the government budget constraint is respected. We find a transfer of 4 percent of GDP, i.e. $\bar{\tau}^L/\bar{y} = 0.04$. We set the persistence of the tax shocks to 0.9, i.e. $\rho_c = \rho_i = 0.9$, consistent with various estimates of the persistence of tax shocks, e.g. Zubairy (2014) and Sims and Wolff (2018). We set the parameter governing the investment adjustment cost, $\kappa = 2.5$, as estimated by Christiano et al. (2005). Finally we set the policy parameter $\gamma_b = 0.15$. This value guarantees that debt is mean reverting. Table D.1 summarises the parametrisation of the model.

Table D.1 – Parametrisation

Parameter	Definition	Value	Restriction
β	Discount Factor	0.993	Data-Targeted moment
φ	Frisch Elasticity	1	Literature (Kimball and Shapiro, 2008)
α_ℓ	Utility Weight on Leisure	12.27	Model restriction
σ	CRRA parameter	1	Literature, various sources
θ	Habit parameter	0.9	Literature (Zubairy, 2014)
α	Capital Income Share	0.41	Data-Targeted moment
δ	Capital Depreciation	0.018	Data-Targeted moment
$\bar{\tau}^c$	steady-state ACTR	0.173	Data-Targeted moment
$\bar{\tau}^i$	steady-state AITR	0.216	Data-Targeted moment
ρ_i	Income Tax Shock Persistence	0.9	Literature (Zubairy, 2014)
ρ_c	Consumption Tax Shock Persistence	0.9	Literature (Sims and Wolff, 2018)
$\frac{\bar{b}}{\bar{y}}$	steady-state debt-to-GDP	0.48	Data-Targeted moment
$\frac{\bar{\tau}^L}{\bar{y}}$	steady-state transfer-to-GDP	0.04	Model restriction
κ	Investment Adjustment Cost	2.5	Literature (Christiano et al., 2005)
γ_b	Debt Feedback Parameter	0.15	Model restriction

Policy Experiment 1: Consumption and Income Tax Shocks This model can be used to obtain a theoretical counterpart for the empirical analysis presented in the main text. This will allow to generate model-based intuitions behind our results. To this end we conduct two different policy experiments. In the first one we shock the model with two independent shocks, one to τ_t^c and one to τ_t^i. The relative size of the two shocks are set such that they have the same effects on aggregate tax revenues. In this way we control for any effects due to different tax basis between consumption and income taxation. Results from this exercise are displayed in Figure D.1.

Consistent with the literature, e.g. Fernández-Villaverde (2010) and Sims and Wolff (2018), we obtain that the income tax multipliers are much larger than consumption tax multipliers. Given our parametrisation, the peak effect of an unexpected cut in τ^i on GDP is several times bigger than a consumption tax cut counterpart (0.28 Vs. 0.04).[4]

Furthermore, while an income tax cut boosts not only GDP but also all its private components, a reduction in consumption tax lowers investment in equilibrium. This is because changes in τ^c trigger a substitution effect between consumption and investment, via a change in their relative price. The crowding out effect on investment lowers the accumulation of capital over time, thus reducing (compared with an income tax shock) the response of private consumption and hours worked.

Another effect of consumption tax is that, for a given level fiscal revenues, this tax component combines a one-time, non-distortionary lump-sum on part of the initial level of wealth with an income tax. This can be seen through the household budget constraint in (5). Since income tax itself is distortionary, it is natural to expect that the wealth effect of a cut in consumption tax to be smaller than the one implied by a cut in income tax.[5]

Summarising, we find two distinct reasons of why consumption tax multipliers are smaller than income tax multipliers. First of all, there is a substitution effect. Reducing τ^c crowds out investment and therefore future consumption and hours worked. Second, there is weaker wealth effect in cutting consumption tax, as part of this cut simply reduces a one-time, indirect lump-sum on the inelastically supplied initial level of wealth.

It is important to stress that the model provides a neat and transparent way of thinking about the different margins and wedges of distinct tax components. However our model is not able to capture the quantitative size of the empirical response of a income tax shock. This said, the size of our theory-based fiscal multipliers are in line with the literature, see inter alia, Leeper and Yang (2008) and Zubairy (2014).[6]

[4]We obtain similar relative results when we calculate the Present Values Multipliers (PVM) as in the empirical counterpart. In this case we obtain that after fours years the PVMs are 0.52 and 0.06 for income and consumption tax shocks, respectively.

[5]A formal proof of this second effect can be found in Correia (2010), page 1678.

[6]Another important aspect worth mentioning is that we consider shocks to AITR and ACTR under the assumption that the government reacts to either tax change with the same fiscal rule, represented by equation (19). In reality governments might decide to respond differently to changes in distinct tax components. This seems to be the case for the UK, where we find that governments reacts by adjusting government spending after an AITR change, i.e. Figures (2) of the Main Text and (E.10), and adjusting public debt after an ACTR change, i.e. Figures (3) of the Main Text and (E.10). As mentioned above, all our results are robust to different fiscal rules.

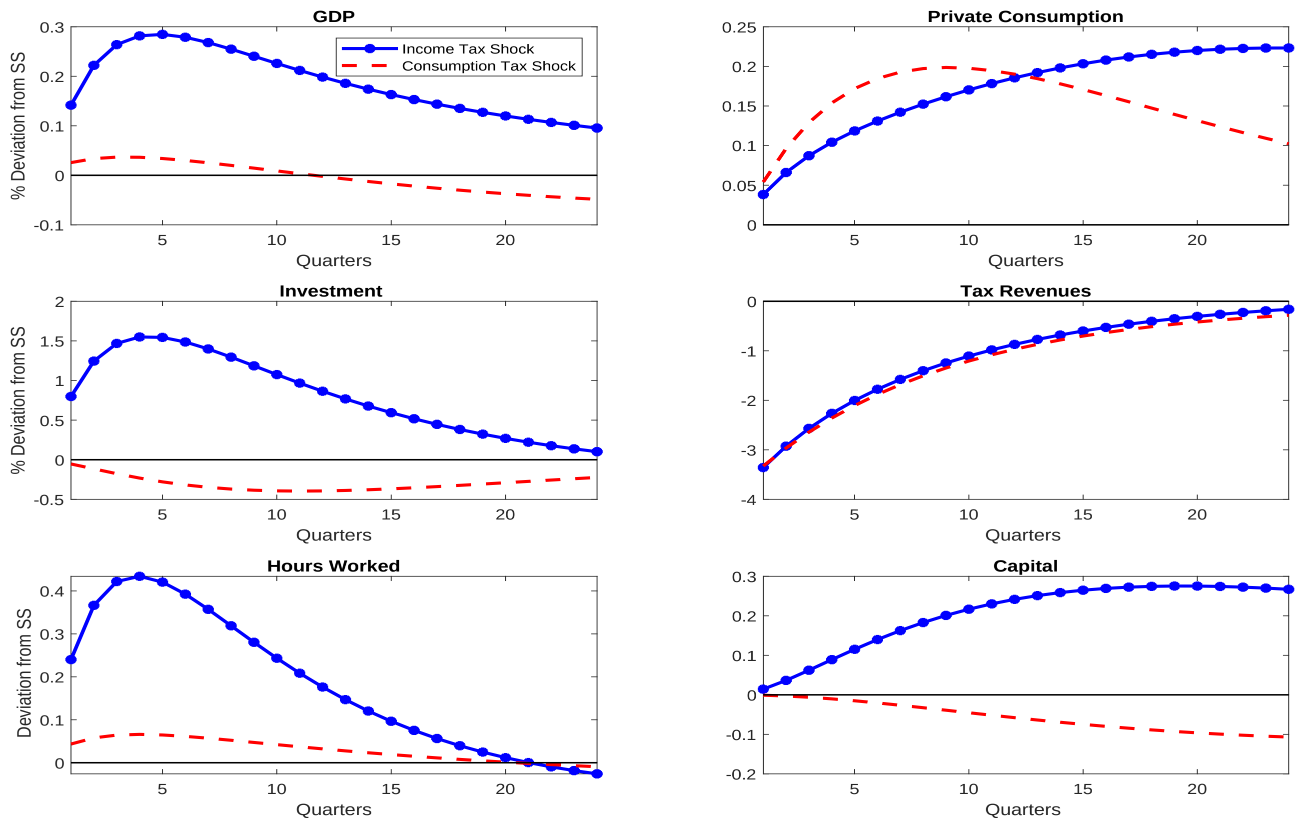


Figure D.1 – DSGE model IRFs for Income and Consumption Tax Shocks. Shocks are normalised so to imply the same effects on revenues.

Policy Experiment 2: Revenue Neutral Tax Tax Change Having explored the transmission mechanism of income and consumption tax, we can now present the theoretical counterpart of shifting the composition of taxation from income to consumption. The exercise is conduct as follows. We shock the income tax rate, and we impose that consumption tax responds in equilibrium in such that revenues do not change. In other words, this policy is neutral on the equilibrium level of debt. Results from this experiment are displayed in Figure D.2.

In the first period of the reform GDP, investment and hours worked increase. Consumption instead reacts but later on as it remains at zero for the first three quarters. Capital accumulation builds up over time, consistent with the increase in investment. In other words and consistent with the conventional public finance literature, e.g. Auerbach et al. (1983), Altig et al. (2001) and Correia (2010), the revenue neutral policy is expansionary. As explained before, an income tax change triggers wealth and substitution effects that are much larger than consumption tax. This means that for a given level of revenues, changing the tax composition from income to consumption increases efficiency.

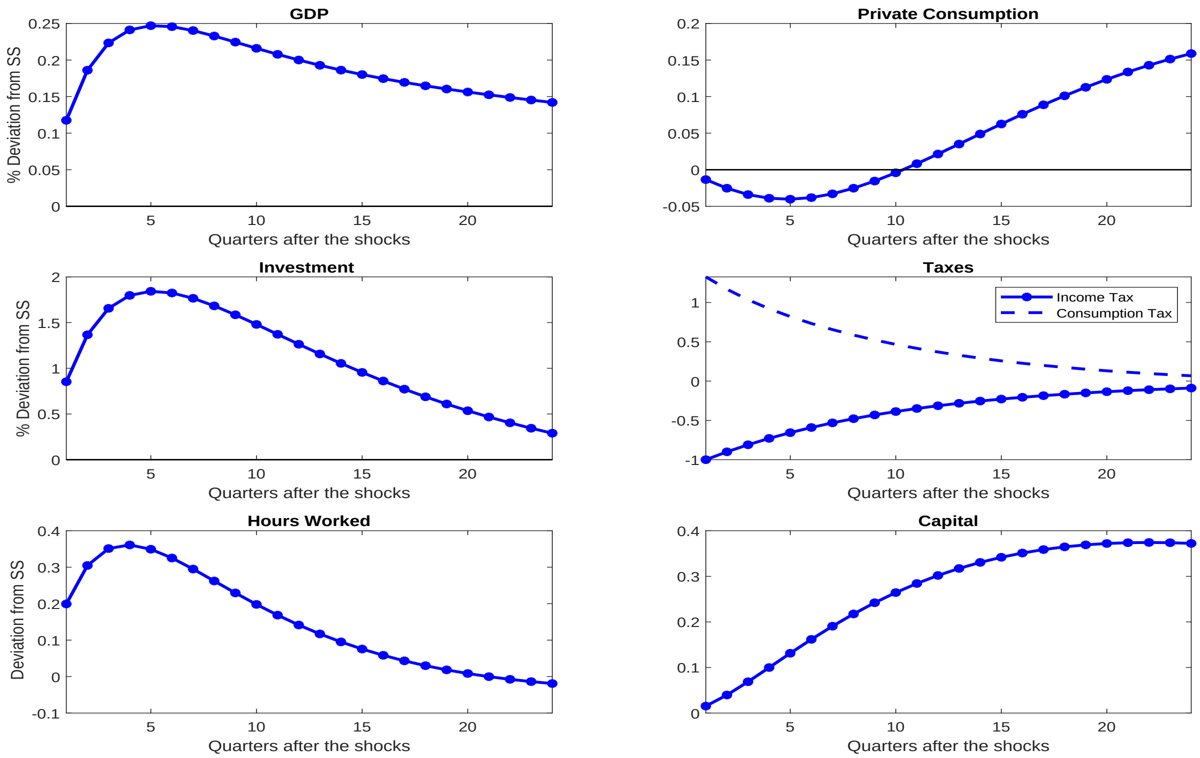


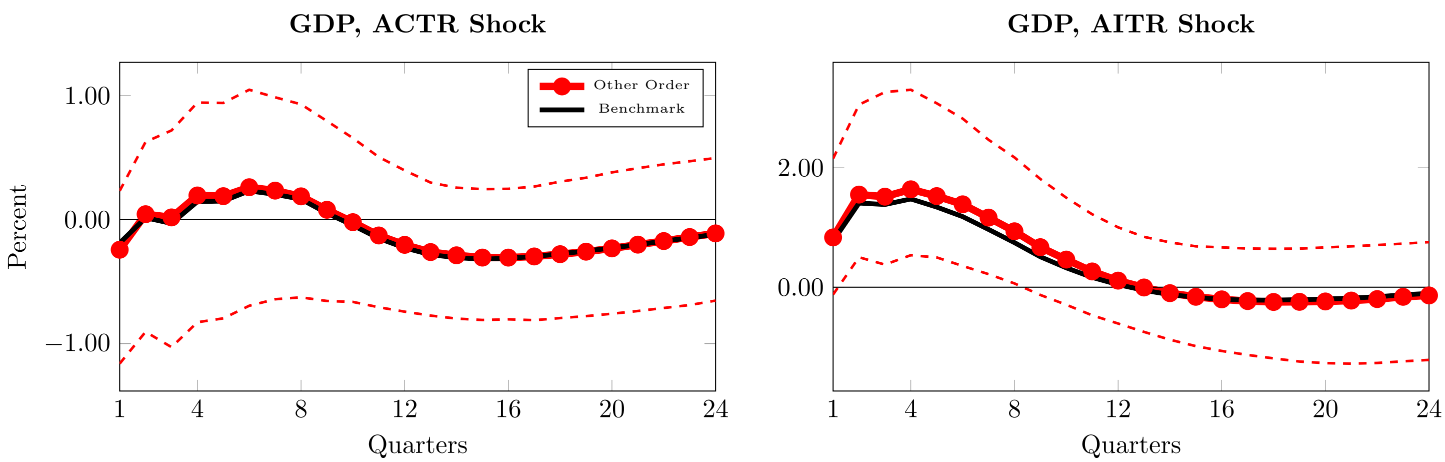
Figure D.2 – DSGE model IRFs for Revenue Neutral Exercise.

E Robustness

E.1 Different Tax Ordering

We start this section by providing robustness regarding the tax ordering. As described in the main text, only the upper triangular restriction ($B_{2,1} = 0$) required by our Cholesky identification, isolates the effects of an unexpected change in AITR, while only the lower triangular restriction ($B_{1,2} = 0$) isolates the effects of an unexpected change in ACTR. Here the reader can find the estimates resulting from the alternative ordering ($B_{1,2} = 0$ for AITR shock and $B_{2,1} = 0$ for ACTR shock) of the tax rate of interest. Results from this exercise are reported in Figure E.1. For all practical purposes, results are identical for GDP and all the other observables in the Benchmark presented in the main text, irrespective of the order imposed in the Cholesky identification.

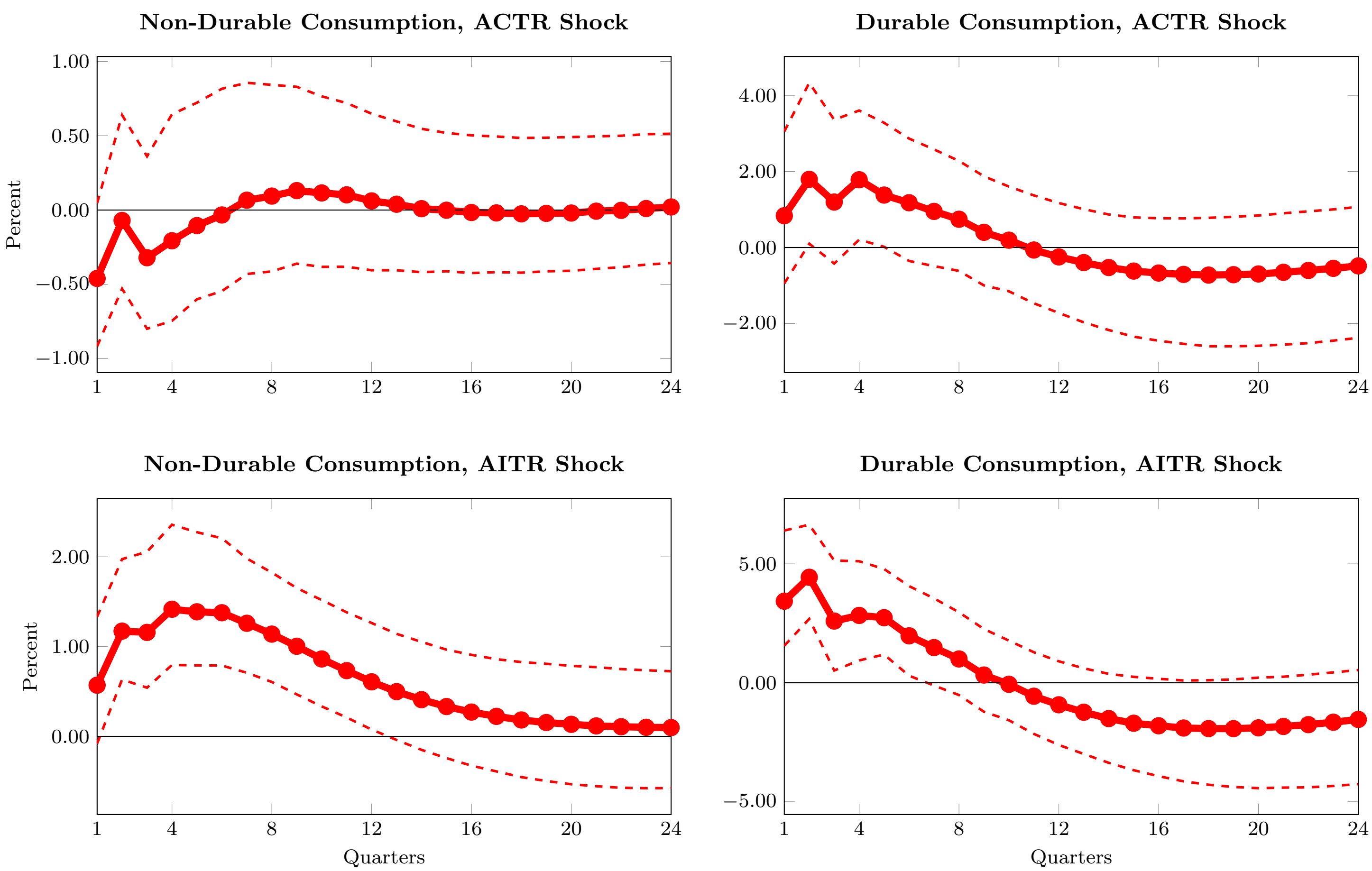
Figure E.1 – IRFs with Different Cholesky Ordering. Broken lines represent the 68 percent confidence bounds.



E.2 Durable and Non-Durable Consumption

This part studies the transmission mechanism of our tax shocks to other components of households expenditure, such as durable purchases. The econometric model includes durable and non-durable expenditure into the set of observables as in our baseline specification presented in the main text, respectively. Results from this exercise are reported in Figure E.2. We find that non-durable consumption responds significantly to an AITR shock, with a maximal response of 1.40 ($p = 0.02$), while the response of the same component to an ACTR shock is not statistically different to zero. Perhaps more interestingly, we find a marginally significant effect of durable consumption to a consumption tax shock, with a peak response of 1.8 percent ($p = 0.14$) in the fourth quarter. We also find that a cut in AITR has a big effect on durable goods, with a peak response of around 5 percent ($p = 0.04$) in the second quarter after the shock.

Figure E.2 – IRFs of Non-Durable and Durable Consumption. Broken lines represent the 68 percent Confidence Bounds.



E.3 Labour Market Variables

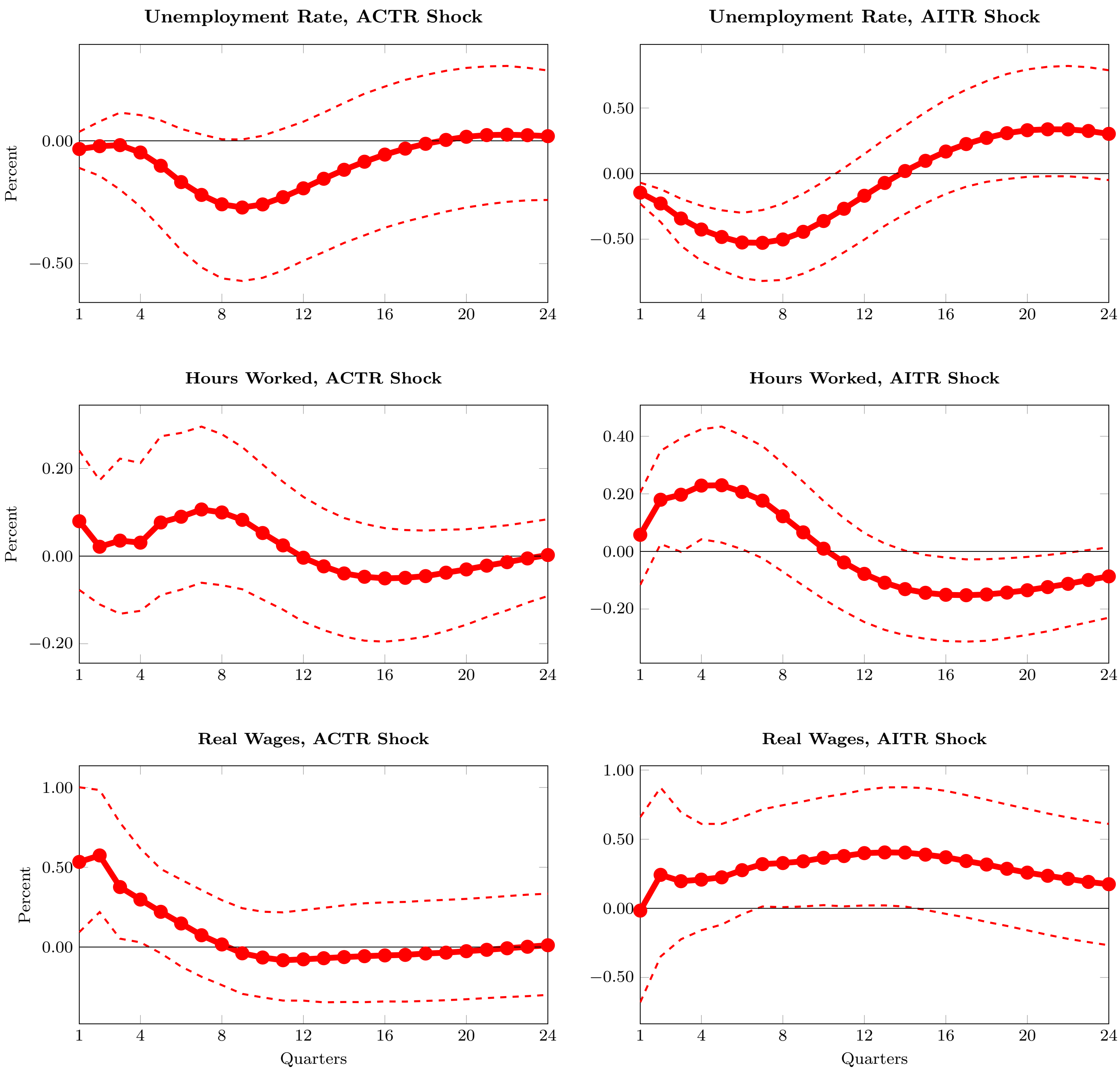
This section presents a set of findings resulting from expanding the set of observable variables in our econometric model, while keeping unchanged our baseline identification strategy. For the sake of brevity, for each extension of the baseline model we report only the IRFs of the variables of interest. Moreover, we present the response to a shock to a tax component resulting from ordering that tax rate last, leaving the other unchanged in cyclically adjusted terms.

The extension includes labour market variables such as the unemployment rate, hours worked and real wages in our baseline model. Including these variables is important as they are often the primary targets of short and long run macroeconomic policies. Results from this estimation are presented in Figure E.3.

The key result from this exercise is that a 1 percentage point decrease in AITR generates important expansionary effects on the labour market. We register a significant reduction of the unemployment rate, with a peak effect of -0.52 ($p = 0.045$), 6 quarters after the tax cut, a significant increase in hours worked with a peak effect of 0.23 ($p = 0.13$) and a borderline and delayed expansionary effect on Real Wages. Differently, a one percentage point cut in ACTR has a small and not significant effect on the unemployment rate and on hours worked. We register a positive response on impact of real wages, mainly due to accounting reasons, see the response of prices in Figure (3) of the Main Text. Therefore this experiment confirms the main conclusions of the paper. Cutting AITR is effective in stimulating the economy, while decreasing consumption taxation is not.[7]

[7] The reliability of the proxies Ξ for each model are: [0.20,0.62] for the model with Unemployment, [0.22,0.62] for the model with Hours Worked and [0.30,0.59] for the model with real Wages.

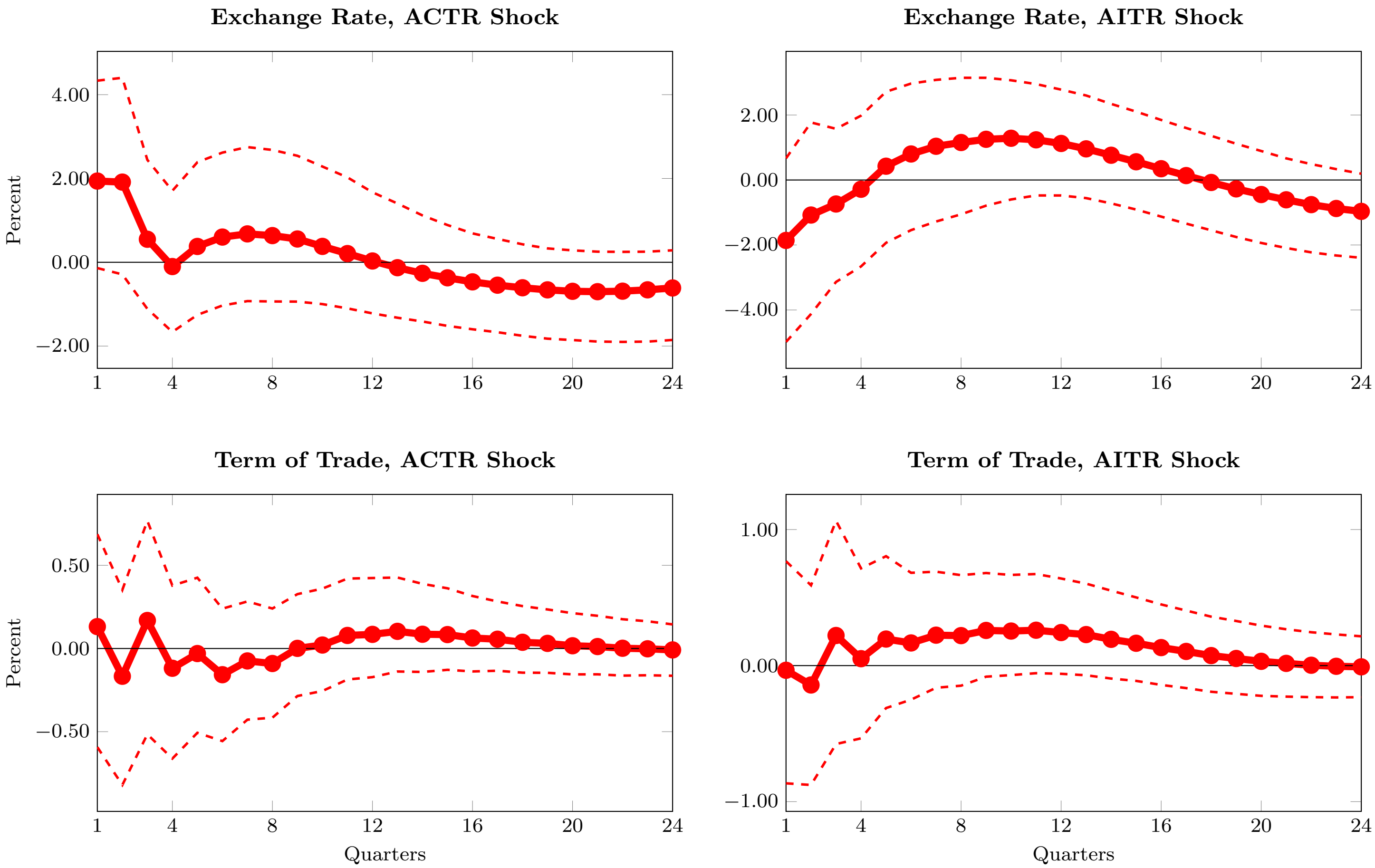
Figure E.3 – IRFs of Labour Market Variables. Broken lines represent the 68 percent Confidence Bounds.



E.4 The Open Economy Dimension of Tax Changes

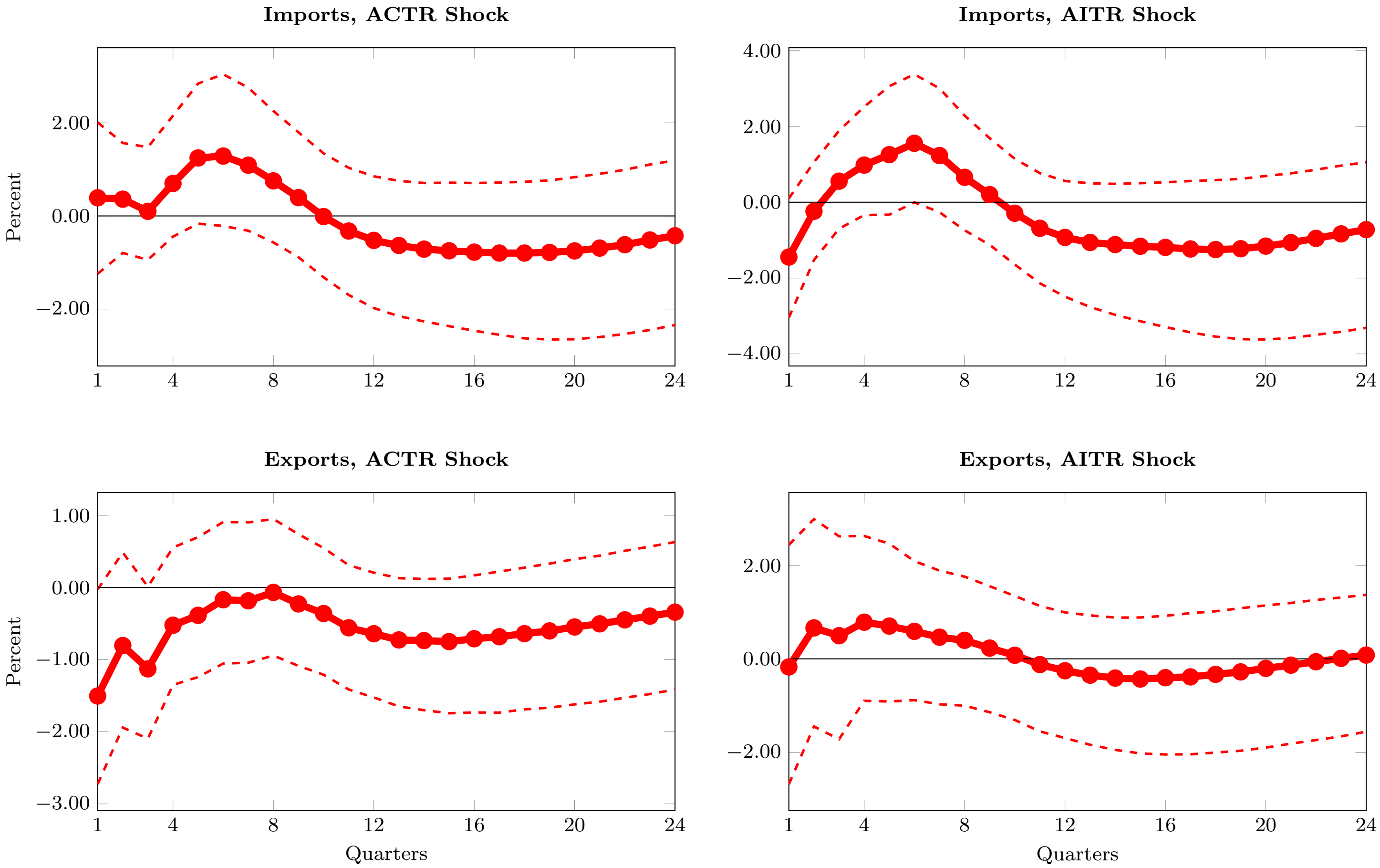
Here we provide evidence over the international dimension of fiscal policy. This is important as the UK can be considered a small open economy. In particular, we investigate the responses of the nominal effective exchange rate, the term of trade, imports and exports to shocks to ACTR and AITR, respectively. Results from these expanded econometric models are reported in Figure E.4. We find that the response of these variables are modest and not statistically different than zero.[8]

Figure E.4 – IRFs of Open Economy Variables. Broken lines represent the 68 percent Confidence Bounds.



[8]The eigenvalues of the Ξ statistic are: [0.30 0.58] for model with NEER, [0.21 0.61] for model with term of trade, [0.28 0.64] for the model with imports and [0.21 0.59] for the model with exports.

Figure E.4 – IRFs of Open Economy Variables. Broken lines represent the 68 percent Confidence Bounds (Continued).

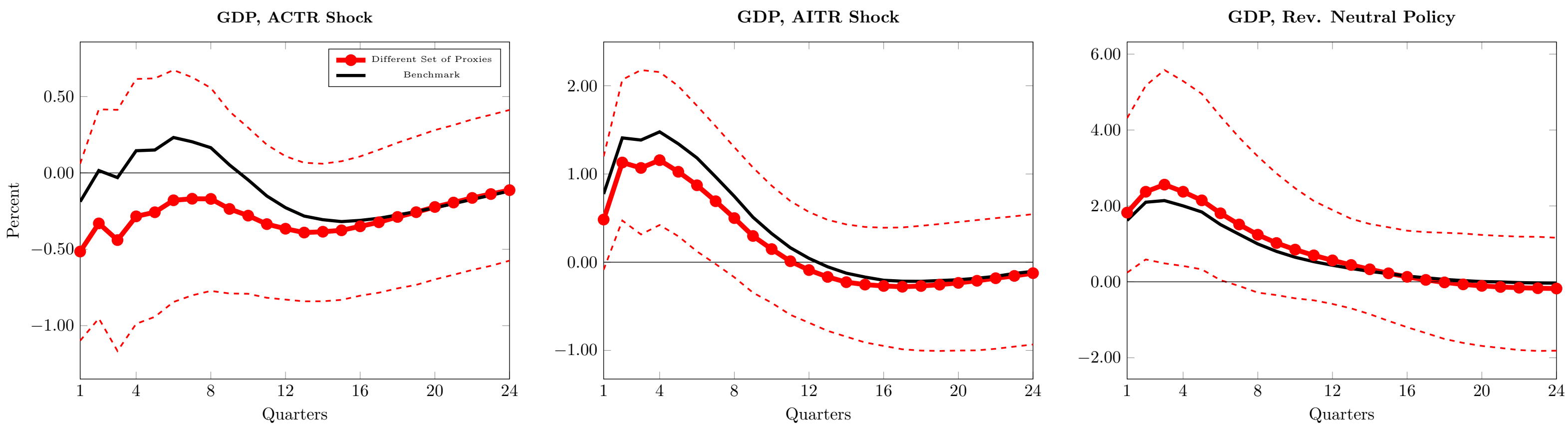


E.5 Isolated Tax Changes, Mainly Income Tax or Mainly Consumption Tax

In this section we present a robustness exercise that uses a modified set of proxies. Ideally we would like to isolate the effects of income and consumption tax shocks separately, however in practice tax changes in various components often happen at the same as part of complex and articulated fiscal reforms. This is an important point of our empirical analysis both under a statistical point of view and an economic one.

As for the statistical point of view, in order to isolate the causal effects of a change in one tax rate, we control for changes in the other via either exclusion restriction a la Cholesky or with Sign Restrictions. Here we use a different approach and we consider all those tax changes in each tax component that happened in isolation of the other, and episodes which were mostly consumption tax led or mostly income tax led. In each of these cases we eliminate, as endogenous, changes in the other tax component. In this way we artificially eliminate any correlation between the proxies. Results for this experiment are reported in Figure E.5 and remain, for all practical purposes, reassuringly similar to the benchmark.

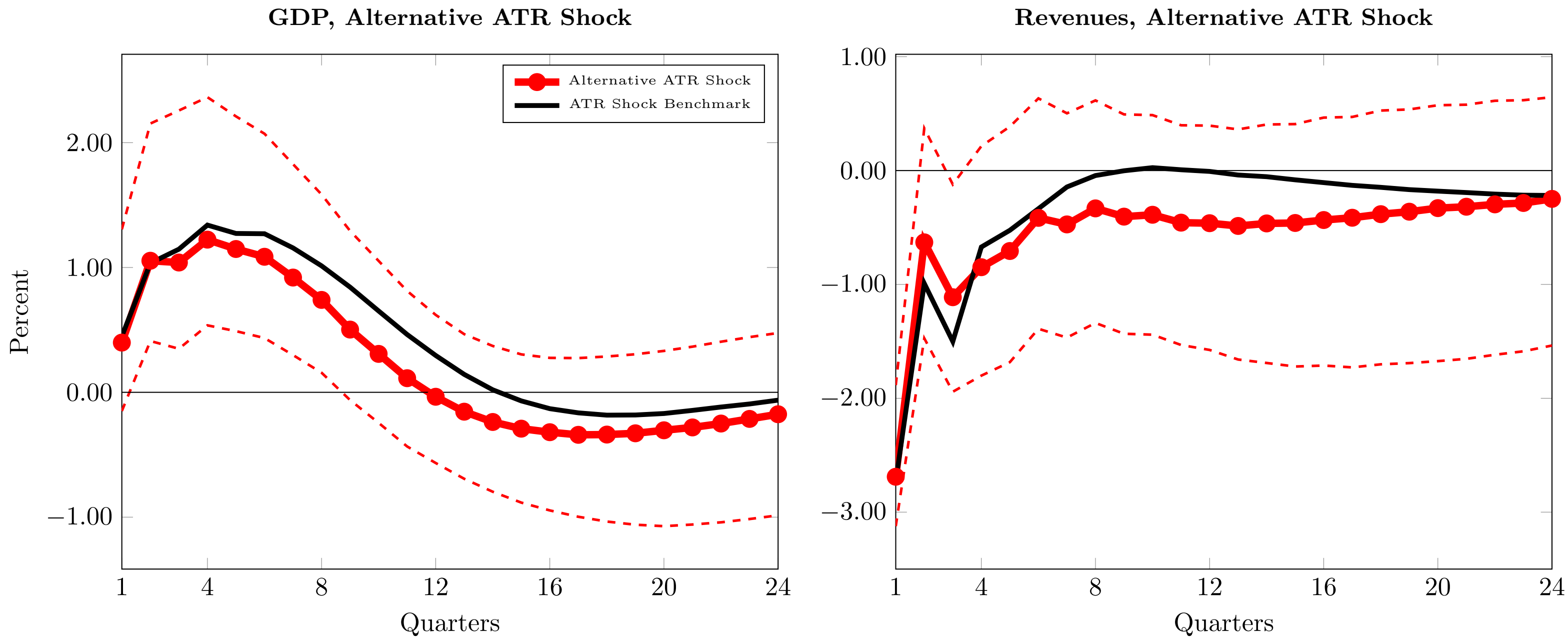
Figure E.5 – IRFs and Revenue Neutral Policy with Alternative Set of Proxies. Broken lines represent the 68 percent confidence bounds.



E.6 Alternative Measure of Aggregate Tax Shock

In the main text we calculate the response to a average tax rate shocks by considering of tax changes in all tax components and not just in either income or consumption. Here we propose a similar exercise in which we impose in the benchmark model two negative shocks of the same magnitude in the two tax components that result in a similar response of tax revenue as presented in Figure (4) of the Main Text. As such the results presented in Figure E.6 represents the statistical counterpart of the tax composition shock. In the revenue neutral exercise, we shift the fiscal burden from income to consumption by keeping the total revenues fixed, while here we reduce the size of total revenues by decreasing both taxes. Crucially the results from the two experiments lead to very similar expansionary effects on GDP in shown in Figure (4) of the Main Text. This finding is not surprising as more than 90 percent of central fiscal revenues come either from income or consumption taxes.

Figure E.6 – IRFs with Alternative ATR Shock. Broken lines represent the 68 percent confidence bounds.



E.7 Traditional Narrative Identification

Here we compare our benchmark results with an alternative identification strategy where the narrative series are added to the benchmark econometric model as exogenous regressors, see inter alia Romer and Romer (2010). In order to do so, we estimate the following model:

$$\tilde{X}_t = \sum_{i=1}^{P} \beta_i \tilde{X}_{t-i} + \sum_{s=0}^{Q} \zeta_s \Delta\tau_{t-s}^{j,n} + \mu_t, \quad \text{with } i = 1, 2, ..., P \text{ and } s = 0, 1, 2, ..., Q; \tag{22}$$

where $\Delta\tau_t^{j,n}$ $(j = i, c)$ are the narratively identified tax changes defined in the Main Text, $\tilde{X}_t$ is the set of observables as in the Benchmark model less the average tax rates, μ_t represents the reduced form innovations, $P = 3$ and $Q = 12$.[9] Figure E.7 reports the IRF to a one percentage point cut in $\Delta\tau_t^{j,n}$ and the 68 percent confidence bounds, as well as our benchmark results for comparison.

Compared to the benchmark results, the approach presented here leads to sizeable differences for both ACTR and AITR cuts. In response to a one percentage point cut in ACTR, GDP expands significantly above zero for over two years, with an impact response of 0.25 percent ($p = 0.04$) and the maximal response in the fifth quarter of around 1 percent ($p = 0.08$).

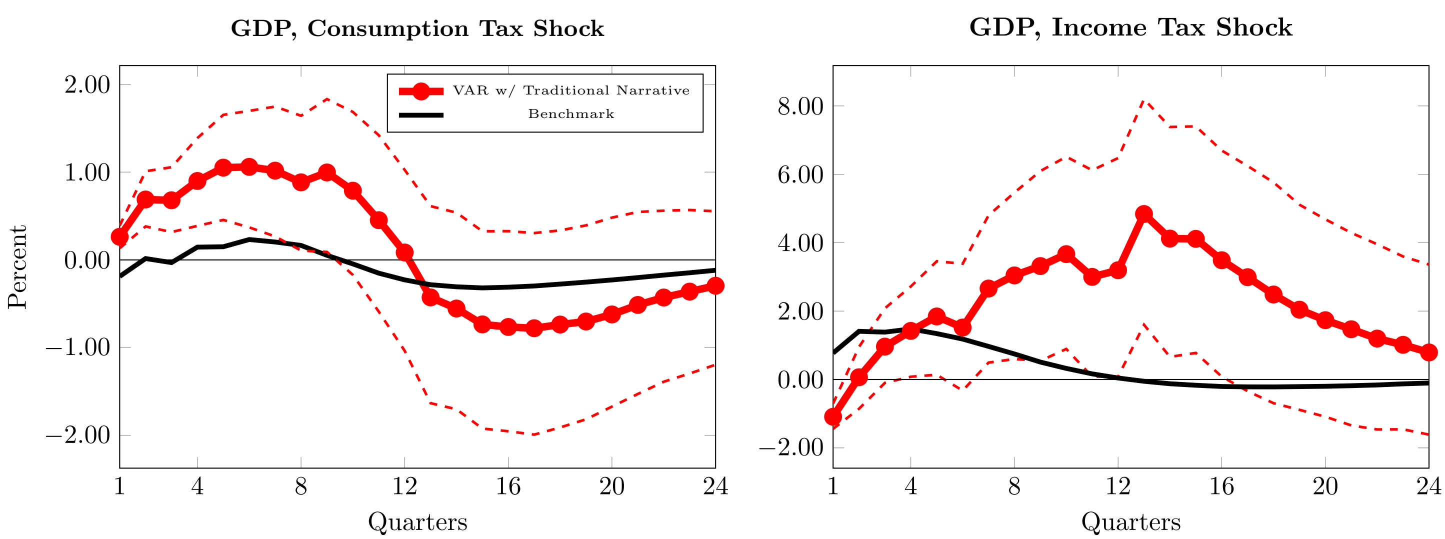
Moving to average income tax shocks, we find that a one percentage point cut in this tax component leads to a significant reduction in GDP on impact of 1.0 percent ($p = 0.004$). Aggregate output increases over time, turning positive one year after the tax shock occurs. The overall expansionary effect on GDP is

[9]Results are similar if we instead include the average tax rates among the set of observables in (22).

much larger than the one obtained under our baseline identification, with a maximal effect of 4.50 percent ($p = 0.007$). Furthermore, compared to our benchmark 'Proxy-SVAR' estimates, the peak increase in GDP occurs at a later horizon.

The main reason that helps explaining the differences obtained under the two identification strategies can be found in measurement problems. Our baseline estimator is robust to the existence of random measurement errors, while the identification in (22) is not and instead assumes perfect correlation between narrative changes and tax shocks. As we discussed in the Main Text, our estimates of the reliability of the proxies indicate that measurement error is quantitatively important.

Figure E.7 – IRFs with Traditional Narrative Identification. Broken lines represent the 68 percent confidence bounds.

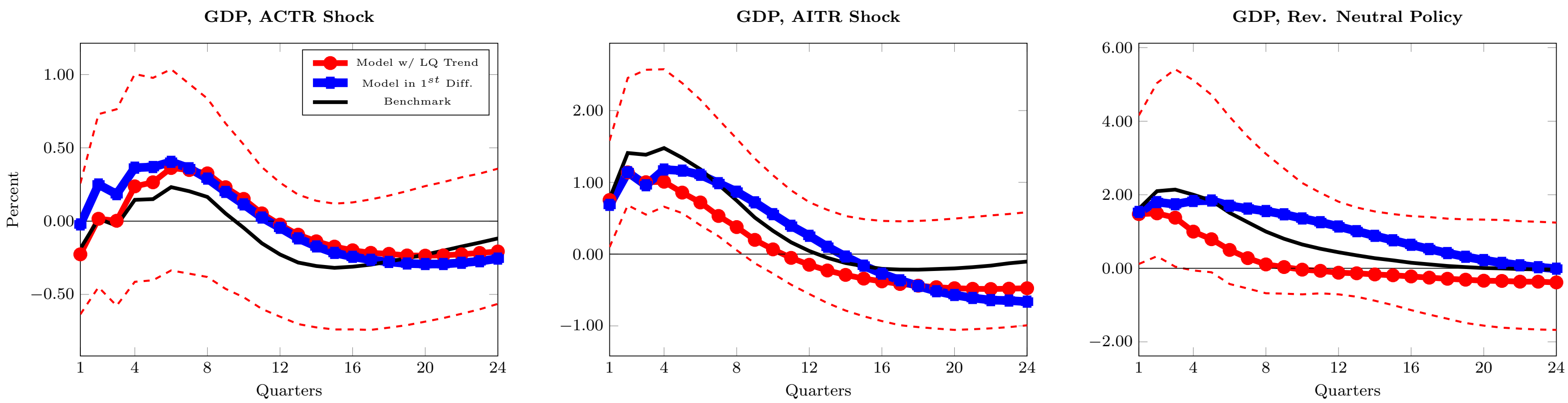


E.8 Trend and Growth Rates

Figure E.8 presents the results from adding a linear-quadratic time trend to the benchmark specification (red, dotted line). Including a deterministic time trend does not affect the response on impact of GDP to a income tax shock, but it yields to slightly smaller peak effect, which is reduced to around 1.3. At the same time, the linear-quadratic time trend improves the relative performance of consumption tax shock on GDP, although it remains statistically insignificant. In this case the reliability test gives values that are somewhat lower than in the benchmark, i.e. the eigenvalues of Ξ are [0.18, 0.58].

Figure E.8 presents also the estimates from using stationary data in the Benchmark Model, i.e. first differences of GDP and prices and ratios of consumption, investment and government spending to total output (blue, thick line). Estimates show a larger output response to an ACTR cut at all horizons although the response remains statistically not different than zero, and slightly lower but more persistent response to an AITR cut. As for the other cases, changing the composition of taxes from income to consumption expands GDP. The reliability test gives values that are slightly smaller than the benchmark one, i.e. the eigenvalues of Ξ are [0.17, 0.56].

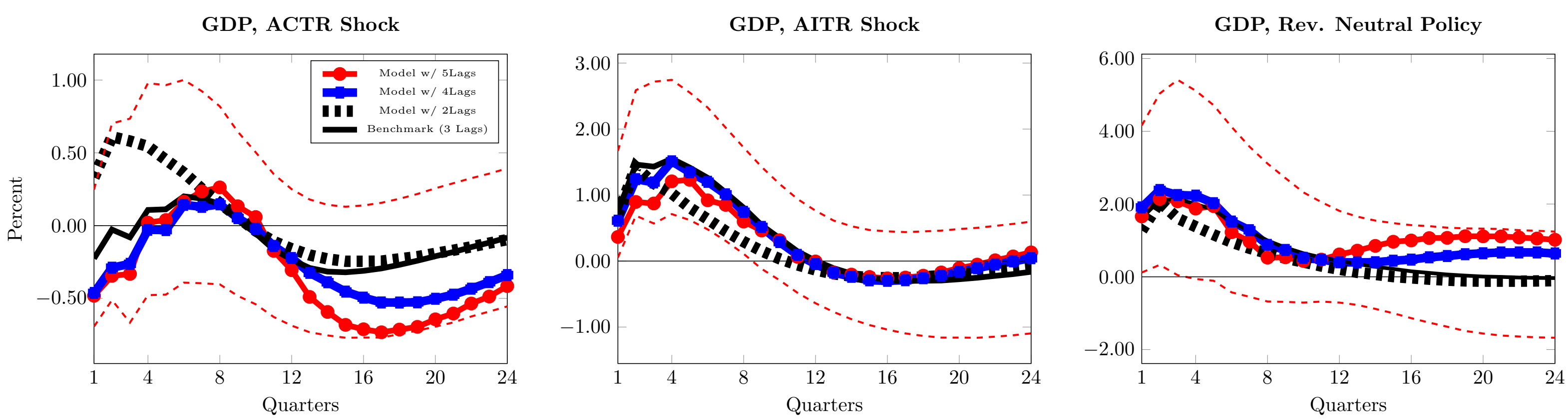
Figure E.8 – IRFs and Revenue Neutral Policy with Linear Quadratic Trend. Broken lines represent the 68 percent confidence bounds.



E.9 Different Lag Structures

We experiment with different lag structures of our Benchmark Model and report the results in Figure E.9. Here we report the results on GDP of imposing 5, 4 and 2 lags, respectively. The main results of the paper are robust to different lag structures, although the confidence bounds on ACTR shocks get wider with the model with 2 lags. We find that the eigenvalues of Ξ are [0.10, 0.63], [0.26, 0.63] and [0.21 0.63] for the models with 2, 4 and 5 lags, respectively.

Figure E.9 – IRFs and Revenue Neutral Policy with Different Lags. Broken lines represent the 68 percent confidence bounds.



E.10 Response of Public Debt

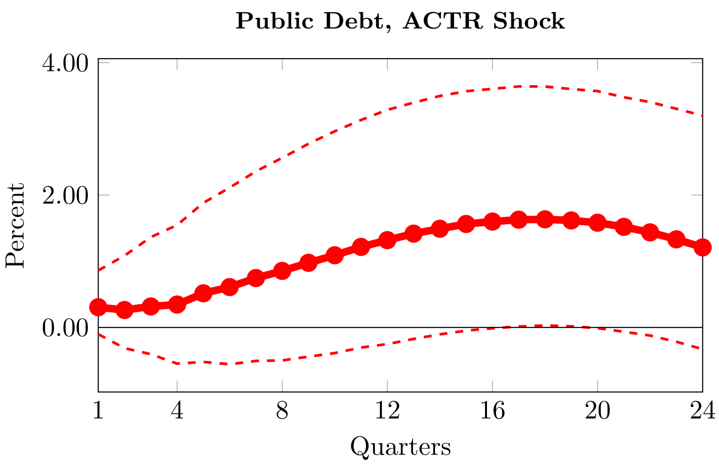
Here we expand our baseline model by inserting public debt. Government debt is a potentially important variable since any change in taxes eventually must lead to adjustments in the fiscal instruments. Unfortunately, UK data on public debt is only available at annual frequency prior to 1997. In order to deal with this problem, we construct a quarterly series of government debt-to-GDP ratio. We proceed as follows.

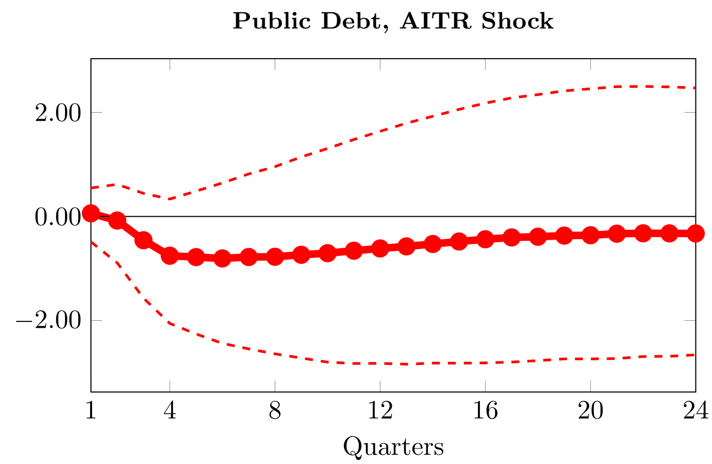
First we construct the year-on-year quarterly public debt growth for the period 1956-2009 with missing values for Q2, Q3 and Q4 of each year up to 1997 and full data afterwards. Then we estimate the missing quarterly values via Kalman Filter through a VAR with GDP growth, inflation and public debt growth. Finally, we use the smoothed series of debt growth to compute the Debt-to-GDP ratio at quarterly frequency for the 1973Q3-1997Q4 sample. For further details on this method, see Casals et al. (2000).

Figure E.10 presents the estimates on the variables of interest of adding our constructed quarterly series of debt-to-GDP to the set of observables in the Benchmark Model presented in the Main Text.

Public debt remains roughly constant under income tax shocks. This is mainly due to the fact that most of the revenue consequences of the policy change are absorbed by public spending. Differently, the stock of public debt slowly builds up under consumption tax shocks, increasing to a marginal significant level four years after the shock. For this model, the values of the reliability test are [0.23, 0.69].

Figure E.10 – Response of Public Debt. Broken lines represent the 68 percent confidence bounds.



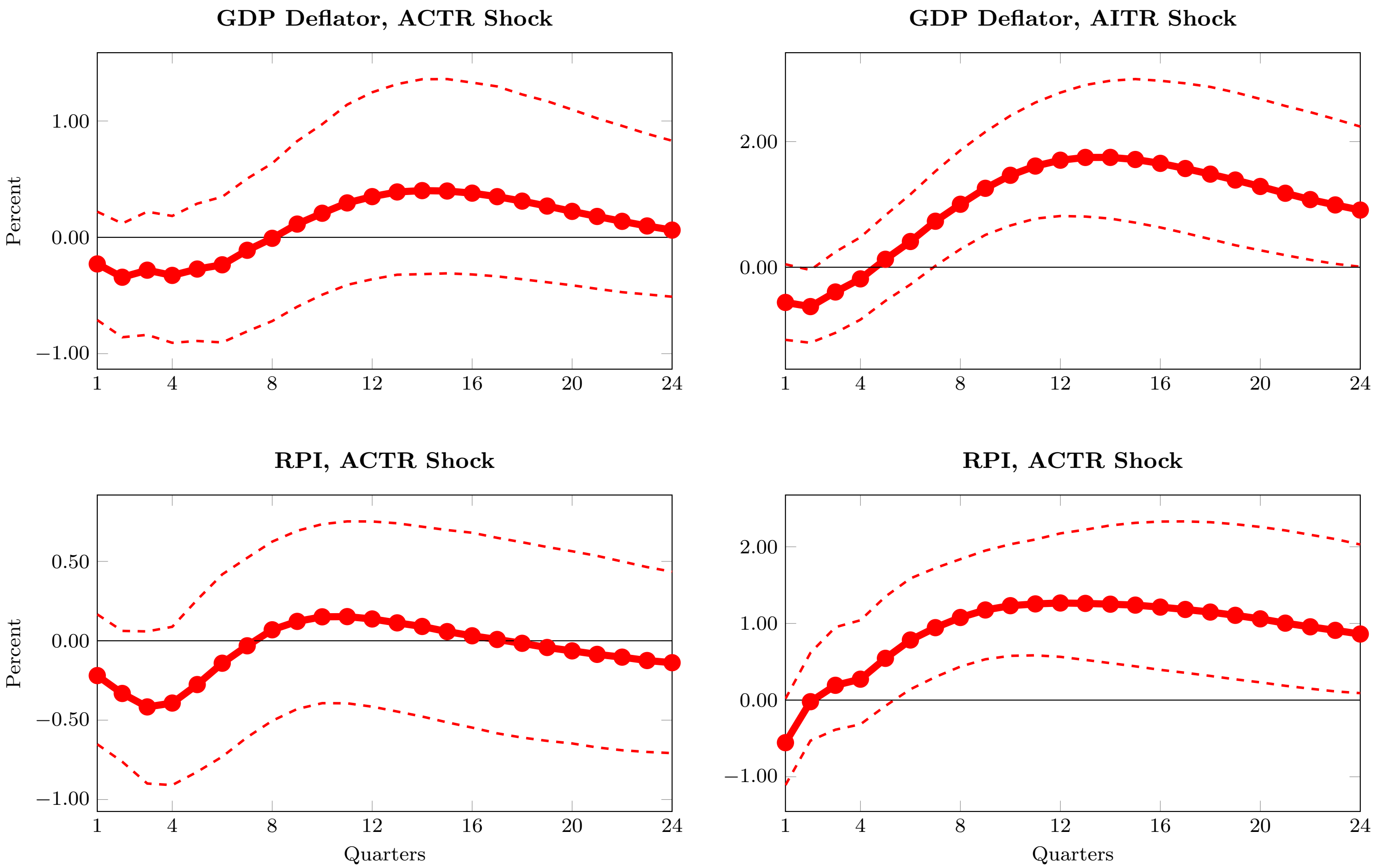


E.11 Different Definitions of Price Level

We estimate the effects of AITR and ACTR on the price level when using different measures of the price level in the Benchmark Model. Ideally one would like to use the Consumer Price Index (CPI), cleared by consumption and other indirect taxes. However, an official measure of CPI is not available for the entire sample and the only price level where indirect taxes are excluded, the RPIY, is available only from 1987. For this reason we adopt the final consumption expenditure by households and NPISH deflator as benchmark, whose cyclical component correlates the most with CPI and is consistent with the measure used in Mertens and Ravn (2013). Here we test the transmission mechanism of tax shocks to different definition of prices. In particular we use the GDP deflator and the Retail Price Index (RPI). Results are reported in Figure E.11.

The short run effects of tax shocks on GDP Deflator and RPI are qualitatively very similar to the response of Consumer Price Deflator index reported in the main paper. However, the response to a ACTR shock is no longer significant at 68 percent. Differently, an income tax rate shock leads to a response of prices that is both qualitatively and quantitatively very similar to the benchmark, with the same significance pattern. The eigenvalues of the Ξ statistics are sensibly smaller than the benchmark, i.e. [0.17, 0.48] for the GDP deflator and [0.16, 0.46] for the RPI, thus revealing a lower reliability of the Proxy.

Figure E.11 – IRFs of Different Price Level Definitions. Broken lines represent the 68 percent Confidence Bounds.



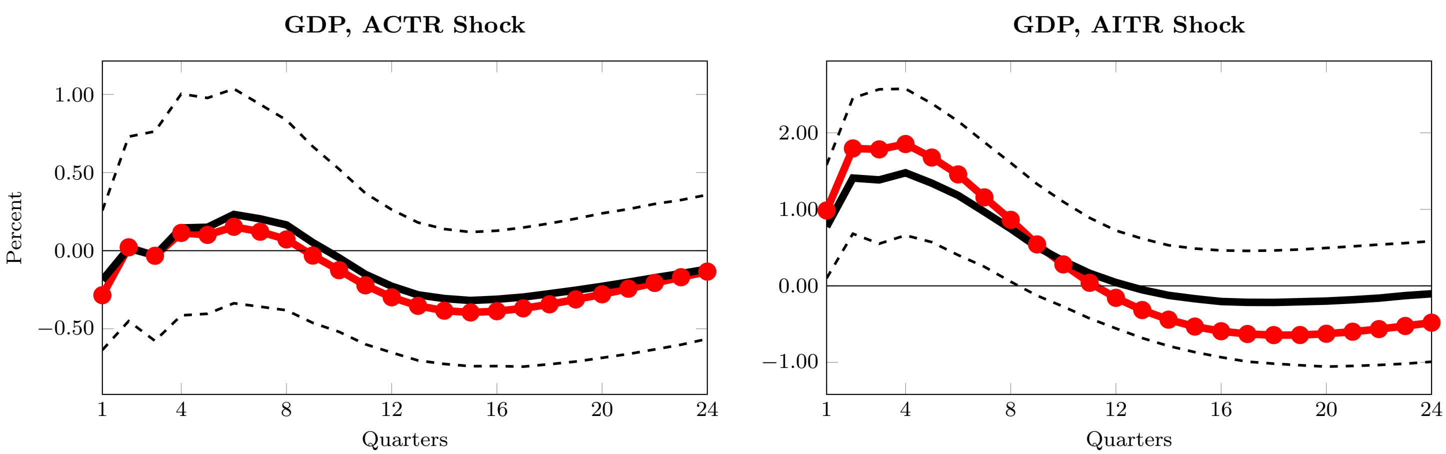
E.12 Timing Error

Finally, we control for the possibility of timing errors in the construction of our narrative account of tax changes. In order to do this, we perform a simulation in the vein of Ramey (2011). This consists of constructing alternative narrative series $\Delta\tilde{\tau}_t^{j,n}$, with $j = i, c$ such that,

$$\Delta\tilde{\tau}_t^{j,n} = \left(1-\varpi^j\right)\Delta\tau_t^{j,n} + \rho^j\varpi^j\Delta\tau_{t-1}^{j,n} + \left(1-\rho^j\right)\varpi^j\Delta\tau_{t+1}^{j,n}, \tag{23}$$

with $\varpi^j \sim U(0, 0.5)$, $\rho^j \sim B(0.5)$. Measurement error is added by allowing up to 50 percent of the value of each observation of the two proxies to be mistimed by a quarter, so that ϖ^j is uniformly distributed between 0 and 0.5 and ρ^j takes the value of 0 with 50 percent probability, and 1 with 50 percent probability. In this way there is an equal chance of mistiming of leading and/or lagging a quarter. We run (23) for 10000 times. For each replication we estimate the baseline Proxy-SVAR with the new generated instruments $\Delta\tilde{\tau}_t^{j,n}$ and calculate the IRFs. Figure E.12 presents the median values of the estimated responses. For comparison we also report the benchmark specification. Not surprisingly, adding time uncertainty changes the response of GDP to AITR and ACTR changes. The major noticeable difference is that output becomes slightly negative several quarters after an income tax cut. However the main conclusions of the paper are unaffected. This is somehow expected as our benchmark identification approach is robust to this type of random timing errors. Obviously, adding timing error decreases sensibly the reliability of our proxies, i.e. the eigenvalues of the statistic Ξ for $\Delta\tilde{\tau}_t^{j,n}$ drop to [0.07, 0.29].

Figure E.12 – IRFs with Timing Error. Broken lines represent the 68 percent Confidence Bounds.



References

Altig, D., A. J. Auerbach, L. J. Koltikoff, K. A. Smetters, and J. Walliser (2001). Simulating fundamental tax reform in the united states. *American Economic Review 91*(3), 574–595.

Auerbach, A. J., L. J. Kotlikoff, and J. Skinner (1983). The efficiency gains from dynamic tax reform. *International Economic Review 24*(1), pp. 81–100.

BIS (2015). Nominal effective exchange rate dataset. https://www.bis.org/statistics/eer.htm.

Casals, J., M. Jerez, and S. Sotoca (2000). Exact smoothing for stationary and non-stationary time series. *International Journal of Forecasting 16*(1), 59 – 69.

Christiano, L. J., M. Eichenbaum, and C. L. Evans (2005). Nominal Rigidities and the Dynamic Effects of a Shock to Monetary Policy. *Journal of Political Economy 113*(1), 1–45.

Cloyne, J. (2012). Discretionary tax shocks in the United Kingdom 1945-2009: a narrative account and dataset. Working Paper 37739, MPRA.

Cloyne, J. (2013a). Discretionary tax changes and the macroeconomy: New narrative evidence from the united kingdom. *American Economic Review 103*(4), 1507–28.

Cloyne, J. (2013b). Narrative dataset for discretionary tax changes and the macroeconomy: New narrative evidence from the united kingdom. https://drive.google.com/file/d/0B0Hi1TiBB5rRQU9lWWJJR2F3RmM/view.

Correia, I. (2010). Consumption Taxes and Redistribution. *American Economic Review 100*(4), 1673–1694.

Fernández-Villaverde, J. (2010). Fiscal policy in a model with financial frictions. *American Economic Review 100*(2), 35–40.

FRED (2015). Data: 3-month or 90-day rates and yields: Treasury securities for the united kingdom. https://research.stlouisfed.org/fred2/series/IR3TTS01GBM156N.

HMRC (2016a). Hm revenue and customs: Air passenger duty bulletin. https://www.uktradeinfo.com/Statistics/StatisticalBulletins/Pages/BulletinArchive.aspx?viewname=Air%20Passenger%20Duty%20Archive.

HMRC (2016b). Hm revenue and customs: Betting and gaming bulletin. https://www.uktradeinfo.com/Statistics/StatisticalBulletins/Pages/BulletinArchive.aspx?viewname=Betting%2c%20Gaming%20and%20Lottery%20Duties%20Archive.

HMRC (2016c). Hm revenue and customs: Insurance premium tax bulletin. https://www.uktradeinfo.com/Statistics/StatisticalBulletins/Pages/BulletinArchive.aspx?viewname=Insurance%20Premium%20Tax%20Archive.

Kimball, M. S. and M. D. Shapiro (2008, July). Labor supply: Are the income and substitution effects both large or both small? Working Paper 14208, National Bureau of Economic Research.

Leeper, E. M. and S.-C. S. Yang (2008). Dynamic scoring: Alternative financing schemes. *Journal of Public Economics 92*(1), 159 – 182.

Mertens, K. and M. O. Ravn (2011). Understanding the aggregate effects of anticipated and unanticipated tax policy shocks. *Review of Economic Dynamics 14*(1), 27 – 54. Special issue: Sources of Business Cycles.

Mertens, K. and M. O. Ravn (2013). The dynamic effects of personal and corporate income tax changes in the united states. *American Economic Review 103*(4), 1212–47.

National Archives (2004). Consumer trends data. https://webarchive.nationalarchives.gov.uk/20070111074709/http://www.statistics.gov.uk/STATBASE/ssdataset.asp?vlnk=8477.

ONS (2016a). Data: Rpi all items- percentage change over 12 months. https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/czbh/mm23.

ONS (2016b). Data: Rpi all items index: Jan 1987=100. https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/chaw/mm23.

ONS (2016c). Labour market statistics time series dataset. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/employmentandemployeetypes/datasets/labourmarketstatistics.

ONS (2016d). Public sector finances borrowing by sub-sector datatset. https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/publicsectorfinance/datasets/publicsectorfinancesborrowingbysubsector.

ONS (2016e). Public sector finances time series datatset. https://www.ons.gov.uk/economy/governmentpublicsectorandtaxes/publicsectorfinance/datasets/publicsectorfinances.

ONS (2016f). Uk economic accounts time series dataset. https://www.ons.gov.uk/economy/grossdomesticproductgdp/datasets/unitedkingdomeconomicaccounts.

Ramey, V. A. (2011). Identifying Government Spending Shocks: It's all in the Timing. *The Quarterly Journal of Economics 126*(1), 1–50.

Romer, C. D. and D. H. Romer (2010). The macroeconomic effects of tax changes: Estimates based on a new measure of fiscal shocks. *American Economic Review 100*(3), 763–801.

Schmitt-Grohé, S. and M. Uribe (2012). What's news in business cycles. *Econometrica 80*(6), 2733–2764.

Sims, E. and J. Wolff (2018). The state-dependent effects of tax shocks. *European Economic Review 107*, 57 – 85.

Trabandt, M. and H. Uhlig (2011). The Laffer curve revisited. *Journal of Monetary Economics 58*(4), 305–327.

Zubairy, S. (2014). On fiscal multipliers: Estimates from a medium scale dsge model. *International Economic Review 55*(1), 169–195.