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Fiscal policy and stock prices in the United States

This paper shows that fiscal policies seeking to stimulate long-term economic activity lead to higher stock prices

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This paper uses structural vector autoregressive models (SVARs) to show that the response of US stock prices to fiscal shocks changed in 1980. Over the period 1955-1979, an expansionary spending or revenue shock was associated with higher stock prices. After 1980, the response of stock prices to the same shock became negative. Using a dynamic stochastic general equilibrium (DSGE) model with a detailed fiscal sector, we show the pre-1980 results may be driven by an expansion in supply after the fiscal shock. In contrast, endogenous growth mechanisms appear to be weaker in the post-1980 period with positive fiscal shocks pushing down consumption, total factor productivity (TFP), and causing inflation and the real interest rate to rise.

Keywords: Fiscal policy shocks, Stock prices, VAR, FAVAR, DSGE

JEL codes: E24, E32, J64, C11

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Abstract

This paper uses structural vector autoregressive models (SVARs) to show that the response of US stock prices to fiscal shocks changed in 1980. Over the period 1955-1979, an expansionary spending or revenue shock was associated with higher stock prices. After 1980, the response of stock prices to the same shock became negative. Using a dynamic stochastic general equilibrium (DSGE) model with a detailed fiscal sector, we show the pre-1980 results may be driven by an expansion in supply after the fiscal shock. In contrast, endogenous growth mechanisms appear to be weaker in the post-1980 period with positive fiscal shocks pushing down consumption, total factor productivity (TFP), and causing inflation and the real interest rate to rise.

Key words: Fiscal policy shocks, Stock prices, VAR, FAVAR, DSGE.
JEL codes: C5, E1, E5, E6

"The president's $1tn tax cuts gamble hasn't worked – the House of Representatives has been lost, the economy has imploded and the stock market has tanked".

Business Leader, the Guardian, 23 December 2018.

1 Introduction

Do tax cuts boost stock markets? In an interview given to the POLITICO Money podcast in October 2017, the US treasury secretary Steven Munchin appeared to back this claim and warned that unless taxes were cut, the gains seen by the US stock market since the election of president Trump could be reversed. However, from the perspective of economic theory, the effect of fiscal policy on stock prices is ambiguous. This has been pointed out in a classic paper by Blanchard (1981) who shows that the sign of the impact of fiscal expansions on the stock market depends on whether agents expect the effect of higher future real interest rates to dominate the expected rise in profits.

While a large literature has focussed on estimating the multiplier of US output to government spending and taxation shocks (see for e.g. Mountford and Uhlig (2009), Ramey (2011), Mertens and Ravn (2014), and Mertens and Ravn (2013)), the issue of the transmission of fiscal shocks to asset prices such as stock prices has received far less attention from the empirical side. Two recent contributions include Afonso and Sousa (2011) and Chatziantoniou et al. (2013). Using an extended version of the

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Vector Autoregression (VAR) of Blanchard and Perotti (2002), they show that, while expansionary government spending shocks reduce US stock prices, expansionary tax shocks are associated with an increase in this variable. However, Afonso and Sousa (2011) do not include any proxy for monetary policy in their VAR model, an omission criticised by Chatziantoniou et al. (2013).[1] These authors examine the impact of government spending on an expanded version of the VAR used by Afonso and Sousa (2011). They find that over the period spanning 1991 to 2010, government spending shocks appear to have little impact on real and financial variables. However, their relatively small sample excludes important innovations in fiscal variables during the 1970s and the early 1980s and it is unclear if their conclusions are robust to using a longer span of data.

The current paper extends this literature along four dimensions. First, we provide VAR results on the transmission of US government spending and taxation shocks to real stock prices that are robust across different identification schemes, thus departing from earlier papers that use one method of identifying fiscal shocks. Second and more importantly, we show that there is a change in the sign and magnitude of the response of stock prices to fiscal shocks after 1980 – expansionary fiscal policy shocks were associated with an increase in the stock price before 1980, while after this date the same policy is associated with large declines. Although previous papers have documented a decline in the magnitude of the fiscal multiplier across these sub-samples, to our knowledge, our paper is one of the first to focus on the change in the response of stock prices to fiscal shocks.[2]Third, in order to explain the possible source of the change in the response of stock prices, we use a factor augmented VAR (FAVAR) to explore possible changes in the response of a large set of variables relevant to real activity, inflation, interest rates and financial conditions. This analysis suggests that in the pre-1980 period fiscal expansions were associated with persistent increases in output, consumption, investment, TFP, business confidence while inflation and measures of volatility declined. In the post-1980 period increases in real activity and TFP are smaller and /or less persistent and inflation and volatility shows an increase.

Finally, to explore the changes in the transmission mechanism, we present a New Keynesian DSGE model (Christiano et al. (2005), Smets and Wouters (2007)) augmented with: i) a detailed fiscal block as in Leeper et al. (2010a), Leeper et al. (2017) and ii) a productive government similar to Leeper et al. (2010b) and Coenen et al. (2012). This setup allows investigation of fiscal shocks without making restrictive assumptions regarding the type of fiscal instruments and the role of the government sector. The model also incorporates a "Learning By Doing" mechanism (Chang et al. (2002), D'Alessandro et al. (2019)) and technology utilisation (Bianchi et al. (2019), Jorgensen and Ravn (2019)).

By using predictive prior and predictive posterior analysis we show that the DSGE model replicates the results obtained via the VAR and FAVAR models. Our results suggest that the increase in the equity price observed in the period between 1955 and 1980 after a fiscal shock is associated with an expansion of the supply side of the economy that exceeds the increase in the demand caused by the stimulus. The two endogenous growth features offer a credible way of replicating these stylised facts. This expansion is absent in the second (post-1980) regime, and the elevated demand is met by reshuffling resources from the private to the public sector.

The composition of fiscal stimulus also appears to be important in the model. When a government consumption spending or a lump-sum tax is used as an instrument, then the sign changes of the stock price response is driven by the parameters that control the size of the endogenous growth mechanism in the model. When the economy is stimulated via government investment spending shocks, then the parameter that seems to explain the difference across the two regimes is the share of the public capital in the production of the intermediate good. Finally, when a capital tax is used, the expansion of the

[1] Using a panel regression, Ardagna (2009) report similar results–stock prices rise around periods of fiscal tightening.

[2] In an independent contribution,Diercks and Waller (2017) also investigate the changing effect of tax and spending shocks on the stock market. We generalise their results by considering the change in the dynamics of large set of macroeconomic and financial variables.

supply is mostly driven by a higher capital utilisation.

The paper is organised as follows: The empirical analysis is presented in section 2. Section 3 introduces the theoretical model and discusses the parameter estimates. Section 4 concludes.

2 Empirical Analysis

2.1 A Bayesian Structural VAR model

We use Bayesian structural VAR (SVAR) models to estimate the impact of government spending and taxation shocks, respectively. The benchmark model is defined as:

$$Y_t = \alpha\tau_t + \sum_{j=1}^{P} \beta_j Y_{t-j} + u_t \tag{1}$$

Y_t is a $N \times 1$ matrix of endogenous variables, β_j denotes $N \times N$ matrix of coefficients on the lags Y_{t-j}, while τ_t is a $k \times 1$ matrix of exogenous variables included in the specification with the associated coefficients $\underbrace{\alpha}_{N\times k}$.

The covariance matrix of the residuals u_t can be written as:

$$\Sigma = (Aq)(Aq)' \tag{2}$$

where A is the lower triangular Cholesky decomposition of Σ, and q is an orthogonal matrix of size N, satisfying $q'q = I_N$, with I_N an $N \times N$ identity matrix. The structural shocks of the VAR model ε_t are defined as:

$$\varepsilon_t = A_0^{-1} u_t, \varepsilon_t \sim \mathcal{N}(0, I_N) \tag{3}$$

where $A_0 = Aq$. It is clear from equation 3 that the rotation matrix q, introduces identifying assumptions into the SVAR model. For example setting $q = I_N$ results in the familiar recursive identification scheme.

Following Auerbach and Gorodnichenko (2012), amongst others, we use this recursive strategy to identify government spending shocks. In particular, in this VAR model, Y_t contains five variables ordered as: (1) a measure of government spending news ($News_{G,t}$) (2) Real per-capita federal government spending (G_t), (3) Real per-capita federal government revenue (T_t), (4) Real per-capita GDP (y_t) and (5) real stock prices (S_t). With this ordering, the shock to G_t is interpreted as an unanticipated spending shock with $News_{G,t}$ acting as a control for expected changes in spending. In our benchmark model, we use defence spending news constructed by Ramey (2011) as a proxy for $News_{G,t}$. Ramey (2011) uses news sources such as the Business Week to construct this narrative measure which is an estimate of the expected discounted value of G_t due to foreign political events.[3]

To identify tax shocks we follow Mertens and Ravn (2013), and use an external instruments or 'proxy' SVAR approach.[4] Mertens and Ravn (2014) have argued persuasively that this narrative approach to identification is preferable to the non-recursive scheme of Blanchard and Perotti (2002) as it avoids strong assumptions regarding structural elasticities embedded in the latter. In addition, the approach adopted by Mountford and Uhlig (2009) to identify fiscal shocks via sign restrictions has

[3] We show below that our key results are preserved when an alternative measure of spending news is used in the VAR model.

[4] While it is possible to use the proxy SVAR approach for spending shocks, Ramey (2016) cautions against the use of Ramey (2011) as an instrument (as opposed to an endogenous variable) as it implies that spending expectations are not explicitly accounted for in the VAR model. However, we show in the technical appendix that a proxy SVAR for spending shocks delivers the same results as the simple recursive benchmark.

been criticised for imposing implicit restrictions that go beyond the inequalities predicted by economic theory (see Arias et al. (2018)).[5]

In the context of our SVAR model, Caldara and Herbst (2019) show that identification via external instruments introduces an additional equation that links the instruments to the structural shock of interest. Note that the endogenous variables in the model used for tax shocks are T_t, G_t, y_t, S_t and $News_{T,t}$ where $News_{T,t}$ is a control for expected tax rates. In the benchmark model, we use the one to five year forward tax rates constructed by Leeper et al. (2012) from municipal bond yields as a measure of tax foresight. The shock of interest in the model is the first shock ε_{1t} in the vector of disturbances $\varepsilon_t = [\varepsilon_{1t}, \varepsilon_{.t}]$, where $\varepsilon_{.t}$ contains the remaining $N-1$ elements in ε_t. To identify the effect of ε_{1t}, we employ an instrument m_t described by the following equation:

$$m_t = \beta\varepsilon_{1t} + \sigma v_t, \quad v_t \sim \mathcal{N}(0,1) \tag{4}$$

where $\mathbb{E}(v_t\varepsilon_t) = 0$. The instrument is assumed to be relevant ($\beta \neq 0$) and exogenous ($\mathbb{E}(m_t\varepsilon_{.t}) = 0$). In our benchmark model m_t is the tax shock proxy built by Mertens and Ravn (2012) who refine the tax measure estimated by Romer and Romer (2010). Romer and Romer (2010) build their shock measure by purging legislated tax changes of movements that are endogenous and driven by policy makers' concerns about growth. However, Mertens and Ravn (2012) argue that the Romer and Romer (2010) tax shock may not satisfy exogeneity as the proxy does not account for implementation lags. In light of this, Mertens and Ravn (2012) propose a proxy based on exogenous tax changes where legislation and implementation are less than a quarter apart.

As discussed in Caldara and Herbst (2019), the role of the instrument in identifying ε_{1t} can be seen by considering the covariance matrix between the VAR residuals u_t and the instrument m_t. Given that:

$$\begin{pmatrix} u_t \\ m_t \end{pmatrix} = L_t \begin{pmatrix} \varepsilon_t \\ v_t \end{pmatrix}, \quad L_t = \begin{pmatrix} Aq & 0 \\ \bar{b} & \sigma \end{pmatrix} \tag{5}$$

with $\underbrace{\bar{b}}_{1\times N} = \begin{bmatrix} \beta & 0 & . & 0 \end{bmatrix}$, the joint distribution of u_t and m_t is assumed to be:

$$\begin{pmatrix} u_t \\ m_t \end{pmatrix} | L_t \sim \mathcal{N}\left(0, L_t L_t'\right) \tag{6}$$

Caldara and Herbst (2019) factor the likelihood of the VAR model as:

$$p(Y_t, m_t|\Xi) = p(Y_t|\Xi)\, p(m_t|Y_t, \Xi) \tag{7}$$

where Ξ denotes all parameters of the VAR. Given the conditional normality assumption in equation 6, the conditional density $p(m_t|Y_t, \Xi)$ is also normal with mean $\mu = \beta q_1' A^{-1} u_t$ and variance $s = \sigma^2$, where q_1 is the first column of q. As discussed in Caldara and Herbst (2019), μ can be interpreted as a linear combination of the orthogonalised residuals $q_1' A^{-1} u_t$. Therefore, in the context of this identification scheme, the VAR parameters and the vector q_1 are drawn from their posterior distributions ensuring that draws that result in the difference between the instrument and this linear combination becoming smaller are given larger weight.

2.1.1 Sub-sample estimation

As discussed in Section 2.1.3 below, we estimate impulse responses using pre and post-1980 sub-samples. To allow for this structural break, we modify the benchmark VAR model in equation 1 as

[5] We show in Section 2.2.1 that the main results are robust to the choice of instruments and the identification scheme.

follows:

$$Y_t = \alpha_S \tau_t + \sum_{j=1}^{P} \beta_{S,j} Y_{t-j} + u_t \tag{8}$$

where $S = 1, 2$ indexes the coefficients in the two sub-samples. The covariance matrix of the residuals and the structural shocks are now defined, respectively, as:

$$\Sigma_S = (A_S q)(A_S q)' \tag{9}$$

$$\varepsilon_t = A_{0,S}^{-1} u_t, \varepsilon_t \sim \mathcal{N}(0, I_N) \tag{10}$$

where A_S is the Cholesky decomposition of Σ_S and $A_{0,S} = A_S q$. As before, q is an identity matrix when employing the recursive scheme to identify spending shocks. When using the proxy SVAR for tax shocks, the equation for the instrument (eq. 4) remains unchanged with its parameters β and σ fixed over time. In short, we allow for a (known) break in the reduced form parameters of the proxy SVAR model but keep the instrument relevance fixed over time. This set-up is chosen to ensure that changes in the impulse response in this model are not driven by shifts in the strength of the instrument across sub-samples and that the estimation exploits the variation in the instrument across the full sample.

2.1.2 Data

We follow Mertens and Ravn (2014) closely in defining government spending and taxes. Government spending is defined as the sum of federal government consumption and investment. Taxes are calculated as current receipts of the federal government plus contributions for social insurance less corporate income taxes from Federal Reserve Banks. Both variables are deflated by the GDP deflator and divided by total population. A full description of data sources and calculations is provided in the technical appendix.

With the exception of the proxies for fiscal news which are not transformed, all remaining variables are included in log levels in the VAR models. The exogenous variables in the benchmark models include a constant, a linear trend, a quadratic trend and a dummy variable for 1975Q2.[6]While the benchmark VAR models are parsimonious, in Section 2.2.2 below, we expand the information set considerably by using factor-augmented VARs (FAVARs) and show that our results still hold.

2.1.3 Model specification and estimation

The benchmark sample runs from 1955Q1 to 2015Q4 for the model that identifies the government spending shock. As the news measure of Leeper et al. (2012) is available until 2005Q4, the model for tax shocks uses a truncated sample. We set the lag length P to 4.

Perotti (2005) provides strong evidence that the transmission of fiscal shocks has changed after 1980. The estimates presented in Perotti (2005) suggest that the response of output to fiscal shocks is smaller after 1980. Similar results are reported by Bilbiie et al. (2008) who suggest that a change in monetary policy and asset market participation may have played a role. Given this evidence, we estimate our model over the full sample and then estimate versions of the model that allows the VAR coefficients and residual covariance to differ over two sub-samples that span 1955Q1 to 1979Q4 and 1980Q1 to 2015Q4, respectively.[7]

The Gibbs algorithm to approximate the posterior distribution for the recursive SVAR used for spending shocks is standard and described in the technical appendix. We use flat priors for the reduced

[6] As discussed in Blanchard and Perotti (2002), there was a large, isolated temporary tax cut episode in 1975Q2 which is distinct from the estimated tax shocks and is therefore dummied out.

[7] For the model with the tax shock, the second sub-sample is 1980Q1 to 2005Q4.

form VAR coefficients and the residual covariance matrix.

For the Bayesian proxy SVAR used for tax shocks, we use the Gibbs sampling algorithm of Caldara and Herbst (2019). The procedure extends the standard Gibbs algorithm for Bayesian VARs to take into account the conditional likelihood for the instrument, i.e. $p\left(m_t|Y_t, \Xi\right)$. As described in the technical appendix, the algorithm can be extended easily to account for the break imposed on the reduced form VAR parameters in 1979Q4. As in the case of the recursive VAR, the priors for the VAR coefficients and covariance are uninformative. As explained in Caldara and Herbst (2019), the priors for parameters of equation 4 play an important role as they influence the strength of the instrument. Mertens and Ravn (2013) use the reliability statistic ρ to judge instrument strength. The reliability ρ is defined as the squared correlation between m_t and ε_{1t}:

$$\rho = \frac{\beta^2}{\beta^2 + \sigma^2} \tag{11}$$

Mertens and Ravn (2014) provide evidence indicating the high relevance of the instrument we employ. In light of this, our benchmark prior for β and σ^2 incorporates the belief that ρ is reasonable large (i.e. $\rho \approx 0.4$).

The Gibbs sampler is run for $500,000$ iterations saving every tenth iteration after a burn-in period of $350,000$. In the technical appendix, we present evidence that supports convergence of the algorithm.

2.2 Empirical results

2.2.1 Impulse response of stock prices to fiscal shocks

Figure 1 plots the estimated response to a unit increase in G_t where the shock is identified via the recursive scheme discussed above. The left panel presents estimates obtained using the full sample while the right panel presents results using the VAR that allows for a break in 1979Q4. The last row of the figure presents our main result. While the full-sample response of real stock prices is imprecisely estimated, there is clear evidence of a switch in sign of the response across sub-samples. In the pre-1980 period S_t increases by about 0.5 to 1 percent at short horizons. However, the post-1980 response to the shock is negative with stock prices falling by 1.3 percent at the two year horizon. The response of the remaining variables to this shock is fairly standard. The response of GDP declines after 1980 with the cumulated multiplier at the two year horizon declining from 2.3 to 0.3 percent.[8] As in Caldara and Kamps (2008), we find that the response of taxes to the shock is negative after 1980.

The response to a unit decrease in T_t is shown in Figure 2. As discussed above, the shock is identified using the tax instrument from Mertens and Ravn (2012). The last panel of the figure shows that the impulse response of stock prices displays the same shift as in the case of spending shocks. In pre-1980 period the median response of stock prices to the tax cut is positive. After 1980, stock prices display a large decline after this fiscal expansion. Note that there is a decline in the impact of the shock on output, with the cumulated multiplier at the two year horizon declining from -6.0 percent pre-1980 to -1.9 after the break.

Robustness Our results regarding the change in response to stock prices in 1980 are robust to a number of sensitivity checks which are reported in detail in the technical appendix.

To check the impact of our identifying assumptions we use a number of alternative schemes. We identify the spending and tax shocks using the non-recursive scheme devised by Blanchard and Perotti (2002) and the sign restrictions based on Mountford and Uhlig (2009), respectively. In both cases, the

[8] The multiplier is calculated as the ratio of the cumulated response of output to the cumulated response of government spending, scaled by the average ratio of output to spending over the sample.

pre and post-1980 response of stock prices is similar to the benchmark results. In addition, estimates from a proxy SVAR that uses the control for fiscal foresight based on SPF forecasts produces responses that provide qualitative support for the benchmark estimates.[9] Similarly, the benchmark results for tax shocks are robust to using the original Romer and Romer (2010) proxy as an instrument.

Next, we consider if refining the definition of spending and tax shocks makes a difference to the results. First we attempt to separately identify government consumption $\left(G_t^C\right)$ and government investment $\left(G_t^I\right)$ shocks. The benchmark VAR model is modified by replacing G_t by its two components G_t^C and G_t^I. We estimate two specifications ordering G_t^C either before or after G_t^I. Figure 7 in the technical appendix shows that this analysis leads to two main conclusions: (i) from a qualitative perspective, the stock price response to G_t^C and G_t^I shocks in the two sub-samples support the benchmark results and (ii) the estimates in figure 1 closely resemble the response to government consumption shocks, while the magnitude of the stock price response to G_t^I shocks is smaller. The latter result is not surprising as G_t^C constitutes about 70 percent of total spending with this proportion remaining fairly constant over time. Following Mertens and Ravn (2013), we consider the effect of personal and corporate tax shocks separately. As described in Mertens and Ravn (2013), the average personal tax rate ($APITR_t$) has increased over the post-1947 period while average corporate tax rates ($ACITR_t$) have declined. We extend the proxy SVAR for tax shocks by replacing T_t with $APITR_t$ and $ACITR_t$ and identify personal and corporate tax shocks by using the narrative instruments built by Mertens and Ravn (2013).[10] As shown in figure 8 in the technical appendix, the response of stock prices to both shocks is close to the benchmark. However, in terms of magnitude, personal tax shocks have a larger impact on S_t than corporate tax shocks, a result consistent with the declining importance of $ACITR_t$.

In further checks, we exclude the Paul Volcker FED chairmanship period from the sub-samples and also estimate the model using pre-2007 data. In addition, we try alternative assumptions regarding trends. While there is some variation in the precision of the stock price responses, the median estimates support the benchmark case.

As noted above, the benchmark models are quite parsimonious and as a consequence information insufficiency may be a potential problem (see Forni and Gambetti (2014)). In the next section we employ a FAVAR which incorporates a large dataset for the US and includes information on various important sectors of the economy. While the focus of the section is on exploring the factors behind the stock price response, we note that our key results regarding the change in the response of stock prices are preserved in this larger model.

2.2.2 Interpreting the stock price response

[9] This proxy for fiscal news is constructed by Auerbach and Gorodnichenko (2012). This is not used in the benchmark model because it is only available from 1966Q4.

[10] As described in the technical appendix, additional restrictions are required to separate the two tax shocks. In the spirit of Piffer and Podstawski (2018), we restrict the instrument for personal taxes to be more correlated with $APITR_t$ and the instrument for corporate taxes to be more correlated with $ACITR_t$.

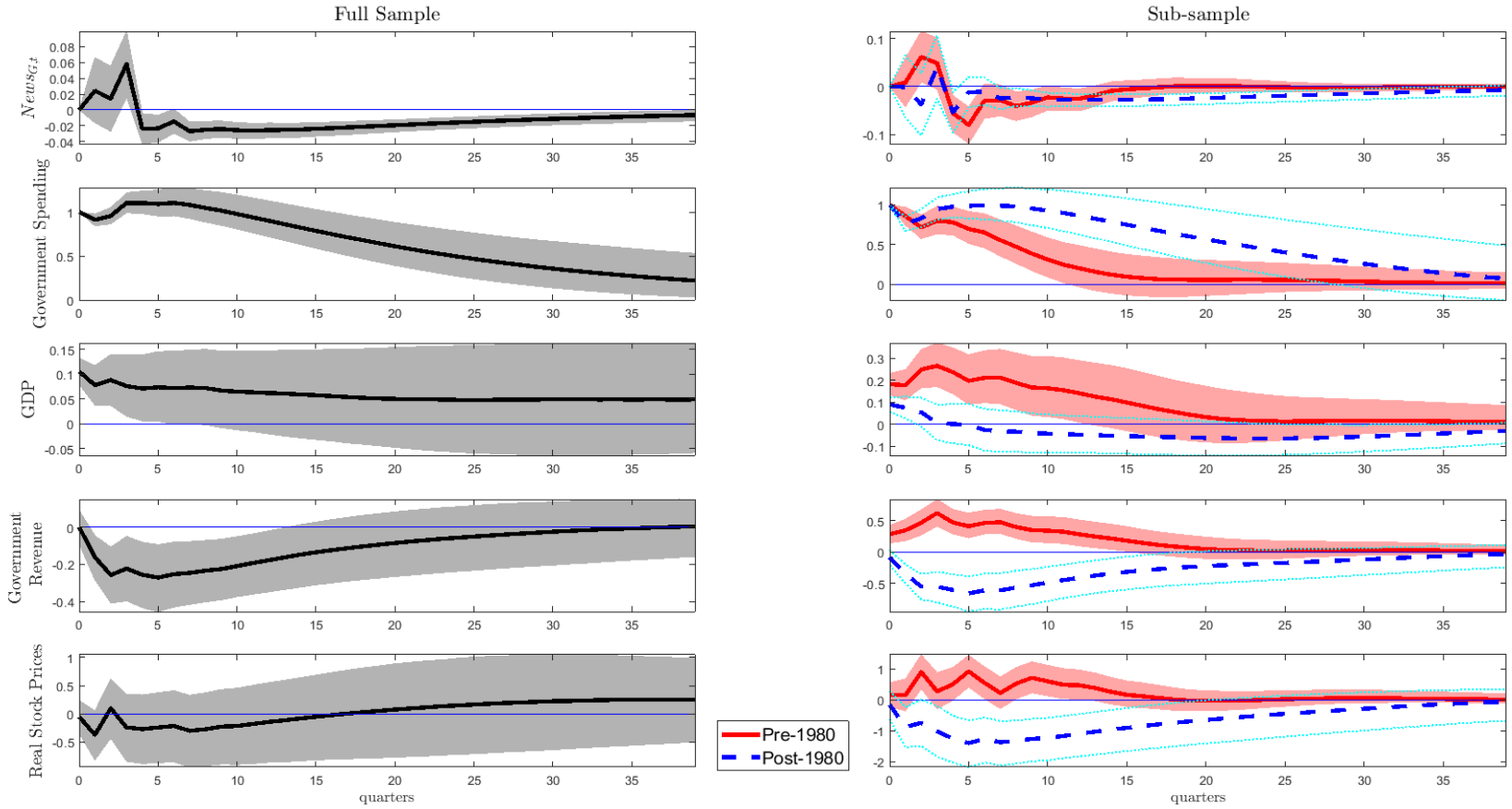

Figure 1: Response to a Government Spending shock. The Y-axis units are in percent for all variables. The solid lines and dashed lines are median responses while the shaded area and dotted lines are the 68% error band.

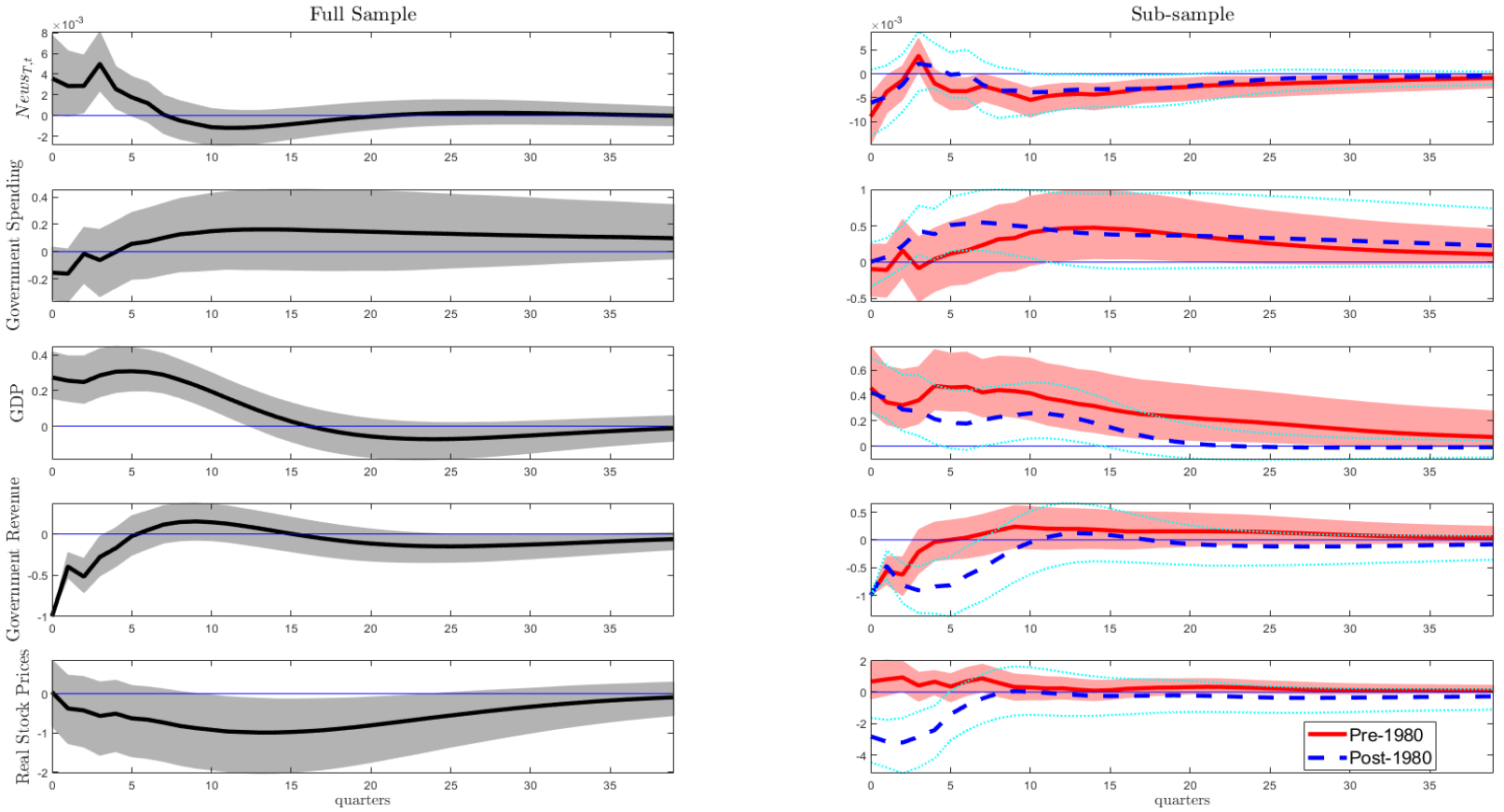

Figure 2: Response to a taxation shock. See notes to Figure 1.

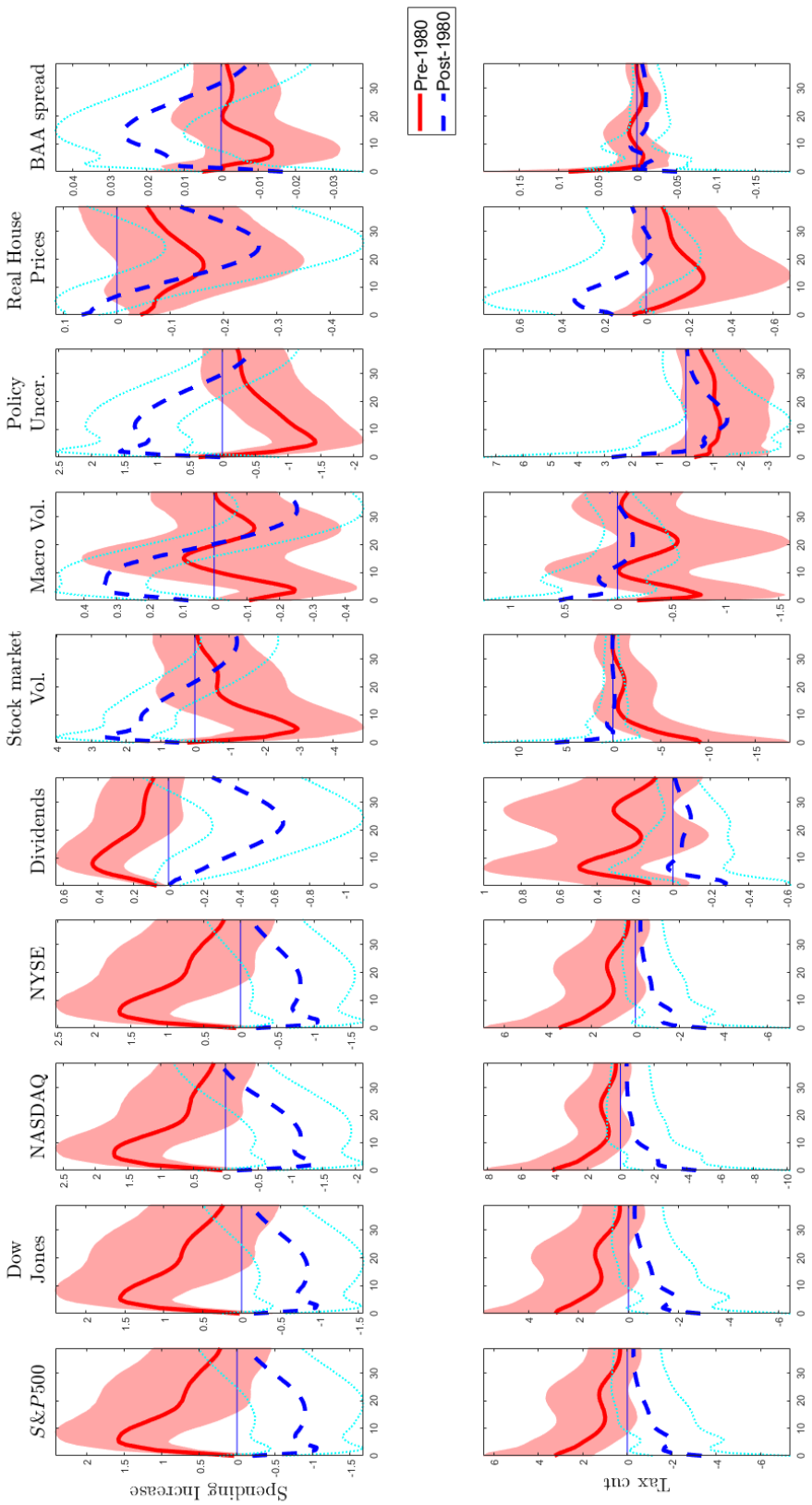

Figure 3: Response of financial variables and volatility

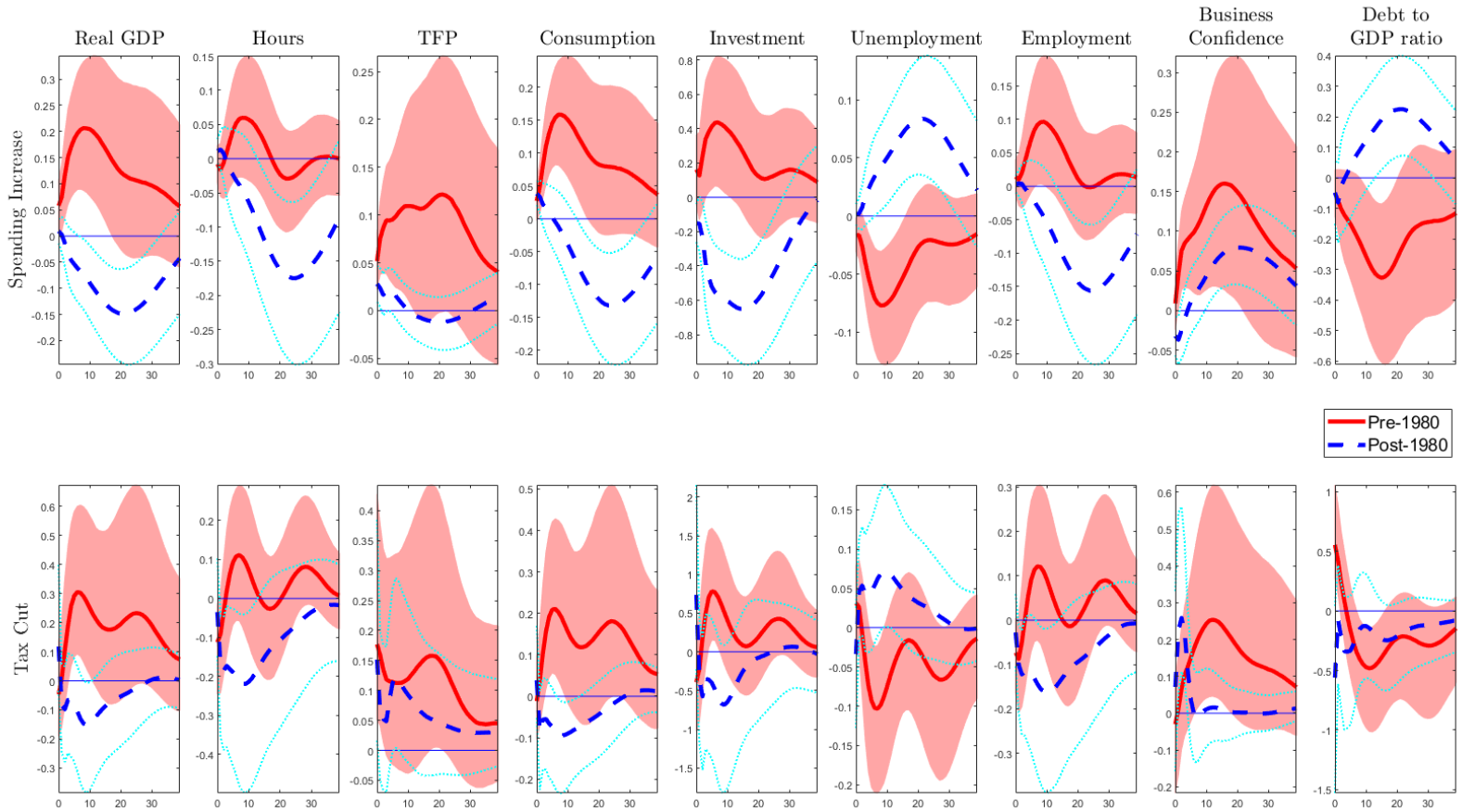

Figure 4: Response of real activity measures

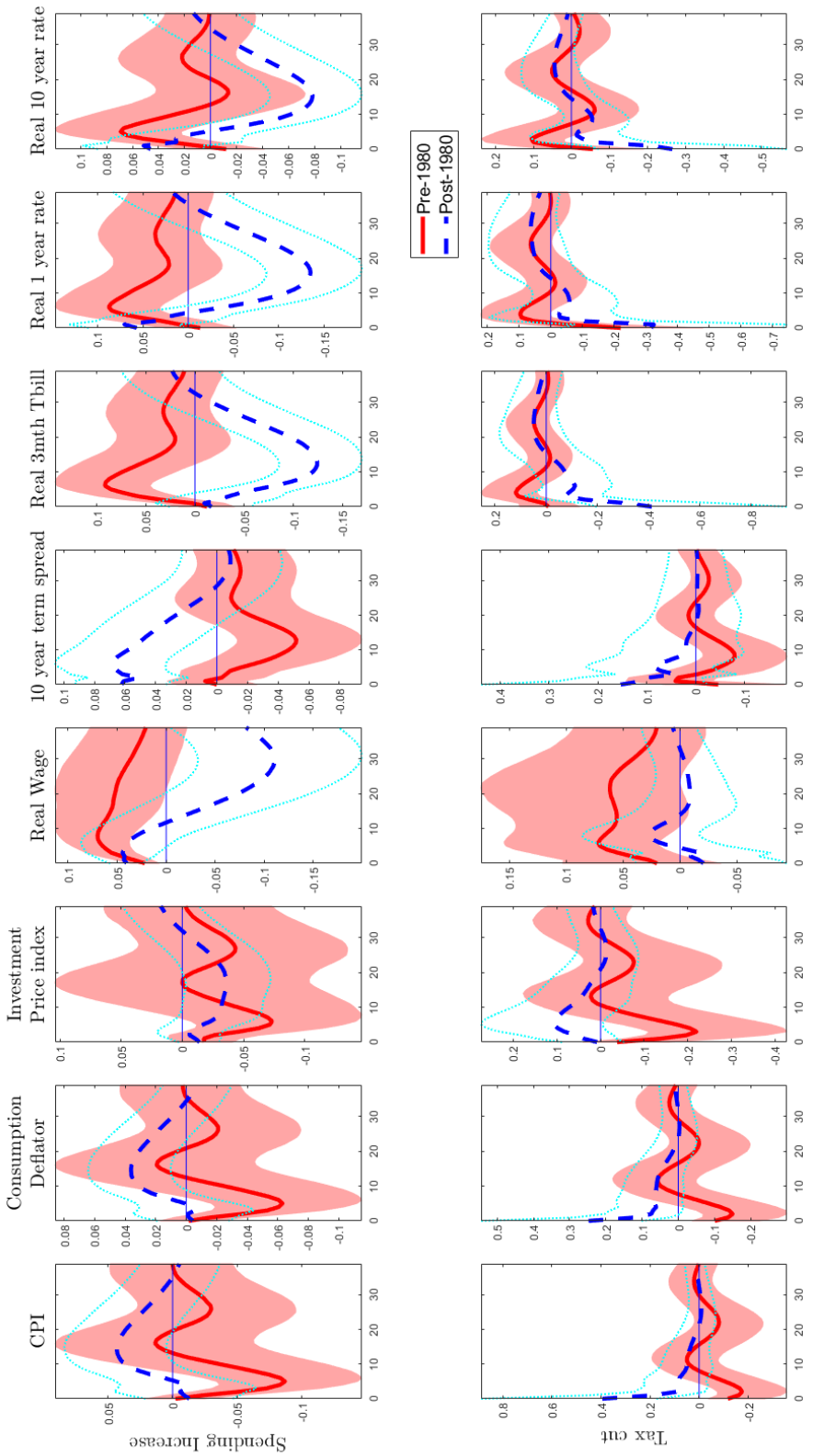

Figure 5: Response of inflation and real interest rates.

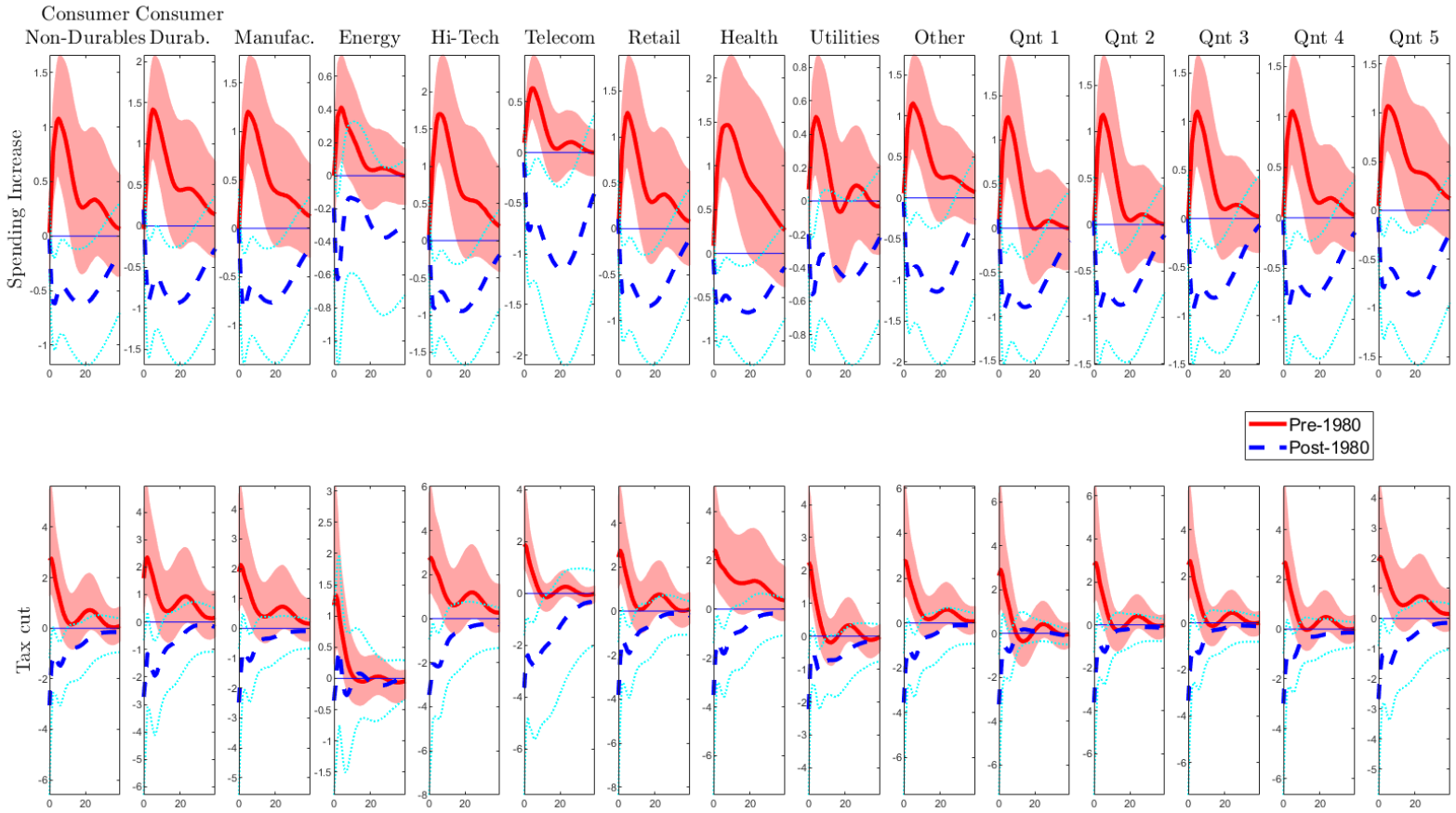

Figure 6: Response of cumulated returns using the 10 industry portfolio of Kenneth French. Also shown are the responses of returns sorted by size into five quintiles.

What drives the change in the response of stock prices after 1980? To investigate the possible answers to this question we employ a FAVAR model that allows us to examine changes in the impulse response of a large number of variables to fiscal shocks. Information from this large scale model is useful in pointing out sectors of the economy that are important as far as the shift in the response to fiscal shocks is concerned.

We adopt the non-stationary factor model setting of Barigozzi et al. (2016). Working in this framework allows us to include data on key variables in log levels and thus offers a direct comparison with benchmark VAR models used above. Consider a panel of M possibly non-stationary time-series X_t. The factor model is defined as:

$$X_t = c_S + b_S\tau + \Lambda_S F_t + \xi_t \tag{12}$$

where c is an intercept, τ denotes a time-trend, F_t are the R non-stationary factors, Λ is a $M \times R$ matrix of factor loadings and ξ_t are idiosyncratic components that are allowed to $I(1)$ or $I(0)$. As described in Barigozzi et al. (2016), the factors can be consistently estimated using a principal components (PC) estimator. In particular, the factor loadings are estimated via PC analysis of the first differenced data ΔX_t. With these in hand, the factors are estimated as $\hat{F}_t = \hat{\Lambda}_S' \left(X_t - \hat{c}_S - \hat{b}_S\tau \right)$. The IC_p information criteria of Bai and Ng (2002) is used to set the number of factors.[11]The factor dynamics are given by the VAR:

$$\tilde{Y}_t = \tilde{c}_S + \sum_{j=1}^{P} \tilde{\beta}_{S,j} \tilde{Y}_{t-j} + \tilde{u}_t \tag{13}$$

where $\tilde{Y}_t = \begin{pmatrix} News_{G,t} \\ G_t \\ \hat{F}_t \end{pmatrix}$ when spending shocks are considered and $\tilde{Y}_t = \begin{pmatrix} T_t \\ \hat{F}_t \end{pmatrix}$ for the model that estimates the response to tax shocks.[12] As in the benchmark case, spending shocks are identified via a recursive ordering where $News_{G,t}$ is ordered first, followed by G_t and the factors. Tax shocks are identified using the benchmark instrument for tax shocks:

$$m_t = \beta\varepsilon_{1t} + \sigma v_t \tag{14}$$

with m_t denoting the tax measure of Mertens and Ravn (2012) and ε_{1t} the shock of interest. Estimation of the parameters of this VAR is carried out using the Gibbs algorithms outlined in Section 2.1.3. Finally note that the subscript $S = 1, 2$ in equations 12 and 13 indicates the pre and post-1980 sub-sample. In other words, the estimation of the factor loadings and the reduced form VAR parameters allows for a break in 1979Q4.

The data X_t runs from 1955Q1 to 2015Q4 and consists of $M = 125$ series. The series are listed in the technical appendix and cover real activity, employment, money and credit, inflation, interest rate spreads, asset prices and measures of volatility. In addition, we include industry-specific stock returns and size portfolios made available by Kenneth French.

Figure 3 plots the response of selected stock indices to expansionary spending and tax shocks. The figure clearly shows that regardless of the index, the FAVAR supports our main result: The response of stock prices to spending and tax shocks switches in sign after 1980. These estimates

[11]The framework of Barigozzi et al. (2016) allows for F_t to be reduced rank with their space spanned by $Q \leq R$ dynamic factors. As we use an identification scheme based on external instruments we follow Alessi and Kerssenfischer (2019) and set $R = Q$.

[12]In the FAVAR model used for tax shocks, the proxy for fiscal foresight, $News_{T,t}$, is included in the data matrix X_t and is thus accounted for by the factors. Note that on the basis of the IC_p statistic $\hat{F}_t$ is chosen to be a 9×1 vector in the case of spending shocks with $News_{G,t}$ and G_t treated as observed factors. The number of endogenous variables are kept the same in the case of tax shocks with one observed factor (T_t) and $\hat{F}_t$ denoting 10 principal components.

also suggest that our main result is robust to information insufficiency. The figure also displays the response of real dividends and some measures of macroeconomic and financial volatility. The response of dividends mimics the stock price response with a negative response after 1980. There is evidence that volatility measures move in the opposite direction to stock prices. For example, in the pre-1980 period the standard deviation of daily stock returns (Stock market vol.) declines substantially after a positive spending shock. However, after 1980 the response positive. Similarly the Jurado et al. (2015) uncertainty measure (Macro vol.) responds negatively before 1980 but the response switches sign and is positive in the second sub-sample. The response of the policy uncertainty measure of Baker et al. (2016) and the BAA spread displays a similar shift in response to spending shocks.

Figure 4 displays the response of real activity measures. The first column of the figure shows that the response of GDP to the fiscal expansion is more persistently positive during the pre-1980 period. A similar pattern is evident for consumption, hours and investment. It is interesting to note that the response of the Basu et al. (2006) utilisation adjusted TFP measure (TFP) to spending shocks is positive and highly persistent in the first regime, thus supporting the results in D'Alessandro et al. (2019). In contrast, after 1980, the increase in TFP is short-lived. The response of employment measures suggest that after 1980, employment conditions deteriorated in the medium term after the fiscal shock. The increase in business confidence after the fiscal expansion is less persistent in the second regime. Finally, note that the dynamics of federal debt also shift across sub-samples. In the pre-1980 period, the response of debt was negative after a spending shock with the sign switching in the post-1980 period. The response of debt to tax shocks became negative after an initial increase during the pre-1980 period. However, in contrast to spending shocks, debt falls after tax cuts in the second regime.

The response of (annual) inflation rates and ex-post real interest rates is shown in Figure 5. The results regarding inflation measures during the pre-1980 sub-sample are similar to those found by D'Alessandro et al. (2019) – inflation falls after a fiscal expansion and real wages rise. However, the post-1980 responses display the opposite pattern. After a fiscal expansion inflation rises and real wages decline. The dynamics of real rates do not suggest a firm conclusion. There is some evidence that the 1 year rate displays a larger increase in response to spending after 1980 than in the first sub-sample, at least at short horizons.

Figure 6 displays the response of cumulated stock returns across industries and size portfolios. Barring the Energy sector (which may be affected strongly by international developments), there is a clear shift in the sign of the response across sub-samples. Similarly, returns in large and small firms display very similar dynamics with the response to fiscal expansion negative after 1980. Overall, evidence of cross-sectional heterogeneity is fairly weak. This is consistent with the argument that factors driving the change in the stock market response are likely to be economy wide phenomena.

In summary, the FAVAR results suggest a number of stylised 'facts' regarding the changing response to fiscal shocks:

1. During the pre-1980 period, fiscal expansions raise output, consumption, TFP and real wages but reduces inflation and measures of volatility.

2. In the post-1980 period, the impact of fiscal expansions on output, consumption and TFP is smaller. Moreover real wages decline and inflation and volatility increases.

3. There is limited evidence suggesting a change in the dynamics of the real interest rate across the sub-sample. The impulse response of federal debt displays a clear shift in 1980.

4. The estimated response of industry specific returns indicates that the change in the dynamics of stock prices was economy-wide

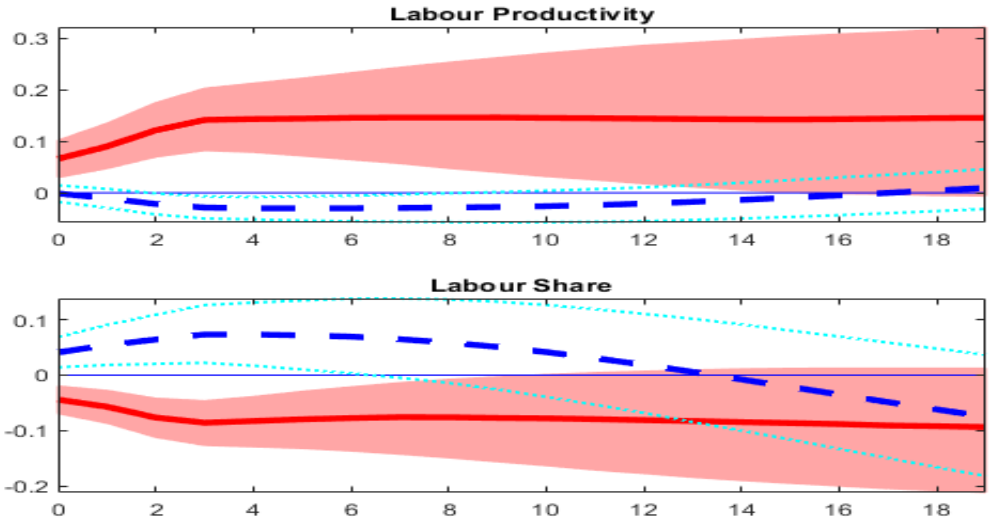

Figure 7: Response to a Government Spending shock. The Y-axis units are in percent for all variables. The solid lines and dashed lines are median responses while the shaded area and dotted lines are the 68% error band.

3 Explaining the change. A DSGE model

Given these empirical results, the aim is to develop a theoretical model that can explain not only the change in the sign of the stock price responses but also to be consistent with the pattern of responses for other key macroeconomic variables included in the FAVAR models. This objective drives our modelling choices below.

The core of the model developed in this section a standard New Keynesian model (Christiano et al. (2005), Smets and Wouters (2007)). We augment this model with a detailed fiscal block (as in Leeper et al. (2010a) and Leeper et al. (2017)) and a productive government similar to Leeper et al. (2010b) and Coenen et al. (2012). By moving away from non-distortionary fiscal instruments and balanced fiscal budgets, we ensure that any changes in impulse responses are not driven by changes in the composition of fiscal stimulus implemented by authorities in the past. A similar logic motivates the existence of a non-wasteful government in the model. The final addition to the model are two endogenous growth features. Following Chang et al. (2002), D'Alessandro et al. (2019), we incorporate labour augmented technology that increases in the skill level of the average worker ('learning by doing'). The model also includes a technology utilisation mechanism (Bianchi et al. (2019), Jorgensen and Ravn (2019)). The motivation behind the inclusion of these mechanisms can be seen in Figure 7 which plots the response of labour productivity and the labour share to government spending shocks obtained from the FAVAR model. The figure shows that although labour productivity rises after a spending shock in the pre-1980 period, the labour share declines. In other words, productivity is estimated to increase by more than the real wage providing an explanation for the negative response of inflation to this shock (see Figures 4 and 5). A meaningful device that could induce the supply side of the economy to expand (more than the demand) after a fiscal policy shock is an endogenous growth mechanism (Jorgensen and Ravn (2019)).

3.1 Key features of the model

In this section we provide a summary of the main sectors of the model with details given in the technical appendix. The model features monopolistically competitive households who consume, supply labour and capital services. As in Erceg et al. (2000), the household supplies a differentiated labour service to the production section. They set their nominal wage and supply any amount of labour demanded by the firms at that wage rate. In each period, a fraction of households receive a random signal and they are allowed to reset wages optimally while all other households can only partially index their wages to past inflation. The firm sector in the model consists of a continuum of intermediate producers that employ labour $\left(\upsilon_t^a \tilde{Z}_t X_t L_t\right)$ and capital services (L_t) and capital produced by the government $\left(\tilde{K}_t^G = (1-\delta_g)\tilde{K}_{t-1}^G + g_{t-1}^k\right)$ to produce the intermediate good for sale to the final producer

$$\tilde{Y}_t = \alpha_t \left[\left(\upsilon_t^a \tilde{Z}_t X_t L_t\right)^{1-\phi} \left(\upsilon_t \tilde{K}_{t-1}\right)^{\phi}\right]^{1-\phi_G} \left(\tilde{K}_{t-1}^G\right)^{\phi_G} \tag{15}$$

where $X_t = X_{t-1}^{\rho_x} L_{t-1}^{\mu_x}$ and $\tilde{Z}_t$ are the stationary and non-stationary part of the labour augmented technology, with X_t being an increasing function of L_t (Chang et al. (2002), D'Alessandro et al. (2019)). υ_t^a denotes the degree of the technology utilisation (Bianchi et al. (2019), Jorgensen and Ravn (2019)) that allows firms to adjust their absorptive capacity but these changes are not cost free.

Intermediate producers operate in two stages: First, they take wage and rental rate of capital as given and decide about labour, private capital, capital utilisation and technology utilisation by maximising their profits. Second, they decide about the price to charge with a fraction of firms allowed to reset their price each period. The government sector consists of a fiscal authority and a monetary authority. The fiscal authority finances government consumption and transfers by raising revenues from taxation and issuing new debt. The budget constraint of the fiscal authority is given by:

$$\frac{\tilde{B}_t}{R_t^G} + \tau_t^c \tilde{C}_t + \tau_t^k R_t^K \upsilon_t \tilde{K}_{t-1} + \tau_t^l \tilde{W}_t L_t = \frac{\tilde{B}_{t-1}}{\Pi_t} + \tilde{G}_t + \widetilde{TR}_t \tag{16}$$

Here, $\tilde{B}_t$ denotes government debt, τ_t^j is the tax rate $(j = c, k, l)$, R_t^G is the effective interest rate faced by households, R_t^K is the rental rate of capital $\left(\upsilon_t \tilde{K}_{t-1}\right)$, υ_t stands for the capital utilisation rate, $\tilde{W}_t$ is wage, L_t denotes hours worked, Π_t is inflation, while $\tilde{G}_t$ and $\widetilde{TR}_t$ denote government consumption and transfers, respectively.[13] The fiscal instruments are based on the following simple rule (Leeper et al. (2010b)):

$$\frac{f_t}{f} = \left(\frac{Y_t}{Y}\right)^{\varphi_f} \left(\frac{B_{t-8}}{Y_{t-8}} \Big/ \frac{B}{Y}\right)^{\zeta_f} u_{f,t} \tag{17}$$

$$u_{f,t} = (u_{f,t-1})^{\rho_f} \exp^{\sigma_f \varepsilon_{f,t}} \tag{18}$$

where $f = \tau^c, \tau^k, \tau^l, g^c, g^k, TR$ and $\tilde{Y}_t$ denotes output.

The monetary authority sets the policy interest rate R_t via the rule:

$$\frac{R_t}{R\Pi_t^*} = \left(\frac{R_{t-1}}{R\Pi_{t-1}^*}\right)^{\rho_R} \left(\frac{\Pi_t}{\Pi_t^*}\right)^{(1-\rho_R)\gamma_\pi} \left(\frac{Y_t}{Y}\right)^{(1-\rho_R)\gamma_y} \left(\frac{Y_t}{Y_{t-1}}\right)^{(1-\rho_R)\gamma_{\Delta y}} \exp^{\sigma_R \varepsilon_{R,t}} \tag{19}$$

where Π_t denotes inflation and Π_t^* the inflation target (which follows an AR(1) process).

We use two definitions of equity prices. In the first case, an equity security in the model is defined

[13] Non stationary variables are denoted by the superscript $\tilde{}$. Variables without a time subscript are steady state values.

as claim on the aggregate intermediate good producers' expected profits (Castelnuovo and Nistico (2010),Fernandez-Villaverde (2010), Diercks and Waller (2017))

$$q_t^e = E_t m_{t+1} \left(\Xi_{I,t+1} + q_{t+1}^e \right) \tag{20}$$

$$\Xi_{I,t} = Y_t - W_t L_t - R_t^K \upsilon_t \frac{K_{t-1}}{\Gamma_t} - \delta \left(\upsilon_t^a \right) \tag{21}$$

where $\delta \left(\upsilon_t^a \right) = \delta^a + \delta_1^a \left(\upsilon_t^a - 1 \right) + \frac{\delta_2^a}{2} \left(\upsilon_t^a - 1 \right)^2$ is the technology utilisation cost, Γ_t represents the growth rate of the non-stationary productivity shock and m_t is the stochastic discount factor (see the technical appendix). In the second case, an equity security is a claim on the expected consumption stream (Bansal and Yaron (2004), Campbell et al. (2014), Swanson (2015)). That is, an equity security in the model is defined as a leveraged claim on the aggregate: i) intermediate good producers' profits and ii) consumption

$$q_t^e = E_t m_{t+1} \left(\Xi_{I,t+1}^{\vartheta} + q_{t+1}^e \right) \tag{22}$$

$$q_t^{c,e} = E_t m_{t+1} \left(c_{t+1}^{\vartheta} + q_{t+1}^{c,e} \right) \tag{23}$$

where ϑ captures the degree of leverage.

3.2 Predictive Prior Analysis

In order to identify the aspects of the model's transmission mechanism that may explain the changes in the VAR impulse responses we use predictive prior analysis.[14] Denote the prior density function of the DSGE parameter vector by $p\left(\theta|\mathcal{M}\right)$. Then the impulse response of the endogenous variables, which are a function of the structural parameter vector, $IRFS = f\left(\theta|\mathcal{M}\right)$ as well as the prior density of the impulse responses $\left(p\left(\mathcal{IRFS}\left(\theta|\mathcal{M}\right)\right)\right)$ can be derived readily via simulation techniques.[15] In our exercise, an additional set of sign restrictions ($\mathcal{R}_{signs}^{j}$, where $j = pre80, post80$) are imposed on the prior distribution of the *pre* and *post* 1980 impulse-response functions $\left(p\left(\mathcal{IRFS}\left(\theta|\mathcal{M},\mathcal{R}_{signs}^{pre80}\right)\right), p\left(\mathcal{IRFS}\left(\theta|\mathcal{M},\mathcal{R}_{signs}^{post80}\right)\right)\right)$. Given these distributions one can back out the implied priors for the DSGE parameters in each regime: $\left(p\left(\theta|\mathcal{M},\mathcal{R}_{signs}^{pre80}\right), p\left(\theta|\mathcal{M},\mathcal{R}_{signs}^{post80}\right)\right)$.

The sign restrictions that we impose are defined in Table 1 and 2. We impose restrictions on three variables : stock prices, inflation and wages. The remaining 15 endogenous variables in the tables are unrestricted a priori. The restrictions are based on the information in Figure 7 and reflect the hypothesis that the supply side of the economy expanded by more than the demand side after a fiscal policy shock during the pre-1980 period. These signs are reversed for the post-1980 sample. Given these minimal restrictions, we can investigate if the reaction of the remaining variables to fiscal shocks matches the empirical results. The corresponding distributions of the structural parameters provide information regarding the mechanism that drives the changes in the impulse responses across time.

The initial prior moments of the structural parameter vector $p\left(\theta|\mathcal{M}\right)$ are discussed in the online appendix. We mention here briefly, that the moments of the parameters that govern the core New Keynesian block of the model are taken from Smets and Wouters (2007), the fiscal block parameters from Leeper et al. (2010a) and the endogenous growth parameters from D'Alessandro et al. (2019) and Bianchi et al. (2019).

[14] See Canova (2005), Traum and Yang (2011), Faust and Gupta (2012), Leeper et al. (2017) and Nelson et al. (2018) for recent applications of this technique.

[15] All the calculations have been implemented using Dynare 4.5.7. The codes and model files can be downloaded from authors' personal pages.

Table 1: $1955Q1 - 1979Q4$ Sign Searching Restriction

Variables	GDP	Consumption	Investment	**Inflation**	**Wage**	Policy Rate
Signs	**?**	**?**	**?**	$-$	$+$	**?**
Variables	TFP	Hours	Capital Utilisation	Technology Utilisation	Labour Productivity	Debt to GDP Ratio
Signs	**?**	**?**	**?**	**?**	**?**	**?**
Variables	Real Rate	Tax Revenues	Government Spending	**Equity Price**		
Signs	**?**	**?**	**?**	$+$		

Table 2: $1980Q1 - 2015Q4$ Sign Searching Restriction

Variables	GDP	Consumption	Investment	**Inflation**	**Wage**	Policy Rate
Signs	**?**	**?**	**?**	$+$	$-$	**?**
Variables	TFP	Hours	Capital Utilisation	Technology Utilisation	Labour Productivity	Debt to GDP Ratio
Signs	**?**	**?**	**?**	**?**	**?**	**?**
Variables	Real Rate	Tax Revenues	Government Spending	**Equity Price**		
Signs	**?**	**?**	**?**	$-$		

3.3 Government Consumption Spending Shock

This section reviews the simulation results when the fiscal stimulus is implemented via a government consumption spending shock. Figure 8 plots the prior distribution of DSGE model's variable responses to a government spending shock when the parameter draws meet the sign restrictions reported in Tables 1 and 2. Figure 8 provides support to the DSGE model's ability to replicate the direction of change of the FAVAR responses across the two sub-samples. It is important also to highlight that model's performance is not only related to a unique parameter vector but an entire distribution of parameters commonly used in the literature.

Figure 9 plots the implied probability density function of the parameters that correspond to different regimes. Almost all distributions overlap across regimes. The two parameter that display the least overlap are those that control: i) the importance of the "Learning By Doing" (μ_x) and the cost to a firm for varying its absorptive capacity (δ_2^a). The simulations are in line with the analysis of D'Alessandro et al. (2019) and Jorgensen and Ravn (2019)), who argue in the favour of an endogenous growth mechanism (in a New Keynesian model) as a plausible device to reproduce the increase in the real wage and the fall in the inflation observed in the data. Interestingly, this mechanism is also able to replicate the responses of the other variables in the system. In other words, in an economy where learning leads to a more effective technology and where firms can adjust the degree of their technology utilisation in a less costly manner, the elevated demand by the public sector is met by an even larger expansion in the supply. The increase in productivity more than compensates for the increase in the real wages and pushes inflation down. Inflation expectations are restored via looser monetary policy that pushes down the (long-term) real interest rate. The lower path of the long-term real interest rate is used to finance the expansion in the private consumption and investment. The productivity is translated to higher profits and together with a lower real interest rate causes the equity price to rise.

On the other hand, when the propagation of the endogenous growth mechanism is not strong enough (or absent), the government demand is met by reshuffling resources from the private to public sector (i.e. the crowding out effect). The fall in consumption increases the supply of labour from households and this leads to lower wages. Despite the fall in wages, labour productivity decreases by more and this generates cost pressures that result in a higher inflation and policy rates. High real (long-term) interest rates and lower profits lead to lower equity prices.

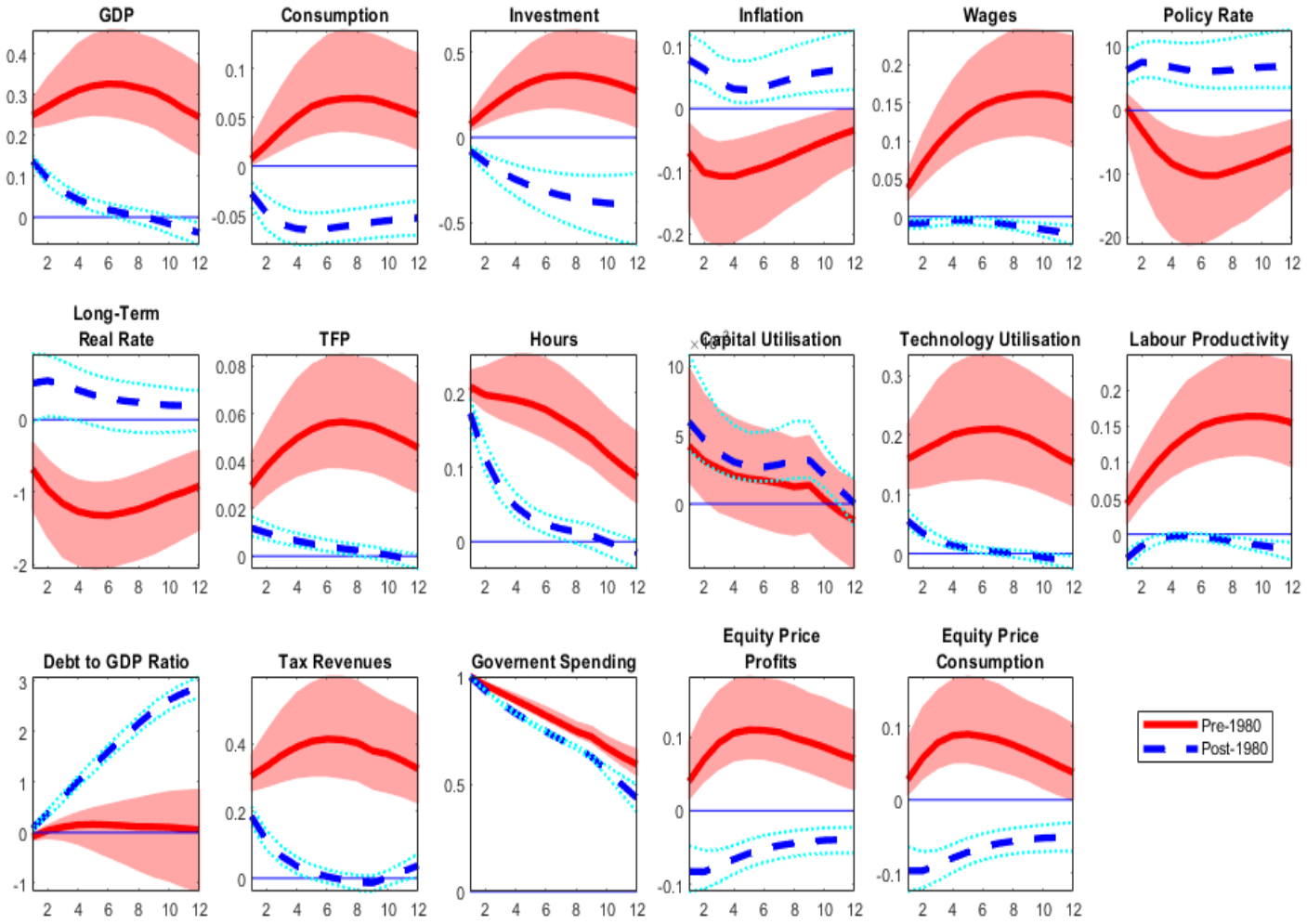

Figure 8: Government Consumption Spending Shock: The shock has been normalised to increase government spending by 1% on impact. The solid lines and dashed lines are median responses while the shaded area and dotted lines are the 68% prior distribution band. The inflation is expressed in annualised percentage points, while the policy rate and long-term interest rates in annual basis points.

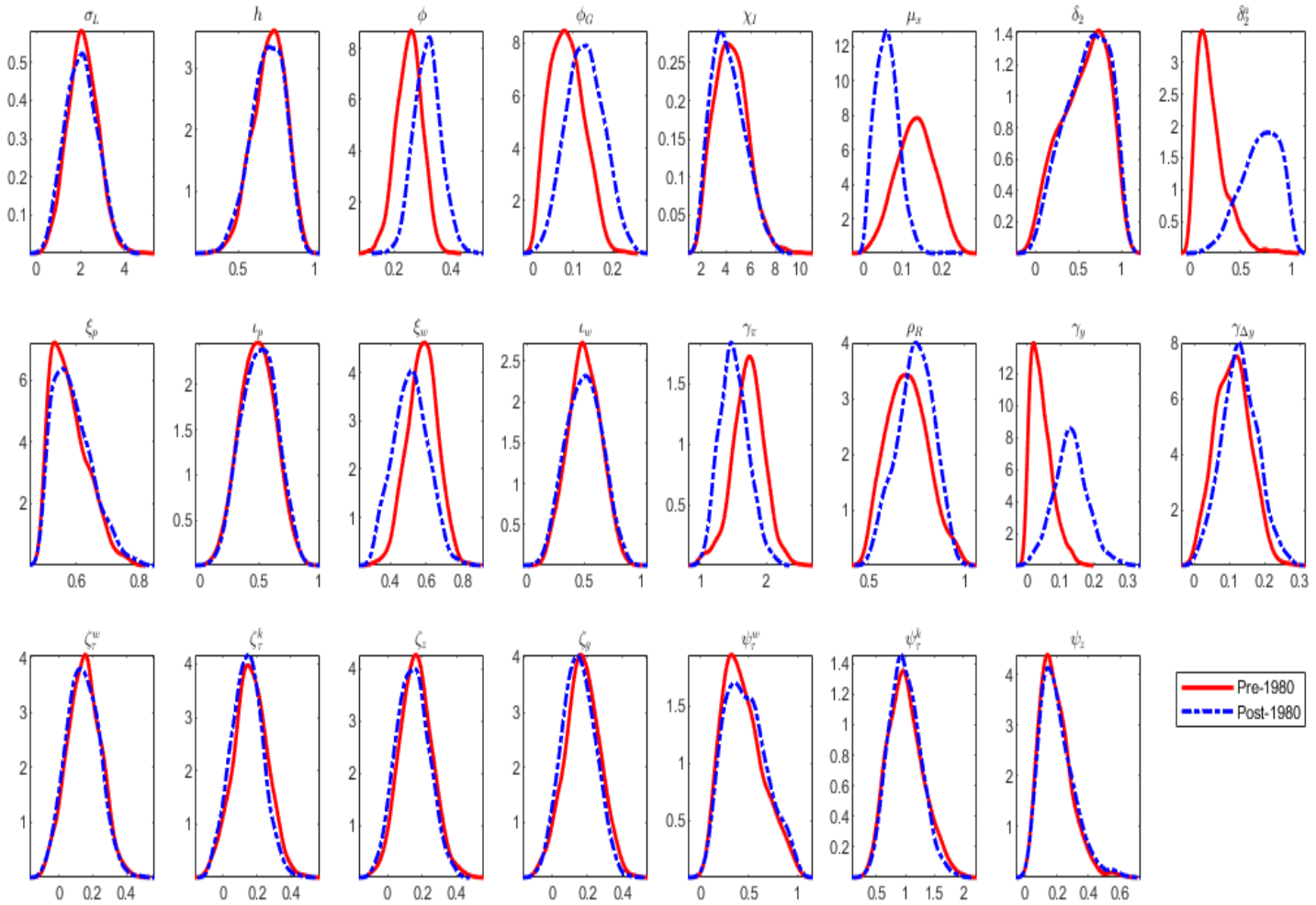

Figure 9: Government Consumption Spending Shock: Parameters.The probability function has been estimated using non-parameter kernel density estimation techniques.

3.4 Simulations using other fiscal instruments

In the online appendix we investigate whether results change when the fiscal stimulus is implemented via a government investment spending shock, a lump-sum tax shock, a labour tax shock or a capital tax shock.

Regarding the government investment spending shock, the DSGE model replicates again remarkably well the FAVAR responses for both regimes (Figures 9 and 10 in the online appendix). The expansion of the supply in this exercise relies less on firm's absorptive capacity and more on the contribution of the government to the production of the value added output. As in this case, the fiscal policy action is actually a productivity shock, a higher government capital share (ϕ_G) leads to a larger expansion of the supply after the government investment shock. However, the distribution of the learning by doing parameter (μ_x) is roughly the same between government consumption and investment spending shock simulations.

The lump-sum tax shock does not affect intermediate output directly and the importance of firm's ability to adjust the technology utilisation rate rises again (δ_2^a, Figures 11 and 12 in the online appendix). Therefore, the mechanism in this case is similar to the benchmark scenario.

Figures 15 and 16 in the technical appendix consider the labour tax shock. This simulation reveals that the cost of adopting new technology is significantly smaller in the pre-1980 sample and this seems to be the primary source of the switch in sign of impulse responses. The mode of the learning by doing parameter is also higher in the first sub-sample, and this could enhance the role of the endogenous growth mechanism further in this period.

On the other hand, if authorities use capital tax shocks to stimulate the economy (Figures 13 and 14 in the online appendix), then the changes in the responses across the two regimes are not explained by variations in the parameters that control the endogenous growth mechanism (i.e., μ_x and δ_2^a). In this case, it is the utilisation of the capital (i.e., lower δ_2) that drives the expansion of the supply side of the economy. The capital tax shock acts as an (investment-specific) productivity shock that raises the real value of capital and investment increases in both regimes. The higher value of the (inverse) labour supply elasticity diminishes the importance of the wealth effect, causing the real wage to increase. However, labour productivity rises by more than the real wage and along with the cost of capital fall lead to a reduction in the marginal cost. The steeper Phillips curve (lower ξ_p) implies a faster pass-through from lower-cost pressures to inflation. As inflation decreases, expectation about policy rate fall, which also drives the reduction in the long-term (real) interest rates.[16]

3.5 Predictive Posterior Analysis

We take a step further in this section, and investigate whether posterior predictive analysis delivers conclusions similar to those derived from the prior predictive analysis. Unlike the discussion in Section 3.2, the parameters are now drawn from the posterior distribution, which is estimated using the quasi-Bayesian technique developed by Christiano et al. (2010). The first step of this methodology is the estimation of the quasi-posterior mode. This is obtained by solving the following optimisation problem:

$$\bar{\theta}_j = \arg\min L\left(\mathcal{R}\left(\theta\right)_j^{DSGE} | \mathcal{R}_j^{BVAR}, \mathcal{W}\right) + \ln p\left(\theta\right) \tag{24}$$

where $j = 1955Q1-1979Q4$ and $1980Q1-2015Q4$, $\mathcal{R}_j^i$ is a $(n \times h)\times 1$ vector of h-period responses of n variables to the government spending shock, $\mathcal{W}$ is the $(n \times h) \times (n \times h)$ diagonal matrix of the inverse variance-covariance matrix of the BVAR responses, L denotes the log of the normal probability density function of $\mathcal{R}\left(\theta\right)_j^{DSGE}$ with mean $\mathcal{R}_j^{BVAR}$ and variance $\mathcal{W}$ and $p\left(\theta\right)$ is the prior probability density

[16] It is crucial to emphasise that the endogenous growth mechanism is active in both regimes. However the sign changes of the FAVAR responses across the two regimes cannot be explained by differences to the μ_x and δ_2^a parameters.

function of the structural parameter vector θ. The full quasi-posterior distribution – $p\left(\theta|\mathcal{R}_j^{BVAR}, \mathcal{W}\right)$ – is derived via a Random-Walk Metropolis-Hastings Markov-Chain-Markov-Chain sampler initiated from $\bar{\theta}_j$. Figure 10 illustrates the ability of the structural model to fit the stylised facts in both sub-samples remarkably well.[17]

Having estimated the posterior distribution of the structural parameter vector, we repeat the benchmark simulation exercise described in Section 3.2, but this time the parameters are drawn from the posterior distribution.[18] Figure 11 illustrates that the model – using draws from the posterior distribution this time – can replicate the pattern of the responses across the two subsamples seen in the data. Figure 12 suggests that the endogenous growth mechanism appears to be much stronger in the pre-1980 period. The posterior predictive analysis favours the "Learning By Doing" part of the endogenous growth mechanism as the key feature that could explain the change in the sign of the responses of interest. The figure shows that the pre-1980 distribution of μ_x is centered to the right of the post-1980 distribution. Although the variation of the degree of technology utilisation (δ_2^a) across the two sample is less pronounced, the mode of the conditional distribution suggest that it is less costly to adopt new technology in the first part of the sample. These conclusions are also supported by the posterior estimates of the parameters (see Figure 17 in the online appendix).[19]

[17] Figure 17 in the online appendix compares the posterior distribution of the structural parameter vector across the two sub-samples.

[18] The posterior draws of both sub-samples are merged and the parameters for the predictive posterior analysis are drawn uniformly from the pooled sample.

[19] As suggested by one of the referees we conduct an additional robustness exercise where all the parameters expect μ_x and δ_2^a are centred around the pre-1980 posterior mean, while μ_x and δ_2^a are drawn from the post-1980 posterior distribution. Figure 18 in the online appendix shows that without a strong endogenous growth propagation mechanism equity prices fall after a government spending shock.

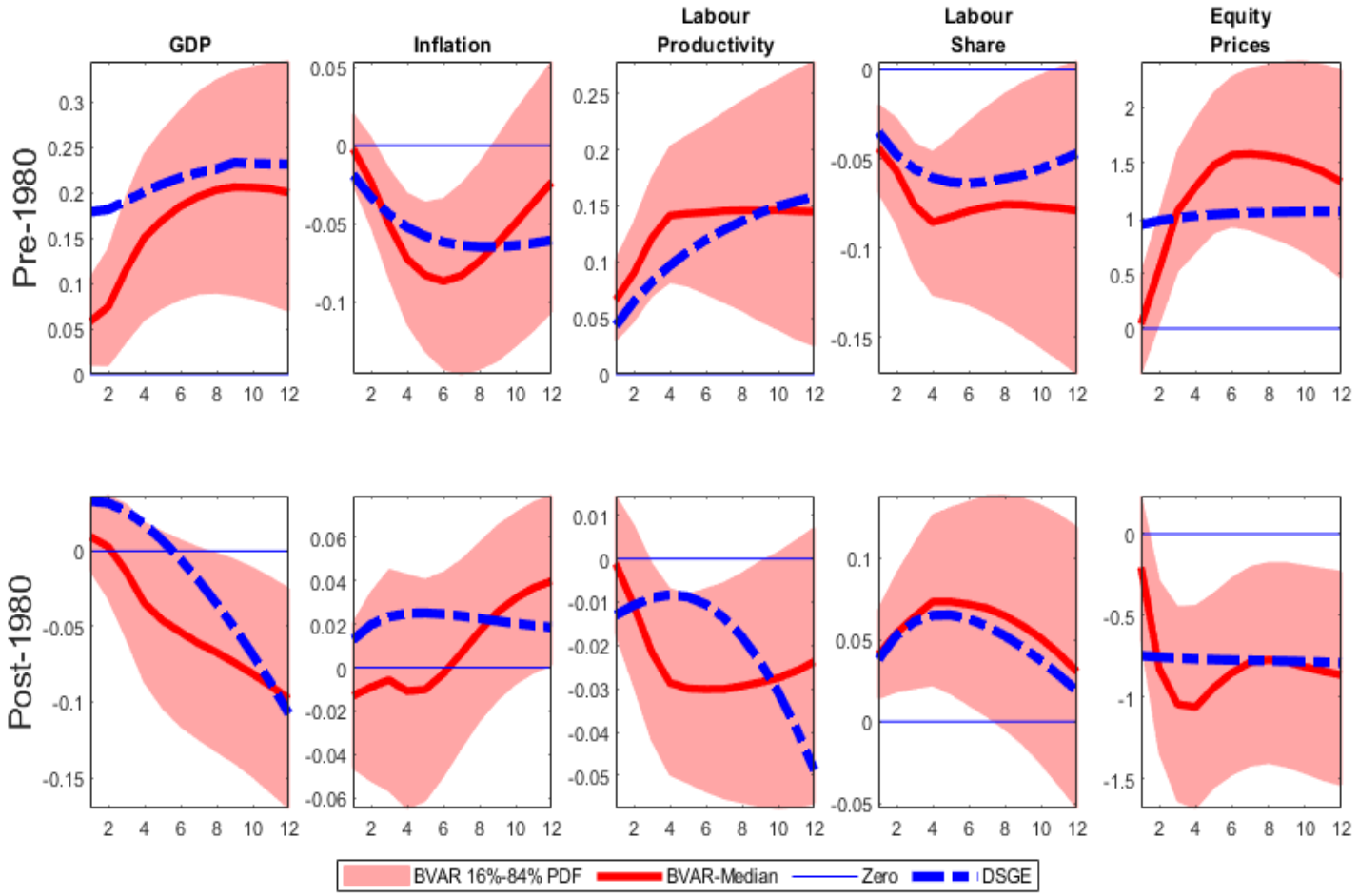

Figure 10: Response to a Government Spending shock. The Y-axis units are in percent for all variables. The solid red line is the median BVAR response, while the blue dashed line denotes DSGE posterior mode. The shaded area is the 16th-84th quantile of the BVAR posterior distribution.

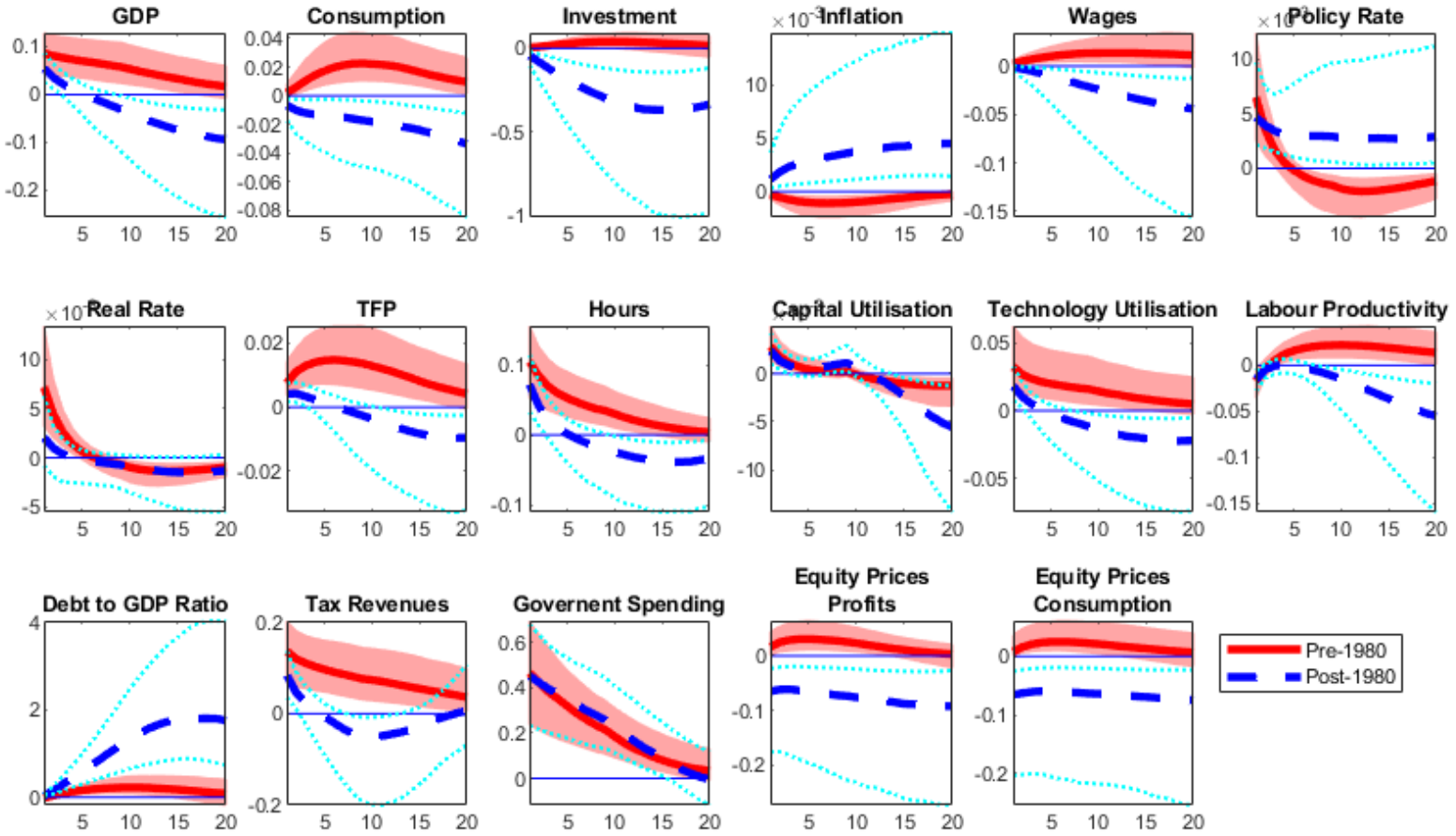

Figure 11: Government Consumption Spending Shock: The shock has been normalised to increase government spending by 1% on impact. The solid lines and dashed lines are median responses while the shaded area and dotted lines are the 68% prior distribution band. The inflation is expressed in annualised percentage points, while the policy rate and long-term interest rates in annual basis points.

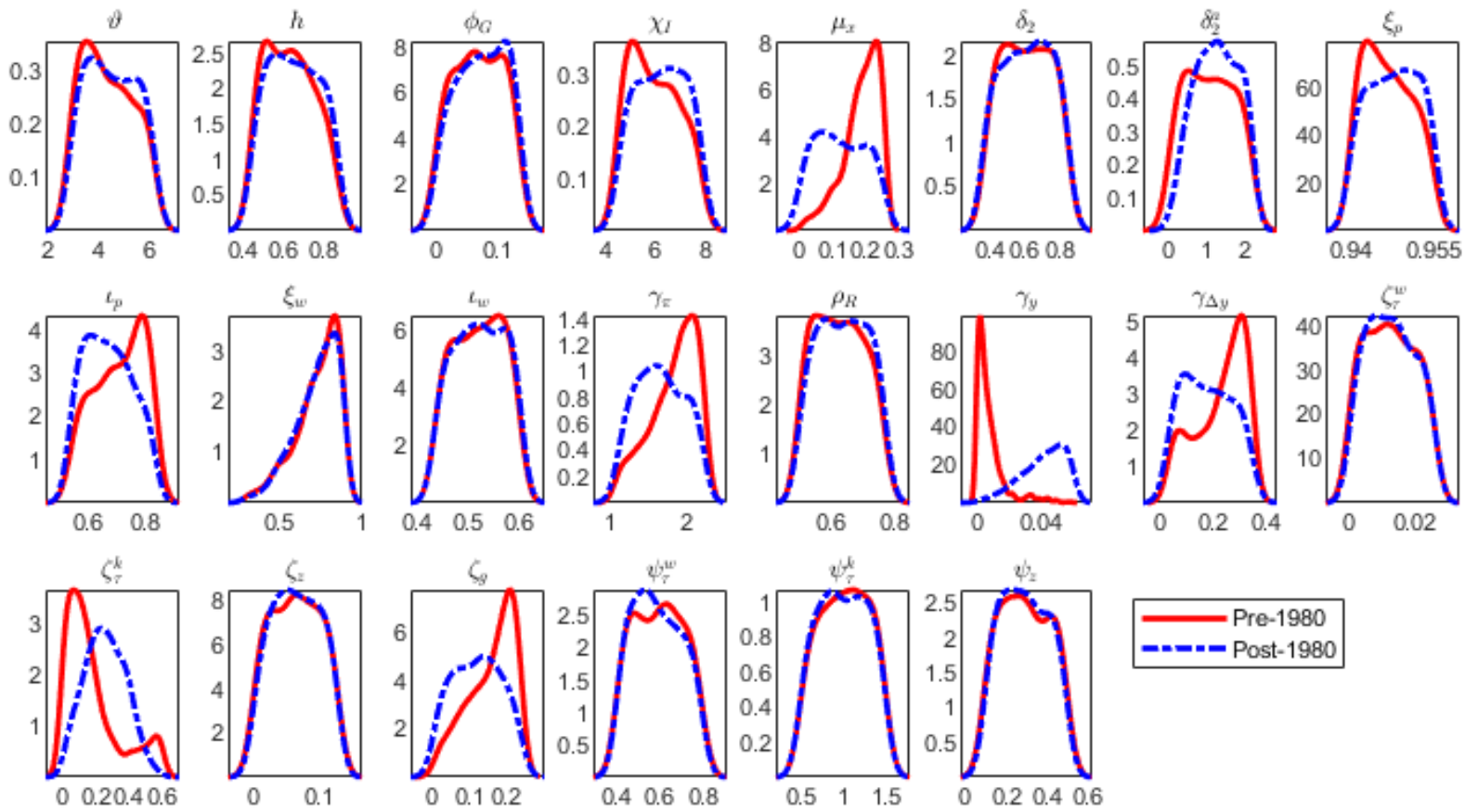

Figure 12: Response to a Government Spending shock: Parameters.The probability function has been estimated using non-parameter kernel density estimation techniques.

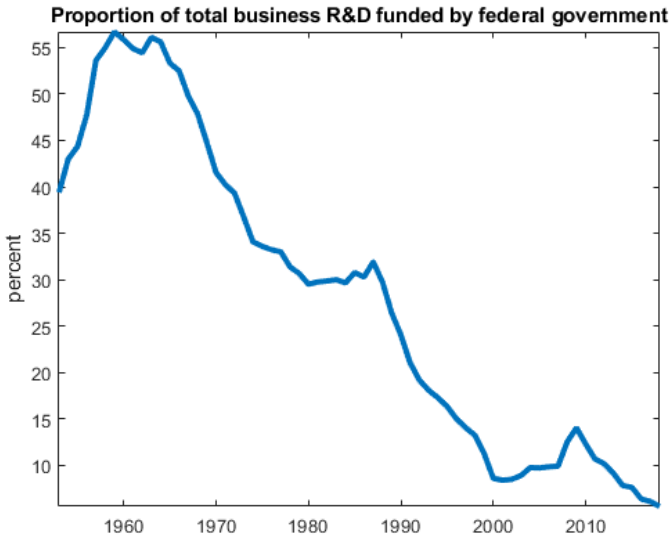

Figure 13: Proportion of R & D performed by companies in the domestic United States paid for by federal government. Source: the national science foundation.

3.5.1 Discussion

In summary, the simulations of the DSGE model provide one possible explanation for our main empirical result. The fall in equity prices in response to expansionary fiscal shocks estimated after 1980 is consistent with a decline in the importance of the endogenous growth mechanism. Our empirical results and simulations suggest that, before 1980 positive fiscal shocks generated an expansion in the supply side of the economy with higher productivity, lower inflation and real rates that pushed up equity prices.

An examination of data on research and development (R&D) provides one narrative that is consistent with this argument. Figure 13 shows that the proportion of US business sector R&D paid for by the federal government has declined significantly over time. Moreover, the effect of government spending shocks on R&D has undergone a shift in the post-1980 period. This is clear from an extended version of our benchmark VAR model that includes total business R&D as an additional endogenous variable.[20]The left panel of figure 14 shows the response of R&D to a spending shock during the pre and post-1980 sample. The right panel of this figure shows the contribution of spending shocks to the forecast error variance (FEV) of this variable. During the pre-1980 period, spending increases are associated with a rise in R&D of 0.5% at the two year horizon. Spending shocks are important for R&D fluctuations in this sub-sample with a contribution of around 20% at medium and long horizons. In the post-1980 period, the impact of the spending shock is substantially smaller in magnitude and persistence. In addition, the contribution of the spending shock to the FEV of R&D is halved after 1980.

[20] As the data on R&D is available only at an annual frequency from the national science foundation, we proceed as follows. Over the full sample, we estimate a mixed frequency VAR (MFVAR see Schorfheide and Song (2015) for details) model where we assume that the available annual observations on R&D are an average of the unobserved quarterly data. We use the estimated quarterly observations on R&D from this model (i.e the posterior median of the draws of quarterly R&D data) in our BVAR estimated on the sub-sample before and after 1980.

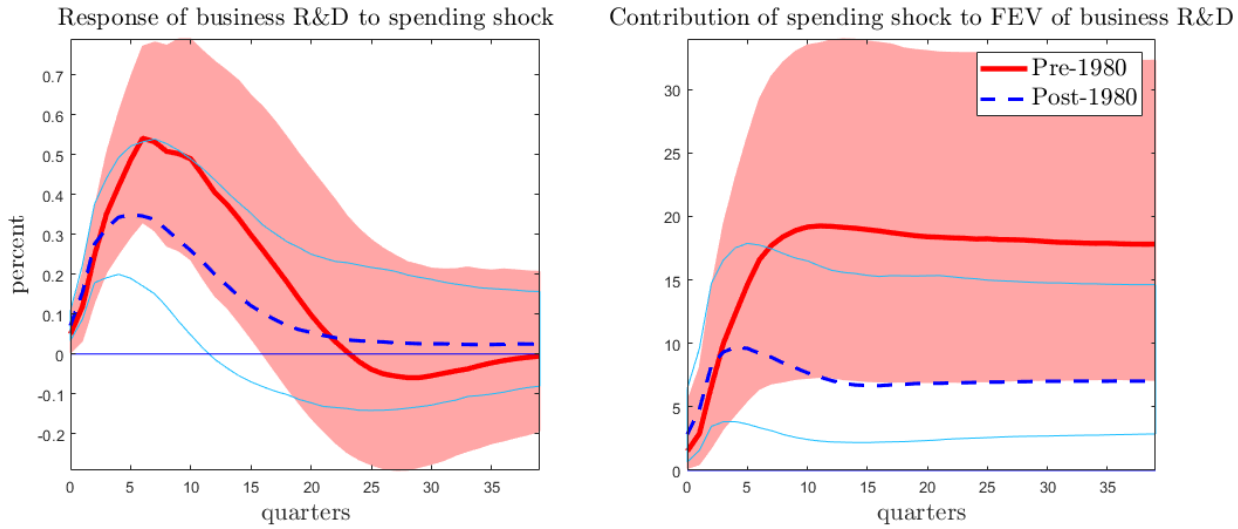

Figure 14: Response of business sector R&D to a government spending shock (left panel). Contribution of spending shocks to the forecast error variance (FEV) of business sector R & D.

These results are a demonstration of the declining role of the endogenous growth mechanism in the transmission of fiscal policy. The last three decades have seen a number of structural changes that could be linked to the reduction in the influence of fiscal policy on R&D and labour productivity. The onset of globalisation and increasing trade openness may mean that R&D expenditure is less sensitive to domestic policy and more exposed to international developments. A report by the National Science Foundation suggests that R&D has become increasingly globalised with a rise in R&D activity by foreign corporations in the US and US corporations carrying out more R&D abroad. A similar argument can plausibly be constructed for structural changes such as the financial liberalisation of the 1980s. If this change improved access of corporations to private funds, then it may explain the reduced effect of government spending on technology.

The explanation based on the endogenous growth mechanism in the model does not preclude the possibility that the change in the stock price response may also be driven by a shift in the reaction function of the Federal Reserve. If the Fed's response to inflationary shocks became stronger after 1980, then this may manifest as an increase in the real interest rate after a fiscal expansion thus pushing down stock prices. However our empirical results do not point strongly towards the importance of this channel. The FAVAR response of the ex-post real interest rate is not consistent with a shift in the reaction of the Fed to fiscal expansions. Similarly, the predictive prior analysis using the DSGE model does not seem to indicate strong shifts in the policy rule parameters. Nevertheless, It should be noted that as changes in the reaction of the Fed and the resulting impact on private sector expectations are hard to pin down (especially in a VAR framework), these results do not necessarily constitute conclusive evidence against this channel.[21]

[21] In an earlier version of this paper we show that parameter estimates of a simple DSGE model with an *unproductive* government sector based on pre and post-1980 samples are consistent with the argument that there was a shift in the reaction function of the monetary authorities. However, this set-up ignored the role of endogenous growth mechanisms.

4 Conclusions

In this paper we use SVAR models to show that the response of US stock prices to an expansionary fiscal shock has changed after 1980. Before this date, an expansionary fiscal shock was associated with an increase in stock prices. Post-1980, the same shock is associated with large declines in stock prices.

Using FAVAR models, we show that the change in the stock price response was accompanied by shifts in the response of real activity, TFP, real wages and inflation. In the pre-1980 sample real activity, TFP and real wages rise after a fiscal expansion with inflation declining. After 1980, the impact of fiscal shocks on real activity and TFP is smaller in magnitude, real wages fall and inflation increases.

Using a DSGE model with a detailed fiscal sector we argue that these changes are consistent with a shift in the importance of the endogenous growth mechanism in the model. In the pre-1980 period learning by doing and technology utilisation play an important part. A positive fiscal shock leads to an expansion in supply characterised by rising productivity and falling inflation. Real rates decline as a result and stock prices rise. After 1980, model simulations suggest that endogenous growth mechanisms are weaker. Fiscal expansions are accompanied by a fall in consumption and TFP. Inflation and the real interest rate increase and stock prices decline.

In future work it would be interesting to explore if the temporal shifts documented in this paper also applies to other developed countries such as the United Kingdom. It may also be useful to investigate if fiscal shocks have economically significant effects on prices of other assets such as homes and whether the estimated impact is stable through time.

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