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1 Introduction

John Habakkuk, writing in 1971 on the method of model-building in economic theory, observed that it was somewhat unusual that formal models were seldom used in the interpretation of economic history:

> "Economic theory characteristically proceeds by building a model, a simplified, abstract version of the real world . . . In view of its power one should perhaps be surprised at the little use made of this method (and its results) in the explanation of past economic events, either by economists or historians." (Habakkuk, 1971, pp. 305).

Since then, the field of cliometrics – "the application of economic theory and quantitative methods to the study of history" – has come to play an important role in both economic history and theoretical economics (Goldin, 1995, pp. 191). Researchers in the field have applied economic theory to the history of economic growth, international trade, financial markets, business cycles, and many other topics (see Diebolt & Haupert, 2019). Specific events in history are, of course, also regularly discussed with reference to economic theory. Somewhat surprising, however, is the rarity of attempts to interpret long historical series of macroeconomic shocks using standard macroeconomic theory.

In this paper, we offer an interpretation of the history of aggregate demand and supply shocks in the United Kingdom (UK) from a Keynesian perspective. While previous work has studied demand and supply shocks in the UK from a variety of angles, we ask a specific question: what does the aggregate demand/aggregate supply (AD-AS) framework implied by benchmark macroeconomic models tell us about the sources of inflation and unemployment events in British economic history? Specifically, we estimate vector autoregressive models (VAR models) in the unemployment and inflation rates, and identify the signs of certain structural shocks by applying sign restrictions to the VAR forecast errors. Our sign restrictions are derived from a baseline AD-AS framework that is consistent with the workhorse New Keynesian model, as well as various Old and Post Keynesian models.

Our research question is related to the recent study by Stuart (2019), who presents a history of aggregate demand and aggregate supply shocks for Britain and Ireland spanning 1922 – 1979. Stuart (2019) is interested in examining the dependence of the Irish economy on the British economy, and uses a bivariate VAR model in GDP and the price level in which aggregate demand and supply shocks are identified by assuming a unit price elasticity of demand. While we follow Stuart (2019) by interpreting our estimated shock series with reference to the narrative historical record, we use considerably weaker identification assumptions consistent with a wide variety of models. Our question is also related to Mathy (2020), who uses data on the inter-war American economy to identify the role that uncertainty shocks played in the Great Depression. As uncertainty shocks can be interpreted as a type of aggregate demand shock (Leduc & Liu, 2016), Mathy's results can be compared to any inter-war shocks uncovered by our approach using British data.

Aside from Stuart (2019), the small number of studies that derive series of aggregate demand and supply shocks using British historical data includes Karras (1993, 1994), Bergman (1996), and Liu & Mumtaz (2011). Karras (1993) presents a history of demand and supply shocks for the UK, Italy and Sweden between 1868 and 1987 identified via the Blanchard-Quah restriction that aggregate demand shocks have no permanent effect on output (Blanchard & Quah, 1989). Karras (1994) applies a similar identifying assumption to the UK, France and Germany between 1960 and 1988, while Bergman (1996) follows the same approach for the UK, Germany, Japan, Sweden and the USA between 1960 and 1990. Liu &

Mumtaz (2011), in comparison, present a historical decomposition of the output gap and inflation rate using a fully specified New Keynesian DSGE model.[1] Finally, it is also worth noting that a number of papers have examined the applicability of Keynesian AD-AS models to the UK economy, including Turner (1993), Funke & Hall (1998), Turner (1999), Jenkins & Tsoukis (2000), and Cover & Mallick (2012). Unlike these papers, which are mainly concerned with the identification of impulse response functions, we are specifically focused on the identification and interpretation of historical shocks.

Building on these papers, we make two contributions. First, we use a long time series of unemployment and inflation spanning the years 1900 – 2016, which provides a comprehensive picture of the type of shocks that have hit the UK economy over time. Second, and more importantly, we utilise a rarely explored feature of sign restrictions in VAR models: their capacity to identify the signs of structural shocks. While sign restrictions are almost always used to identify a set of impulse response functions, we show that they can also yield economically interesting information about the nature of shocks. Specifically, we use sign restrictions to pin down the direction of macroeconomic shocks, allowing us to classify them as positive or negative aggregate demand or aggregate supply shocks. This approach requires considerably weaker identification assumptions than point-identification, making use of the sign restrictions implied by the familiar AD-AS framework and very little else. This element of our contribution is inspired by Charles Manski's approach to partial identification:

> "Social scientists and policymakers alike seem driven to draw sharp conclusions, even when these can be generated only by imposing much stronger assumptions than can be defended. We need to develop a greater tolerance for ambiguity. We must face up to the fact that we cannot answer all of the questions that we ask." (Manski, 1995, pp. 7-8).

Our partial identification approach identifies the signs of certain shocks (e.g., the existence of a negative demand shock in 2009), but not the exact magnitude of those shocks. However, as our partial history only requires very weak assumptions, it ought to be more reliable than a complete history of shocks that imposes strong assumptions.

Overall, we find that aggregate demand shocks appear to be more important than aggregate supply shocks, in the sense that most of the large forecast errors implied by our VAR models are associated with demand shocks. Our results also support a number of well-known interpretations of UK economic history, including the identification of the two World Wars as positive demand shocks, the identification of the Great Depression and Great Recession as negative demand shocks, and the identification of the 1979 oil price events as a negative supply shock. In addition, we provide a new perspective on two major episodes:

a. Aggregate supply shocks in 1927 and 1971, which we attribute to changes in the bargaining power of organised labour;

b. Aggregate demand shocks in 1974 and 1975, which we attribute to expansionary fiscal policy.

These examples illustrate two important uses of our empirical approach: its ability to highlight certain shocks that rarely make it into the 'textbook' accounts of major macroeconomic events, and its ability to provide a new perspective on well-known events.

[1] After an initial literature search, we searched the set of papers that cited Karras (1993, 1994) or Bergman (1996) for papers that presented *histories* of aggregate demand and supply shocks for the UK. There also exist papers that do this for other countries, e.g. Fackler & McMillin (1998) for the USA.

The paper proceeds as follows. Section 2 derives an aggregate demand and supply framework from the workhorse New Keynesian model, and explains the expected effects of aggregate demand and supply shocks on economic activity and inflation. Section 3 then explains how sign restrictions derived from the workhorse New Keynesian model can be used to infer the signs of structural shocks from a reduced-form VAR model. Section 4 discusses the reduced-form VAR estimation and presents the sample of reduced-form residuals. Section 5 then presents the history of identified structural shock signs, and interprets a subset of the shocks using secondary references from economic history (the full set of shocks are interpreted in appendix B). Section 6 presents an alternative approach based on impulse indicator saturation, and demonstrates that the shocks derived using this method are similar to those derived in section 5. Finally, section 7 summarises our findings and presents concluding remarks.

2 AD-AS and the New Keynesian model

Despite criticism following the 2008 financial crisis, the workhorse New Keynesian model continues to form the basis of much theoretical and empirical macroeconomics, as well as an important part of economic pedagogy (Fontana & Setterfield, 2009; Galí, 2018). In its reduced form, it boils down to a familiar AD-AS framework that can also be derived from other well-known macroeconomic theories. Given its present popularity, we will use the New Keynesian model as a starting point to derive the AD-AS model that informs our empirical approach.

At its heart, the workhorse New Keynesian model is a simple three-equation model, made up of a dynamic IS-curve, a Phillips curve, and a monetary policy rule:

$$y_t = \mathsf{E}_t y_{t+1} - \sigma(i_t - \mathsf{E}_t \pi_{t+1}) + g_t, \tag{IS}$$

$$\pi_t = \beta \mathsf{E}_t \pi_{t+1} + \kappa y_t + \eta_t, \tag{PC}$$

$$i_t = \phi \pi_t + \epsilon_t, \tag{MP}$$

where y_t denotes the output gap (defined as the difference between actual and potential output); π_t denotes inflation; i_t denotes the nominal interest rate; g_t, η_t and ϵ_t are aggregate demand, aggregate supply, and monetary policy shocks, respectively; and σ, β, κ and ϕ are positive parameters. As all the variables are in deviations from their steady state values, we omit intercept terms. We have assumed in (MP) that the central bank is a strict inflation targetter, but incorporating output into the monetary policy rule does not change the relevant results. For a detailed derivation and discussion, see Galí (2008).

A determinate solution to a dynamic stochastic general equilibrium model like the New Keynesian model is one in which the endogenous variables are functions of the predetermined variables and shock processes. As there are no pre-determined variables in the simple New Keynesian model – e.g., there is no capital stock – a determinate solution is one in which the endogenous variables are functions of the shocks,

$$\begin{bmatrix} y_t \\ \pi_t \\ i_t \end{bmatrix} = B \begin{bmatrix} g_t \\ \eta_t \\ \epsilon_t \end{bmatrix},$$

for some 3×3 matrix B – see e.g. Blanchard & Kahn (1980). As a result, if the shock processes are AR(p), then a determinate solution to the New Keynesian model is a VAR(p) model in which the lag length p is inherited from the shock processes. For example, if g_t, η_t and ϵ_t follow AR(1) processes, then the solution to the New Keynesian model is of the form,

$$z_t = Cz_{t-1} + D\xi_t,$$

where $z_t = [y_t, \pi_t]'$, C and D are 2×2 matrices and ξ_t is a 2×1 white noise vector – see e.g. Dennis (2005). Note that in this particular case the interest rate i_t is dropped from the solution, as it is a static variable which can be substituted out.

To understand the sign structure of the responses of output and inflation to the various shocks hitting the economy, consider the simple case in which g_t, η_t and ϵ_t are mean zero white noise. This means that $\mathsf{E}_t g_{t+1} = \mathsf{E}_t \eta_{t+1} = \mathsf{E}_t \epsilon_{t+1} = 0$, and therefore – given the determinate solution form described above – that $\mathsf{E}_t y_{t+1} = \mathsf{E}_t \pi_{t+1} = 0$. Thus, the model with white noise shocks simplifies to,

$$y_t = -\sigma i_t + g_t,$$

$$\pi_t = \kappa y_t + \eta_t,$$

$$i_t = \phi \pi_t + \epsilon_t,$$

which, by substituting out i_t from the IS-curve, yields an AD-AS model,

$$y_t = -\sigma\phi\pi_t + d_t, \tag{AD}$$

$$\pi_t = \kappa y_t + \eta_t, \tag{AS}$$

where η_t is the aggregate supply shock and $d_t = g_t - \sigma\epsilon_t$ is the aggregate demand shock. Note that an increase in d_t is a positive aggregate demand shock, but an increase in η_t is more commonly referred to as a negative aggregate supply shock, as its initial effect is to increase costs (and therefore inflation, ceteris paribus).

It is worth pointing out that this reduced-form AD-AS model is fairly generic, and can be arrived at in a number of ways. In particular, as demonstrated in Dutt & Skott (1996), the Old Keynesian neoclassical synthesis model, the Monetarist model, the New Classical model, as well as several Post Keynesian models can all be formulated as an AD-AS reduced form. Theoretical differences arise with respect to the behavioural foundations, including the use of the price level versus the inflation rate, and the expected elasticities of the demand and supply functions. But in general – and in the New Keynesian model – the aggregate demand curve is downward-sloping in (y_t, π_t) space as the central bank raises interest rates when inflation is above its target, and the aggregate supply curve is upward-sloping as firms increase prices when the output gap is positive. This sign structure is consistent with the traditional neoclassical synthesis model and with Post Keynesian models in which inflation is the outcome of distributional conflict (e.g. Hein & Stockhammer, 2010).

With this sign structure, a positive aggregate demand shock increases output and inflation while a positive aggregate supply shock increases output and decreases inflation. This can also be deduced if we write the solution for output and inflation in terms of the shocks:

$$y_t = \left(\frac{1}{1+\sigma\phi\kappa}\right)(d_t - \sigma\phi\eta_t),$$

$$\pi_t = \left(\frac{1}{1+\sigma\phi\kappa}\right)(\kappa d_t + \eta_t),$$

implying that demand shocks make output and inflation move in the same direction, and supply shocks make output and inflation move in opposite directions.

3 Identifying the signs of demand and supply shocks

In our outline of the New Keynesian model in section 2, we framed the discussion in terms of the deviations of output and inflation from their steady state values. For the empirical exercise, we replace output with the unemployment rate, as – for reasons discussed in more detail below – we expect historical unemployment data to be more reliable than historical estimates of GDP. Consider, therefore, a structural VAR model in the unemployment rate u_t and the inflation rate π_t,

$$Az_t = a + \sum_{i=1}^{p} A_i z_{t-i} + \epsilon_t, \tag{1}$$

where $z_t = (u_t, \pi_t)'$, and $\epsilon_t = (\epsilon_t^d, \epsilon_t^s)'$ is a mean zero white noise vector process with variance covariance matrix Ω_ϵ. From (1) we have,

$$\mathbb{E}[z_t|z_{t-1}, ..., z_{t-p}] = A^{-1}a + A^{-1}\sum_{i=1}^{p} A_i z_{t-i}, \tag{2}$$

and therefore,

$$z_t - \mathbb{E}[z_t|z_{t-1}, ..., z_{t-p}] = A^{-1}\epsilon_t = v_t, \tag{3}$$

where $v_t = (v_t^u, v_t^\pi)'$ are the reduced form innovations, or one-step-ahead forecast errors.

Ordinarily, a VAR practitioner has to make certain assumptions on A and Ω_ϵ to identify the elements of A from the information contained in the variance-covariance matrix of v_t. This is because A has four elements, but there are only three elements in the (symmetric) variance-covariance matrix Ω_ϵ. A popular source of restrictions is the type of sign information derived in section 2, in which AD-AS theory implies that demand shocks make output and inflation move in the same direction, and supply shocks make output and inflation move in opposite directions. Mountford (2005), for example, uses a sign-restricted VAR model to investigate the effects of UK monetary policy, in which positive aggregate supply shocks are assumed to increase output and decrease the price level, and positive aggregate demand shocks are assumed to increase output and increase the price level. However, as discussed by Fry & Pagan (2011) and Lütkepohl & Kilian (2017), sign restrictions only result in set identification, not point identification. In other words, sign restrictions narrow down the set of structural impulse response functions, variance decompositions, and historical decompositions that are consistent with the reduced-form VAR, but do not uniquely identify them. Non-sign information therefore has to be appealed to in order to pin down unique impulse response functions, variance decompositions, and historical decompositions.

Mountford (2005), for example, follows Uhlig (2005) by using a loss function approach to pin down unique 'representative' impulse response functions following set identification by sign restrictions. Essentially, out of the set of impulse response functions which satisfies the sign restrictions, this method chooses the functions which satisfy the sign criteria by the largest margin. The non-sign information appealed to in this example is a loss function, which as the author admits, is arbitrary and does not follow from the theoretical model itself (Mountford, 2005, pp. 602). Fry & Pagan (2011) observe that any solution to the problem of set identification requires the introduction of extra information over and above the information contained in the sign restrictions. Bayesian approaches are the most common way to introduce this non-sign information, but as recently discussed in Wolf (2020), the popular Haar prior over impulse response functions identified using sign restrictions may well lead to misleading inference.

Although rarely exploited, there is in fact some unambiguous and economically interesting inference that can be gleaned from sign restrictions without recourse to non-sign information (Calvert Jump, 2018). While much of the VAR-literature has focused on the limited use of sign restrictions for identifying impulse response functions, sign restrictions can also be employed to identify the signs of structural shocks. To see this, recall the basic New Keynesian model discussed in section 2, which implies that a positive aggregate demand shock increases output and increases inflation while a positive aggregate supply shock increases output and decreases inflation. Recalling that we have replaced output with the unemployment rate, and assuming that unemployment is negatively related to output, we can impose the following AD-AS sign restrictions on the matrix A in (1) – (3),

$$A = \begin{bmatrix} 1 & -\alpha \\ \beta & 1 \end{bmatrix}, \tag{4}$$

where $\alpha > 0$ and $\beta > 0$, implying that unemployment is increasing in inflation and inflation is decreasing in unemployment. Using (4), we can write (3) as,

$$\begin{bmatrix} u_t \\ \pi_t \end{bmatrix} - \begin{bmatrix} \mathbb{E}[u_t|z_{t-1}, ..., z_{t-p}] \\ \mathbb{E}[\pi_t|z_{t-1}, ..., z_{t-p}] \end{bmatrix} = \begin{bmatrix} 1 & \frac{\alpha}{1+\alpha\beta} \\ \frac{-\beta}{1+\alpha\beta} & 1 \end{bmatrix} \begin{bmatrix} \epsilon_t^d \\ \epsilon_t^s \end{bmatrix} = \begin{bmatrix} v_t^u \\ v_t^\pi \end{bmatrix}. \tag{5}$$

Consistent with our discussion of η_t in section 2, we will refer to $\epsilon_t^d < 0$ as a positive demand shock, as this corresponds to a decrease in unemployment, and $\epsilon_t^s < 0$ as a positive supply shock, as this corresponds to a decrease in inflation. Using (5), consider the implications of the four possible combinations of structural shock signs:

1: $\epsilon_t^d < 0,\ \epsilon_t^s < 0 \implies v_t^u = \epsilon_t^d + \frac{\alpha}{1+\alpha\beta}\epsilon_t^s < 0,\ v_t^\pi = \frac{-\beta}{1+\alpha\beta}\epsilon_t^d + \epsilon_t^s \lesseqgtr 0,$

2: $\epsilon_t^d < 0,\ \epsilon_t^s > 0 \implies v_t^u = \epsilon_t^d + \frac{\alpha}{1+\alpha\beta}\epsilon_t^s \lesseqgtr 0,\ v_t^\pi = \frac{-\beta}{1+\alpha\beta}\epsilon_t^d + \epsilon_t^s > 0,$

3: $\epsilon_t^d > 0,\ \epsilon_t^s < 0 \implies v_t^u = \epsilon_t^d + \frac{\alpha}{1+\alpha\beta}\epsilon_t^s \lesseqgtr 0,\ v_t^\pi = \frac{-\beta}{1+\alpha\beta}\epsilon_t^d + \epsilon_t^s < 0,$

4: $\epsilon_t^d > 0$, $\epsilon_t^s > 0 \implies v_t^u = \epsilon_t^d + \frac{\alpha}{1+\alpha\beta}\epsilon_t^s > 0$, $v_t^\pi = \frac{-\beta}{1+\alpha\beta}\epsilon_t^d + \epsilon_t^s \lesseqgtr 0$.

To summarise, a positive demand shock and positive supply shock (case 1) results in a negative unemployment forecast error and an inflation forecast error of unknown sign. A positive demand shock and negative supply shock (case 2) results in an unemployment forecast error of unknown sign and a positive inflation forecast error. A negative demand shock and a positive supply shock (case 3) yields an unemployment forecast error of unknown sign and a negative inflation forecast error. Finally, a negative demand shock and a negative supply shock (case 4) results in a positive unemployment forecast error and an inflation error of unknown sign.

Working backwards from cases 1 – 4 above, it is straightforward to deduce the following results:

A: $v_t^u < 0$, $v_t^\pi > 0 \implies \epsilon_t^d < 0$,

B: $v_t^u > 0$, $v_t^\pi < 0 \implies \epsilon_t^d > 0$,

C: $v_t^u > 0$, $v_t^\pi > 0 \implies \epsilon_t^s > 0$,

D: $v_t^u < 0$, $v_t^\pi < 0 \implies \epsilon_t^s < 0$.

To summarise, a negative unemployment forecast error and a positive inflation forecast error (case A) imply the existence of a positive demand shock, and nothing can be said about the sign of the supply shock. A positive unemployment forecast error and a negative inflation forecast error (case B) imply a negative demand shock, and the sign of the supply shock is unknown. A positive unemployment forecast error and a positive inflation forecast error (case C) imply a negative supply shock, and nothing can be said about the sign of the demand shock. Finally, a negative unemployment forecast error and negative inflation forecast error (case D) imply a positive supply shock, and the sign of the demand shock is unknown.

It is also straightforward to infer the results in cases A – D graphically, as illustrated in figure 1. This shows four standard AD-AS diagrams, corresponding to cases 1 – 4 above, with the forecast errors of unemployment and inflation on the horizontal and vertical axes rather than the observed unemployment and inflation rates. As the models considered here are linear, the reader can think of the graphs as showing observed unemployment and inflation rates on the horizontal and vertical axes, respectively, with their expected values at the origin.

Importantly, these results have been arrived at solely with the use of sign restrictions derived from a standard AD-AS model. No non-sign information has been appealed to, and it is also worth noting that no assumptions have been made on the variance-covariance matrix of the structural shocks – see Cover et al. (2006) or Enders & Hurn (2007) for papers arguing that structural demand and supply shocks in AD-AS models should not be modelled as uncorrelated. Based on this identification strategy, reduced-form residuals $\hat{v}_t^u$ and $\hat{v}_t^\pi$ can be estimated from a VAR to infer the signs of aggregate demand and aggregate supply shocks. In the sequel we focus on large forecast errors to mitigate inferential problems related to small forecast errors. Given our series of VAR forecast errors and identification strategy, we can then interpret the implied structural shock signs using secondary sources from economic history, as recommended by Rudebusch (1998) and Kliem & Kriwoluzky (2013).

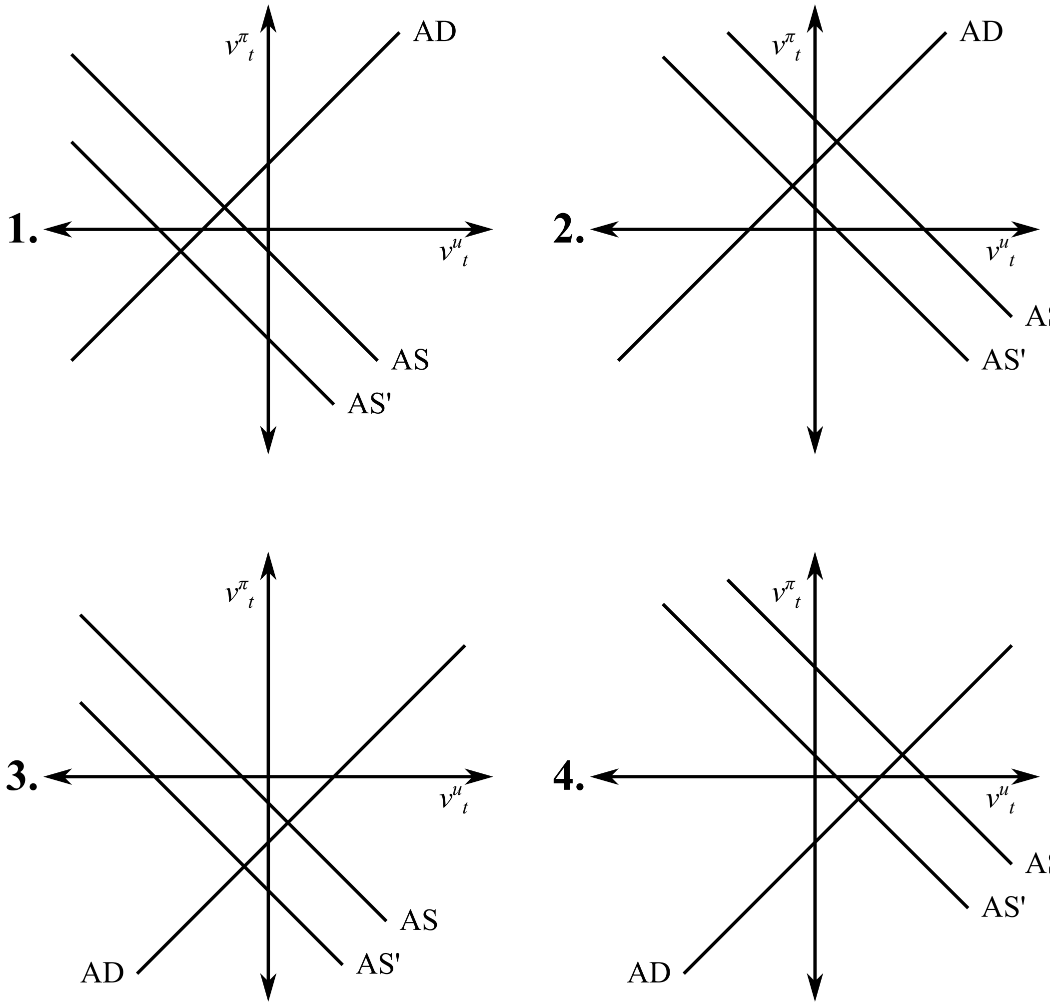

Figure 1: Cases 1 – 4 in section 3. Note the illustrations use differences in the size of the supply shock, but in general the results follow from differences in the relative size of the demand and supply shocks and the magnitudes of α and β.

4 A VAR model in unemployment and inflation

A reduced form VAR model in the unemployment rate and inflation rate is estimated from 1900 – 2016, using the Bank of England's 'millennium of macroeconomic data' dataset.[2] This long sample period allows a number of important sources of shocks to be contained within the sample, including the financial turbulence of the 1920s and 1930s, the two World War periods, the high inflation episodes during the 1970s and the Great Recession of 2009. Figure 2 plots the two series. The rapid inflation during and after the First World War followed by the rapid deflation in the 1920s and 1930s are both visible, as is the unemployment peak of 15.4% in 1932. The prolonged period of low unemployment and decreasing inflation following the end of the Second World War is also evident, followed by the rapid increase in inflation during the late 1960s and early 1970s, culminating in the oil price shocks of the 1970s. The sample ends with the relatively high unemployment rates following the early 1980s recession, and the Great Recession following the 2008 financial crisis.

[2]Specifically, this is the millenniumofdata_v3_final.xlsx sheet, downloaded on 25/08/2017 11.37am from www.bankofengland.co.uk/research/Pages/datasets/default.aspx. The LFS consistent measure of the unemployment rate and the consumer price inflation series are used, both from tab "A1. Headline Series".

Figure 2: UK unemployment rates and inflation rates, 1900 – 2016.

We use the unemployment rate rather than GDP because, given the long time series we employ, we expect the former variable to be more accurately measured than the latter. In the Bank of England dataset, real GDP estimates are taken from Solomou & Weale (1991) between 1900 and 1913, Sefton & Weale (1995) between 1920 and 1947, and national statistics thereafter, with a 'compromise estimator' used for the First World War and immediate post-war period. As argued by Solomou & Ristuccia (2004), there are significant differences between output, expenditure and income estimates of GDP prior to the advent of centralised national statistics, and the implied measurement errors are unlikely to be random. As a result, different ways of reconciling the estimates can yield very different GDP figures. Furthermore, as discussed in chapter 5 of Sefton & Weale (1995), the underlying data on which pre-War output, expenditure and income estimates are based are themselves taken from a variety of sources on consumer expenditure, capital formation, wages and salaries, and industrial output. This reflects the absence of modern national accounting in the UK prior to the Second World War.

Unemployment figures, in comparison, are somewhat more straightforward to estimate. The Bank of England dataset uses estimates from Boyer & Hatton (2002) and Feinstein (1972) between 1900 and 1949, and national statistics thereafter. The Boyer & Hatton (2002) and Feinstein (1972) estimates are partly based on trade union unemployment rates, which were also used in official Board of Trade statistics. Boyer & Hatton (2002) extended these figures by using employment data for non-unionised sectors, alongside labour force weights based on the decennial census. Given the conceptual simplicity of employment and unemployment compared to gross domestic product, and the availability of administrative

Point estimates:

$$\begin{bmatrix} u_t \\ \pi_t \end{bmatrix} = \begin{bmatrix} 1.27 & 0.14 \\ -0.63 & 0.78 \end{bmatrix} \begin{bmatrix} u_{t-1} \\ \pi_{t-1} \end{bmatrix} + \begin{bmatrix} -0.32 & -0.08 \\ 0.73 & 0.03 \end{bmatrix} \begin{bmatrix} u_{t-2} \\ \pi_{t-2} \end{bmatrix} + \begin{bmatrix} v_t^u \\ v_t^\pi \end{bmatrix}.$$

Misspecification tests:

Autocorrelation		Heteroskedasticity		Normality	
Statistic	p-value	χ^2 statistic	p-value	Statistic	p-value
8.18	0.09	46.9	0.00	104.22	0.00

Tests employed: Serial correlation=Lagrange Multiplier; Heteroskedasticity=White (no cross terms); Normality=Doornik-Hansen. Only first-order autocorrelation is reported.

Box 1: Estimation output for VAR in unemployment rate and inflation rate.

data from trade unions, the Inspectors of Mines, the Board of Trade and others, alongside official statistics from the census, one would expect unemployment to be more accurately measured than GDP. This is most likely to be the case during the First and Second World Wars, in which we are certain that full employment was approximately achieved, but relatively uncertain about the exact level of real GDP.

The VAR estimates are summarised in box 1. Unit root tests are inconclusive, although there is no obvious drift in either the unemployment or inflation series. Both the Akaike and Bayesian information criteria indicate a two lag model. The intercept terms were dropped in the final estimations because they were statistically insignificant at the 5% level, and the inflation equation became slightly more stable when the intercept was excluded. Intuitively, if both unemployment and inflation follow a unit root process with no drift, then the intercept estimator is $\sqrt{T}$-consistent, so converges at a slower rate than the T-consistent slope estimator. Including intercepts appears to increase parameter instability in our VAR estimates, and therefore they are excluded. However, the residual series from the VARs estimated with and without intercepts are almost identical; see the scatter matrix and kernel densities in figure D2 in appendix D.

The model does not suffer from autocorrelation at the 5% level, but does exhibit heteroskedasticity. This is unsurprising given the large shocks obvious in figure 2, but given that the objective of this study is to identify these historical shocks, we do not attempt to correct for it in our VAR analysis. As the residuals are highly non-normal, RESET tests for omitted non-linearities were applied equation-by-equation, but no evidence of non-linearity was found. Despite the sample being relatively long, the estimates are remarkably stable, as illustrated by the CUSUM plots of the cumulative sum of the recursive residuals, as well as recursive parameter estimate plots presented in appendix A. The CUSUM plot for the inflation equation in figure A2 can be compared to its equivalent from a VAR estimated with intercepts in figure D1, for evidence that the estimates excluding intercepts are slightly more stable. This also suggests that no significant non-linearities have been omitted.

The model described in box 1 has two real eigenvalues equal to 0.98 and 0.74, and two

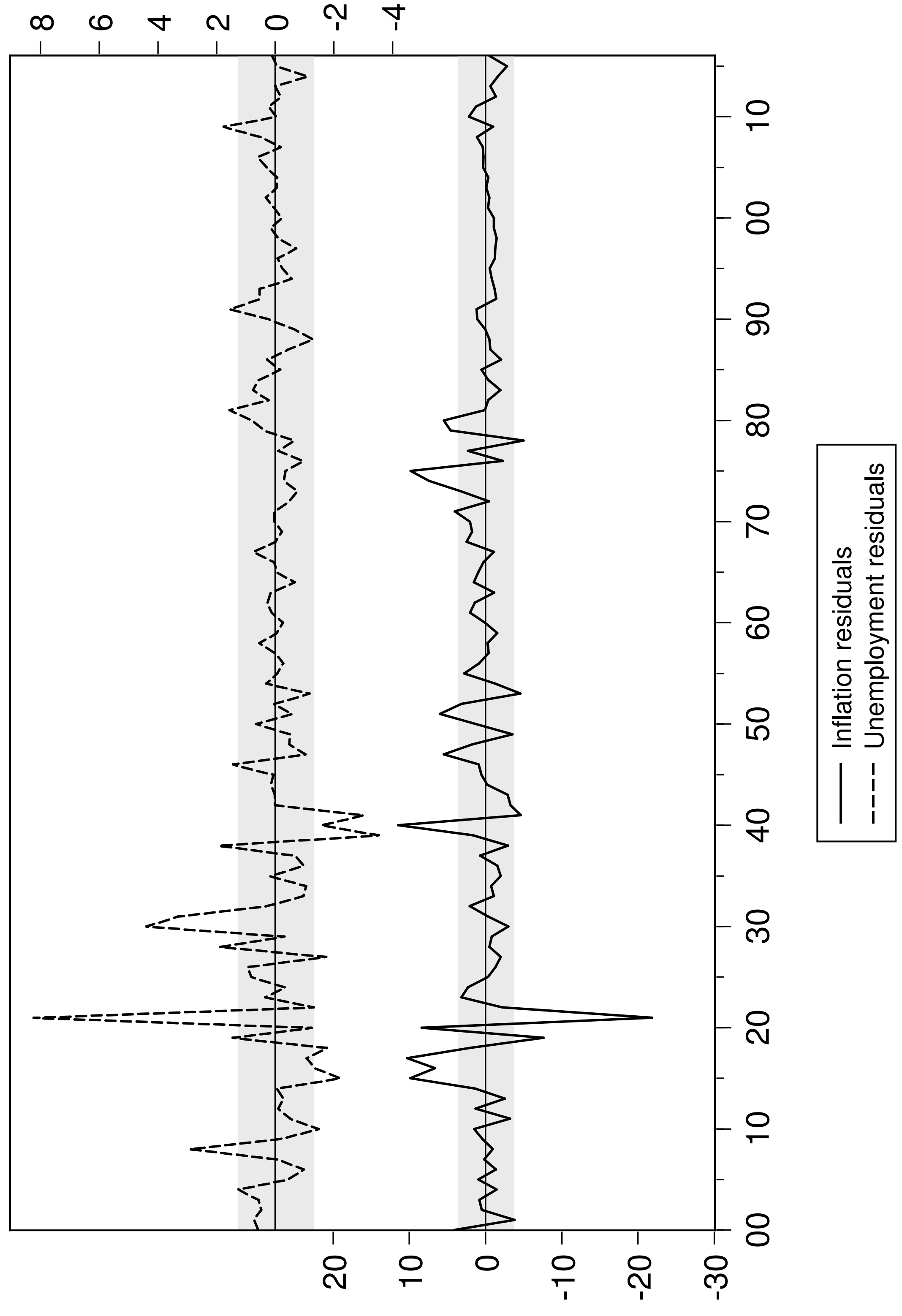

Figure 3: VAR residuals, 1900 – 2016, with ±1 standard deviation regions shaded in grey.

complex conjugate eigenvalues equal to $0.17 \pm 0.21i$. The eigenvalue equal to 0.98 suggests a unit root process, providing further support to our exclusion of the intercepts from the final model, given that neither series has an obvious drift that would be captured by an intercept term. The complex conjugate eigenvalues imply a business cycle component with an average period of approximately 7 years, although from figure 2 it is obvious that the business cycle component does not account for a large part of the variance of unemployment and inflation in the UK.[3] Instead, there are clearly large shocks impacting unemployment and inflation. These shocks lead to the reduced form residuals plotted in figure 3, from which the considerable forecast errors during the war periods and 1920s are immediately apparent. Large inflation forecast errors are also apparent in the late 1940s and early 1950s, and the late 1970s and early 1980s. Large unemployment forecast errors are visible around the recessions of the early 1980s, early 1990s, and late 2000s. Using the method outlined in section 3, these forecast errors will be used to derive a history of aggregate demand and supply shocks in the next section.

5 A partial history of aggregate demand and supply shocks

Table 1 presents unemployment and inflation residuals and the implied demand and supply shocks, using the sample of residuals plotted in figure 3 and the identification strategy outlined in section 3. Only those years for which at least one of the unemployment and inflation residuals are greater in magnitude than their respective sample standard deviations are examined. We provide a detailed historical discussion of the majority of the shocks in appendix B, and summarise our reasoning in the 'source' column in table 1. We first note that our classification of some of the most well-known events is in line with common interpretations. The World Wars between 1914 – 1918 and 1939 – 1945 are associated with positive demand shocks, whereas negative demand shocks are present during the Great Depression in 1930 and 1931 and the Great Recession in 2009. Negative supply shocks are present following the 1979 oil price shock. Second, we find that there are considerably more large aggregate demand shocks than large aggregate supply shocks, so on this measure demand shocks were more important than supply shocks for the evolution of UK unemployment and inflation between 1900 and 2016. However, we also note that large supply shocks are more prevalent than large demand shocks after 1970, which is consistent with the results of Liu & Mumtaz (2011), who find that aggregate supply shocks are relatively important for output fluctuations using a sample that starts in 1970.

Two of the most interesting episodes are the positive supply shock in 1927, and the negative supply shock in 1971, whose economic interpretation might be less evident. The 1927 shock, in particular, is rarely included as a 'textbook' example of an important macroeconomic shock. We attribute both shocks to changes in the bargaining power of organised labour. The positive shock in 1927 can be linked to a sudden fall in bargaining power following the 1926 general strike. This strike took place over nine days at the beginning of May 1926, and followed a long period of failed negotiations over miners' wages (which had fallen significantly since the end of the First World War). After the failure of the strike, the Trade Disputes and Trade Unions Act (1927) and the Unemployment Insurance Act (1927) were passed. Unions were prevented from acting in a 'political' manner, secondary strike action was made illegal, and,

[3] A pair of complex conjugate eigenvalues $\lambda = a \pm bi$ imply a sinusoidal component of period $2\pi/\arctan(b/a)$, which in this case is $2\pi/\arctan(0.21/0.17) = 7.058$. See Shibayama (2008) for details.

Table 1: Implied demand and supply shocks

Date	$\hat{v}_t^u$	$\hat{v}_t^\pi$	Implied demand shock	Implied supply shock	Source
1900	0.58	4.07		−	Commodity prices
1901	0.73	-3.82	−		Panic of 1901
1908	2.91	-0.96	−		1907 financial crisis
1910	-1.48	1.51	+		'People's Budget'
1915	-2.22	9.86	+		First World War
1916	-1.36	6.60	+		First World War
1917	-1.07	10.30	+		First World War
1918	-1.76	1.96	+		First World War
1919	1.45	-7.61	−		Fiscal retrenchment
1920	-1.24	8.40	+		Global post-war boom
1921	8.24	-21.82	−		Gold standard
1922	-1.32	-2.19		+	*Unknown*
1927	-1.74	-1.98		+	Bargaining power
1928	1.88	-0.49	−		*Unknown*
1930	4.40	-2.98	−		Great Depression
1931	3.32	-0.34	−		Great Depression
1938	1.93	-2.95	−		Recession in USA
1939	-3.54	1.65	+		Second World War
1940	-1.58	11.46	+		Second World War
1941	-3.02	-4.61		+	*Unknown*
1946	1.45	0.90		−	*Unknown*
1947	-1.03	5.50	+		*Unknown*
1951	-0.57	5.96	+		Korean War
1953	-1.17	-4.56		+	*Unknown*
1971	0.01	4.02		−	Bargaining power
1974	-0.30	7.40	+		Fiscal expansion
1975	-0.35	9.85	+		Fiscal expansion
1978	-0.64	-4.98		+	Social contract
1979	0.36	4.56		−	Oil prices
1980	0.78	5.48		−	Oil prices
1981	1.57	0.09		−	Oil prices
1991	1.55	1.178		−	Oil prices
2009	1.77	-1.00	−		2008 financial crisis

Notes: Only those years in which at least one of $|v_t^u|$ and $|v_t^\pi|$ are greater than their respective sample standard deviations are displayed. In columns 4 and 5, "+" denotes a positive shock and "−" denotes a negative shock. World War years are highlighted in grey.

> "What followed was a systematic campaign to tighten up the existing administration of unemployment insurance. The 'seeking work' test, of course, had already made its mark. By 1927 one in ten of all claimants was being refused benefit because of an 'unsatisfactory attitude to work'." (Garside, 1990, pp. 48).

The 'seeking work' test had already been introduced in 1921 and required claimants to show that they were genuinely seeking work, with unemployed workers being obliged to accept any work at a reasonable wage. This tightening of unemployment insurance, alongside the new restrictions on trade union activity, constitute a reduction in bargaining power which may be taken as the primary source of the observed supply shock in 1927.

The negative supply shock in 1971, by comparison, can be viewed as a reflection of the positive supply shock in 1927. Whereas the latter shock constituted, to some extent at least, an exogenous decrease in the bargaining power of workers, the events in 1971 are in part accounted for by an exogenous increase in the bargaining power of workers. Thus, Nicholas Woodward observes that,

> "By the early 1970s, [wage inflation] had risen to between 12 and 13 per cent. This wage explosion, moreover, was associated with an apparent upsurge in labour militancy. For example, over this period there was a rapid increase in trade union membership from 42.7 per cent of the labour force in 1968 to 47.2 in 1972. At the same time there was a significant increase in strike activity, and . . . this was reflected in all the main strike indicators." (Woodward, 1991, pp. 197-198).

Woodward goes on to argue that the usual interpretation of the increase in inflation during this period is that, "it was the product of autonomous wage pressures", i.e. a shock to workers' bargaining power (Woodward, 1991, pp. 198). Interestingly, unemployment only increased marginally in 1971, with the bulk of the shock being felt in a large increase in inflation. This is rather different to 1927, in which the unemployment and inflation rates both decreased by similar magnitudes, and may reflect institutional differences between the more managed, high-employment economy that existed in 1971 compared with the relatively laissez-faire, depressed economy of the 1920s.

A second series of events that is of special interest are the shocks in 1974 and 1975. The late 1973 to early 1974 spikes in oil prices are often identified as a negative aggregate supply shock related to the Yom Kippur War, and are commonly used as a textbook case study (e.g. Blanchard, 2017, pp. 207-208). The interpretation of the mid-1970s as a period of oil price shocks is also offered in Hendry (2001), based on an econometric model of UK inflation over the period 1875 – 1991. Hendry (2001) finds that foreign prices were a major driver of price inflation in 1974 and in 1975, which then triggered domestic wage inflation. Barsky & Kilian (2001), Kilian (2008) and Antolín-Díaz & Rubio-Ramírez (2018) argue that the 1973 events should not be included in a list of exogenous oil market events, as no OPEC oil facilities were attacked during the Yom Kippur War, and there is scant evidence of oil production shortfalls caused by the War. But regardless of the exact mechanisms operating in the oil markets, one would still expect increased oil prices to generate negative supply pressure in the UK.

Interestingly, our identification approach implies the existence of two positive demand shocks in 1974 and 1975, and is silent on the sign of any aggregate supply shocks that existed in these years. The aggregate demand shocks coincide with a continuation of expansionary fiscal policy in the mid-1970s following the Barber Boom earlier in the decade, and a 250%

increase in the public sector borrowing requirement between 1974 and 1976 (Tomlinson, 1985, pp. 130). Provided that the mid-1970s oil price crisis did indeed constitute a negative supply shock, one can interpret this episode in British economic history as a conscious attempt by the government to mitigate its impact on employment. In November 1974, discussing the Labour administration's fiscal response to the oil crisis, the Chancellor Denis Healey could state in the Commons that,

> "Yet there is no real evidence that in this situation the adoption of deflationary policies will produce a worthwhile impact on the rate of inflation – at any rate within a time scale that democracy will tolerate." (quoted in Tomlinson, 1985, pp. 171).

He went on to argue that, despite Britain being badly affected by the oil crisis, "to adopt a strategy which requires mass unemployment would be no less an economic than a moral crime." (Hansard, 1974).

The foregoing suggests that Healey chose reflationary policy, which may have exacerbated inflation but prevented further increases in unemployment, over deflationary policy, which would have reduced inflation at the expense of increasing unemployment. Artis et al. (1992) observe that the Labour government's reliance on incomes policies to mitigate any inflationary effects of the March 1974 budget was a rational economic strategy, but,

> "The package as a whole embodied a high level of risk. It was uncertain what other countries would do, or to what extent the foreign exchange markets would finance a UK balance of payments deficit. It was certainly not clear that wage bargaining in Britain would in the event conform to the needs of the time. The strategy was full of forecasting problems and uncertainty over theoretical and empirical relationships." (Artis et al., 1992, pp. 42).

Despite this, Artis et al. (1992) conclude that the decision to maintain fiscal expenditures while using incomes policies to limit inflation was reasonable, and its failure was not a foregone conclusion in the summer of 1974. Eventually, the various iterations of Labour's Social Contract under Wilson and Callaghan did have some effect on the inflation rate, which is reflected in the presence of a positive supply shock in 1978 in table 1. However, the Social Contract contributed in part to the Winter of Discontent and the fall of the Callaghan administration, and the incoming Thatcher government heralded the abandonment of full-employment as a policy goal.

6 An alternative approach: impulse indicator saturation

In this section, we compare and contrast our econometric approach to an alternative method of dealing with shocks in macroeconomic time series: impulse indicator saturation (IIS). IIS has been developed in the context of a general-to-specific approach to macroeconometric modelling that considers a wide range of potential determinants of a time series, both theoretical and idiosyncratic, rather than starting from a specific theory. General-to-specific modelling in this context is a data-driven approach that involves starting from a general unrestricted model that encompasses multiple explanatory variables as well as a set of dummy variables to capture idiosyncratic events. Specifically, it is argued that extraneous events such as wars, natural disasters, policy regime shifts and so forth are typically not captured by the explanatory variables derived from theoretical models, but can be a major source of variance. Not accounting for such shocks can distort parameter estimation and inference. IIS provides a selection algorithm that helps identify dummy variables that absorb those shocks. Castle & Hendry (2014) and Santos et al. (2007) are good sources for the statistical properties of IIS, and Castle & Hendry (2009) Castle et al. (2012) and Hendry & Mizon (2011) present empirical applications.

More specifically, IIS selects relevant impulse indicators, i.e. dummy variables that are unity in a specific period and zero otherwise, which absorb shocks that are not captured by the explanatory variables. In the split-half approach, a subset of size $T/2$ from a full set of impulse indicators denoted by I_t, $t = 1, .., T$, is included in the regression equation along with the observable variables, which is then estimated on the T observations. By only using the first half of the T impulse indicators, it is ensured that there are enough degrees of freedom to estimate the parameters of the equation. In the next step, the second half of the impulse indicators is included. Finally, only those indicators that are statistically significant at a predetermined level are retained to arrive at the desired model.

To compare our approach with IIS, we re-estimate the VAR in unemployment and inflation from section 4 using IIS to select a set of statistically significant impulse dummies. IIS has so far mostly been used in a single-equation context. In order to apply it to our bivariate VAR, we simply retain indicators whenever they are statistically significant in either one or both of the two equations. The structural VAR model augmented with impulse indicators is,

$$Az_t = a + \sum_{i=1}^{p} A_i z_{t-i} + \beta_t I_t + \epsilon_t, \tag{6}$$

and the forecasts errors augmented by the impulse indicators are,

$$z_t - \mathbb{E}[z_t | z_{t-1}, ..., z_{t-p}] = A^{-1}\beta_t I_t + A^{-1}\epsilon_t = b_t I_t + v_t, \tag{7}$$

where $v_t = (v_t^u, v_t^\pi)'$ are the reduced form innovations, I_t are the impulse indicators selected by IIS, and $A^{-1}\beta_t = b_t = (b_t^u, b_t^\pi)'$ are the reduced form parameters on the impulse indicators. Comparison of (7) with (3) shows that the large shocks will be captured by $b_t I_t$, with the estimated parameters $\hat{b}_t = (\hat{b}_t^u, \hat{b}_t^\pi)'$ replacing the estimated residuals $\hat{v}_t = (\hat{v}_t^u, \hat{v}_t^\pi)'$ in the periods in which indicators are selected. As a result, we can interpret the IIS results in the same way that we interpret the large forecast errors in section 5, with $\hat{v}_t$ replaced with $\hat{b}_t$.

Table 2 summarises the main results, in which the impulse indicators are selected using a significance level of 5%; the full results are reported in Appendix C. The table includes the date of each selected impulse indicator, the reduced-form parameter estimates on the indicator for each equation, and the signs of the implied aggregate demand or supply shock identified using the theory-based sign restrictions discussed above. In addition, the sixth column indicates whether the implied demand or supply shock is consistent with the implied shock in table 1. With a 5% significance level, 34 impulse indicators are retained, of which 26 match the corresponding shocks in table 1, 7 are not included in table 1, and only one shock is inconsistent with the corresponding shock in table 1.[4] This is the 1946 shock, which is identified as a negative supply shock in table 1 and a negative demand shock in table 2, for which – as discussed in appendix B – there is no obvious explanation. Overall, therefore,

[4]With a statistical significance level of 10%, 45 indicators, and with a 1% level only 16 indicators are retained, see Appendix C.

Table 2: Implied demand and supply shocks, impulse indicator saturation

Date	$\hat{b}_t^u$	$\hat{b}_t^\pi$	Implied demand shock	Implied supply shock	Match with table 1
1900	0.56	3.36		−	✓
1901	0.68	-4.23	−		✓
1904	1.17	-1.95	−		*Not in table 1*
1908	2.98	-1.24	−		✓
1910	-1.51	1.29	+		✓
1911	-0.25	-2.93		+	*Not in table 1*
1913	-0.22	-2.78		+	*Not in table 1*
1915	-2.24	9.35	+		✓
1916	-1.11	7.02	+		✓
1917	-1.08	10.51	+		✓
1918	-1.85	2.50	+		✓
1919	1.31	-7.40	−		✓
1920	-1.72	7.44	+		✓
1921	8.34	-21.41	−		✓
1922	-2.66	-5.19		+	✓
1923	0.585	2.79		−	*Not in table 1*
1927	-1.80	-2.21		+	✓
1928	2.18	-0.35	−		✓
1930	4.46	-3.13	−		✓
1931	2.86	-1.19	−		✓
1938	2.23	-2.30	−		✓
1939	-3.67	1.50	+		✓
1940	-1.05	12.28	+		✓
1941	-2.60	-3.35		+	✓
1942	0.14	-3.20	−		*Not in table 1*
1943	-0.07	-3.55		+	*Not in table 1*
1946	1.25	-0.25	−		✗
1947	-1.40	4.21	+		✓
1949	-0.63	-4.08		+	*Not in table 1*
1951	-0.74	5.09	+		✓
1953	-1.37	-4.99		+	✓
1974	-0.23	7.54	+		✓
1975	-0.36	10.28	+		✓
1980	0.83	5.91		−	✓

Notes: Indicators were selected using a 5% significance level. In column 6, ✓ denotes a match with table 1 and ✗ denotes a mismatch. The identification of shocks is based on the method discussed in section 3 and does not follow from IIS.

there is a strong correspondence with the shocks identified in section 5, particularly when using the 5% threshold.

This exercise shows that the history of significant shocks presented in section 5 is robust to the method used to identify large forecast errors. However, it is import to stress that IIS is a data-driven approach that – by itself – does not provide any interpretation of the shocks captured by the impulse indicators. In practice, the latter are often discussed in an ad-hoc fashion. For example, in a study of UK real wages over the period 1863 to 2004, Castle & Hendry (2009, p.20) use IIS to select indicator variables for the years 1918, 1940, 1975 and 1977. These are interpreted as extraneous shocks associated with the first and second World War, the first oil crisis and incomes policies, respectively, but the IIS algorithm itself does not allow the authors to assign any further economic meaning to these shocks. By contrast, the theory-driven approach taken in this paper offers an economic interpretation of major shock events through the lens of an AD-AS model. While these shocks are indeed often associated with known extraneous events such as wars and global crises (see the discussion in section 5 and appendix B), their specific macroeconomic impact is typically not self-evident. By using sign restrictions derived from an AD-AS model, we are able to say more about the supply- or demand-side effects of major shocks.

7 Concluding remarks

In this paper, we have presented an interpretation of the history of aggregate demand and supply shocks in the United Kingdom from a Keynesian perspective. To achieve this, we have proposed a simple yet rarely used method to infer the signs of structural shocks from the reduced-form residuals of a VAR model, using minimal identification assumptions. Our approach utilises the sign restrictions implied by the aggregate demand/aggregate supply model that can be derived from the workhorse New Keynesian model and a variety of other macroeconomic models, including Old Keynesian neoclassical synthesis and Post Keynesian models. We have also demonstrated that our approach is robust to changes in the method used to select major shocks.

Our results include the identification of World War years as positive aggregate demand shocks, the Great Depression and Great Recession as negative aggregate demand shocks, and the identification of the 1979 oil price events as a negative aggregate supply shock. Overall, we find a greater role for aggregate demand shocks, rather than aggregate supply shocks, in British macroeconomic history. We also uncover some interesting events which are less well-known, including aggregate supply shocks in 1927 and 1971. These correspond to labour market reforms in the aftermath of the 1926 General Strike and a period of heightened union militancy, respectively. The negative supply shock in 1971 was primarily associated with a steep rise in inflation, without any significant effect on the unemployment rate. It was followed by positive aggregate demand pressure in the mid-1970s alongside the introduction of various incomes policies. We attribute this positive demand shock to expansionary fiscal policy in the face of adverse international pressure, providing a new perspective on an otherwise well-known event. After 1979, our history is dominated by negative aggregate supply shocks until the Great Recession in 2009, which is the last major shock we identify.

While previous research has often relied on relatively strong theoretical assumptions to achieve identification (e.g. Bergman 1996; Karras 1993, 1994; Liu & Mumtaz 2011; Stuart 2019), we show that sign restrictions can provide economically interesting information with much weaker assumptions. Our approach could easily be applied to other countries, particularly those with long historical time series and a well documented historical record. The USA and France are ideal candidates, as both of of these countries have long, reliable time series data and a great deal of documented economic history. At the same time, in order to further explore the applicability of the AD-AS model to the UK, it may be worth applying other identification methods such as identification by heteroskedasticity or non-normality. As far as we are aware, neither of these methods having been applied to historical UK time series data, and the heteroskedasticity and normality test results reported in this paper suggest that they may well be useful. Finally, we note that the incorporation of more information in our identification method, for example the assumption of independent shocks, might result in more detailed inference. We leave these avenues to future research.

References

Antolín-Díaz, J., & Rubio-Ramírez, J. F. (2018). Narrative sign restrictions for SVARs. *American Economic Review*, *108*(10), 2802–29.

Artis, M., Cobham, D., & Wickham-Jones, M. (1992). Social democracy in hard times: the economic record of the Labour government 1974–1979. *Twentieth Century British History*, *3*(1), 32–58.

Backhouse, R. E., & Forder, J. (2013). Rationalizing incomes policy in Britain, 1948-1979. *History of Economic Thought and Policy*.

Barsky, R. B., & Kilian, L. (2001). Do we really know that oil caused the great stagflation? A monetary alternative. *NBER Macroeconomics Annual*, *16*, 137–183.

Bergman, M. (1996). International evidence on the sources of macroeconomic fluctuations. *European Economic Review*, *40*(6), 1237–1258.

Blanchard, O. (2017). *Macroeconomics, Seventh Edition, Global Edition*. Pearson.

Blanchard, O. J., & Kahn, C. M. (1980). The solution of linear difference models under rational expectations. *Econometrica*, *48*, 1305–1311.

Blanchard, O. J., & Quah, D. (1989). The dynamic effects of aggregate demand and aggregate supply disturbances. *The American Economic Review*, *79*(4), 655–673.

Boyer, G. R., & Hatton, T. J. (2002). New estimates of British unemployment, 1870-1913. *Journal of Economic History*, (pp. 643–675).

Cairncross, A. (1985). *Years of Recovery: British Economic Policy, 1945–51*. New York: Methuen.

Calvert Jump, R. (2018). Unambiguous inference in sign-restricted VAR models. Tech. rep., University of the West of England.

Castle, J. L., Doornik, J. A., & Hendry, D. F. (2012). Model selection when there are multiple breaks. *Journal of Econometrics*, *169*(2), 239–246.

Castle, J. L., & Hendry, D. F. (2009). The long-run determinants of UK wages, 1860–2004. *Journal of Macroeconomics*, *31*(1), 5–28.

Castle, J. L., & Hendry, D. F. (2014). Model selection in under-specified equations facing breaks. *Journal of Econometrics*, *178*, 286–293.

Cloyne, J. (2013). Discretionary tax changes and the macroeconomy: new narrative evidence from the United Kingdom. *American Economic Review*, *103*(4), 1507–28.

Cover, J. P., Enders, W., & Hueng, C. J. (2006). Using the aggregate demand-aggregate supply model to identify structural demand-side and supply-side shocks: Results using a bivariate VAR. *Journal of Money, Credit, and Banking*, *38*(3), 777–790.

Cover, J. P., & Mallick, S. K. (2012). Identifying sources of macroeconomic and exchange rate fluctuations in the UK. *Journal of International Money and Finance*, *31*, 1627–1648.

Dennis, R. (2005). Specifying and Estimating New Keynesian Models with Instrument Rules and Optimal Monetary Policies. *Federal Reserve Bank of San Francisco Working Paper*.

Diebolt, C., & Haupert, M. (2019). *Handbook of Cliometrics, 2nd edition*. Berlin Heidelberg: Springer-Verlag.

Dow, J. C. R. (1964). *The Management of the British Economy: 1945-60*. Cambridge: Cambridge University Press.

Dutt, A. K., & Skott, P. (1996). Keynesian theory and the aggregate-supply/aggregate-demand framework: A defense. *Eastern Economic Journal*, *22*(3), 313–331.

Enders, W., & Hurn, S. (2007). Identifying aggregate demand and supply shocks in a small open economy. *Oxford Economic Papers*, *59*(3), 411–429.

Fackler, J. S., & McMillin, W. D. (1998). Historical decomposition of aggregate demand and supply shocks in a small macro model. *Southern Economic Journal*, (pp. 648–664).

Feinstein, C. (1972). *National income, expenditure and output of the United Kingdom, 1855-1965*. Cambridge: Cambridge University Press.

Fontana, G., & Setterfield, M. (Eds.) (2009). *Macroeconomic Theory and Macroeconomic Pedagogy*. Edward Elgar.

Fry, R., & Pagan, A. (2011). Sign restrictions in structural vector autoregressions: A critical review. *Journal of Economic Literature*, *49*(4), 938–60.

Funke, M., & Hall, S. (1998). Aggregate demand and aggregate supply in UK regions. *Journal of Economic Studies*.

Galí, J. (2008). *Monetary Policy, Inflation, and the Business Cycle*. Princeton: Princeton University Press.

Galí, J. (2018). The state of New Keynesian economics: a partial assessment. *Journal of Economic Perspectives*, (pp. 87–112).

Garside, W. (1990). *British Unemployment 1919–1939: A Study in Public Policy*. Cambridge: Cambridge University Press.

Goldin, C. (1995). Cliometrics and the Nobel. *Journal of Economic Perspectives*, (pp. 191–208).

Habakkuk, J. (1971). Economic history and economic theory. *Daedalus*, (pp. 305–322).

Hansard (1974). HC Deb. vol.881 cols.244-53, 12 November 1974. `https://hansard.parliament.uk/Commons/1974-11-12`. Accessed: 3 November 2020.

Hein, E., & Stockhammer, E. (2010). Macroeconomic policy mix, employment and inflation in a post-keynesian alternative to the new consensus model. *Review of Political Economy*, *22*(3), 317–354.

Hendry, D. F. (2001). Modelling UK inflation, 1875-1991. *Journal of Applied Econometrics*, *16*(3), 255–275.

Hendry, D. F., & Mizon, G. E. (2011). Econometric modelling of time series with outlying observations. *Journal of Time Series Econometrics*, *3*(1).

Jenkins, M., & Tsoukis, C. (2000). Nominal inertia and shock persistence in UK business cycles. *Applied Economics*, *32*(7), 901–907.

Karras, G. (1993). Aggregate demand and supply shocks in Europe: 1860–1987. *Journal of European Economic History*, *22*(1), 79.

Karras, G. (1994). Sources of business cycles in Europe: 1960–1988. Evidence from France, Germany, and the United Kingdom. *European Economic Review*, *38*(9), 1763–1778.

Kilian, L. (2008). Exogenous oil supply shocks: how big are they and how much do they matter for the US economy? *The Review of Economics and Statistics*, *90*(2), 216–240.

Kliem, M., & Kriwoluzky, A. (2013). Reconciling narrative monetary policy disturbances with structural VAR model shocks? *Economics Letters*, *121*(2), 247–251.

Leduc, S., & Liu, Z. (2016). Uncertainty shocks are aggregate demand shocks. *Journal of Monetary Economics*, *82*, 20–35.

Liu, P., & Mumtaz, H. (2011). Evolving macroeconomic dynamics in a small open economy: An estimated markov switching DSGE model for the UK. *Journal of Money, Credit and Banking*, *43*(7), 1443–1474.

Lütkepohl, H., & Kilian, L. (2017). *Structural Vector Autoregressive Analysis*. Cambridge: Cambridge University Press.

Manski, C. F. (1995). *Identification Problems in the Social Sciences*. Massachusetts: Harvard University Press.

Martin, B. (1991). The state of the economy. In *The State of the Economy 1991*. Institute of Economic Affairs.

Mathy, G. P. (2020). How much did uncertainty shocks matter in the Great Depression? *Cliometrica*, *14*(2), 283–323.

Mountford, A. (2005). Leaning into the wind: a structural VAR investigation of UK monetary policy. *Oxford Bulletin of Economics and Statistics*, *67*(5), 597–621.

Peden, G. C. (1991). *British economic and social policy: Lloyd George to Margaret Thatcher*. Oxford: Philip Allan.

Richardson, H. W. (1967). *Economic Recovery in Britain, 1932-9*. London: Weidenfeld and Nicolson.

Rudebusch, G. D. (1998). Do measures of monetary policy in a VAR make sense? *International Economic Review*, (pp. 907–931).

Santos, C., Hendry, D. F., & Johansen, S. (2007). Automatic selection of indicators in a fully saturated regression. *Computational Statistics*, *23*(2), 317–335.

Sefton, J., & Weale, M. (1995). *Reconciliation of national income and expenditure: Balanced estimates of national income for the United Kingdom, 1920-1990*, vol. 7. Cambridge: Cambridge University Press.

Shibayama, K. (2008). On the periodicity of inventories. Tech. rep., Department of Economics, University of Kent.

Solomou, S., & Ristuccia, C. A. (2004). British Episodic Economic Growth 1850-1938. *Working Paper, Cambridge Faculty of Economics*.

Solomou, S., & Weale, M. (1991). Balanced estimates of UK GDP 1870–1913. *Explorations in Economic History*, *28*.

Stuart, R. (2019). UK shocks and Irish business cycles, 1922–79. *The Economic History Review*, *72*, 618–640.

Thomas, R., Hills, S., & Dimsdale, N. (2010). The uk recession in context – what do three centuries of data tell us? *Bank of England Quarterly Bulletin*.

Thorp, W. L. (1926). *Business Annals*. New York: National Bureau of Economic Research.

Tomlinson, J. (1985). *British Economic Policy since 1940*. London: Croom Helm.

Turner, P. (1999). Alternative identifying restrictions in a model of UK real output and prices. *Applied Economics*, *31*(3), 279–286.

Turner, P. M. (1993). A structural vector autoregression model of the UK business cycle. *Scottish Journal of Political Economy*, *40*(2), 143–164.

Uhlig, H. (2005). What are the effects of monetary policy on output? Results from an agnostic identification procedure. *Journal of Monetary Economics*, *52*(2), 381–419.

Wolf, C. K. (2020). SVAR (Mis) identification and the Real Effects of Monetary Policy Shocks. *American Economic Journal: Macroeconomics*, *12*(4), 1–32.

Woodward, N. (1991). Inflation. In N. Crafts, & N. Woodward (Eds.) *The British Economy since 1945*. Oxford: Oxford University PRess.

Appendices

A Stability plots

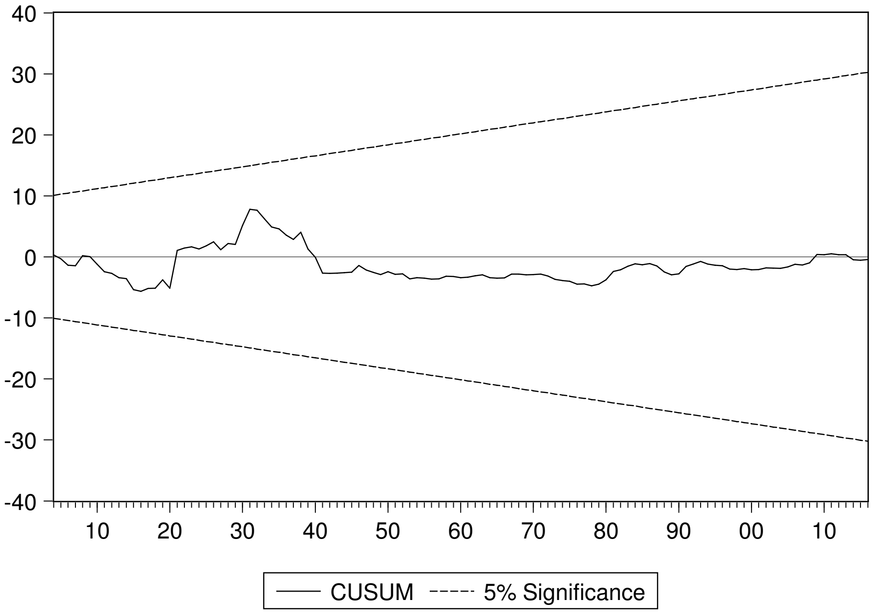

Figure A1: CUSUM test output, unemployment equation.

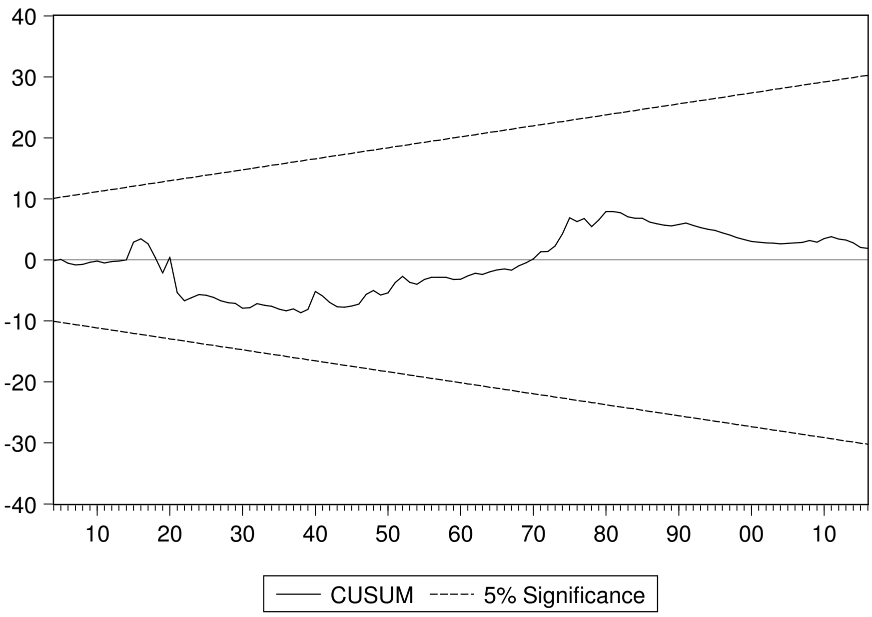

Figure A2: CUSUM test output, inflation equation.

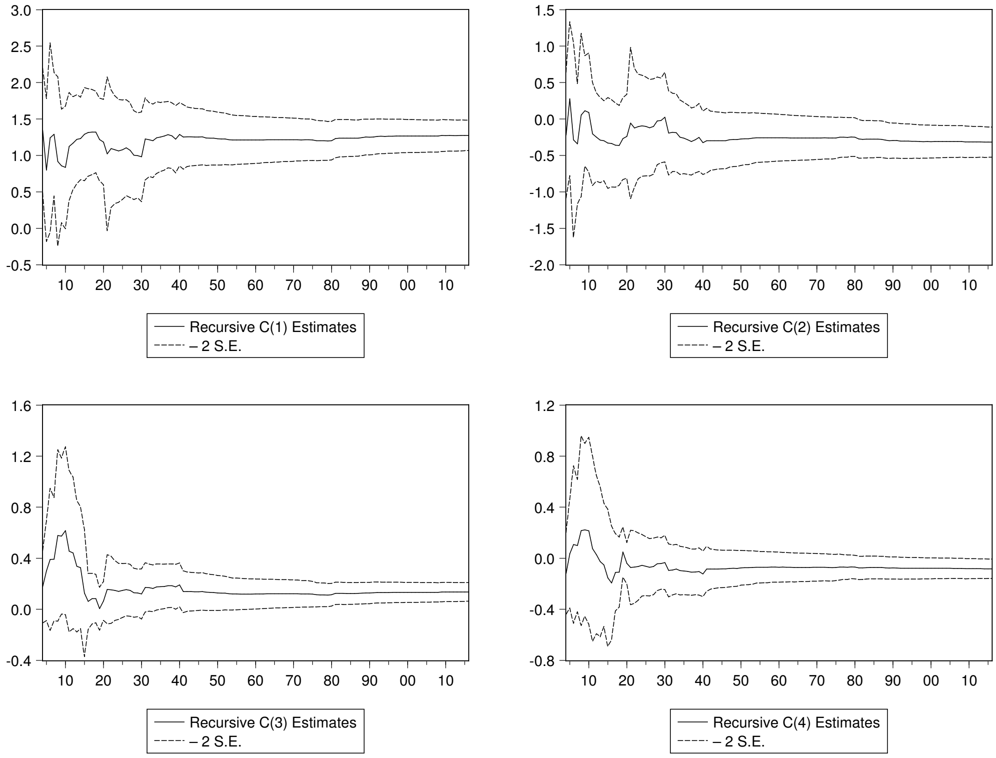

Figure A3: Recursive parameter estimates, unemployment equation.

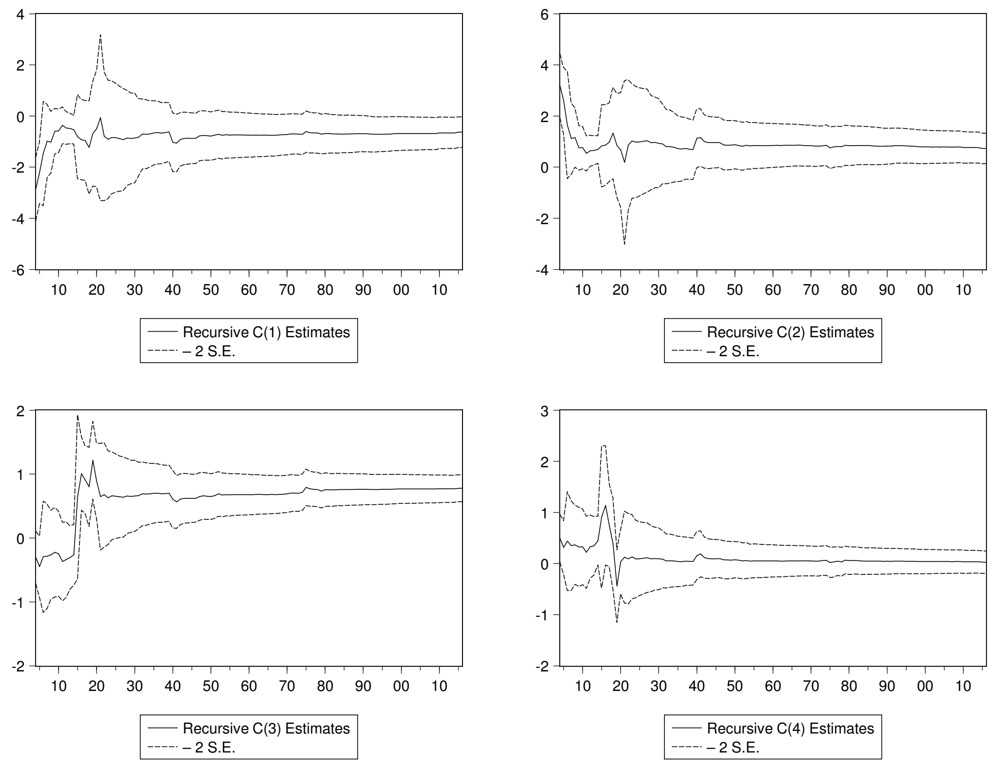

Figure A4: Recursive parameter estimates, inflation equation.

B Detailed discussion of shocks in table 1

B.1 1900 - 1901

Willard Long Thorp, in an exhaustive narrative account of business cycle conditions from 1790 to 1925, describes 1900 as a prosperous year, leading to recession in the Summer, with,

> "Activity and progress, first half-year, yield to dullness and decline, summer; gradual increase in unemployment; commodity prices reach peak and the decline; coal prices extremely high; big increase in volume of foreign trade, slackening later in year . . . Money tight, with large government loans floated; stock market unsteady with rapid rise in industrial stocks, first quarter, and boom in American railways . . . Smaller crops, except oats; higher prices . . . War continued with increasing demands for men and materials; British successes begin, March." (Thorp, 1926, pp. 173).

The war that Thorp refers to is the Boer War, which was declared the preceding year. The high commodities prices, with higher crop prices due to a poor harvest, may be taken as the source of the negative supply shock in table 1. Thorp describes 1901, the year of Queen Victoria's death, as a mild depression, with,

> "Continued recession; some shrinkage in volume of activity, but chiefly in prices; construction industry severely curtailed; decline in prices and wages; increased unemployment; volume of foreign trade unchanged, but value decline marked." (Thorp, 1926, pp. 173).

It is not clear how Thorp differentiates between the volume and value of foreign trade, but the Bank of England dataset from which the VAR data is drawn in section 4 shows a decrease in the real value of exports in 1901. This may be taken as evidence of a negative demand shock emanating from the 1901 panic on the New York Stock Exchange. Although Thorp notes that the money market was "firm" in 1901, "industrial stocks reach peak, March, and decline rapidly", which provides further evidence for this interpretation of the demand shock in 1901 (Thorp, 1926, pp. 173).

B.2 1908

The negative aggregate demand shock in 1908 listed in table 1 can easily be explained by the 1907 financial crisis in the USA, which took place in October and the beginning of November of that year. This was the high point of pre-war globalisation, and as pointed out in Thomas et al. (2010),

> "The UK business cycle became more closely aligned with external factors as international linkages became more important following the widespread adoption of the gold standard system of fixed exchange rates. Consequently . . . the UK economy was vulnerable to international financial crises, such as the 1907 US financial crisis." (Thomas et al., 2010).

Willard Long Thorp, in his account of business cycle conditions, describes 1908 as a depression, with,

> "Marked and rapid decline in all branches of industry; stagnation; severe unemployment reaches peak, autumn; many wage reductions; severe engineering strike, summer, and general lockout in Lancashire cotton industry, autumn; many failures; large reduction in volume of foreign trade." (Thorp, 1926, pp. 175).

Thus, sharp reduction in foreign trade, driven in the main by the 1907 financial crisis, marks this period out as suffering from a severe negative aggregate demand shock, although the "dull" stock exchange and declining stock prices also point to a degree of financial contagion from the crisis (Thorp, 1926, pp. 175).

B.3 1910

Unemployment, having risen to 7.08% in 1908 and 7.51% in 1909, fell back to 5.77% in 1910 during the recovery from the previous recession. Inflation rose from 0.19% to 2.12% from 1909 to 1910, leading to the positive aggregate demand shock listed in table 1. This period is, of course, before any attempts at active demand management by the Government, and the Bank Rate was steady at 4.5% between 1909 and 1910. However, 1910 did see the passage of Lloyd George's 'People's Budget', which was to be a central plank of his war on poverty. This budget was redistributionary whilst being relatively budget-neutral, although it is worth noting that public sector net lending was negative in 1909, after being positive for the previous two years. Thus,

> "[Lloyd George] described his Budget as a 'war budget' for waging 'implacable warfare against poverty and squalidness'. His friends hailed it as 'the People's Budget'; his enemies saw it as being a war budget against property and denounced it as socialistic." (Peden, 1991, pp. 25).

As a matter of fact, the increased taxation in the 'People's Budget' did not fall on the working or middle classes, and instead were made up of super-taxes and land value taxes on those parts of the income distribution which may be assumed to have a low marginal propensity to consume out of current income. If we allow for a stimulating effect of redistribution – particularly during an era of extreme inequality – then the 'People's Budget' may account for the positive aggregate demand shock listed in table 1.

B.4 1915 – 1918

The positive aggregate demand shocks in 1915 – 1918 listed in table 1 are, of course, explained by the First World War. During this period, government expenditure and borrowing rapidly increased to pay for the war effort. At the same time, the Gold Standard was suspended, allowing substantial increases in money stocks and credit aggregates – although the Bank rate was actually higher during the War than directly preceding it. This is still the era of public finance that pre-dates demand management. Treasury officials in 1914 were quick to advise Lloyd George – still the Chancellor of the Exchequer – that in the past, "nearly half the cost of wars had been met from taxation", and that he should not rely too heavily on borrowing (Peden, 1991, pp. 38-40). However,

> "Lloyd George, who cared very little for conventional financial wisdom, chose not to follow this advice, and set himself the more modest task of raising enough revenue to pay for normal expenditure in peace, plus a margin to pay for the interest on loans raised to pay for the war." (Peden, 1991, pp. 40).

Hence the succession of large aggregate demand shocks from 1915 – 1918, which apparently constituted a novel event in the history of British war financing.

B.5 1919 – 1922

The UK in 1919 – 1922 underwent a sequence of varied shocks according to table 1, with a negative demand shock in 1919, a positive demand shock in 1920, a negative demand shock in 1921, and a positive supply shock in 1922. This reflects the extreme volatility in this period, where inflation fell from 22% to 10.1% from 1918 to 1919, jumping back to 15.4% in 1920, then falling in the deflationary years of the 1920s to -8.6% and -14% in 1921 and 1922. Similarly, the unemployment rate jumped from 0.65% in 1918 to 3.02% in 1919, fell back to 1.95% in 1920, before rising to 11.02% in 1921 and 9.68% in 1922.

The negative demand shock in 1919 implied by these movements in inflation and unemployment can easily be explained by the end of the First World War. Government consumption, unsurprisingly, fell rapidly between 1918 and 1919, and public sector borrowing, having risen continuously during the War, was also heavily cut back in 1919. At the same time, the positive labour supply shock resulting from demobilisation at the end of 1918 and 1919 should not be discounted as a partial explanation of the unexpected rise in unemployment during 1919, and in principle this goes some way in accounting for the unexpected fall in inflation.

The positive demand shock of 1920 can be assigned to the post-war boom, driven in the main by an expansion of trade and shipping following the end of the War. In turn, the major deflation of the early 1920s is usually attributed to monetary and fiscal austerity in an attempt to return to the Gold Standard at pre-war parity, which was eventually achieved in 1925. Both the bank rate and gilt rates increased from 1919 to 1920, with both the nominal and real exchange rates rising rapidly from 1921 onwards. Even more dramatic was the increase in the real interest rate, which rose precipitously from 1920 to 1921. These events may be taken as proximate causes of the 1921 negative demand shock, although the scale of the deflation is still quite impressive given the relatively modest movements in monetary and fiscal policy.

B.6 1927 – 1928

1927 and 1928, according to table 1, saw a positive supply shock and negative demand shock, respectively. The positive aggregate supply shock in 1927 can partly be explained by a sudden fall in the bargaining power of workers following the 1926 general strike, after which the Trade Disputes and Trade Unions Act (1927) and the Unemployment Insurance Act (1927) were passed. The former Act incorporated a number of provisions to prevent unions acting in a "political" manner, including restrictions on union funding of the Labour Party, and made secondary strike action illegal. The latter Act did, in principle, embody a number of provisions which would improve the welfare of unemployed workers. However, it also required all claimants to prove that they were seeking work. As the costs and associated debt of the Unemployment Fund increased, this led the government to tighten up the eligibility process. Thus,

> "What followed was a systematic campaign to tighten up the existing administration of unemployment insurance. The 'seeking work' test, of course, had already made its mark. By 1927 one in ten of all claimants was being refused

> benefit because of an 'unsatisfactory attitude to work'. But thereafter the test was applied with particular severity." (Garside, 1990, pp. 48).

This tightening of the administration of unemployment insurance, alongside the new restrictions on trade union activity, constitute a clear reduction in bargaining power which may be taken to contributed to the observed supply shock in 1927. The source of the negative demand shock in 1928, meanwhile, is not as clear, as it pre-dates the 1929 Wall Street crisis.

B.7 1930 – 1931

The rapid increases in unemployment and the rate of deflation experienced in the early 1930s, leading to the implied negative demand shocks in table 1, are straightforwardly attributable to the Great Depression that followed the 1929 Wall Street crisis. As in 1907 – 1908, the effects of the Depression were transmitted through collapses in trade and capital flows, although the UK economy, having never fully recovered from the volatility of the 1920s, started out from a low base. Whether or not the continued collapse of trade volumes constituted an endogenous response to the crisis, or a secondary exogenous shock resulting from the imposition of trade barriers, is controversial. However, it is worth noting that the Hawley-Smoot Tariff Act of 1930 in the USA and the Abnormal Importation Act of 1931 in the UK coincide with the negative demand shocks listed in table 1 during this period. At the end of this period, a final negative demand shock occurred in the form of a deflationary budget, with unemployment benefits and public sector wages both cut by the incumbent Labour government. As well as adding further deflationary pressure to the economy, this resulted in a political crisis and National Government at the end of 1931.

B.8 1938

Re-armament in preparation for the Second World War is generally considered to be the proximate cause behind the recovery in employment after the early 1930s. However, tight fiscal and monetary policy by the Roosevelt administration during this period led to a recession from 1937 – 1938 in the USA, which may be taken to be the source of the negative aggregate demand shock in table 1 in 1938. Thus Harry Richardson, in *Economic Recovery in Britain 1932 – 1939*, argues that,

> "There had been a lull in the American recovery from the end of 1936, Wall Street had looked very shaky at least since the spring of 1937 and industrial activity in the United States turned downwards in the late Summer. In Britain, on the other hand, some indicators continued to move upwards while others fell in the second half of 1937, and only at the end of the year was a check to recovery generally admitted. On first sight, it looks as if this is the usual sequence of recession being transmitted to the United Kingdom from the United States." (Richardson, 1967, pp. 31).

Richardson goes on to argue that the recession of 1937-8 was, "as much due to internal causes as to depression abroad" (Richardson, 1967, pp. 31). But we are chiefly interested in the exogenous movements here; internal movements (i.e., those predictable given the information set) are already taken into account in the VAR model.

B.9 1939 – 1941

As with the positive aggregate demand shocks from 1915 – 1918, the positive aggregate demand shocks in 1939 and 1940 are easily attributable to the increases in government expenditure and borrowing to pay for the Second World War. The return to a full employment War economy via planning is also of obvious importance, and a sudden increase in centrally planned employment allocation alongside price controls would manifest itself as a demand shock given our identification assumptions, even though the New Keynesian model does not reflect these institutional arrangements. The positive aggregate supply shock of 1941 listed in table 1 is somewhat more puzzling, and coincides with the sharp decrease in the inflation rate during this period.

B.10 1946 – 1947

According to table 1, the UK suffered a negative supply shock in 1946 and enjoyed a positive demand shock in 1947. The negative supply shock is difficult to square with historical events. On the face of it, one would expect a negative demand shock to have occurred at the close of the War, as in 1919. Government expenditure and borrowing were reduced with demobilisation, and the latter should have been expected to reduce inflation alongside the increase in unemployment. At the same time, the economy was still subject to widespread planning, import quotas, and price control during this period, and as noted above the New Keynesian model is not designed to account for movements in prices and employment under these institutional arrangements.

Unfortunately, the positive demand shock of 1947 in table 1 is as difficult to account for as the negative supply shock of 1946. One of the most well known events in 1947 is the coal crisis at the beginning of the year. Cairncross (1985), for example, notes that a large part of the manufacturing industry had to shut down for lack of power during the crisis, leading to a shortage of steel and other materials. Similarly, Dow (1964) reports that the crisis led to the weekly press being halted for two weeks, and that the disruption of production led to a reduction of £200 million in export earnings (Dow, 1964, pp. 22). This is a classic example of a supply shock, but, according to table 1, unemployment was unexpectedly low in this year. Again, the transitory nature of this period, as well as the multitude of controls and quotas in force, apparently make it difficult for the AD-AS model's predicted shocks to square well with the narrative record.

B.11 1951

In contrast to the ambiguity of the immediate post-war years, the period 1950-51 is a classic episode of high aggregate demand pressure, caused in the main by the outbreak of the Korean War. As Dow (1964) notes,

> "In a world already heading for a boom, this caused the sharpest burst of inflation in the post-war period, and world-wide shortage of materials. To the United Kingdom it brought rising prices; a major increase in defence spending; and within a year, a balance of payments crisis." (Dow, 1964, pp. 54-55).

Thus, part of the 1951 positive aggregate demand shock listed in table 1 can be attributed to a sharp increase in global aggregate demand, and part can be attributed to an increase in domestic defence expenditure. At the same time, as Dow points out, both the rapid recovery of Western Germany in 1949-1950 and the recovery of the USA from its 1949 recession had put a great deal of pressure on raw materials prices during this period.

B.12 1953

By 1953 the economic repercussions of the Korean boom had come to an end, and the post-war consensus of Butskellism in demand management was firmly established. Whereas the sources of the 1951 demand shock are quite obvious, there is no obvious global or domestic event in 1953 that corresponds to the positive aggregate supply shock listed in table 3. However, Dow (1964) notes that falling import prices had, "greatly slowed down the rise in retail prices", which is consistent with the large negative inflation residual in 1953 (Dow, 1964, pp. 75).

B.13 1971

1971 is an interesting year, as the negative supply shock can potentially be viewed as a reflection of the positive supply shock in 1927. Whereas the latter shock reflected, to some extent at least, an exogenous decrease in the bargaining power of workers, the events in 1971 are in part accounted for by an exogenous increase in the bargaining power of workers. Thus, Nicholas Woodward observes that,

> "By the early 1970s, [wage inflation] had risen to between 12 and 13 per cent. This wage explosion, moreover, was associated with an apparent upsurge in labour militancy. For example, over this period there was a rapid increase in trade union membership from 42.7 per cent of the labour force in 1968 to 47.2 in 1972. At the same time there was a significant increase in strike activity, and . . . this was reflected in all the main strike indicators." (Woodward, 1991, pp. 197-198).

Woodward goes on to argue that the usual interpretation of the increase in inflation during this period is that, "it was the product of autonomous wage pressures", i.e. a shock to workers' bargaining power (Woodward, 1991, pp. 198). Despite the existence of monetarist counter-arguments, it is worth noting that days lost to strikes in 1971 were the highest they had been since the General Strike of 1926 – although the miners' strikes of 1972, 1974, and 1984 would all see a greater number of days lost, as would the Winter of Discontent.

B.14 1974 – 1975

Interestingly, the Barber Boom of the early 1970s is not listed in table 1, and one might imagine that 1974, at least, would show the negative effects of the 1973 Yom Kippur War and subsequent OPEC embargo as a negative aggregate supply shock. However, as discussed in more detail in the main body of text, it is well established that UK fiscal policy was expansionary during 1974, with a 250% increase in the public sector borrowing requirement from 1974 – 1976 coinciding with a "crisis of public expenditure" in the mid-1970s (Tomlinson, 1985, pp. 130). In November of 1974, in the face of a sharp increase in inflation, the Labour Chancellor Denis Healey could state that,

> "Yet there is no real evidence that in this situation the adoption of deflationary policies will produce a worthwhile impact on the rate of inflation – at any rate within a time scale that democracy will tolerate." (quoted in Tomlinson, 1985, pp. 171).

Participants in the bond market appeared to have disagreed, with a market consensus that government borrowing was too high during this period leading to a gilt strike in 1976 (Tomlinson, 1985, pp. 132). In addition, figure 1 in Cloyne (2013) shows a number of exogenous (and endogenous) tax cuts during the early to mid-1970s that are derived from the UK budget statements published during this period. Thus the positive aggregate demand shocks in 1974 and 1975 listed in table 1 can be explained by (relatively) expansionary fiscal policy, which in turn can be interpreted as a conscious attempt by the Labour government to mitigate the impact on employment of the negative cost pressures induced by the 1973-4 oil price crisis.

B.15 1978

Inflation fell continuously in the UK from 1975 to 1978, with the largest fall between 1977 and 1978. Whilst the relative stability in the dollar oil price from 1975 to 1978 will mechanically serve to reduce consumer price inflation, in itself it does not constitute the positive supply shock listed in table 1. Instead, we can attribute this shock to Labour's Social Contract, in which unions limited wage increases in return for various pieces of legislation (see Backhouse & Forder (2013) for a brief history of post-war incomes policies and their rationale). This policy coincided with the 1975 to 1978 period of falling inflation, and although it can hardly be considered as unexpected by the general public – it contributed, in part, to the Winter of Discontent – it is certainly not the type of systematic macroeconomic policy that can be considered endogenous in a parsimonious model. It can therefore be taken as an example, albeit an unusual example, of a negative aggregate supply shock.

B.16 1979 – 1981

The obvious explanation for the negative supply shocks listed in table 3 in 1979, 1980, and 1981 are the start of the Iranian revolution (December 1978 to January 1979) and the outbreak of the Iran-Iraq War (September 1980 to October 1980). These events are discussed in the context of identifying oil market shocks in Antolín-Díaz & Rubio-Ramírez (2018), and the subsequent oil price rises are generally acknowledged to be the proximate causes of the increases in unemployment and inflation in the UK during this period.

B.17 1991

The recession in the early 1990s saw inflation jumping from 5.23% in 1989 to 6.97% in 1990, and then to 7.53% in 1991, before falling back to 4.26% in 1992. Unemployment also increased from 1990 to 1991, but did not peak until 1993, at 10.37%. These shifts in unemployment and inflation, with the former lagging the latter, explain the implied negative supply shock in table 1. Ironically, this recession followed the "Lawson Boom" in which extensive supply side reforms were believed to have paved the way for a prolonged expansion. Thus Nigel Lawson, in his 1988 budget speech, could confidently state that,

> "The plain fact is that the British economy has been transformed. Prudent financial policies have given business and industry the confidence to expand, while supply side reforms have progressively removed the barriers to enterprise."[5]

However, the boom led to bust, with house prices reaching their peak in 1989. Whilst the bulk of the events around this period point towards a natural end to an expansion, including the fall in house prices, and some negative aggregate demand shocks, including

[5]From Lawson's 1988 budget speech – see e.g. the speech archive at Margaret Thatcher Foundation website, www.margaretthatcher.org.

the ERM entrance in 1990 and deflationary monetary policy from 1992 onwards, the negative aggregate supply shock in table 1 can be explained by the adverse oil price shock engendered by the outbreak of the first Gulf War in August 1990. This view of the recession was not uncommon at the time, for example,

> "Although special factors (food, oil) are partly to blame, the main reason for the scale and tenacity of today's inflation problem is undoubtedly the vibrant nature of the Lawson Boom. That boom, one of the most vigorous of all post-war upturns, left a lingering legacy of inflation which finds expression in an oversized balance-of-payments deficit, persistent capacity problems, and, by European standards, an untypically low level of unemployment." (Martin, 1991, pp. 29).

As in 1938, therefore, the bulk of the 1991 recession is explainable by internal developments, with a negative shock exacerbating the situation.

B.18 2009

The last large shock listed in table 1 is the negative aggregate demand shock in 2009. This coincides with a significant global recession, which followed the financial crisis of 2008. As with the negative demand shocks following the 1907 financial crisis and the Great Depression in the early 1930s, the source of this shock was the USA, with its effects being transmitted through financial contagion channels between Wall Street and the City of London. At the same time, global trade volumes rapidly contracted, with the Baltic Dry Index collapsing between the end of 2008 and the beginning of 2009. Unlike during the Great Depression, however, a large coordinated response from governments and central banks prevented the recession turning into a depression, explaining the lack of any further negative shocks in table 1 after 2009.

C VAR estimation with impulse indicator saturation

Table C3: **VAR(2) in unemployment and inflation rate, impulse indicator saturation**

	< 10%	< 10%	< 5%	< 5%	< 1%	< 1%
	u_t	π_t	u_t	π_t	u_t	π_t
u_{t-1}	1.514***	-0.581***	1.394***	-0.509***	1.448***	-0.973***
	(0.000)	(0.001)	(0.000)	(0.001)	(0.000)	(0.000)
u_{t-2}	-0.560***	0.485***	-0.469***	0.436***	-0.523***	0.946***
	(0.000)	(0.006)	(0.000)	(0.003)	(0.000)	(0.000)
π_{t-1}	0.129***	0.755***	0.128***	0.697***	0.085***	0.893***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
π_{t-2}	-0.103***	-0.009	-0.079***	0.036	-0.062***	-0.092
	(0.000)	(0.878)	(0.000)	(0.505)	(0.001)	(0.279)
1900	0.588	3.575***	0.564	3.364***		
	(0.153)	(0.002)	(0.225)	(0.008)		
1901	0.586	-4.414***	0.681	-4.226***		
	(0.163)	(0.000)	(0.148)	(0.001)		
1904	1.003**	-1.852*	1.170**	-1.949		
	(0.015)	(0.100)	(0.011)	(0.119)		
1905	-0.844**	0.624				
	(0.045)	(0.589)				
1906	-1.016**	-1.373				
	(0.013)	(0.219)				
1908	2.953***	-1.265	2.976***	-1.241	3.003***	-1.854
	(0.000)	(0.258)	(0.000)	(0.321)	(0.000)	(0.440)
1909	-0.914**	-0.145				
	(0.041)	(0.906)				
1910	-1.696***	1.536	-1.507***	1.287	-1.628***	1.595
	(0.000)	(0.172)	(0.001)	(0.302)	(0.003)	(0.506)
1911	-0.220	-2.987***	-0.250	-2.929**		
	(0.597)	(0.009)	(0.592)	(0.021)		
1913	-0.226	-2.864**	-0.224	-2.777**		
	(0.581)	(0.011)	(0.628)	(0.027)		
1915	-2.236***	9.291***	-2.237***	9.348***	-2.199***	8.866***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1916	-0.856*	6.330***	-1.114**	7.015***		
	(0.074)	(0.000)	(0.032)	(0.000)		

Table C4: **VAR(2) in unemployment and inflation rate, impulse indicator saturation (continued)**

	< 10%	< 10%	< 5%	< 5%	< 1%	< 1%
	u_t	π_t	u_t	π_t	u_t	π_t
1917	-0.717	10.007***	-1.082**	10.505***	-0.562	8.535***
	(0.119)	(0.000)	(0.032)	(0.000)	(0.328)	(0.001)
1918	-1.432***	1.879	-1.850***	2.497*		
	(0.004)	(0.165)	(0.001)	(0.090)		
1919	1.895***	-7.500***	1.309**	-7.395***	1.742***	-8.113***
	(0.000)	(0.000)	(0.011)	(0.000)	(0.003)	(0.002)
1920	-1.463***	8.047***	-1.719***	7.442***	-1.863***	9.657***
	(0.003)	(0.000)	(0.001)	(0.000)	(0.002)	(0.000)
1921	8.644***	-21.841***	8.341***	-21.406***	8.808***	-23.459***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
1922	-3.382***	-3.287	-2.661***	-5.188**	-3.860***	2.888
	(0.000)	(0.141)	(0.001)	(0.014)	(0.000)	(0.418)
1923	0.274	3.380***	0.585	2.792**		
	(0.553)	(0.008)	(0.253)	(0.044)		
1924	-0.388	2.265*				
	(0.408)	(0.078)				
1925	0.766*	-0.348				
	(0.074)	(0.767)				
1927	-2.092***	-1.903*	-1.803***	-2.214*	-1.976***	-1.648
	(0.000)	(0.097)	(0.000)	(0.079)	(0.000)	(0.495)
1928	2.181***	-0.180	2.177***	-0.351	2.107***	-0.979
	(0.000)	(0.876)	(0.000)	(0.784)	(0.000)	(0.688)
1930	4.304***	-2.933***	4.459***	-3.133**	4.353***	-3.142
	(0.000)	(0.009)	(0.000)	(0.012)	(0.000)	(0.190)
1931	2.202***	-0.613	2.862***	-1.188	2.461***	1.037
	(0.000)	(0.660)	(0.000)	(0.395)	(0.000)	(0.691)
1932	-0.818	2.495*				
	(0.120)	(0.084)				
1933	-1.312***	0.160				
	(0.004)	(0.897)				
1934	-0.897**	0.803				
	(0.038)	(0.500)				
1936	-0.898**	-0.587				
	(0.031)	(0.606)				

Table C5: **VAR(2) in unemployment and inflation rate, impulse indicator saturation (continued)**

	$< 10\%$	$< 10\%$	$< 5\%$	$< 5\%$	$< 1\%$	$< 1\%$
	u_t	π_t	u_t	π_t	u_t	π_t
1938	2.196***	-2.356**	2.230***	-2.298*	2.363***	-3.713
	(0.000)	(0.039)	(0.000)	(0.070)	(0.000)	(0.125)
1939	-3.957***	1.855	-3.670***	1.503	-3.824***	2.274
	(0.000)	(0.109)	(0.000)	(0.235)	(0.000)	(0.349)
1940	-0.823*	12.159***	-1.050**	12.283***		
	(0.071)	(0.000)	(0.033)	(0.000)		
1941	-2.359***	-4.256***	-2.600***	-3.352**	-1.864***	-7.488***
	(0.000)	(0.003)	(0.000)	(0.029)	(0.003)	(0.005)
1942	0.725	-3.124**	0.144	-3.195**		
	(0.139)	(0.020)	(0.775)	(0.020)		
1943	0.262	-3.480***	-0.072	-3.550***		
	(0.544)	(0.003)	(0.879)	(0.006)		
1946	1.327***	-0.262	1.248***	-0.252		
	(0.001)	(0.817)	(0.007)	(0.842)		
1947	-1.504***	4.293***	-1.402***	4.207***	-1.487***	5.003**
	(0.000)	(0.000)	(0.003)	(0.001)	(0.008)	(0.041)
1949	-0.484	-4.159***	-0.634	-4.079***		
	(0.239)	(0.000)	(0.171)	(0.001)		
1950	0.701*	0.591				
	(0.097)	(0.610)				
1951	-0.718*	5.060***	-0.741	5.092***		
	(0.079)	(0.000)	(0.109)	(0.000)		
1953	-1.269***	-5.098***	-1.373***	-4.992***		
	(0.002)	(0.000)	(0.003)	(0.000)		
1974	-0.077	7.379***	-0.234	7.536***		
	(0.853)	(0.000)	(0.616)	(0.000)		
1975	-0.219	9.882***	-0.357	10.281***		
	(0.619)	(0.000)	(0.471)	(0.000)		
1979	0.586	4.976***				
	(0.187)	(0.000)				
1980	0.885**	5.713***	0.826*	5.910***		
	(0.035)	(0.000)	(0.081)	(0.000)		
Constant	0.160	1.375***	0.202*	1.391***	0.287**	1.079*
	(0.158)	(0.000)	(0.095)	(0.000)	(0.031)	(0.063)

D VAR estimation with intercepts

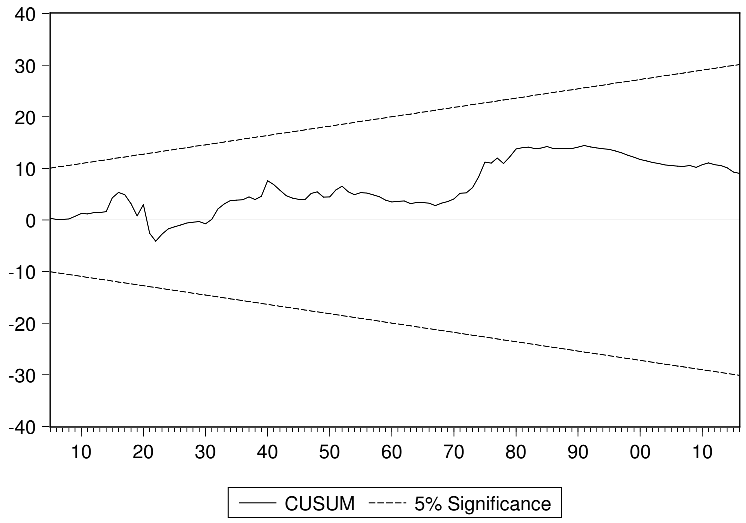

Figure D1: CUSUM test output, inflation equation (including intercept).

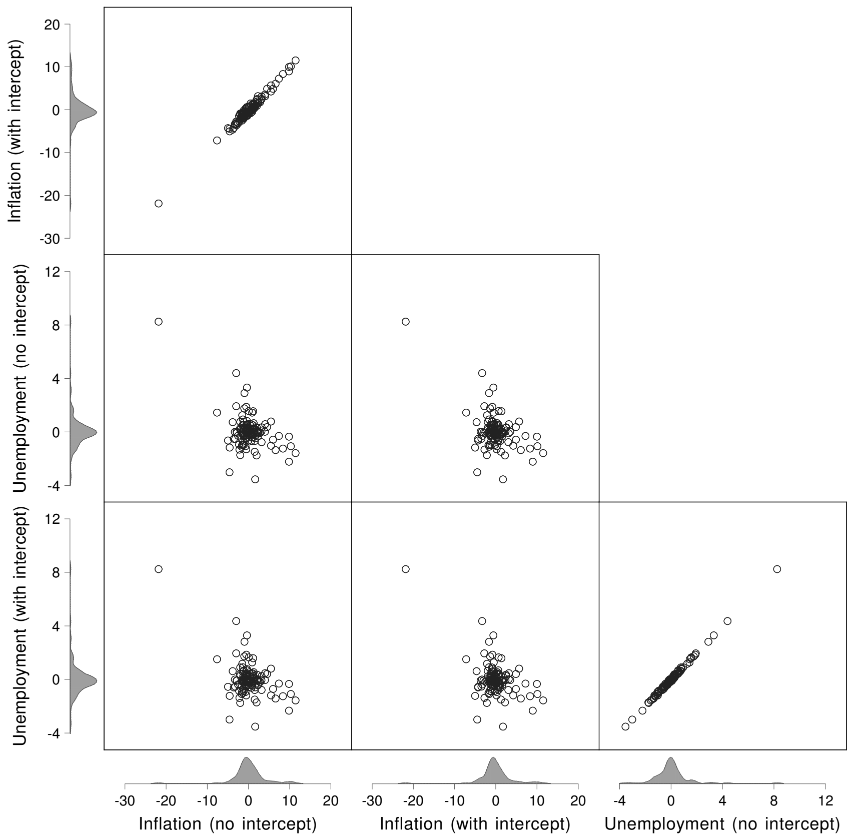

Figure D2: Scatter matrix and kernel densities for residuals from VAR models estimated with and without intercepts.