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Time-Varying Impact of Uncertainty Shocks on Macroeconomic Variables of the United Kingdom: Evidence from Over 150 Years of Monthly Data

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Abstract

In this paper, we analyse the impact of uncertainty (corporate bond spread) shock on inflation rate, unemployment rate, monetary policy rate, and nominal exchange rate returns of the United Kingdom over the monthly period of 1855:01 to 2016:12. Given that we use data spanning over one and a half century, we use a time-varying parameter vector autoregressive (TVP-VAR) model. We find that a positive uncertainty shock reflects a negative demand shock as suggested by theory, and results in declines in the inflation, interest rate and dollar-pound exchange rate returns, and an increase in the unemployment rate. However, this impact varies over time, with the strongest effect observed for the period after World War II until the start of the Great Moderation, and during the recent global crisis. Our results are in general robust to an alternative econometric framework (breaks-based VAR) and a metric of uncertainty (stock market volatility).

Keywords: Uncertainty, Macroeconomic Effects, Time-Varying Vector Autoregression, United Kingdom

JEL Codes: C32, E30, E40, F31

1. Introduction

The adverse effect of uncertainty on aggregate economic activity is generally explained by the theory of irreversible investment under uncertainty, following Henry (1974), Bernanke (1983) and Dixit and Pindyck (1994), and more recently by Bloom (2009). According to this theory, irreversible investments are postponed during periods of uncertainty which, in turn, causes temporary declines in aggregate output level (or increases the unemployment rate).[1] While, the existing theories of uncertainty are relatively old and well-established, the need to measure uncertainty – a latent variable, and empirically quantify its impact on the macroeconomy, only gained momentum in the wake of the "Great Recession" in the United States (US), and the Global Financial Crisis (GFC) that followed thereafter. This has resulted in a plethora of studies analysing the impact of uncertainty on macroeconomic variables (and financial markets[2]), for not only the US, but also for other advanced and emerging market economies (see for example, Bloom (2014, 2017) and Castelnuovo, et al., (2017), Gupta et al., (2018, 2019) for detailed reviews of this literature).[3]

The existing studies have however, only analysed post World War II data. Given this, we aim to add to this literature from a historical perspective, by analysing the impact of uncertainty on macroeconomic variables in the United Kingdom (UK), spanning the monthly period of 1855:1

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[1] Uncertainty can also negatively impact aggregate demand by causing consumers to reduce current spending on consumption and increase precautionary savings (Visco, 2017).

[2] See Chuliá et al., (2017) for a detailed review of the literature analyzing the impact of uncertainty on financial markets via the discount rate and cash-flow channels.

[3] For an important working paper in this regard, see Castelnuovo (2019).

to 2016:12. Note that, the choice of the UK is purely driven by availability of continuous long-span monthly data on unemployment, price-level, interest rate, exchange rate and uncertainty, derived from the "Millenium of Macroeconomic Data" database, maintained by the Bank of England. For our purpose we use a full-fledged time-varying parameter vector autoregressive (TVP-VAR) model. Our paper would thus, provide information on the role uncertainty shocks have played historically in affecting the economy of the UK, and help us compare our results with the effects observed during the recent global turmoil that followed since 2007 onwards. To the best of our knowledge, this is the first paper to analyse the time-varying impact of uncertainty shocks for the UK covering over 150 years of macroeconomic data, and in the process of using the longest possible data sample available for the UK, our paper is unlikely to suffer from any sample selection bias. The remainder of the paper is organized as follows: Section 2 discusses the data and provides a brief outline of the TVP-VAR model, while Section 3 discusses the econometric results, with Section 4 concluding the paper.

2. Data and Methodology

Our model includes four macroeconomic variables: unemployment rate, the month-on-month inflation rate based on the Wholesale Price Index (WPI), the Bank rate capturing monetary policy, the US dollar to UK pound exchange rate, and the metric for uncertainty. Following, Gilchrist et al., (2014), Jones and Olson (2015), Caldara et al., (2016), and Gupta et al., (forthcoming), and availability of data, we use the corporate bond spread, i.e., the difference between the yields of corporate and government bonds, as our measure of uncertainty.[4] Our sample period covers 1855:01 to 2016:12, and the database is available for downloadable from: https://www.bankofengland.co.uk/statistics/research-datasets. Note that, since our TVP-VAR requires approximately stationary variables, unemployment rate, inflation, interest rate, uncertainty are in levels, while exchange rate is converted into its log-returns form.[5] The variables are named as Inflation, Unemployment, Bank rate, Uncertainty, and Exchange rate to capture the inflation rate, unemployment rate, the monetary policy rate, the corporate bond spread and exchange rate returns of the dollar relative to the pound. The data has been plotted in Figure A1 in the Appendix of the paper. Corporate bond spread is found to be relatively high during the inter-war period, the Great Depression and Great Recession, the oil shock and breakdown of the Bretton Woods system, and between the late 1980s and early 1990s, and early 2000s, associated with global stock crash following "Black Monday" (the crash of 1987), the resignation of Margaret Thatcher, Iraq War and the "Dotcom bubble" (NASDAQ crash) respectively. In other words, the corporate bond spread does seem to be a good metric for uncertainty.

Given the description of the data of the five variables (inflation rate, unemployment rate, the monetary policy rate, the corporate bond spread, and dollar-pound exchange rate returns) that comprise our model economy of the UK, we next describe the TVP-VAR model with stochastic volatility as developed by Primiceri (2005). The TVP-VAR model is derived from the basic constant parameter VAR model, with the latter defined as follows:

$$Ay_t = F_1 y_{t-1} + ... + F_s y_{t-s} + u_t \qquad t = s+1, ..., n \tag{1}$$

where y_t denotes a $k \times 1$ vector of observed variables (which in our case is the inflation rate, unemployment rate, the policy rate, the nominal exchange rate and uncertainty), and $A, F_1, ..., F_s$ denote $k \times k$ matrices of coefficients. The disturbances u_t is a $k \times 1$ structural shock assumed to

[4] Historical news-based measures of uncertainty at monthly frequency for the UK has been developed by Baker et al., (2016) and Lennard (2018). However, the former data set covers 1900 to 2008, while the latter is only available for the inter-war period of 1920 to 193, and hence were not usable.

[5] Standard unit root tests confirm the mean-reversion of all the variables entering into our TVP-VAR model. Complete details of these results are available upon request from the authors.

follow a normal distribution of the form $u_t \sim N(0, \Sigma)$, , where

$$\Sigma = \begin{pmatrix} \sigma_1 & 0 & \cdots & 0 \\ 0 & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ 0 & \cdots & 0 & \sigma_k \end{pmatrix}. \tag{2}$$

and A takes on a lower-triangular structure as follows:

$$A = \begin{pmatrix} 1 & 0 & \cdots & 0 \\ a_{21} & \ddots & \ddots & \vdots \\ \vdots & \ddots & \ddots & 0 \\ a_{2k} & \cdots & a_{k,k-1} & 1 \end{pmatrix}. \tag{3}$$

The model in (1) can be written in a reduced-form specification as:

$$y_t = B_1 y_{t-1} + ... + B_s y_{t-s} + A^{-1}\Sigma\varepsilon_t, \qquad \varepsilon_t \sim N(0, I_k) \tag{4}$$

where $B_i = A^{-1}F_i$ for $i = 1,\ ...,\ s$. Stacking the elements in the rows of the $B_i^{'}s$ to form β ($k^2s\times 1$ vector), and defining $X_t = I_k \otimes (y_{t-1}^{'},\ ...,\ y_{t-s}^{'})$, where $\otimes$ denotes the Kronecker product, we can rewrite the model as follows:

$$y_t = X_t\beta + A^{-1}\Sigma\varepsilon_t. \tag{5}$$

All parameters in Equation (5) are time-invariant. By allowing the parameters to change over time, Equation (5) further extends to the following specification:

$$y_t = X_t\beta_t + A_t^{-1}\Sigma_t\varepsilon_t,\ \ t = s+1, ..., n, \tag{6}$$

where the coefficients β_t, and the parameters A_t and Σ_t are all time varying. To model the process for these time-varying parameters, Primiceri (2005) assumes the parameters in equation (6) follow a random walk process. Let $a_t = (a_{21},\ a_{31},\ a_{32},\ a_{41},\ ...,\ a_{k,k-1})'$ denote a stacked vector of the lower-triangular elements in A_t and $h_t = (h_{1t}, ..., h_{kt})'$ with $h_{jt} = \log\sigma_{jt}^2$ for $j = 1,\ ...,\ k$, $t = s+1,\ ...,\ n$. Thus,

$$\begin{aligned} \beta_{t+1} &= \beta_t + u_{\beta_t}, \\ a_{t+1} &= a_t + u_{a_t}, \\ h_{t+1} &= h_t + u_{h_t}, \end{aligned} \qquad \begin{pmatrix} \varepsilon_t \\ u_{\beta_t} \\ u_{a_t} \\ u_{h_t} \end{pmatrix} \sim N\left(0, \begin{pmatrix} I & 0 & 0 & 0 \\ 0 & \Sigma_\beta & 0 & 0 \\ 0 & 0 & \Sigma_a & 0 \\ 0 & 0 & 0 & \Sigma_h \end{pmatrix}\right) \tag{7}$$

for $t = s+1,\ ...,\ n$, where $\beta_{s+1} \sim N(\mu_{\beta_0}, \Sigma_{\beta_0})$, $a_{s+1} \sim N(\mu_{a_0}, \Sigma_{a_0})$ and $h_{s+1} \sim N(\mu_{h_0}, \Sigma_{h_0})$.

The TVP-VAR model is estimated using Markov-Chain Monte-Carlo (MCMC) methods with Bayesian inference, based on 30,000 draws after an initial burn-in of 30,000 (i.e., we use a total of 60,000 iterations). The MCMC method assesses the joint posterior distributions of the parameters of interest based on certain prior probability densities that we set in advance, which in turn, are identical to those used in Primiceri (2005). Once the model is estimated, we can produce time-varying impulse response functions of the variables in the model following the uncertainty shock. Since, the literature is not clear-cut in terms of the ordering of the uncertainty variable in the VAR model (see for example, Colombo (2013), and Jurado et al., (2015) for detailed discussions in this regard), we identify the impact of the uncertainty shock using the generalized impulse response functions (as developed by Pesaran and Shin (1998)), which are orthogonal set of innovations that does not depend on the ordering of the variables in the VAR.[6]

3. Empirical Results

3.1. Main Result

In Figure 1, we report the time-varying generalized impulse responses functions of inflation rate, unemployment rate, the monetary policy rate, and the dollar-pound exchange rate returns following a one unit shock to the corporate bond spread, i.e., uncertainty. We report the impulse response functions spanning up to a horizon of two years, i.e., 24 months following the one standard deviation of uncertainty shock. As uncertainty affects the economy based on the irreversible investment theory, it can, understandably be considered as a negative aggregate demand shock. Given this, the expectations is that an increase in uncertainty will reduce inflation, and raise the unemployment rate, and the monetary authority will react to nullify the recessionary impact on the economy by cutting on the interest rate. The weak economy associated with lower interest rates is likely to reduce the demand for the assets denominated in the British pound, and result in a depreciation (appreciation) of pound-dollar (dollar-pound) due to capital outflows.

The main observations from Figure 1 can be summarized as follows: (1) The effects of the uncertainty shock on the four variables of concern are indeed time varying; (2) The sign of the impacts on the inflation rate, unemployment rate, the monetary policy rate, and the exchange rate returns are also in line with the effects associated with a negative demand shock. In other words, we find that the inflation rate (at shorter-horizons), interest rate (consistently at all horizons, barring the early part of the 20th century) and the pound-dollar exchange rate returns (at all horizons except for the period post World War II and until the collapse of the Bretton Woods) are negatively affected in general over the entire sample period, but in varied magnitude. As far as our main variable of interest, i.e., the unemployment rate is concerned it generally increases following the positive uncertainty shock, with strongest effects observed post the World War II until the setting-in of the Great Moderation (about a peak of 0.7 percentage point), and of course during and after the recent global crisis (approximately a maximum of 0.5 percentage point). The size of the impacts during these two periods are in line with the trends in the unemployment rate that can be observed from the data plots in Figure A1 in the Appendix of the paper. Though the impact of uncertainty shocks on the unemployment rate during the interwar period (with double-digit unemployment rates) is positive as well, and similar in magnitude with the findings of Lennard (2018), it is way smaller compared to the abovementioned two phases. In sum, our results are theory-consistent in a time-varying manner.

3.2. Additional Analyses

In this segment, we conduct two extra analyses. First, as in Bataa et al., (2019), we estimate a breaks-based VAR model, whereby first, break dates are obtained in the multivariate setting (as reported in Table 1), and then generalized impulse responses are computed over the identified sub-samples based on a bootstrap procedure. The five break dates correspond respectively with end of the World War I; end of the "Great Depression" and start of World War II; deep recession of the mid-1950s (due to inflationary pressures from oil embargo by the North Atlantic Treaty Organization (NATO) and other Arab countries, and the associated interest rate hikes and credit squeeze); breakdown of the Bretton Woods system, and; the beginning of the "Great Moderation". The impulse responses of inflation, unemployment rate, the bank rate and the exchange rate to a corporate bond spread shock have been reported in Figure 2, and in general, confirm the results derived from the TVP-VAR model. In other words, the uncertainty shock is again more like a negative demand shock which reduces the inflation rate, interest rate and exchange rate returns, and increases the unemployment rate, with strongest effects being felt over the post-World War

[6] Intuitively, the generalized impulse responses from an innovation to the *j*-th variable are derived by applying a variable specific Cholesky factor computed with the *j*-th variable at the top of the Cholesky ordering.

II period till the beginning of the Great Moderation, and at the end of the sample period in the wake of the GFC. Second, following Jones and Olson (2015), we derive an alternative measure of uncertainty based on a Generalized Autoregressive Conditional Heteroskedasticity (GARCH(1,1)) model fitted to log-returns of the share price index data (again derived from the Millenium of Macroeconomic Data database and plotted in Figure A1 in the Appendix). Then we analyse the impact of the shock to stock market volatility on the variables of our concern in the TVP-VAR model. Again our results, as reported in Figure 3, are in line with those derived under the corporate bond spread shock, though the effects are relatively less aligned (particularly for the unemployment rate) with theory of uncertainty shocks being aggregate demand shocks (and also less pronounced, as in Jones and Olson, 2015)). This result possibly suggests that the stock market volatility is a comparatively less accurate measure of uncertainty than the corporate bond spread.[7]

4. Concluding Remarks

Unlike the existing literature on the impact of uncertainty on macroeconomic variables which is restricted to only post World War II data, we use a TVP-VAR model to analyse the effect of uncertainty (corporate bond spread) shocks on macroeconomic variables (inflation rate, unemployment rate, monetary policy rate, and nominal exchange rate returns) of the UK, spanning the monthly period of 1855:01 to 2016:12. We find that a positive uncertainty shock have effects consistent with a negative demand shock as it produces reduction in the inflation, interest rate and dollar-pound exchange rate returns, and an increase in the unemployment rate. But this impact is indeed time-varying, with the strongest effect observed during the period following the World War II until the Great Moderation, and then during the recent global crises. When we use a breaks-based VAR model as an alternative econometric framework, and stock market volatility to capture uncertainty, our results derived from the corporate bond spread shock in the TVP-VAR model continues to hold in general. Our analysis imply that to capture the true effects of uncertainty shock, one would need to use a time-varying approach, as the macroeconomic effects do not remain the same over time. Naturally this has important ramifications in terms of monetary policy decisions, since the size of the expansionary monetary policy to counteract the negative impact of uncertainty would depend upon the current magnitude of the effect of uncertainty shocks on the macroeconomic variables. In other words, monetary policy would need to be state-specific, with policymakers continuously required to evaluate the nature and strength of the impact of uncertainty on the macroeconomy based on a time-varying approach.

[7] The impact of the stock market volatility shock under the breaks-based VAR is presented in Figure A2 in the Appendix of the paper. The impact varies over the identified sub-samples, derived based on the iterative procedure of Bataa et al., (2013) (as reported in Table A1), but in general, the fact that increases in uncertainty is associated with a negative demand shock is again confirmed from the movements of the variables in the model.

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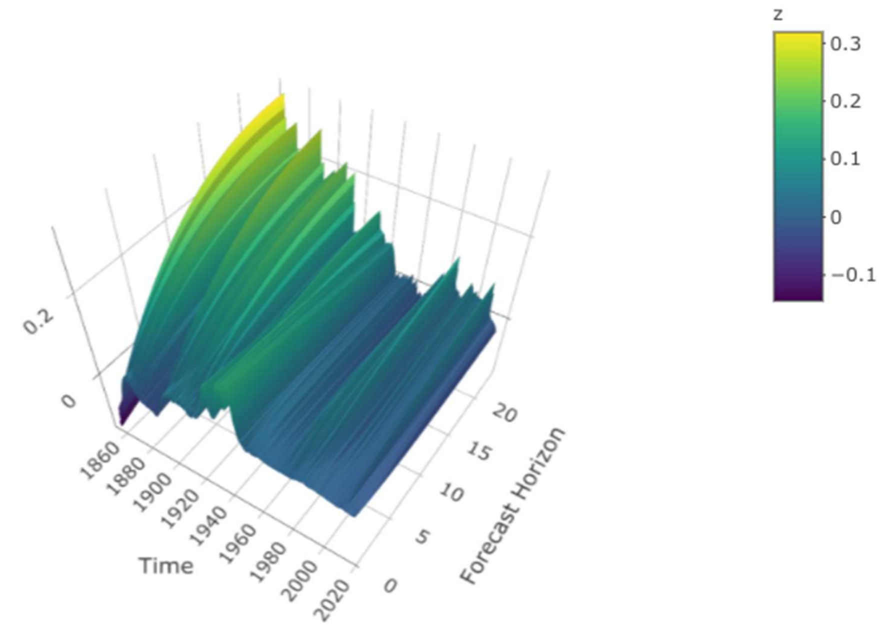
Table 1. Coefficients Breaks in the VAR Model with Corporate Bond Spread as a Measure of Uncertainty

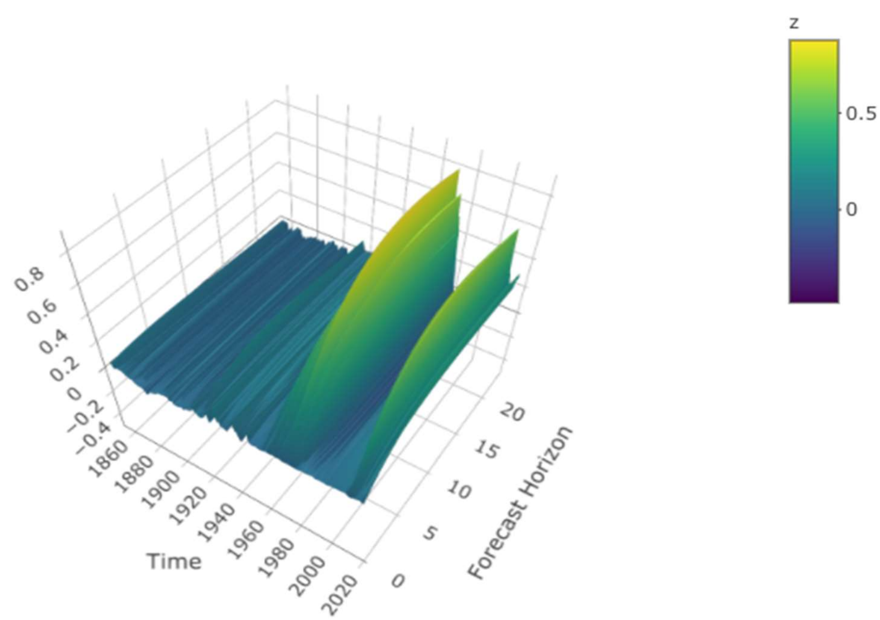
	Inflation	**Unemployment**	**Bank rate**	**Corporate Bond Spread**	**Exchange rate**
Break 1	1920:10	1915:02	1974:02	1957:02	1931:10
	[1920:08 – 1928:12]	[1914:08-1921:04]	[1973:03 – 1976:07]	[1955:04 – 1959:07]	[1931:04 – 19439:07]
Break 2	1950:09	1937:04	1993:06	1989:08	1971:05
	[1938:12 – 1951:10]	[1936:08 – 1943:01]	[1989:05 – 1995:10]	[1987:05 – 1992:08]	[1967:11 – 1974:10]
Break 3	1980:09	1989:12			1992:01
	[1973:05-1981:12]	[1987:08 – 1993:01]			[1989:02 – 1995:10]

Notes: Break dates based on the iterative procedure discussed in Bataa et al., (2013).

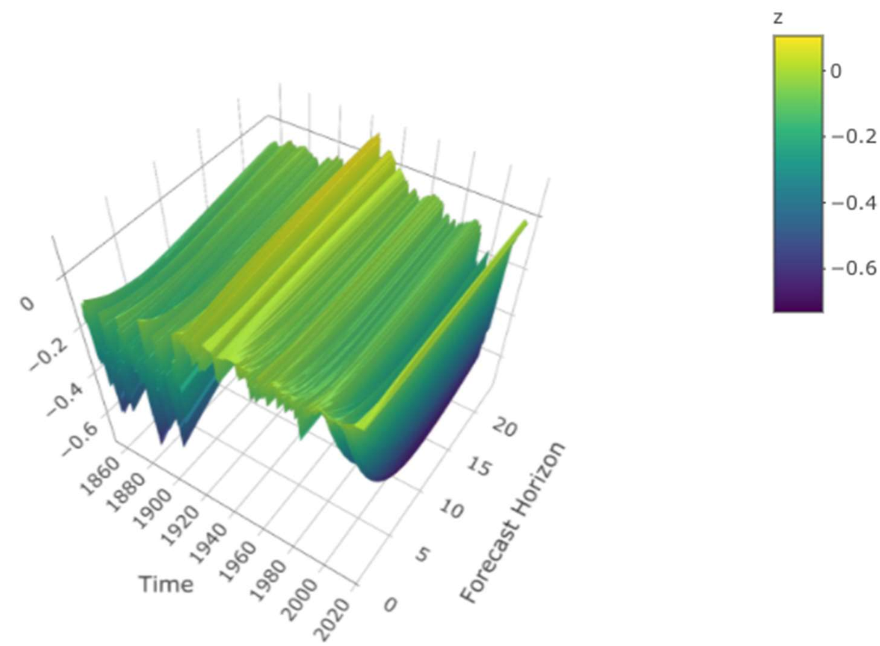
Figure 1. Response to Uncertainty (Corporate Bond Spread) Shock in the TVP-VAR Model



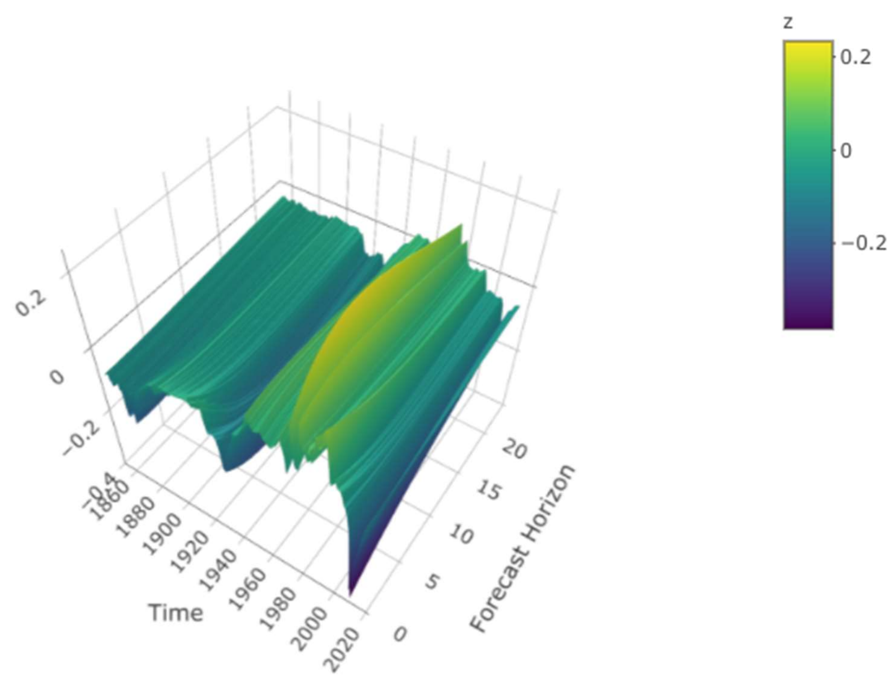
3(a). Response of Inflation



3(b). Response of Unemployment

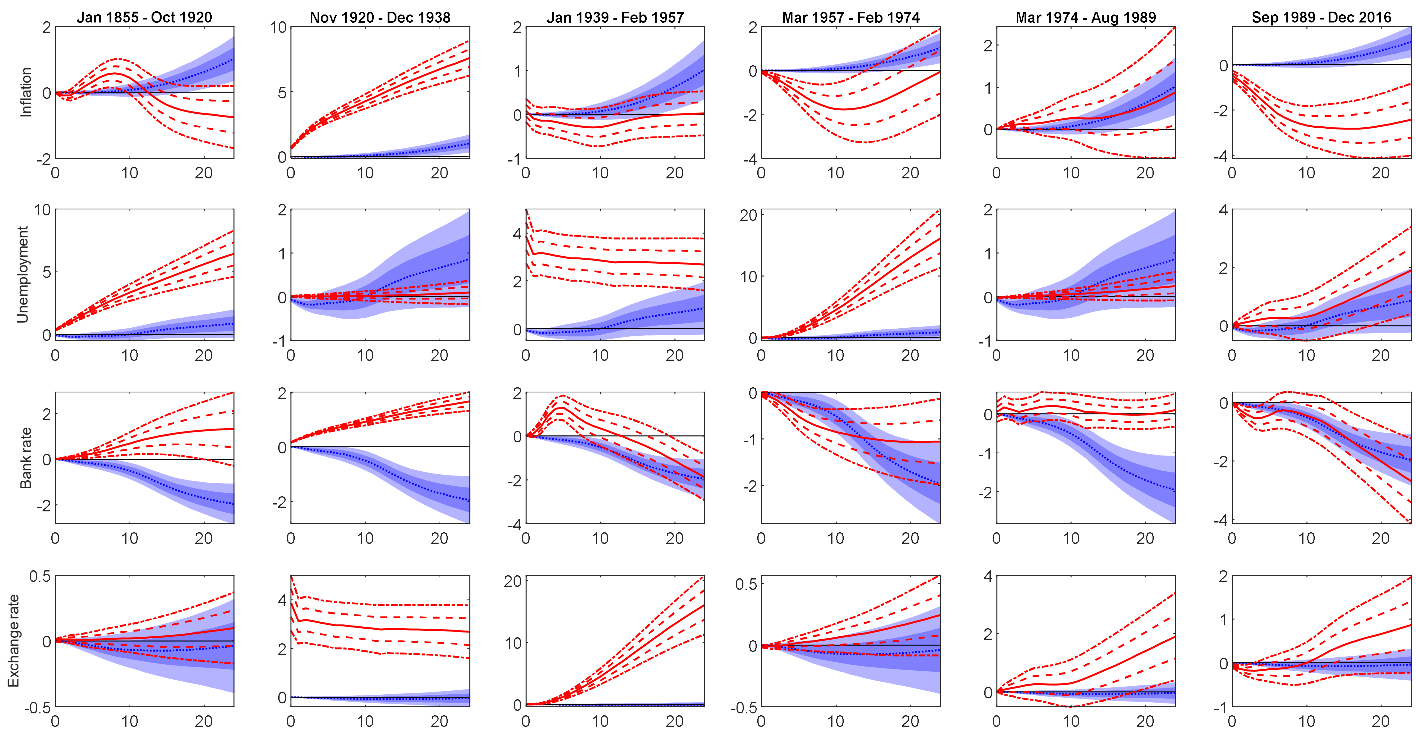


3(c). Response of Bank rate



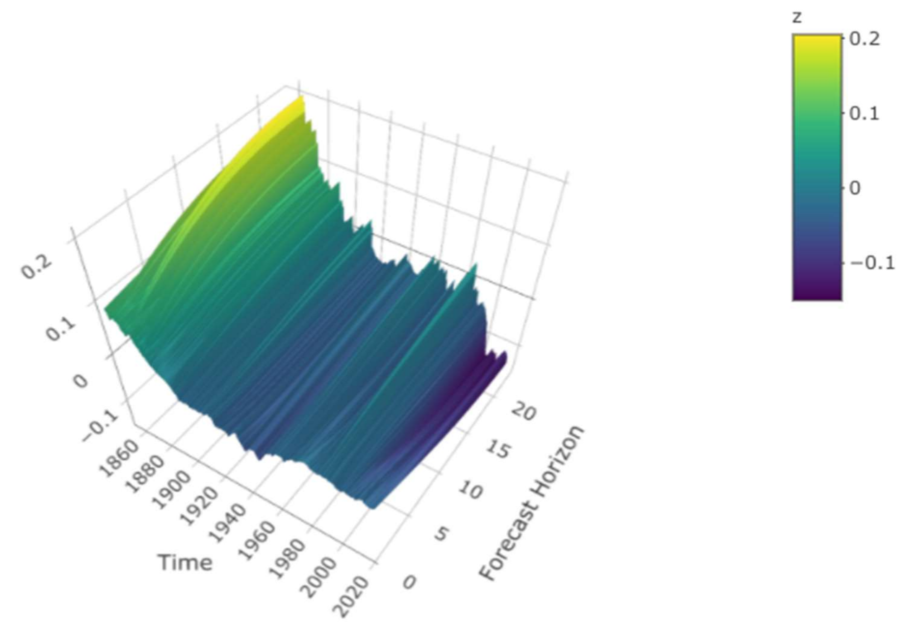
3(d). Response of Exchange rate

Figure 2. Response to Uncertainty (Corporate Bond Spread) Shock in the Breaks-Based VAR Model

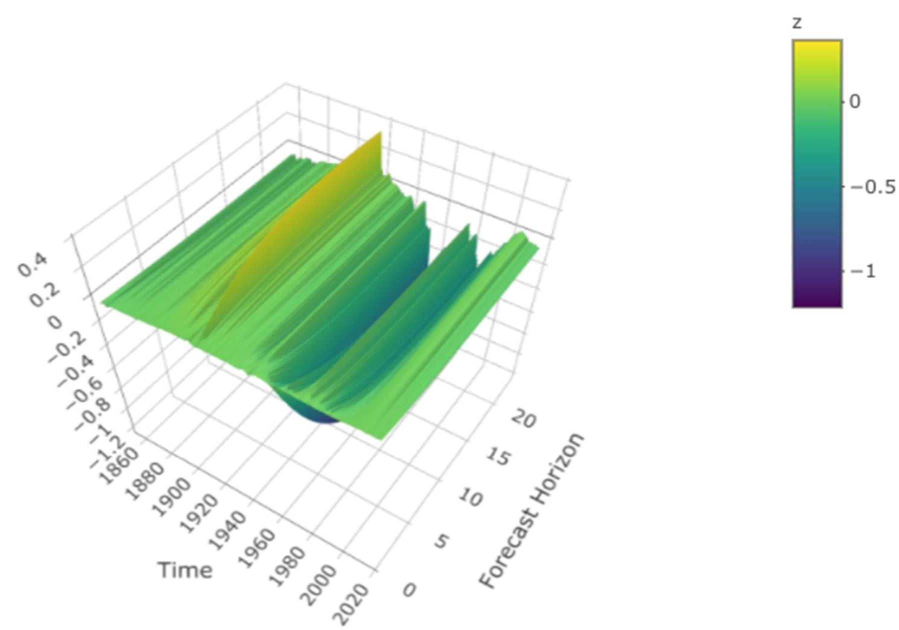


Note: Each of the six columns represents a sub-sample as defined by the coefficient break dates and confidence intervals of Table 1. Each plot includes one (dashed line) and two (dashed-dotted line) standard deviation confidence bands. The background shaded areas provide corresponding confidence intervals around the responses (dotted line) for a constant parameter model estimated over the whole sample period.

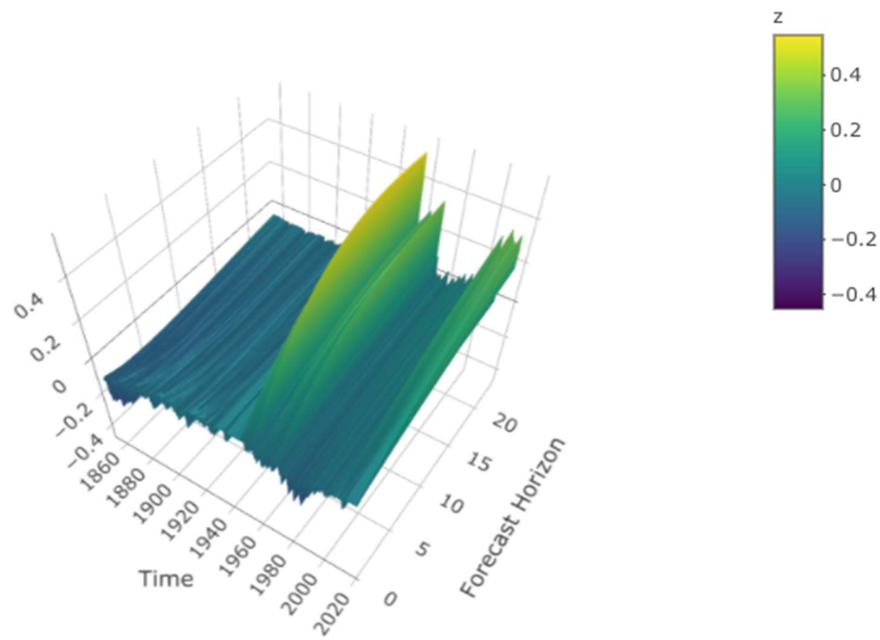
Figure 3. Response to Uncertainty (GARCH(1,1) Stock Returns Volatility) Shock in the TVP-VAR Model



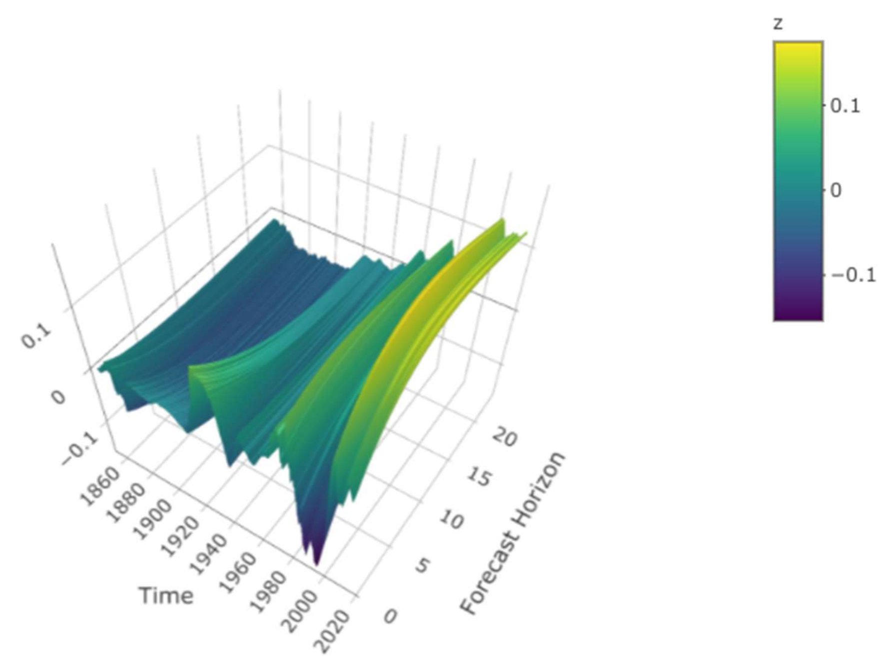
3(a). Response of Inflation



3(b). Response of Unemployment



3(c). Response of Bank rate



3(d). Response of Exchange rate

APPENDIX:

Table A1. Coefficients Breaks in the VAR Model with GARCH(1,1) Stock Market Volatility as a Measure of Uncertainty

	Inflation	**Unemployment**	**Bank rate**	**Stock Returns Volatility**	**Exchange rate**
Break 1	1897:08	1914:10	1935:10	1956:01	1933:03
	[1896:01 – 1898:07]	[1910:11-1920:06]	[1934:05 – 1940:01]	[1949:03 – 1963:03]	[1931:06 – 1941:08]
Break 2	1914:12	1935:07	1972:01	1975:02	1975:05
	[1914:06 – 1920:10]	[1933:04 – 1941:10]	[1969:09 – 1974:05]	[1971:04 – 1977:04]	[1974:01 – 1978:10]
Break 3	1942:05	1980:06	1993:04	1987:10	1994:05
	[1941:11-1949:08]	[1973:08 – 1986:09]	[1989:12 – 1995:08]	[1986:11 – 1989:09]	[1991:07 – 1995:08]
Break 4	1992:04				
	[1992:02 – 1995:08]				

Notes: Break dates based on the iterative procedure discussed in Bataa et al., (2013).

Figure A1. Data Plots

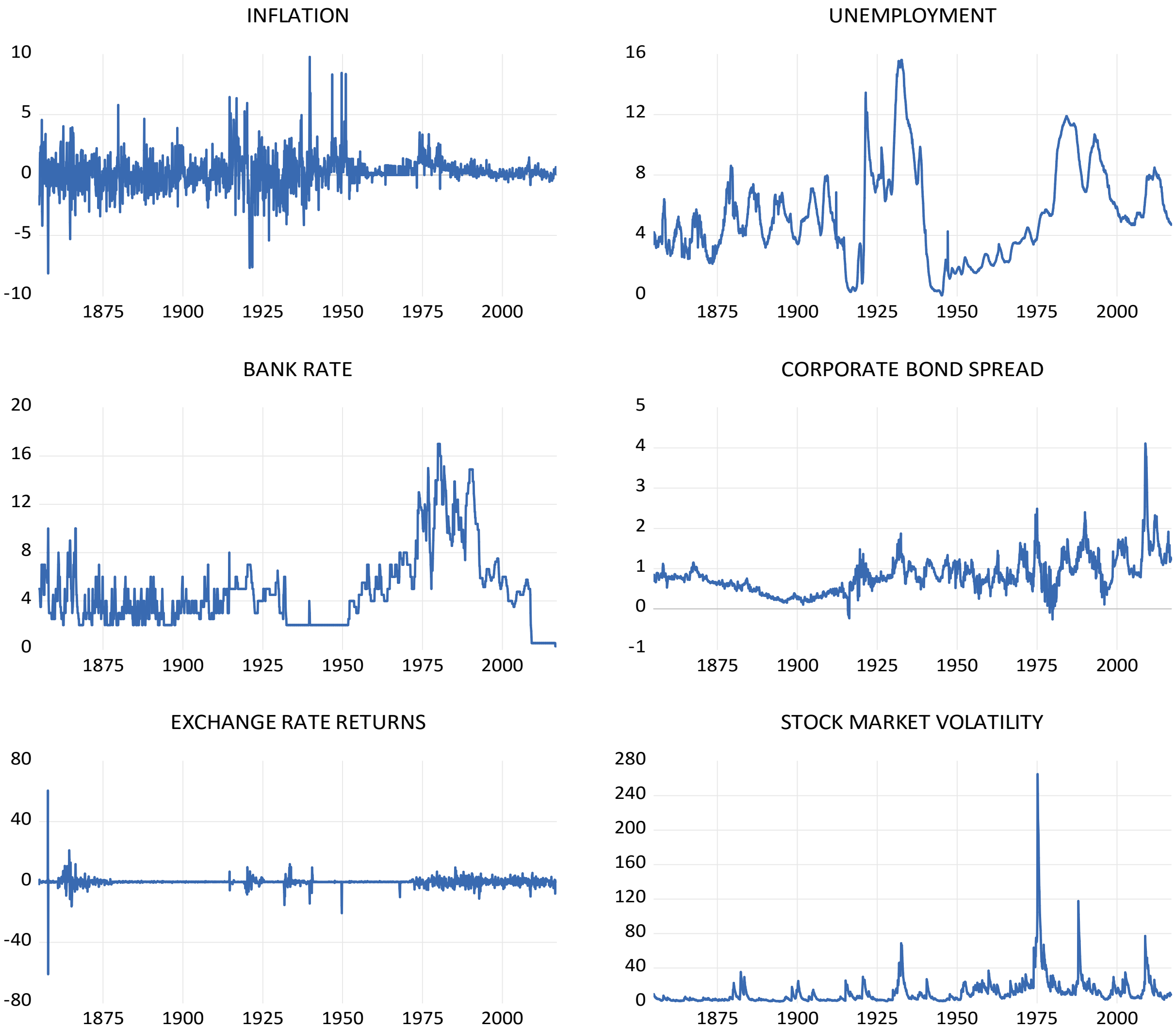
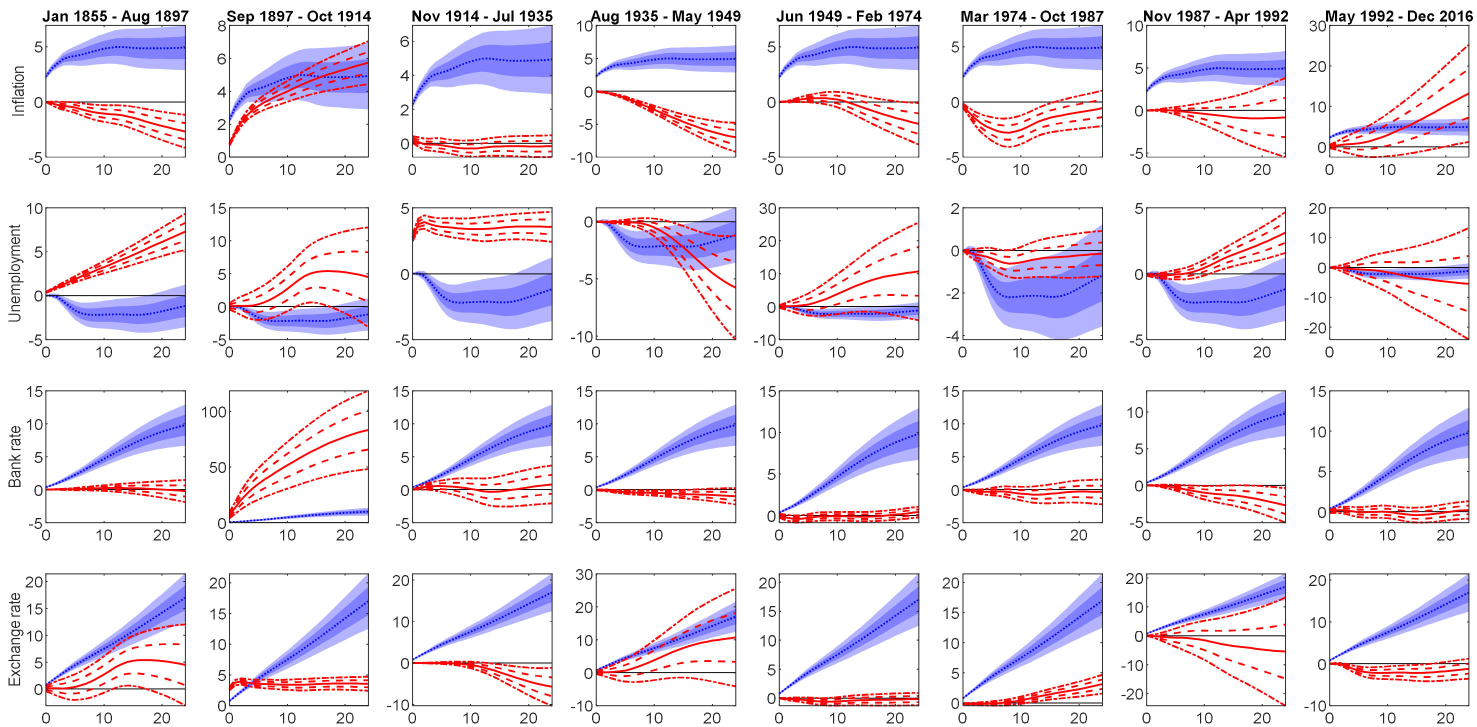


Figure A2. Response to Uncertainty (GARCH(1,1) Stock Returns Volatility) Shock in the Breaks-Based VAR Model



Notes: Each of the eight columns represents a sub-sample as defined by the coefficient break dates and confidence intervals of Table A1. Each plot includes one (dashed line) and two (dashed-dotted line) standard deviation confidence bands. The background shaded areas provide corresponding confidence intervals around the responses (dotted line) for a constant parameter model estimated over the whole sample period.