The International Effects of U.S. Uncertainty

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Abstract

We propose domestic uncertainty shocks may serve as a channel through which business cycles are transmitted internationally. To quantify uncertainty, we use two measures from the current literature and estimate vector autoregressions (VARs) to evaluate the effects U.S. uncertainty shocks have on the Japanese and British economies. Our results suggest U.S. uncertainty shocks have international effects consistent with a demand shock in the context of an open-economy IS/LM model with sticky prices.

JEL classifications: E30, F41, F44
Key words: Uncertainty Shocks, International Business Cycles

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1. Introduction

In Chairman Bernanke's July 21, 2010 Semiannual Monetary Policy Report to Congress, he surprised many market participants by coining the phrase "unusually uncertain" to describe the U.S. economic outlook. Fittingly, Bernanke (1983) was one of the first to emphasize the impact uncertainty shocks have on macroeconomic activity. While policy makers understand the adverse effects uncertainty may have on the domestic economy by fostering "wait-and-see" attitudes among economic actors[1], the current academic literature regarding uncertainty shocks is relatively sparse. Bloom (2009) and Bloom et al. (2009) develop structural models in which positive uncertainty shocks lead to temporary reductions in investment and employment causing output to decline. Similarly, Gilchrist, Sim, and Zakrajsek (2009) suggest uncertainty shocks raise the cost of capital leading firms to reduce investment. A related topic that has not received attention in the current literature is the degree to which domestic uncertainty shocks may transmit business cycles internationally. While many business cycle transmission mechanisms have been documented, to our knowledge, uncertainty shocks have not been evaluated in this context.[2]

We seek to build on Bloom (2009), Bloom et al. (2009), and Gilchrist, Sim and Zakrajsek (2009) and evaluate how U.S. uncertainty shocks affect the economies of large U.S. trading partners. To that end, we estimate SVARs using two measures of uncertainty taken from the above mentioned literature. To preview our results, we find that the international effects of U.S. uncertainty shocks are consistent with a demand shock in an open-economy IS/LM model with sticky prices; U.S. uncertainty shocks induce a statistically significant decline in foreign exports

[1] Consider the FOMC statement after 9/11, "the events of September 11 produced a marked increase in uncertainty […] depressing investment by fostering an increasingly widespread wait-and-see attitude."

[2] Kindleberger (1962) and Meltzer (1976) first noted the significance of trade in the propagation of international business cycles. Frankel and Rose (1998), Clark and van Wincoop (2001), and Baxter and Kouparitsas (2005) all document the positive relationship between trade volume and business cycle synchronization. There are also a variety of trade transmission mechanisms that have been examined that produce business cycle comovements among trading partners: production sharing, dependence on foreign inputs, and common external shocks such as oil price shocks (Burstein et al. 2008; Backus et al., 1995; Baxter, 1995; Stockman and Tesar, 1995; Backus and Crucini, 2000).

and inflation and cause foreign currencies to appreciate relative to the dollar. The rest of the paper proceeds as follows: Section 2 discusses our uncertainty measures and methodology, Section 3 presents our results of U.S. uncertainty shocks on U.S., Japanese, and British output, Section 4 evaluates the effects of uncertainty shocks on Japanese and British exchange-rates, exports, and inflation rates, Section 5 presents our historical decompositions, and Section 6 concludes.

2. Data and Methodology

2.1 Data

Three factors influenced our decision to select Japan and the U.K. as the foreign economies of interest. First, both countries have reliable long term data. Second, according to the Census Bureau, as of December 2011, Japan was the fourth largest trading partner with the U.S., and the U.K. was the sixth. Third, exports compose a substantial portion of each country's domestic economy. In 2011, the Japanese economy totaled $5.86 trillion with exports totaling $800.8 billion. In the U.K., 2011 GDP totaled $2.48 trillion with exports amounting to $495.4 billion.

Output for the U.S., Japan, and the U.K. is defined as the log monthly change in industrial production which we obtained from the IFS International Statistics Database for the 1968 – 2010 time period. Since no consensus exists in the literature as to a variable which best captures macroeconomic uncertainty, our approach is to use two different measures from previous studies. First, as in Gilchrist, Sim, and Zakrajsek (2009), we use the spread between the 30-year Baa corporate bond and the 30-year Treasury bond. Second, similar to Bloom (2009), we use the volatility of the S&P 500.[3] Our data series are shown in Figure 1.

[3] Ideally, we would use the VIX as our measure of S&P 500 volatility as in Bloom (2009). However, VIX data is only available after1986; so, we obtain our S&P 500 volatility by estimating a GARCH (1,1) model. The correlation between the Bloom (2009) series and our estimated conditional volatility is 0.83.

The uncertainty variables likely capture different information in the U.S. economy. Therefore, we estimate the following four-variable SVAR for each measure of U.S. uncertainty:

$$\begin{bmatrix} U_{us_t} \\ y_{us_t} \\ y_{jp_t} \\ y_{uk_t} \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) & A_{13}(L) & A_{14}(L) \\ A_{21}(L) & A_{22}(L) & A_{23}(L) & A_{24}(L) \\ A_{31}(L) & A_{32}(L) & A_{33}(L) & A_{34}(L) \\ A_{41}(L) & A_{42}(L) & A_{34}(L) & A_{44}(L) \end{bmatrix} \begin{bmatrix} U_{us_{t-1}} \\ y_{us_{t-1}} \\ y_{jp_{t-1}} \\ y_{uk_{t-1}} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{bmatrix} \tag{1}$$

where U_{us_t} is U.S. uncertainty, y_{us_t}, y_{jp_t}, and y_{uk_t} are U.S., Japanese, and U.K. output, respectively, A_{ij} (L) are polynomials in the lag operator L, and the e_{it} are regression residuals.

The regression residuals e_{it} are composed of four shocks such that

$$\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} & g_{13} & g_{14} \\ g_{21} & g_{22} & g_{23} & g_{24} \\ g_{31} & g_{32} & g_{33} & g_{34} \\ g_{41} & g_{42} & g_{34} & g_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_{ut} \\ \varepsilon_{ust} \\ \varepsilon_{jpt} \\ \varepsilon_{ukt} \end{bmatrix} \tag{2}$$

where ε_{ut}, ε_{ust}, ε_{jpt}, and ε_{ukt} are uncertainty, U.S. output shocks, Japanese output shocks, and U.K. output shocks, respectively. Each shock is an i.i.d., zero-mean random variable and all are mutually uncorrelated such that $E_{t-1}\varepsilon_{it}\,\varepsilon_{kt} = 0$ for $i \neq k$. The estimated VAR yields ten distinct elements of the variance-covariance matrix Ee_te_t and the g matrix contains sixteen elements. Therefore it is necessary to impose six additional restrictions to obtain an identified system. For robustness, we implement three different identification schemes. First, we impose a Choleski decomposition such that $g_{12}=g_{13}=g_{14}=g_{23}=g_{24}=g_{34}=0$, therefore matrix (2) becomes

$$\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{bmatrix} = \begin{bmatrix} g_{11} & 0 & 0 & 0 \\ g_{21} & g_{22} & 0 & 0 \\ g_{31} & g_{32} & g_{33} & 0 \\ g_{41} & g_{42} & g_{34} & g_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_{ut} \\ \varepsilon_{ust} \\ \varepsilon_{jpt} \\ \varepsilon_{ukt} \end{bmatrix}. \tag{3}$$

The interpretation of the above restrictions is straightforward. Shocks to U.K. output, ε_{ukt}, have no contemporaneous effects on U.S. uncertainty, U.S. output, or Japanese output. Japanese output shocks, ε_{jpt}, have no contemporaneous effects on either U.S. output or U.S. uncertainty. Shocks to U.S., Japanese, and U.K. output have no contemporaneous effect on U.S. uncertainty.

While it is plausible that shocks to Japanese and U.K. output have no contemporaneous effects on U.S. uncertainty, it seems unlikely that shocks to U.S. output have no contemporaneous effect on U.S. uncertainty. For this reason we implement two other identification schemes.

First, we simply reverse the ordering of the U_{us} and y_{us} variables. Second, we impose the following Sims-Bernanke (short run) and Blanchard-Quah (1989) (long run) restrictions:

$$\begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{bmatrix} = \begin{bmatrix} g_{11} & g_{12} & 0 & 0 \\ *g_{21} & g_{22} & 0 & 0 \\ g_{31} & g_{32} & g_{33} & 0 \\ g_{41} & g_{42} & g_{34} & g_{44} \end{bmatrix} \begin{bmatrix} \varepsilon_{ut} \\ \varepsilon_{ust} \\ \varepsilon_{jpt} \\ \varepsilon_{skt} \end{bmatrix}. \quad (4)$$

The interpretation of the short-run restrictions, $g_{13}=g_{14}=g_{23}=g_{24}=g_{34}=0$, is the same as the interpretation for (3). The long-run restriction we impose is

$$*g_{21}\left[1-\sum_{i=1}^{p} a_{21_p}\right]=0 \quad (5)$$

where a_{21p} are the individual coefficients in A_{21} (L). The economic interpretation of this restriction is that uncertainty shocks have no long-run effects on U.S. output. Thus, this identification scheme allows for U.S. uncertainty shocks and U.S. output to contemporaneously affect each other while allowing the possibility that the effects of U.S. uncertainty shocks are propagated internationally.

3. Results

For brevity and because the results were not qualitatively different, we only report the results using the first decomposition.[4] Unit root tests indicate that each country's output, as defined in Section 2.1, is stationary, and all measures of uncertainty are found to be stationary in levels. We select the lag length of the VAR according to two criteria. First, we check the adequacy of the model by calculating Ljung-Box Q-statistics for the residuals to ensure the

[4] All results from the alternative decompositions may be obtained upon request from the authors.

absence of serial correlation. Second, we use the multivariate generalizations of the Akaike Information Criterion (AIC) and Schwartz Bayesian Criterion (SBC) to measure the overall fit of alternative models.

Panels A and B in Figure 2 display the cumulative impulse responses of U.S. output to U.S. uncertainty shocks along with 95% bootstrapped confidence intervals. While the point estimates using the two measures of uncertainty are slightly different, both point estimates display a similar pattern and indicate that U.S. output is negatively affected. Panels A and B suggest that a U.S. uncertainty shock lowers output by 0.6% and 0.4%, respectively. Output is only slightly contemporaneously affected by the uncertainty shock. However, output declines sharply from the first to the sixth month after the shock and then stabilizes. Our results largely confirm those in Bloom (2009), Bloom et al. (2009), and Gilchrist, Sim and Zakrajsek (2009). However, we do not find evidence of "overshooting" in domestic output six months after the shock as reported in Bloom (2009).[5]

The effects of the uncertainty shock on Japanese output are displayed in Figure 2. Panel A suggests a U.S. uncertainty shock has a similar negative effect on Japanese output. The most striking feature of Panel A is the speed at which output declines in Japan in the first two months following the shock. Output declines by 0.6% which accounts for most of the decline in Japanese output. Similar to the U.S., output in Japan stops declining approximately six months after the shock. Panel B displays a pattern similar to that in Panel A. While the effects are not always statistically different from zero at the 95% level, the point estimates are all negative. Again, note the speed at which output declines in the first two months after the shock. While it is not as

[5] One possible explanation for this difference is Bloom's (2009) use of the HP filter. Cogley and Nason (1995) and Harvey and Jaeger (1993) present evidence that the HP filter may generate spurious business cycle dynamics.

pronounced as in Panel A, Panel B suggests that most of the negative effects on Japanese output from U.S. uncertainty shocks are propagated within the first two months.

The effects on British output are similar to those in Japan and are displayed in Figure 3. Panel A suggests a significant (-0.4%) cumulative decline in British output two years after the shock. As in the U.S. and Japan, British output declines for approximately six months after the shock and then subsequently stabilizes. Again, examination of Panel B offers a similar pattern to Panel A. Most of the negative effects (-0.3%) in Panel B are almost entirely accounted for in the first two months after the shock.

Our results do suggest negative international effects of U.S. uncertainty shocks. The results are somewhat dependent on the uncertainty measure. While the point estimates using both uncertainty measures are consistently negative, the results using the corporate bond spread suggest a more negative impact on output in all three countries. Given that uncertainty shocks do appear to adversely affect foreign output, the next section of the paper examines the effects uncertainty shocks have on foreign exports, foreign inflation, and exchange rates.

4. U.S. Uncertainty Effects on Foreign Exchange Rates, Exports, and Inflation

Again, we obtained monthly U.K. and Japanese export, exchange rate, and CPI data from the IFS database for the 1970-2010 time period. We estimate the following four-variable VAR for Japan and the U.K.:

$$\begin{bmatrix} U_{us_t} \\ Ex_{i_t} \\ X_{i_t} \\ \pi_{i_t} \end{bmatrix} = \begin{bmatrix} A_{11}(L) & A_{12}(L) & A_{13}(L) & A_{14}(L) \\ A_{21}(L) & A_{22}(L) & A_{23}(L) & A_{24}(L) \\ A_{31}(L) & A_{32}(L) & A_{33}(L) & A_{34}(L) \\ A_{41}(L) & A_{42}(L) & A_{34}(L) & A_{44}(L) \end{bmatrix} \begin{bmatrix} U_{us_{t-1}} \\ Ex_{i_{t-1}} \\ X_{i_{t-1}} \\ \pi_{i_{t-1}} \end{bmatrix} + \begin{bmatrix} e_{1t} \\ e_{2t} \\ e_{3t} \\ e_{4t} \end{bmatrix} \tag{6}$$

where U_{us_t} is the measure of uncertainty in the U.S., Ex_{i_t} is the log first difference in the exchange rate, X_{i_t} is the log first difference in foreign exports, π_{i_t} is the foreign inflation rate, A_{ij} (L) are polynomials in the lag operator L, and the e_{it} are regression residuals. To obtain the impulse response functions we simply impose a Choleski decomposition with the above ordering.[6] For brevity and because the results are not qualitatively different, we only report results using the corporate bond spread as the uncertainty measure.

As can be seen in Panel A of Figure 4, the point estimate suggests a U.S uncertainty shock induces a 0.5% contemporaneous depreciation of the dollar relative to the yen. The dollar reaches a trough of -0.75% three months after the shock and then subsequently rebounds. While the point estimates remain persistently below zero, there is no statistically significant effect on the dollar four months after the shock. Examination of Panel B in Figure 4 suggests a much larger effect on Japanese exports. While there is no contemporaneous effect on the level of Japanese exports, there is a statistically significant decline beginning in the first month after the shock and continuing through month five. Export demand subsequently stabilizes, but note that exports remain 3% lower than pre-shock levels after two years. The cumulative effects of the uncertainty shock on Japanese inflation are statistically significant as well. As displayed in Panel C of Figure 4, there is no contemporaneous effect on Japanese inflation. However, beginning in the second month after the shock, Japanese inflation begins a downward trend which continues for two years after the shock. Inflation ends up 0.50% below pre-shock levels. Note that the decline in exports in Figure 4 is very similar to the decline in output displayed in Panel A of Figure 2. The negative effects of the shock on output and exports stabilize approximately six months after the U.S. uncertainty shock.

Panel A of Figure 5 displays the impulse responses of the dollar/pound exchange rate to the U.S. uncertainty shock. The depreciation of the U.S. dollar in this case is similar to the depreciation of the dollar against the yen. While the point estimates suggest a -0.25% contemporaneous depreciation of the dollar relative to the pound, it is not statistically significant.

[6] The results were not substantially altered by changing the ordering of the last three variables.

The dollar reaches a trough of -0.75% six months after the shock. While the point estimates remain persistently below zero, there is no statistically significant effect on the dollar seven months after the shock. British exports also react much like Japanese exports. There is no contemporaneous effect on British exports, but exports begin a statistically significant downward trend beginning one month after the shock. After two years, British exports are -1.5% below pre-shock levels. The effects on British inflation display a pattern similar to Japanese inflation. British inflation declines approximately 0.6% two years after the U.S. uncertainty shock.

Note that the international effects of U.S. uncertainty shocks appear consistent with a demand shock in an open-economy IS/LM model with sticky prices. Domestic uncertainty shocks lower domestic investment (as in Bloom (2009), Bloom et al. (2009), and Gilchrist, Sim and Zakrajsek (2009)) relative to savings due to a "wait and see" attitude among economic actors and shift the domestic IS curve leftward. This lowers the equilibrium interest rate and causes the domestic currency to depreciate. Lower domestic output and a weaker domestic currency induce a decline in foreign exports causing foreign output and inflation to decline. In short, our results suggest U.S. uncertainty shocks cause a leftward shift in the foreign economies' IS curves.

5. Historical Decompositions

Our findings suggest U.S. uncertainty shocks significantly affect foreign economies. In this section, we seek to answer the following question: did U.S. uncertainty shocks contribute to the fluctuations in foreign economies' output during with the recent financial crisis? To answer this question we forecast each equation in our VAR without any shocks. Then we reforecast the equations adding each shock one at a time. Our methodology is similar to Cover (2011), and Figure 6 shows the results.[7] The dotted line in Panel A shows the level of uncertainty assuming

[7] The results shown use the corporate bond spread as the uncertainty measure. The results are not substantially different using the S&P 500 index as the uncertainty measure.

that the only shock is the uncertainty shock, and the dashed line assumes that the only shocks are the uncertainty shock and the shock to U.S. output. Finally, the thick solid line consists of all shocks and is shown as the actual value of uncertainty. Panel A reveals that most of the increase in uncertainty is the result of the uncertainty shock.

Panels B, C, and D show the historical decompositions for the U.S., Japan, and the U.K., respectively during the recent financial crisis. The thin solid line in each panel represents forecasts with all of the shocks turned off. We cumulatively add the forecasts each period to obtain the forecast values. The thick solid line in each Panel is the actual value of industrial production while the dotted and dashed lines represent contributions of the U.S. uncertainty shock and U.S. output shock, respectively. Hence, the distance between the U.S. output shock and the realized actual values represents the portion of the forecast error explained by the combination of Japanese and U.K. output shocks, and the distance between the forecast and the uncertainty shock represents the portion of the forecast error that is explained by the uncertainty shock. In each Panel, uncertainty explains a large portion of the variation in output for each country during the recent financial crisis. In Panel B, uncertainty explains roughly the same amount of the forecast error as U.S. output. However, for each of the foreign economies, uncertainty explains more of the forecast error than U.S. output and roughly the same as the foreign economies' output shock. This would suggest that U.S. uncertainty played a significant role in reducing foreign countries' output during the recent financial crisis.

6. Conclusion

Our results suggest that domestic uncertainty shocks appear to be a mechanism by which business cycles may be transmitted internationally. U.S. uncertainty shocks have results consistent with an adverse, open-economy demand shock. Point estimates suggest that uncertainty shocks (1) reduce foreign output, (2) induce a depreciation of the domestic currency, (3) reduce foreign exports, and (4) slow foreign inflation. We also find using historical decompositions that uncertainty shocks during the recent financial crisis explain an important part of the declines in foreign economies' output. Further research is needed to understand other channels through which domestic uncertainty shocks may affect foreign economies.

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Figure 1: Time Series Plot of Variables

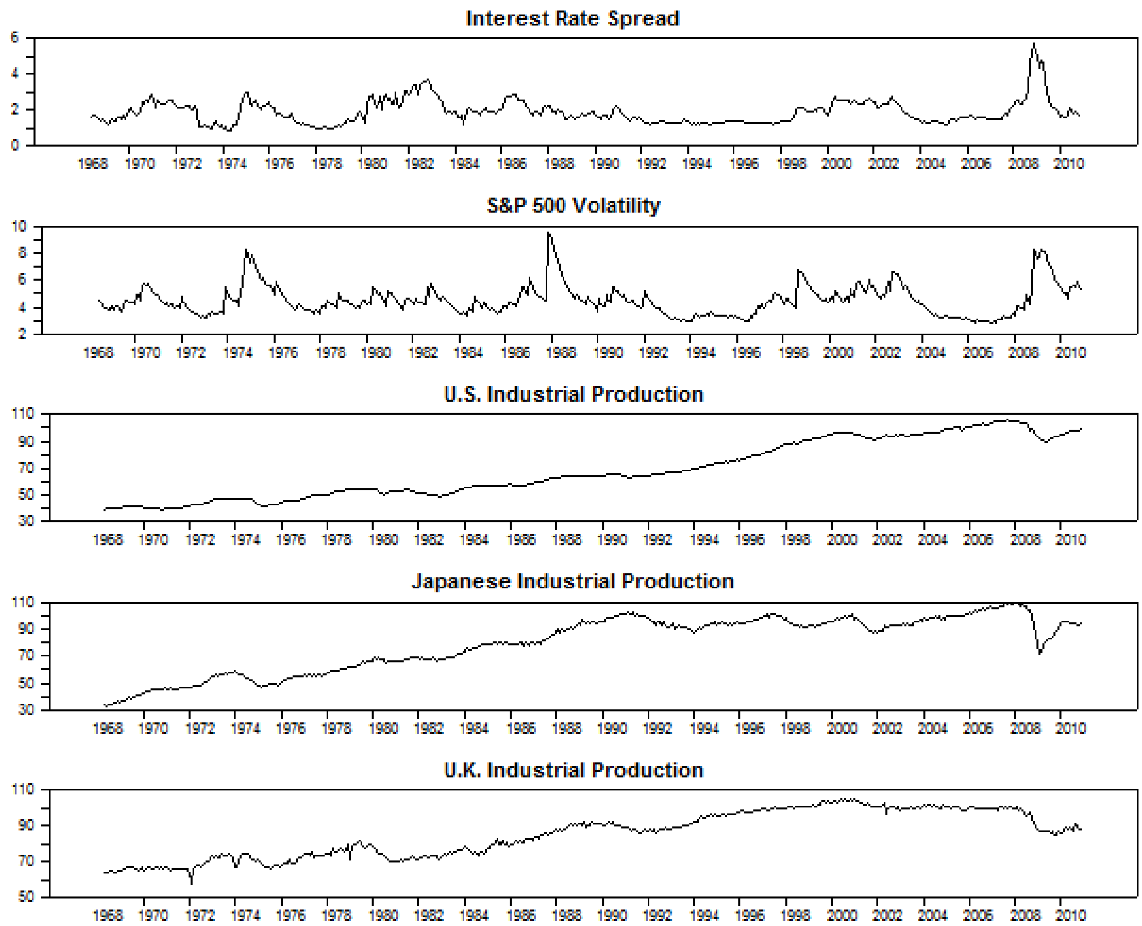
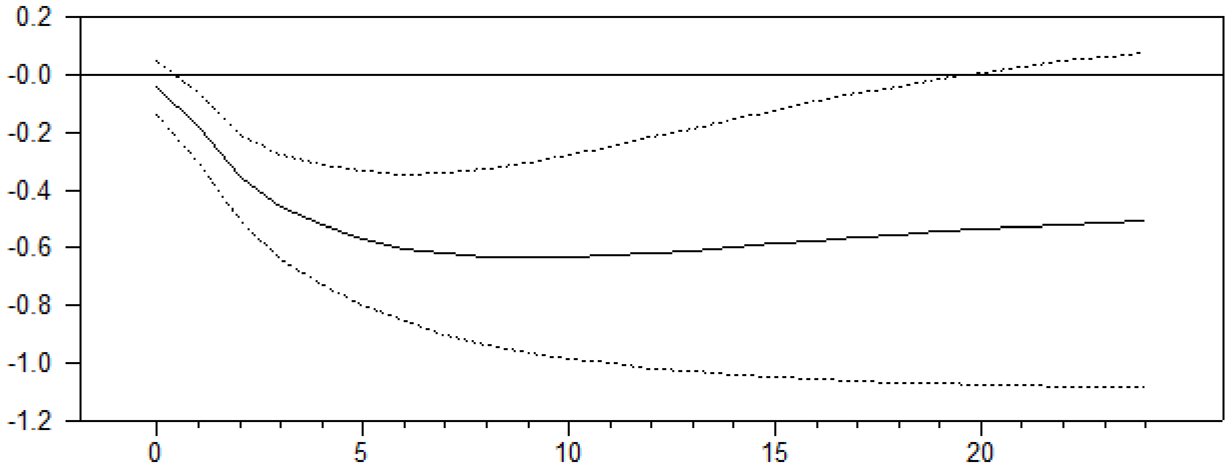


Figure 2: U.S. Output Response to a U.S. Uncertainty Shock

Panel A: U.S. Uncertainty Measure (Bond Spread)



Panel B: U.S. Uncertainty Measure (S&P 500 Volatility)

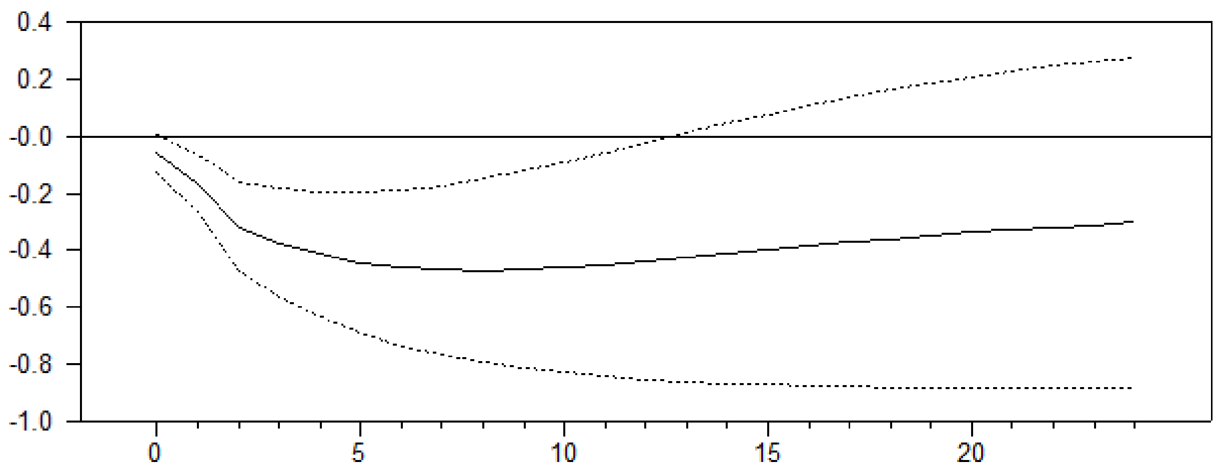
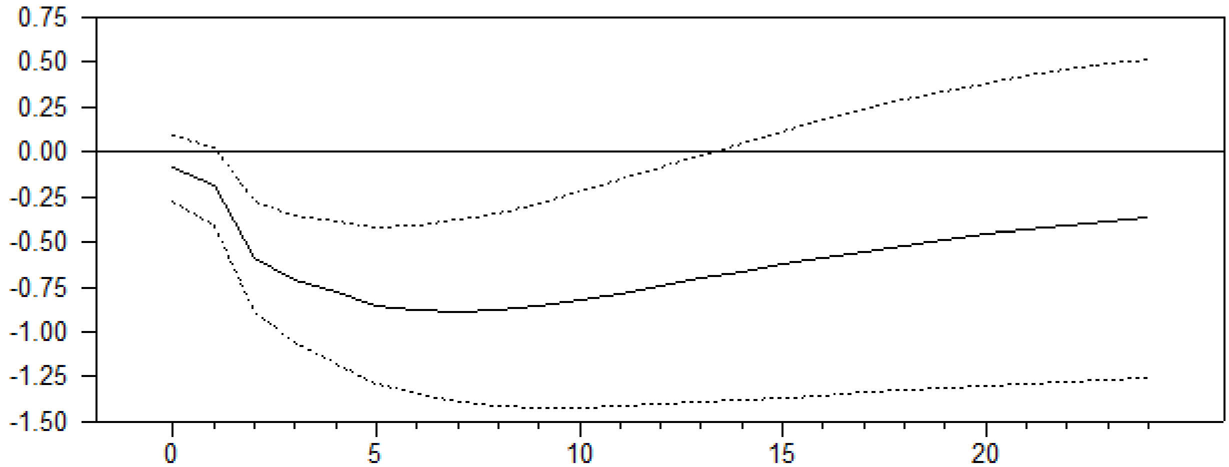


Figure 2 – The above displays the cumulative impulse response functions of U.S. output to a one standard deviation shock to U.S. uncertainty along with 95% bootstrapped confidence intervals.

Figure 3: Japanese Output Response to a U.S. Uncertainty Shock

Panel A: U.S. Uncertainty Measure (Bond Spread)



Panel B: U.S. Uncertainty Measure (S&P 500 Volatility)

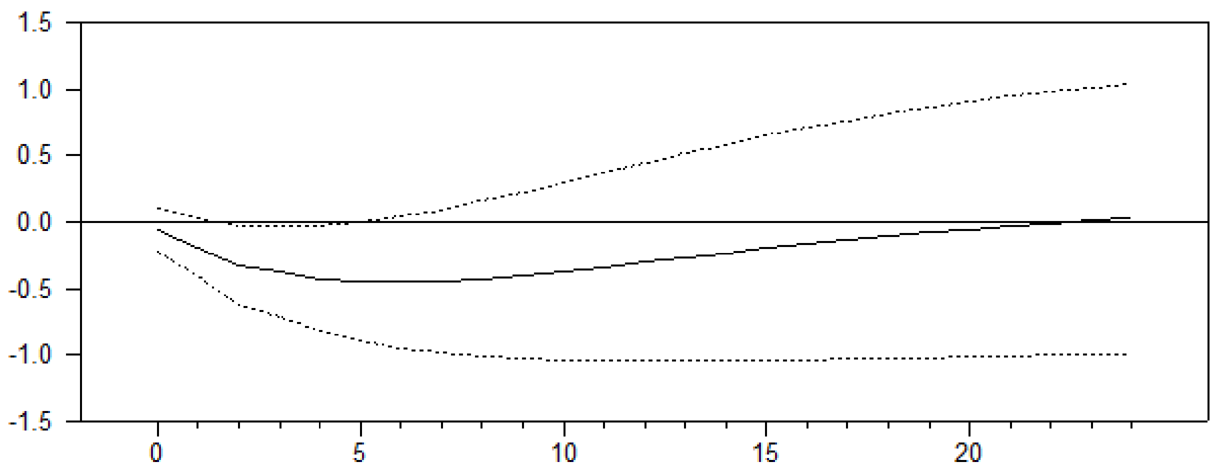
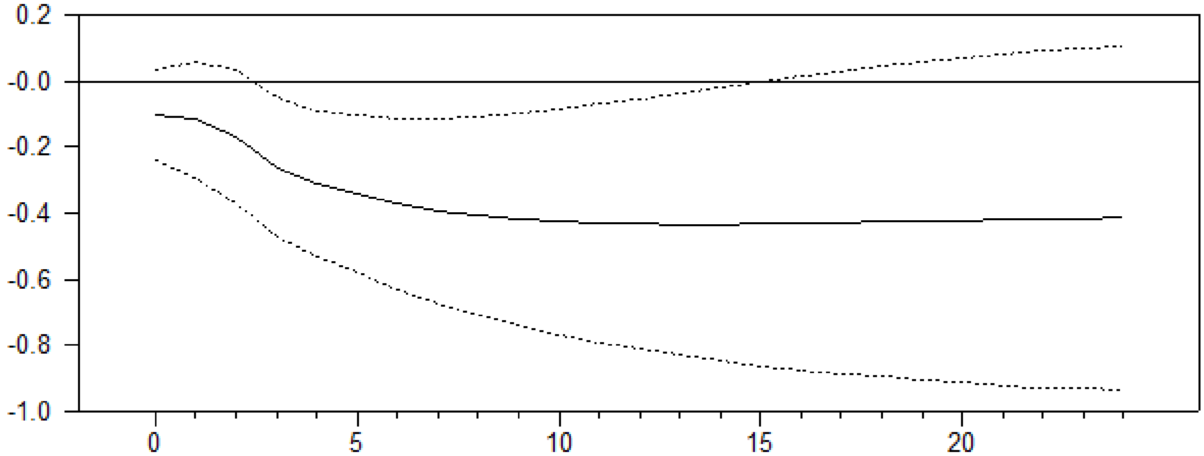


Figure 3 – The above displays the cumulative impulse response functions of Japanese output to a one standard deviation shock to U.S. uncertainty along with 95% bootstrapped confidence intervals.

Figure 4: U.K Output Response to a U.S. Uncertainty Shock

Panel A: U.S. Uncertainty Measure (Bond Spread)



Panel B: U.S. Uncertainty Measure (S&P 500 Volatility)

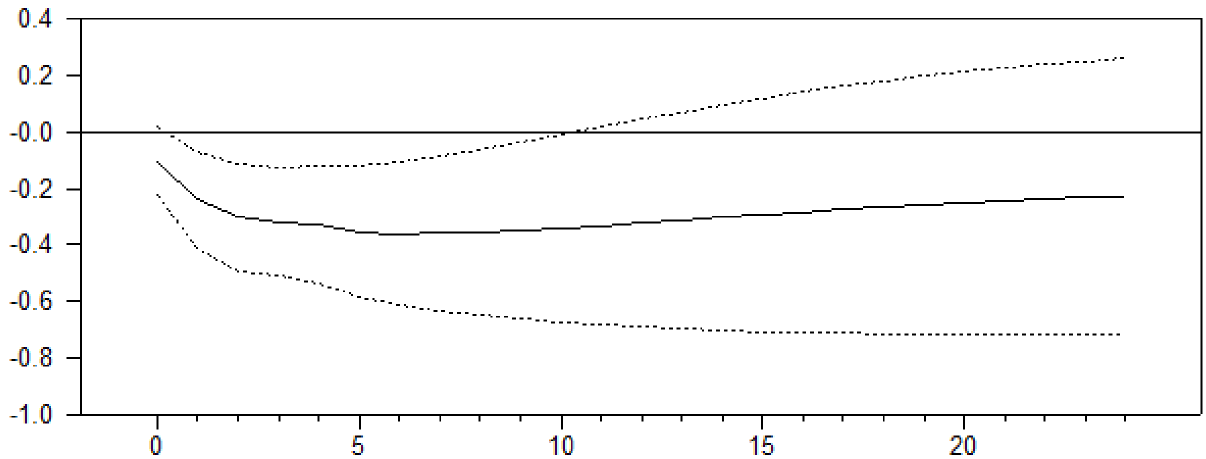
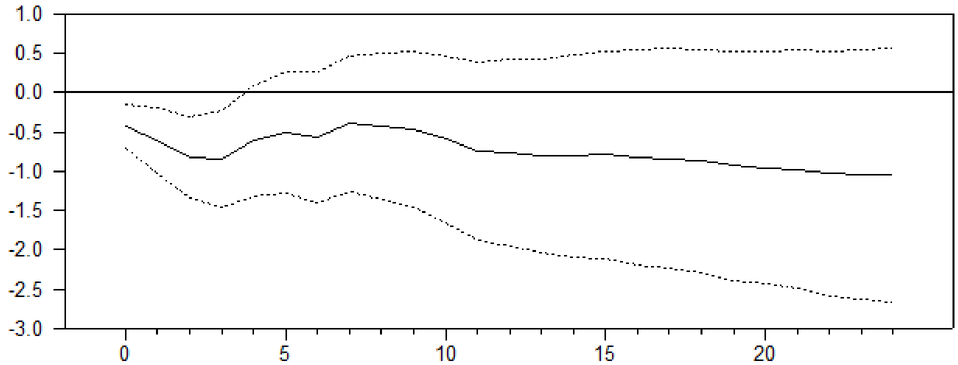


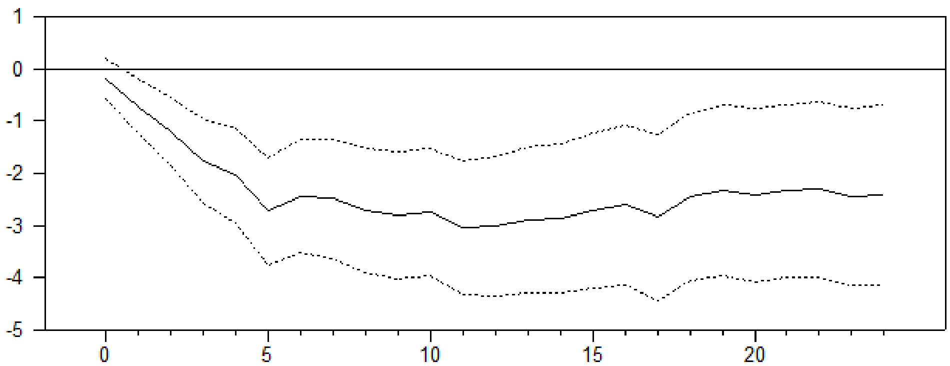
Figure 4 – The above displays the cumulative impulse response functions of British output to a one standard deviation shock to U.S. uncertainty along with 95% bootstrapped confidence intervals.

Figure 5: Japanese Responses to a U.S. Uncertainty Shock

Panel A: Dollar/Yen Exchange Rate



Panel B: Japanese Exports



Panel C: Japanese Inflation

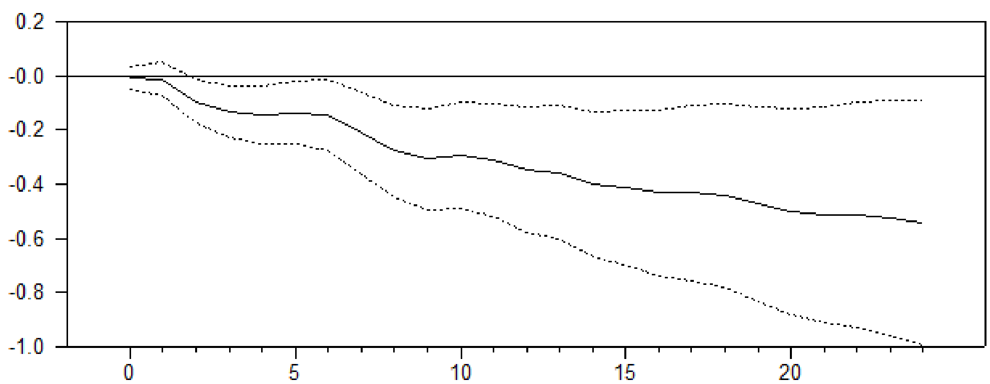
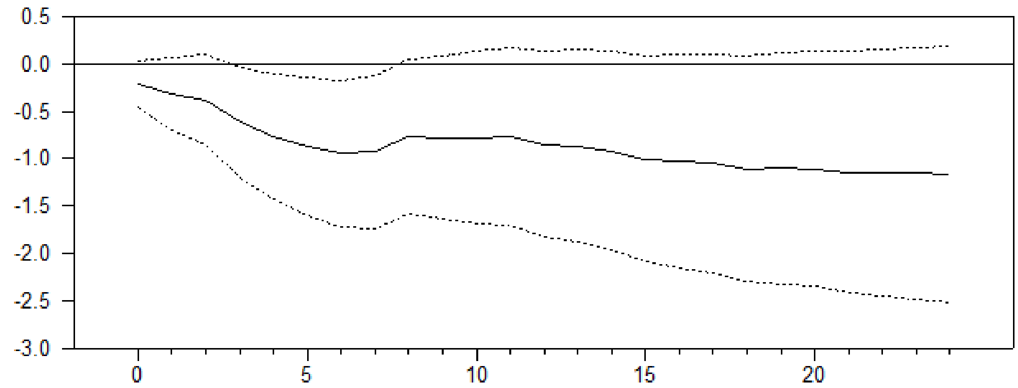


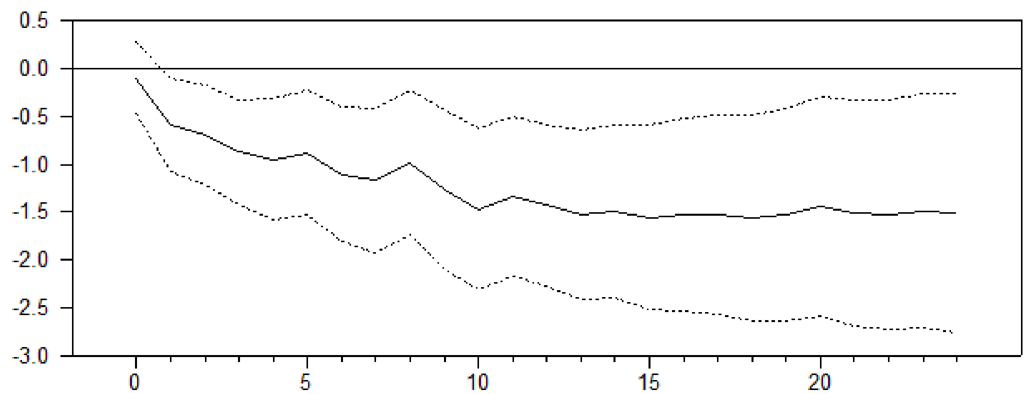
Figure 5 – The above displays the cumulative impulse responses of Japanese exports, dollar/yen exchange rate, and Japanese inflation to a one standard deviation shock to U.S. uncertainty as measured by the difference between 30-year Baa corporate bond and the 30-year Treasury bond with bootstrapped 95% confidence intervals.

Figure 6: U.K. Responses to a U.S. Uncertainty Shock

Panel A: Dollar/Pound Exchange Rate



Panel B: U.K. Exports



Panel C: UK Inflation

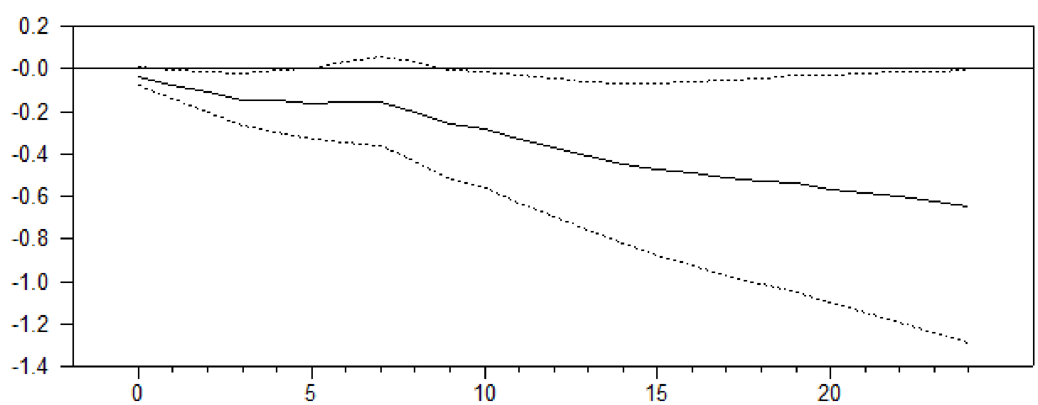


Figure 6 – The above displays the cumulative impulse responses of British exports, dollar/pound exchange rate, and Bristish inflation to a one standard deviation shock to U.S. uncertainty as measured by the difference between 30-year Baa corporate bond and the 30-year Treasury bond with bootstrapped 95% confidence intervals.

Figure 7: Historical Decompositions