Economic Policy Uncertainty Spillovers in Booms and Busts*

Giovanni Caggiano
University of Padova

Efrem Castelnuovo
University of Melbourne

Juan Manuel Figueres
University of Padova

January 2016
- preliminary -

Abstract

We estimate a Smooth Transition VAR to quantify to what extent economic policy uncertainty shocks originating in the U.S. may affect the Canadian business cycle in boom and bust phases. We find strong evidence in favor of spillover effects in recessions. Differently, Canada turns out to be economically resilient to U.S. economic policy uncertainty shocks during expansions. Different phases of the business cycle are associated not only to heterogeneous macroeconomic responses in terms of size, but also in terms of sign. This evidence is robust to a number of controls, including an index measuring economic policy uncertainty in Canada.

Keywords: Economic Policy Uncertainty Shocks, Spillover Effects, Unemployment Dynamics, Smooth Transition Vector AutoRegressions, Recessions.

JEL codes: C32, E32, E52.

* Authors' email accounts: Giovanni Caggiano: giovanni.caggiano@unipd.it ; Efrem Castelnuovo: efrem.castelnuovo@unimelb.edu.au ; Juan Manuel Figueres: juanmanuelfigueres@gmail.com . Financial support from the Australian Research Council via the Discovery Grant DP160102281 is gratefully acknowledged.

1 Introduction

Is economic policy uncertainty a driver of the business cycle? A recent paper by Baker, Bloom, and Davis (2015) build up an index of economic policy uncertainty for the U.S. and a number of other countries in the world to tackle this important question. Focusing on the U.S. in particular, they find that jumps in the level of uncertainty associated to policy decisions can explain a non-negligible share of the U.S. business cycle. This result is important for two reasons. First, because it reaffirms that uncertainty can very well be one of the drivers of fluctuations in real activity in the United States, a result previously found by a number of authors (for a survey of the young but already voluminous contributions, see Bloom, Fernández-Villaverde, and Schneider (2013) and Bloom (2014)).[1] Second, because it points to a particular type of uncertainty - the one directly or indirecly connected to policy decisions - as an independent source of fluctuations in real activity.

This paper investigates economic policy uncertainty spillovers. It does so by estimating an nonlinear, Smooth Transition VAR (STVAR) model for Canada in which economic policy uncertainty shocks are allowed (but not necessarily required) to act as drivers of the Canadian business cycle. The STVAR set up enables us to isolate recessionary episodes while retaining enough information to estimate a richly parametrized VAR framework. We consider the case in which an exogenous increase in EPU occurs in the United States. After studying the nonlinear effects of this shock within the U.S., we study the spillover effect of such shock on a number of Canadian macroeconomic variables, including real activity indicators (industrial production, unemployment) and nominal ones (inflation, a short-term interest rate, and the U.S./Canadian dollar exchange rate). In particular, we investigate to what extent uncertainty shocks originating in the U.S. exert different effects on the Canadian business cycle during periods of economic slack as opposed to booms. Importantly, we compute impulse responses à la Koop, Pesaran, and Potter (1996) to account for the feedback effect going from the evolution of real activity after the shock to the probability of being in a recessionary state. In other words, the probability of being in a bust is a fully endogenous object in our framework. This is important for our analysis, because a priori we would expect a potentially recessionary shock to force the Canadian economy to switch from, say, a booming phase to a bust. Our empirical model will indeed enable us to assess to what

[1] Uncertainty may very well be in part endogenous and due to a number of mechanisms (Bachmann and Moscarini (2012), Bachmann and Bayer (2013)). We discuss the endogeneity issue and the way in which we tackle it in the next Section.

extent this is true as regards an EPU shocks realizing in the U.S. and spilling over in Canada.

Our evidence points to statistically and economically relevant nonlinear spillover effects. An equally-sized economic policy uncertainty hike originating in the U.S. is found to trigger a strong and persistent recession in Canada in the the 1985-2015 period, and a much more modest effect during booms. In recessions, the growth rate of industrial production drops by about 1% and the unemployment rate raises by more than 0.1% in the aftermath of the shock, while inflation falls by 0.2% and the nominal interest rate by almost 30 basis points, and a persistent depreciations realize. Differently, the response of the Canadian economy to U.S. EPU uncertainty shocks occurring in expansions are significantly milder in absolute value, and also feature changes in sign. In particular, it associated to a modest change in industrial production and unemployment, and to moderate increase in inflation and the policy rate.

Our paper joins two different but related strands of the literature on the role of uncertainty shocks. One the one hand, some research has recently focused on the role of uncertainty in an open economy context. Fernández-Villaverde, Guerrón-Quintana, Rubio-Ramírez, and Uribe (2011) find changes in the volatility of the real interest rate at which small open emerging economies borrow to have a quantitatively important effect on real activity in open economies such as Argentina, Ecuador, Venezuela, and Brazil (see Born and Pfeifer (2014) for a refinement of this study). Colombo (2013) studies the spillover effects of an economic policy uncertainty shock originating in the United States for the Euro area. She finds such shocks to be an important driver of the European policy rate. Carrière-Swallow and Céspedes (2013) study the impact of uncertainty shocks originating in the U.S. on a number of developed and developing countries. They find substantial heterogeneity in the response of investment and consumption across countries. In particular, the response is more accentuated in developing countries, a stylized fact which the authors interpret in light of the different credit frictions affecting the functioning of financial markets in the countries under scrutiny. Gourio, Siemer, and Verdelhan (2013) build up a two-country RBC model in which aggregate uncertainty is time-varying and countries have heterogeneous exposures to a world aggregate shock. To test the empirical predictions of their framework, they construct a measure of international uncertainty by averaging up the volatility of equity returns of the G7 countries. They show that a shock to this measure of international uncertainty triggers a drop, rebound, and overshoot-type of response of industrial production in all these countries. Moreover, unemployment is also shown to respond to such shock. Handley (2014) and Handley and Limão (2014, 2015) study the interconnections between policy uncertainty, trade, and real activity in a number of countries. They find policy uncertainty to be a key factor affecting trade and investment decisions. A similar finding is proposed by Born, Müller, and Pfeifer (2013), who find that terms of trade uncertainty may be a relevant driver of real GDP in Chile. Our paper adds to this literature by unveiling the different effects along the business cycle that economic policy uncertainty shocks are likely to exert on open economies like Canada, which are strictly interconnected with the country where the shock originates - the United States in our empirical exercise. In this sense, our paper complements previous contributions which have focused on spillover effects from the U.S. to Canada due to first-moment shocks (see, for instance, Schmitt-Grohe (1998), Justiniano and Preston (2010), and Faccini, Mumtaz, and Surico (2016)).

A second literature that our paper connects to is the one modeling real activity indicators in general, and unemployment in particular. The unemployment rate has often been found to feature asymmetric dynamics in recessions and expansions (see, among others, Koop and Potter, 1999, van Dijk, Teräsvirta, and Franses, 2002, Morley and Piger, 2012, Morley, Piger, and Tien, 2012). Moreover, uncertainty is typically high during recessions, when unemployment also tends to increase abruptly (Jurado, Ludvigson, and Ng, 2013, Bloom, Floetotto, Jaimovich, Saporta-Eksten, and Terry (2014)). Hence, the effects triggered by uncertainty shocks in recessions are likely to be different than those occurring in expansions. Recent evidence along this line is provided by, among others, Alessandri and Mumtaz (2014), Nodari (2014), Caggiano, Castelnuovo, and Groshenny (2014), and Caggiano, Castelnuovo, and Nodari (2015). Our paper makes a further step along this path by showing that uncertainty spillovers are likely to be relevant for open economies' business cycle, and by clarifying that such relevance may be state-dependent.

The structure of the paper is the following. Section 2 presents the Smooth Transition VAR model employed in our analysis. Section 3 presents our results on the domestic effects of an economic policy uncertainty shock originating in the U.S., while Section 4 focuses on the spillover effects of such shock as regards the Canadian economy. Robustness checks are presented in Section 5. Section 6 concludes.

2 Empirical model

As anticipated in the Introduction, we identify the macroeconomic effects of uncertainty shocks during post-WWII U.S. recessions by modeling some selected U.S. macroeconomic series with a Smooth-Transition VAR framework (for a reference textbook, see Teräsvirta, Tjøstheim, and Granger (2010)).

STVAR model. Formally, our STVAR model reads as follows:

$$\boldsymbol{X}_t = [1 - F(z_{t-1})]\boldsymbol{\Pi}_R(L)\boldsymbol{X}_t + F(z_{t-1})\boldsymbol{\Pi}_E(L)\boldsymbol{X}_t + \boldsymbol{\varepsilon}_t \tag{1}$$

$$\boldsymbol{\varepsilon}_t \sim N(0, \boldsymbol{\Omega}) \tag{2}$$

$$F(z_t) = \{1 + \exp[-\gamma(z_t - c)]\}^{-1}, \gamma > 0, z_t \sim N(0,1) \tag{3}$$

where $\boldsymbol{X}_t$ is a set of endogenous variables which we aim to model, $F(z_{t-1})$ is a logistic transition function which captures the probability of being in an expansion and whose smoothness parameter is γ, z_t is a transition indicator, c is the threshold parameter identifying the two regimes, $\boldsymbol{\Pi}_R$ and $\boldsymbol{\Pi}_E$ are the VAR coefficients capturing the dynamics of the system during recessions and expansions (respectively), and $\boldsymbol{\varepsilon}_t$ is the vector of reduced-form residuals having zero-mean and whose variance-covariance matrix is $\boldsymbol{\Omega}$. In brief, this model combines two linear VARs, one capturing the dynamics of the economy in recessions and the other one in expansions. Conditional on the transition indicator z_t, the logistic function $F(z_t)$ indicates the probability of being in a boom. The transition from a regime to another is regulated by the smoothness parameter γ. Large values of this parameter imply abrupt switches from a regime to another. Viceversa, moderate values of γ enable the economic system to spend some time in each regime before switching to the alternative one.

A key choice for our empirical exercise is that of the transition indicator z_t. A number of contributions in the literature have considered a moving average of the growth rate of real GDP, which offers a good approximation of the ups and downs experienced by the U.S. business cycle as captured by the NBER recessions (see, among others, Auerbach and Gorodnichenko (2012), Bachmann and Sims (2012), Caggiano, Castelnuovo, and Groshenny (2014), Berger and Vavra (2014), Nodari (2014), Caggiano, Castelnuovo, Colombo, and Nodari (2015), and Figueres (2015)). In our empirical exercise, we deal with monthly data to maximize the number of observations for the countries we study while retaining the possibility of studying the impact of EPU uncertainty shocks via the indexes developed by Baker, Bloom, and Davis (2015) for the U.S. and Canada. Hence, in our baseline exercises we employ a moving average of the growth rate of industrial production.[2]

Conditional on our choice for z_t, we jointly estimate the parameters $\{\mathbf{\Pi}_R, \mathbf{\Pi}_E, \mathbf{\Omega}, \gamma, c\}$ of model (1)-(3) with conditional maximum likelihood as suggested by Teräsvirta, Tjøstheim, and Granger (2010).[3] To to so, we use the data and the specification of the vector $\boldsymbol{X}_t$ for the U.S. and Canada described in the following sections.

Computation of the GIRFs. We document the response of the U.S. and Canadian economy to an EPU shock occurring in the U.S. by computing generalized impulse response functions (GIRFs). In short, we follow Koop, Pesaran, and Potter (1996) and compute impulse responses as follows:

$$\begin{aligned} GIRF(h, \delta, \boldsymbol{\omega}_{t-1}) &= E\left\{\mathbf{X}_{t+h} \left| \widetilde{\varepsilon}_t^{EPU} = \delta, \boldsymbol{\varepsilon}_{t+h} = \widetilde{\boldsymbol{\varepsilon}}_{t+h}, h > 0, \boldsymbol{\omega}_{t-1} \right.\right\} \\ &\quad - E\left\{\mathbf{X}_{t+h} \left| \boldsymbol{\varepsilon}_{t+h} = \widetilde{\boldsymbol{\varepsilon}}_{t+h}, h > 0, \boldsymbol{\omega}_{t-1} \right.\right\} \end{aligned}$$

where h is the horizon of the impulse responses, δ is the size of the shock, $\boldsymbol{\omega}_{t-1}$ is the history (realizations of lagged values of the STVAR) identifying a particular recession or expansion in the sample, and $\widetilde{\boldsymbol{\varepsilon}}_{t+h}$ is a set of draws of residuals from the empirical distribution (2). In practice, the GIRFs are computed as the difference between a stochastic simulation in which our orthogonal EPU shock $\widetilde{\varepsilon}_t^{EPU}$ takes the value δ and a stochastic simulation in which such shock takes a nil value. The shock is calibrated to induce a one-standard deviation impulse to the U.S. EPU indicator in our vector. Importantly, a given history $\boldsymbol{\omega}_{t-1}$ is associated to a given realization of the transition indicator z_{t-1}. Hence, conditional on our estimated threshold parameter $\widehat{c}$ in (3), it is possible to classify each given history as "recession" or "expansion". However, it is easy to think of histories closer to the threshold value as being less informative on the different dynamics possibly occurring in the two regimes than those that are more distant. To sharpen the information associated to each regime, we then follow Caggiano, Castelnuovo, Colombo, and Nodari (2015) and focus on "tail events", i.e., on deep recessions and strong expansions which are identified with the realizations

[2] We employ a moving average of the month-by-month growth rate of industrial production involving six terms. This moving average returns a higher correlation (in absolute value) with the NBER recession dummy (-0.60) than alternatives such as the simple growth rate of industrial production (-0.48) and a moving average involving twelve terms (-0.51).

[3] Teräsvirta, Tjøstheim, and Granger (2010) point out that γ is not a scale-free parameter. To make it scale free, we follow their suggestion (p. 381 of their book) and standardize the transition indicator so that z_t takes a unitary standard deviation. This operation, along with the fact that we demean such indicator, makes our estimates more easily comparable with those present in the extant literature.

under the 5th percentile (recessions) and over the 95th percentile (expansions) of the distribution of the transition indicator z.[4]

3 U.S. case

The U.S. economy is modeled as follows: $\boldsymbol{X}_t^{US} = [EPUD_t^{US}, \Delta IPMA_t^{US}, u_t^{US}, \pi_t^{US}, R_t^{US}]'$. The $EPUD_t^{US}$ refers to a 0/1 dummy identifying spikies in economic policy uncertainty (discussed below), $\Delta IPMA_t^{US}$ stands for the six-term moving average of the monthly growth rate of industrial production (percentualized and annualized), u_t^{US} stands for the unemployment rate, π_t^{US} stands for CPI inflation (y-o-y percentualized growth rate of the monthly index), and R_t^{US} is the federal funds rate. As for Canada, all data were downloaded from the Federal Reserve Bank of St. Louis' website, with the exception of the EPU index, which was downloaded (as in the Canadian case) from the website http://www.policyuncertainty.com/ . We focus on the sample 1954M7-2014M10. The beginning of the sample refers to the month in which the effective federal funds rate became available, while the end of the sample is due to the availability of the EPU historical index for the United States.[5]

Construction of the EPU dummy. To contruct the $EPUD_t^{US}$ 0/1 dummy the we implement the following steps. First, we compute the cyclical component of the U.S. EPU index via the Hodrick-Prescott filter (smoothing weight: 129,600). This is done to control for changes in the low-frequency component of this index over the post-WWII period which are related to the increasing role played by fiscal components in

[4] Per each regime we consider all the initial histories falling in the 5th/95th percentiles (recessions/expansion). Per each history, we draw 250 different realizations of the residuals, which deliver 250 different point estimates for our GIRFs. Then, per each history we compute the median across the different realizations of residuals. Finally, we compute median values across the histories belonging to each regime. Our figures plots the regime-specific horizon-wise median. In order to compute confidence bands, we repeat the previous steps for 250 bootstrap replications of the STVAR model (1)-(3). This provides us with 250 median realization for our GIRFs per each regime. Then the 16th and 84th percentiles are computed over the distribution of the medians. Our Appendix provides a formal presentation and further details on the computation of our GIRFs (TO COME).

[5] To be precise, there are two indicators of U.S. EPU available at http://www.policyuncertainty.com/ . One is the historical version of the EPU index, which is the one we use in our analysis. The other one is an index available since 1985 and constantly updated by the researchers behind the EPU project. This latter index measures policy-related economic uncertainty on the basis of three components, i.e., uncertainty as present in selected newspapers, federal tax code provisions set to expire in future years, and disagreement among economic forecasters as a proxy for uncertainty. Differently, the historical EPU index is constructed on the newspaper-component only. To preserve homogeneity and, at the same time, maximize the degrees of freedom of our exercise, we focus on the historical version of the EPU index.

the U.S. economic system as well as political polarization and its implications for the policy-making process and policy choices (for a documentation and a discussion, see Baker, Bloom, Canes-Wrone, Davis, and Rodden (2014)). Second, we isolate spikes in uncertainty by selecting realizations of the cyclical component of the EPU index larger that 1.65 times its standard deviation. This strategy follows Bloom's (2009), which applied it to the U.S. stock market volatility to isolate spikes in uncertainty linked to the U.S. stock market. This strategy leads to the identification of realizations of uncertainty which are likely to have a strong exogenous component and, therefore, can help us identify a causality running from movements in uncertainty to changes in the U.S. macroeconomic environment. Figure 1 plots the EPU index and the so-constructed dummy. (INTERPRETATION TO COME)

Estimation of the probability of being in a recession. We the estimate model model (1)-(3) by considering the above described vector $\boldsymbol{X}_t^{US}$. Two lags have been selected, based on standard information criteria.[6]

Figure 2 plots the estimated probability of being in a recession, which is computed by considering the logistic function (3) and the point estimates for the slope parameter $\widehat{\gamma} = 4.8$ and the threshold value $\widehat{c} = -1.01$. Noticeably, most realizations of $(1 - \widehat{F})$ take a value larger than 0.5 hinting to a recession in correspondence to the official NBER recessions. The only two clear exceptions are due to two extremely negative realizations of our indicator z_t at the beginning of the sample. Overall, however, our estimated model appears to be able to clearly discriminate between booms and busts of the U.S. business cycle.

Orthogonalization of the EPU shock. We now turn to the impulse responses to an EPU shock. To make sure that this shock is orthogonal to the other stochastic elements in our model, we model the impulse vector responsible of the on-impact response of the variables in the vector $\boldsymbol{X}_t^{US}$ by employing a Cholesky-decomposition of the reduced-form variance covariance matrix $\boldsymbol{\Omega}$. This implies that, on impact, EPU shocks can affect the rest of the system, while the EPU dummy is assumed to be contemporaneouly exogenous to the rest of the system. In light of the contruction of this dummy discussed above, we believe this assumption to be a reasonable one.

We now move to the presentation of our impulse responses for the U.S. economy.

Baseline case: Results. Figure 3 depicts the dynamic responses of our variables to

[6] More precisely, we estimate the STVAR using the number of lags selected for the linear version of the VAR(p) model, with $2 \leq p \leq 12$. In this case, two of the three information criteria we consider, i.e. the BIC, HQ, indicate that two lags should be included.

a one-standard deviation increase in the dummy. Bottom line: The evidence of nonlinear effects appears to be clear. In particular, downturns opened by an EPU uncertainty shock when occurring in recessions are clearly more severe, as indicated by the responses of industrial production and unemployment. EPU shocks occurring in recessions are also clearly deflationary, and call for an aggressive response by monetary policy makers, as confirmed by the evolution of the federal funds rate following the shock. Differently, EPU shocks in expansions appear to trigger a much milder downturn and, consistently, a very moderate monetary policy response. Importantly, Figure 4, which depicts the density of the difference of these impulse responses, confirms that the dynamic paths produced by our model in the two states are statistically different. The drop-rebound-overshoot dynamics followed by industrial production after an uncertainty shock in recessions is confirmed to be statistically different from the dynamics observed in good times. Importantly, the differentce responses of unemployment and inflation in the two regimes turn out to be significant from a statistical viewpoint, highlighting how policy-related uncertainty shocks trigger different responses depending on the stance of the business cycle. Such differences are reflected in the state-dependent responses of monetary autorithies to heightened uncertainty, as shown by the dynamics followed by the federal funds rate.

Wrapping up, our results point to economically and statistically relevant differences in the responses of real activity, inflation, and the federal funds rate to an EPU shocks in booms and busts. Spikes in EPU occurring in recessions have clearly the effect of prolonguing the negative phase of the business cycle, have significantly deflationary effects, and call for an aggressive reduction in the policy rate to (at least partly) tackle the recessionary effects they induce. Differently, equally-sized EPU shocks realizing when the economy is booming trigger very modest macroeconomic responses.

Our evidence is consistent with the one put forth by previous empirical contributions on the negative effects of economic policy uncertainty shocks (see, among others, Benati (2013), Mumtaz and Surico (2013), Baker, Bloom, and Davis (2015), and Istrefi and Piloiu (2015)). Importantly, our evidence qualifies such previous finding by unveiling the tight link between economic policy uncertainty and real activity in recessions. Our findings also offer support to theoretical contributions modeling nominal and real frictions to get a downward response of real activitiy and inflation after an uncertainty shock (Leduc and Liu (2015) as well as to generate comovements (Basu and Bundick (2014)). Thinking of the different response of the unemployment rate in the two states, one possible interpretation points to a larger impact exerted by real frictions on the labor market during recessions (e.g., lower likelihood to form a firm-worker match, higher probability of breaking a previously formed-match).

4 EPU spillovers: The Canadian case

For Canada, we account for the relevance of external pressures and the possibility of EPU spillovers from the U.S. by adding the bilateral real exchange rate and the EPU U.S. index, respectively: $\boldsymbol{X}_t^{CAN} = [EPUD_t^{US}, EPU_t^{CAN}, \Delta IPMA_t^{CAN}, u_t^{CAN}, \pi_t^{CAN}, R_t^{CAN}, \Delta\epsilon_t^{CANUS}]'$ where all variables have an obvious interpretation in light of the description previously provided for the variables in $\boldsymbol{X}_t^{US}$, and $\Delta\epsilon_t^{CANUS} \equiv \pi_t^{US} + \Delta s_t^{CANUS} - \pi_t^{CAN}$ is the growth rate of the bilateral real exchange rate between Canada and the U.S. constructed by considering the inflation rates in the two countries and combining it with Δs_t^{CANUS}, which is the y-o-y growth rate of the Canada/US nominal exchange rate. We consider the sample 1985M1-2014M10. The beginning of the sample is dictated by the availability of the Canadian EPU index produced by Baker, Bloom, and Davis (2015), which we use here to make sure that spikes in the U.S. EPU index deliver information over and above the one delivered by abrupt changes in the Canadian one.

Figures 5 plots the impulse responses of the Canadian macroeconomic variables to a one-standard deviation shock to the U.S. EPU dummy. A number of interesting results arise. First, there is significant evidence of a spillover effect going from the U.S. to Canada. In particular, an unexpected hike in the American economic policy uncertainty index triggers an increase in the Canadian uncertainty, unemployment rate, a depreciation of the real exchange rate, a decrease in industrial production, and a significant response of inflation and the policy rate. Second, the response of the Canadian uncertainty index is different in the two states, with a more abrupt and short-lived reaction in recessions and a more gradual and persistent response in expansions. Third, the short-run recessionary effects of unemployment and industrial production are more severe if the shock hits the Canadian economy during a bust. Fourth, the shape of the response of unemployment is similar in the two phases, but the quantitative response is very different, with unemployment responding more abruptly in recessions and remaining persistently high after the shock. Fifth, and differently from unemployment, industrial production displays an abrupt drop, and quick rebound, and a prologued (but temporary) overshoot when the shock hit in recessions, a pattern which goes in contrasts with the hump-shaped response after an increase in uncertainty in expansions. Interestingly, the pattern in recession is closer to the one followed by real activity indicators in the partial equilibrium model by Bloom (2009), while the second one resambles the one followed by real GDP when consumption smoothing is allowed to play a role as in the model by Bloom et al. (2014). This may be due to a higher cost, or difficulty in general, by households to have access to financial markets during recessions (for a theoretical elaboration, see Canzoneri, Collard, Dellas, and Diba (2015)). Interestingly, this result corroborates previous findings conditional on an autarkic empirical model for the U.S. by Caggiano, Castelnuovo, and Nodari (2015). Sixth, the response of inflations is found to be different in the two states not only quantitatively but also qualitatively. The response of the growth rate of domestic CPI is negative, and persistently so, in recessions, a behavior consistent with a demand-driven interpretation of price formation. Viceversa, a positive short run reaction is detected when uncertainty hits during booms. This result may find its rationale in the behavior of firms subject to sticky wages, which may want to avoid paying the costs related to "too costly" workers and anticipate this possibility by raising their prices before uncertainty vanishes in order to maximize their expected profits. A theoretical model embedding this mechanism is proposed by Mumtaz and Theodoridis (2015). Most likely, the different response of the inflation rate in the two states is the reason why the policy rate suggests a prolongued easening in recessions and a short-lived tightening in expansions. Finally, the depreciation of the real exchange rate in the aftermath of the shock is much larger in recessions. Importantly, as shown in Figure 6, most of these responses are also significantly different between states.

5 Robustness checks & extra exercises

[TO COME]

6 Conclusions

We investigate the spillover effects of a jump in U.S. economic policy uncertainty as regards Canada. Using a nonlinear (Smooth-Transition) VAR, we find that such effects are present, significant, and asymmetric over the Canadian business cycle. In particular, our empirical model points to a strong evidence of spillovers in recessions, and a much more moderate one in expansions. The macroeconomic responses in these two states are found to be different from a statistical standpoint. These differences are not only relevant in terms of size, but are also found - for some variables, in particular for the Canadian inflation rate - to affect the sign of the short-run response to a foreign economic policy uncertainty shock. This evidence is robust to a number of controls, including an index measuring economic policy uncertainty in Canada.

From a modeling standpoint, our study suggests that nonlinear, state-dependent versions of DSGE frameworks modeling uncertainty shocks originating in the rest of the world are needed to dig deeper and offer a structural interpretation to our impulse responses.

From a policy perspective, our findings suggest that uncertainty shocks may be substantially more costly than linear models suggest. Future policy moves which are difficult to predict foster policy uncertainty and have a negative impact on the business cycle. As discussed by Davis (2015), the large increase in the number of norms and regulations that the U.S. economy has experienced for several years now is likely to have increased such inpredictability. Our paper supports the call for a clear, simple, and easy do administer regulatory system, a simple tax system, and predictable, timely, and clearly communicated policies recently made by Baker, Bloom, and Davis (2015) and Davis (2015).

References

Alessandri, P., and H. Mumtaz (2014): "Financial Regimes and Uncertainty Shocks," Queen Mary University of London Working Paper No. 729.

Auerbach, A., and Y. Gorodnichenko (2012): "Measuring the Output Responses to Fiscal Policy," *American Economic Journal: Economic Policy*, 4(2), 1–27.

Bachmann, R., and C. Bayer (2013): ""Wait-and-See" Business Cycles," *Journal of Monetary Economics*, 60(6), 704–719.

Bachmann, R., and G. Moscarini (2012): "Business Cycles and Endogenous Uncertainty," RWTH Aachen University and Yale University, mimeo.

Bachmann, R., and E. Sims (2012): "Confidence and the transmission of government spending shocks," *Journal of Monetary Economics*, 59(3), 235–249.

Baker, S., N. Bloom, and S. J. Davis (2015): "Measuring Economic Policy Uncertainty," NBER Working Paper No. 21633.

Baker, S. R., N. Bloom, B. Canes-Wrone, S. J. Davis, and J. Rodden (2014): "Why Has US Policy Uncertainty Risen Since 1960?," *American Economic Review Papers and Proceedings*, 104(5), 56–60.

Basu, S., and B. Bundick (2014): "Uncertainty Shocks in a Model of Effective Demand," Federal Reserve Bank of Kansas City Research Working Paper No. 14-15.

Benati, L. (2013): "Economic Policy Uncertainty and the Great Recession," University of Bern, mimeo.

Berger, D., and J. Vavra (2014): "Measuring How Fiscal Shocks Affect Durable Spending in Recessions and Expansions," *American Economic Review Papers and Proceedings*, 104(5), 112–115.

Bloom, N. (2009): "The Impact of Uncertainty Shocks," *Econometrica*, 77(3), 623–685.

——— (2014): "Fluctuations in Uncertainty," *Journal of Economic Perspectives*, 28(2), 153–176.

Bloom, N., J. Fernández-Villaverde, and M. Schneider (2013): "The Macroeconomics of Uncertainty and Volatility," *Journal of Economic Literature*, in preparation.

Bloom, N., M. Floetotto, N. Jaimovich, I. Saporta-Eksten, and S. J. Terry (2014): "Really Uncertain Business Cycles," Stanford University, mimeo.

Born, B., G. Müller, and J. Pfeifer (2013): "Terms of trade uncertainty and business cycle fluctuations," Universities of Bonn and Mannheim, mimeo.

Born, B., and J. Pfeifer (2014): "Risk Matters: The Real Effects of Volatility Shocks: Comment," *American Economic Review*, 104(12), 4231–4239.

Caggiano, G., E. Castelnuovo, V. Colombo, and G. Nodari (2015): "Estimating Fiscal Multipliers: News From a Nonlinear World," *Economic Journal*, 125(584), 746–776.

Caggiano, G., E. Castelnuovo, and N. Groshenny (2014): "Uncertainty Shocks and Unemployment Dynamics: An Analysis of Post-WWII U.S. Recessions," *Journal of Monetary Economics*, 67, 78–92.

Caggiano, G., E. Castelnuovo, and G. Nodari (2015): "Uncertainty and Monetary Policy in Good and Bad Times," University of Padova and University of Melbourne, mimeo.

Canzoneri, M., F. Collard, H. Dellas, and B. Diba (2015): "Fiscal Multipliers in Recessions," *Economic Journal*, forthcoming.

Carrière-Swallow, Y., and L. F. Céspedes (2013): "The impact of uncertainty shocks in emerging economies," *Journal of International Economics*, 90, 316–325.

Colombo, V. (2013): "Economic policy uncertainty in the US: Does it matter for the Euro Area?," *Economics Letters*, 121(1), 39–42.

Davis, S. J. (2015): "Regulatory Complexity and Policy Uncertainty: Headwinds of Our Own Making," Document prepared to accompany remarks delivered at he Hillsdale College Free Market Forum on "Markets, Government, and the Common Good" in Omaha, Nebraska on 15-17 October 2015.

Faccini, R., H. Mumtaz, and P. Surico (2016): "International fiscal spillovers," *Journal of International Economics*, 99, 31–45.

Fernández-Villaverde, J., P. Guerrón-Quintana, J. F. Rubio-Ramírez, and M. Uribe (2011): "Risk Matters: The Real Effects of Volatility Shocks," *American Economic Review*, 101, 2530–2561.

Figueres, J. M. (2015): "News on State-Dependent Fiscal Multipliers: The role of Confidence," University of Padova Marco Fanno Working Paper No. 202.

Gourio, F., M. Siemer, and A. Verdelhan (2013): "International Risk Cycles," *Journal of International Economics*, 89(2), 471–484.

Handley, K. (2014): "Exporting under trade policy uncertainty: Theory and evidence," *Journal of International Economics*, 94(1), 50–66.

Handley, K., and N. Limão (2014): "Policy Uncertainty, Trade and Welfare: Theory and Evidence for China and the U.S.," University of Michigan and University of Maryland, mimeo.

——— (2015): "Trade and Investment under Policy Uncertainty: Theory and Firm Evidence," *American Economic Journal: Economic Policy*, 7(4), 189–222.

Istrefi, K., and A. Piloiu (2015): "Economic Policy Uncertainty and Inflation Expectations," Banque de France, mimeo.

Justiniano, A., and B. Preston (2010): "Can structural small open-economy models account for the influence of foreign disturbances?," *Journal of International Economics*, 81, 61–74.

Koop, G., M. Pesaran, and S. Potter (1996): "Impulse response analysis in nonlinear multivariate models," *Journal of Econometrics*, 74(1), 119–147.

Koop, G., and S. Potter (1999): "Dynamic Asymmetries in U.S. Unemployment," *Journal of Business and Economic Statistics*, 17(3), 298–312.

Leduc, S., and Z. Liu (2015): "Uncertainty Shocks are Aggregate Demand Shocks," Federal Reserve Bank of San Francisco, Working Paper 2012-10.

Morley, J., and J. Piger (2012): "The Asymmetric Business Cycle," *Review of Economics and Statistics*, 94(1), 208–221.

Mumtaz, H., and P. Surico (2013): "Policy Uncertainty and Aggregate Fluctuations," Queen Mary University of London and London Business School, mimeo.

Mumtaz, H., and K. Theodoridis (2015): "The International Transmission of Volatility Shocks: An Empirical Analysis," *Journal of the European Economic Association*, 13(3), 512–533.

Nodari, G. (2014): "Financial Regulation Policy Uncertainty and Credit Spreads in the U.S.," *Journal of Macroeconomics*, 41, 122–132.

Schmitt-Grohe, S. (1998): "The International Transmission of Economic Fluctuations: Effects of US Business Cycles on the Canadian Economy," *Journal of International Economics*, 44, 257Ű287.

Teräsvirta, T., D. Tjøstheim, and C. W. Granger (2010): "Modeling Nonlinear Economic Time Series," Oxford University Press, Oxford.

van Dijk, D., T. Teräsvirta, and P. H. Franses (2002): "Smooth Transition Autoregressive Models - A Survey of Recent Developments," *Econometric Reviews*, 21(1), 1–47.

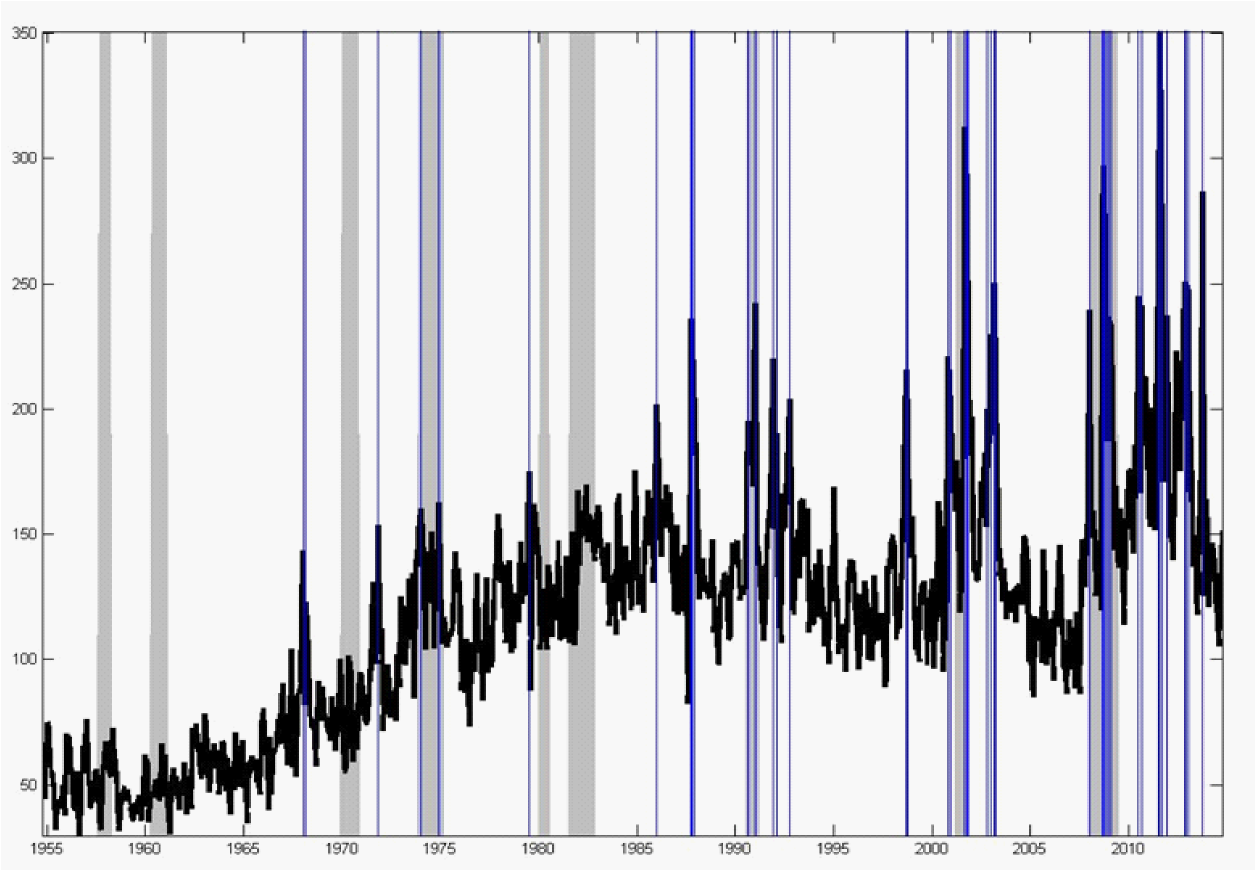

Figure 1: **U.S. EPU Dummy, sample: 1954:M7-2014:M10.** Black line: Historical EPU index for the United States as in Baker, Bloom, and Davis (2015). Blue vertical lines: Realizations of the cyclical component of the EPU index (computed via the Hodrick-Prescott filter, smoothing weight: 129,600) whose value is larger than 1.65 times the standard deviation of the EPU index cyclical component. Grey vertical bars: NBER recessions.

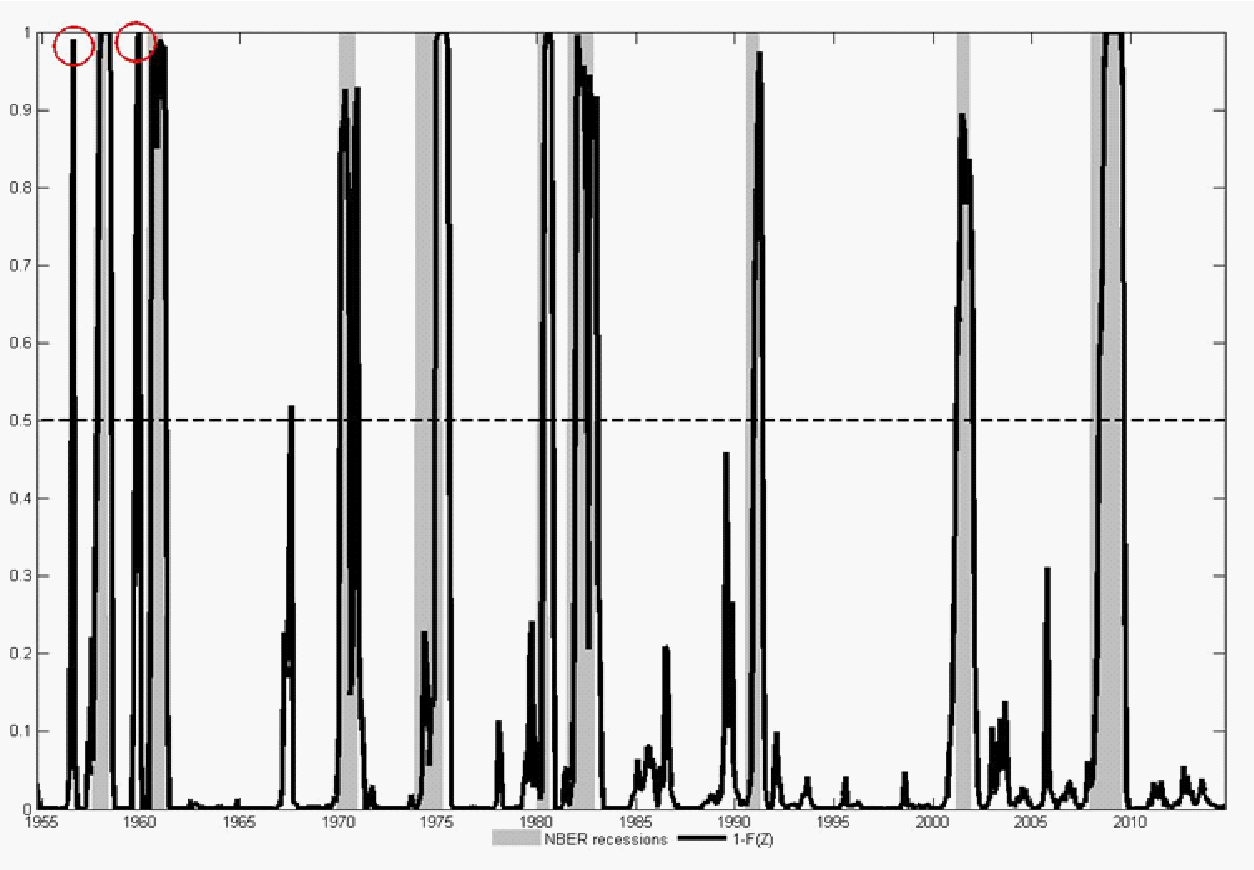

Figure 2: **Recession Probabilities for the U.S. as Estimated by the STVAR model, mple: 1954:M7-2014:M10.** Function (1-F(z)) estimated jointly with the STVAR for the U.S., baseline version with U.S. EPU dummy.

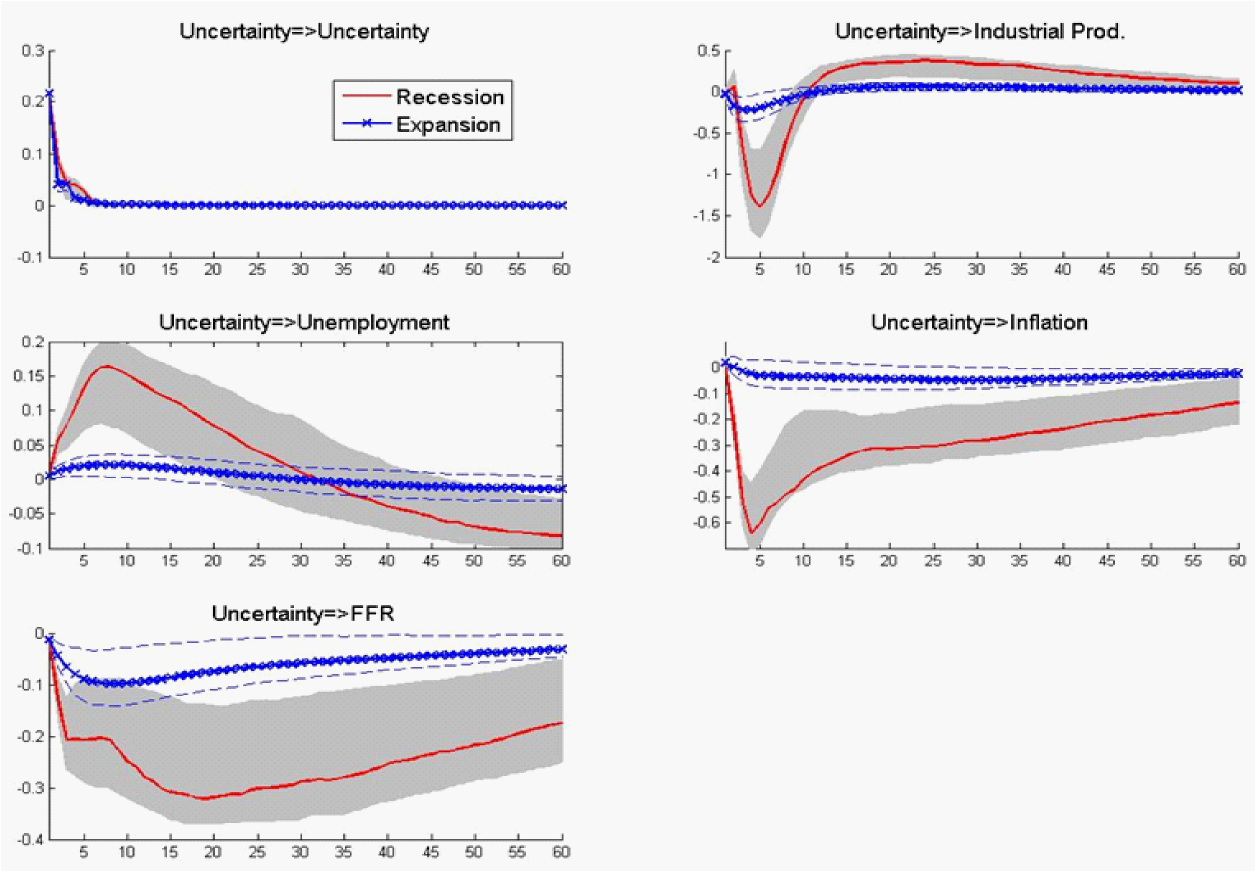

Figure 3: **Effects of a Shock to the U.S. EPU Dummy: U.S. economy, sample: 1954:M7-2014:M10.** Generalized median impulse responses to a one-standard deviation shock to the U.S. EPU dummy hitting the U.S. economy in recessions (red dashed line) and expansions (blue circled line). 68% confidence intervals identified via shaded areas (recessions) and dashed blue lines (expansions).

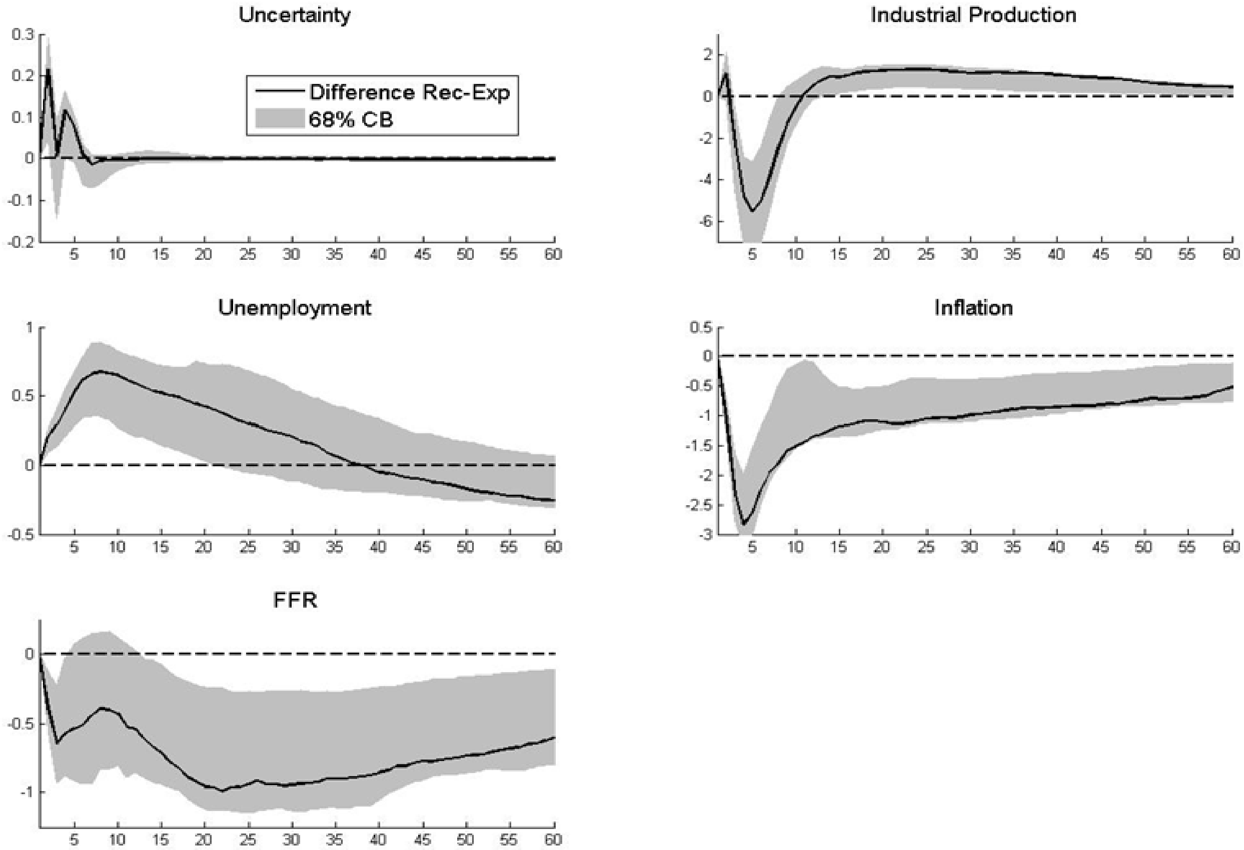

Figure 4: **Effects of a Shock to the U.S. EPU Dummy: Different between GIRFs, U.S. economy, sample: 1954:M7-2014:M10.** Differences between generalized median impulse responses in recessions and expansions to a one-standard deviation shock to the U.S. EPU dummy. Median realizations identified via black lines, 68% confidence intervals identified via shaded areas.

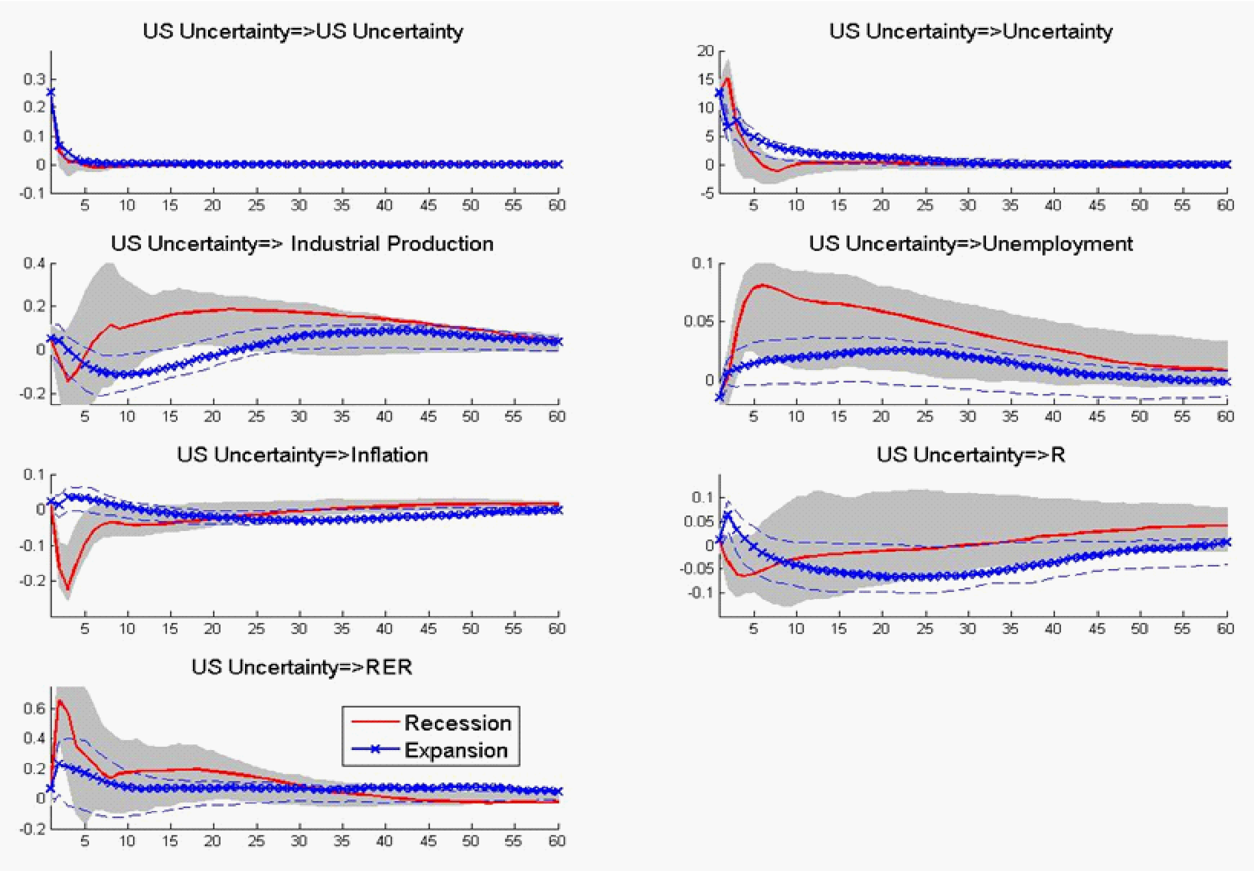

Figure 5: **Effects of a Shock to the U.S. EPU Dummy: Canadian economy, sample: 1985:M1-2014:M10.** Generalized median impulse responses to a one-standard deviation shock to the U.S. EPU dummy hitting the U.S. economy in recessions (red dashed line) and expansions (blue circled line). 68% confidence intervals identified via shaded areas (recessions) and dashed blue lines (expansions). Transition indicator for Canada: 12-term moving average of the growth rate of the Canadian industrial production.

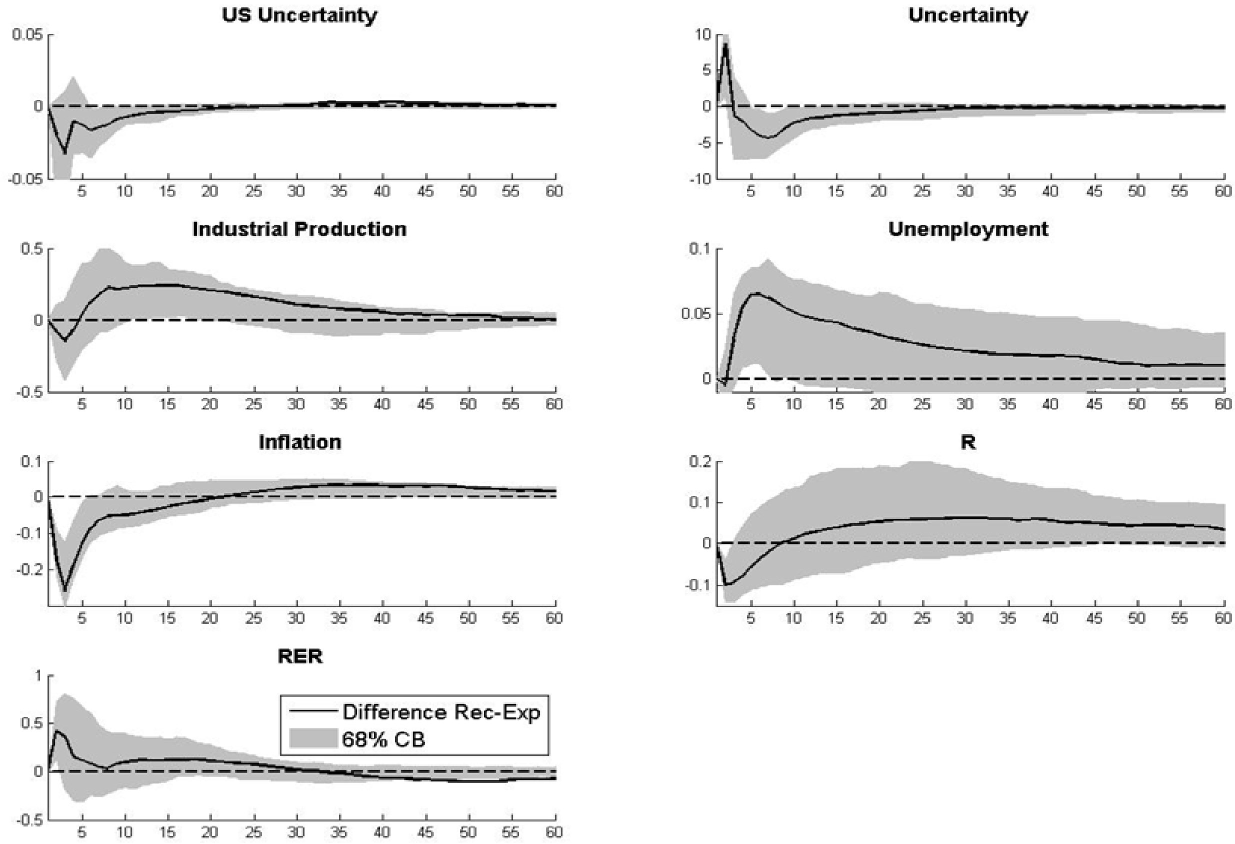

Figure 6: **Effects of a Shock to the U.S. EPU Dummy: Different between GIRFs, Canadian economy, sample: 1985:M1-2014:M10.** Differences between generalized median impulse responses in recessions and expansions to a one-standard deviation shock to the U.S. EPU dummy. Median realizations identified via black lines, 68% confidence intervals identified via shaded areas. Transition indicator for Canada: 12-term moving average of the growth rate of the Canadian industrial production.

7 Appendix

A - linearity test
B - algorithm to estimate the model via conditional maximul likelihood
C - computation of the GIRFs
D - extra results