Online Appendix to "A Note on International Spillovers of Economic Policy Uncertainty across Business Cycles: Evidence from OECD Countries"

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1 Estimation Strategy to Panel ST-VAR

We estimate the model using a Markov Chain Monte Carlo method as in Chernozhukov and Hong (2003) to find a global optimum and create confidence intervals.

$\Psi = \{\Pi_R(L), \Pi_E(L), \Lambda_R(L), \Lambda_E(L), \mathbf{\Omega}_R, \mathbf{\Omega}_E, \gamma\}$ is the set of parameters that need to be estimated. Conditional on $\{\mathbf{\Omega}_R, \mathbf{\Omega}_E, \gamma\}$, the model is linear in $\{\Pi_R(L), \Pi_E(L), \Lambda_R(L), \Lambda_E(L)\}$. In the estimation, for a given value of $\{\mathbf{\Omega}_R, \mathbf{\Omega}_E, \gamma\}$, we can estimate $\{\Pi_R(L), \Pi_E(L), \Lambda_R(L), \Lambda_E(L)\}$ using weighted least squares with weights given by $\mathbf{\Omega}_t$. We then iterate on $\{\mathbf{\Omega}_R, \mathbf{\Omega}_E, \gamma\}$ until an optimum is reached. To ensure that $\mathbf{\Omega}_R$ and $\mathbf{\Omega}_E$ are positive definite, we use their Cholesky decomposition $chol(\mathbf{\Omega}_R)$ and $chol(\mathbf{\Omega}_E)$ instead in the estimation. Specifically, we employ a Metropolis-Hastings algorithm as follows:

1. Draw a candidate vector of parameter values $\Theta^{(n)} = \Psi^{(n)} + \psi^{(n)}$ for the chain's $n+1$ state, where $\Psi^{(n)}$ is from state n, $\psi^{(n)}$ is a vector of i.i.d. disturbances draw from $N(0, \Sigma_\psi)$. Σ_ψ is diagonal.

2. The parameter values from the $n+1$ state of the chain are given by

$$\Psi^{(n+1)} = \begin{cases} \Theta^{(n)} \text{ with probability } \min\{1, \exp[\log L(\Theta^{(n)}) - \log L(\Psi^{(n)})]\} \\ \Psi^{(n)} \text{ otherwise} \end{cases},$$

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where $\log L$ is the log likelihood function defined as $\log L = const - \frac{1}{2}\sum_{t=1}^{T} \log|\mathbf{\Omega}_t| - \frac{1}{2}\sum_{t=1}^{T} \mathbf{u}_t' \mathbf{\Omega}_t^{-1} \mathbf{u}_t$.

To pick the starting value $\Psi^{(0)}$, we set $\gamma^{(0)} = 5.5$ to match the observed duration of recessions using the OECD based recession indicators for the selected countries. We estimate $\{chol(\mathbf{\Omega}_R^{(0)}), chol(\mathbf{\Omega}_E^{(0)})\}$ using the residuals from regressing X_t on a second order approximation to equation (3) - (4). Conditional on $\{\gamma^{(0)}, chol(\mathbf{\Omega}_R^{(0)}), chol(\mathbf{\Omega}_E^{(0)})\}$, we estimate $\{\Pi_R^{(0)}(L), \Pi_E^{(0)}(L), \Lambda_R^{(0)}(L), \Lambda_E^{(0)}(L)\}$ using weighted least squares to maximize the log likelihood. The initial Σ_ψ is chosen to be one percent of the parameter values and later adjusted on the fly for the first 50,000 draws to generate a 0.3 acceptance rate. We employ 250,000 draws and drop the first 50,000 burn-in draws. We construct the confidence intervals using the generated chains of parameter values. The impulse response functions (IRFs) are constructed using the estimated regime-specific parameters. Conditional on a specific regime, the model is simply a linear VAR with exogenous regressors, so inferences on the impulse responses can be obtained in a similar way. By construction, the IRFs describe the behavior of the system in deep recessions ($f(z) = 1$) or strong expansions ($f(z) = 0$) while the system stays in the same regime during the forecast horizon.

2 Data Appendix

Table A1 lists the data used in the analysis. The transformation code indicates how the series was transformed to ensure stationarity. With the pre-transformed series at time t denoted X_t, the transformation codes are as follows: (1) no transformation (X_t); (2) difference ($\triangle X_t$); (3) logged ($log(X_t)$); (4) log difference ($\triangle log(X_t)$).

Table A1: Data

Variable	Period	Source	Transformation Code
Economic Policy Uncertainty	1998Q1-2017Q4	EPU website	3
Real GDP	1998Q1-2017Q4	FRED	4
Consumer Price Index	1998Q1-2017Q4	FRED	4
Short-term Interest Rate	1998Q1-2017Q4	FRED	1
Nominal Exchange Rate Index	1998Q1-2017Q4	FRED	4
Real Exchange Rate Index	1998Q1-2017Q4	FRED	4
Real Exports	1998Q1-2017Q4	FRED	4
Real Imports	1998Q1-2017Q4	FRED	4
Real Consumption	1998Q1-2017Q4	FRED	4
Recession Indicator	1998Q1-2017Q4	FRED	1
Business Confidence Index	1998Q1-2017Q4	OECD	2
Consumer Confidence Index	1998Q1-2017Q4	OECD	2
Total Share Prices	1998Q1-2017Q4	OECD	4
Bilateral Trade Flow	1998, 2005, 2010	United Nations	1
World Economic Activity Index	1998Q1-2017Q4	Lutz Killian's website	1
Global Economic Policy Uncertainty	1998Q1-2017Q4	EPU website	3

3 Robustness Checks

To check the robustness of our baseline results, we perform the following exercises.

3.1 Estimated EPU Spillover Shocks and Alternative Weighting Schemes

We identify EPU spillover shocks using the method in Section 3 of the main text. The *EPUShock* to each recipient country is constructed by weighting the foreign unanticipated *EPU* innovations by bilateral trade intensity in the base year of 2005. Figure A1 presents the estimated foreign economic policy uncertainty shocks that spill to each of the countries conditional on this base year selection. For comparison, we also plot the estimated *EPUShock* using equal weights, using 1998 as alternative base year, and using time-varying weights given by past year's trade intensity. We find that the estimated shocks are very similar to our baseline as the four lines largely overlap for all countries.

In the baseline estimate, we weight the EPU shocks originating in other countries using the bilateral trade flow data from base year 2005. To check the robustness of our results, we performed the following

robustness checks:

1. Weight the EPU shocks originating in other countries using the bilateral trade flow data from 1998. The impulse responses are reported in Figure A2.

2. Apply equal weights to the EPU shocks originating in other countries. The impulse responses are reported in Figure A3.

3. Weight the EPU shocks originating in other countries using the bilateral trade flow data from previous year. Note that we use the trade flow data from the previous year to avoid having possible feedback from the measured shocks on the weights through their effect on the trade flows. The impulse responses are reported in Figure A4.

Our results are qualitatively robust to these alternative weighting schemes.

3.2 Alternative Ordering

In the baseline specification, EPU is ordered last in the ST-VAR. This specification assumes that EPU is a fast-moving variable that responds contemporaneously to shocks to other variables. Given that there is no consensus on the ordering of uncertainty given the endogenous nature of the variables, we also check for robustness with a different ordering of the variables. Figures A5-A9 report our results when we order EPU first in our VAR specification. Figure A4 reports the IRFs of our economic indicators to a unit-standard deviation EPU spillover shock during expansions and recessions. Figures A6-A9 reports the IRFs after we remove the endogenous responses of domestic EPU, share price index, exports, and BCI index respectively to examine the importance of the channels of interest.

We find our results qualitatively robust to this specification.

3.3 Alternative Transition Indicator

We model the transition indicator z using a standardized backward-looking 7-quarter moving average of real GDP growth. The selection is made consistent to the literature and based on the fact that real GDP growth alone conveys significant information regarding the state of the economy. To check for robustness, we also consider a standardized backward-looking 4 quarter moving average of real GDP growth instead. The alternative transition indicator features a more abrupt transition between recessions and expansions. Figure A10 plots the transition probabilities for the sample countries. The IRFs are reported in Figure A11. We find that the results in the baseline specification are qualitatively robust.

3.4 Alternative Measure of Trade Flow

Section 4.2.4 finds that the trade channel has limited importance in transmitting EPU spillover shocks to real GDP. We used exports as a measure of trade flow in the baseline specification. In this section, we perform two robustness exercises.

First, we replace exports using imports in our estimation, and remove the movements of imports when we isolate the effect of the trade channel. The restricted and unrestricted IRFs are reported in Figure A12. The response and the effect of the trade channel appear similar to the baseline results.

Second, we also explore the role of the real exchange rate in explaining the trade intensity. Using the strategy described in Section 4.1, we remove the endogenous response of the real exchange rate in the baseline specification. The results are reported in Figure A13. The unrestricted and restricted baseline IRFs nearly overlap in all economic indicators included in the study, suggesting minimal importance of the trade channel using the real exchange rate as a measure for trade intensity.

4 Figures for Online Appendix

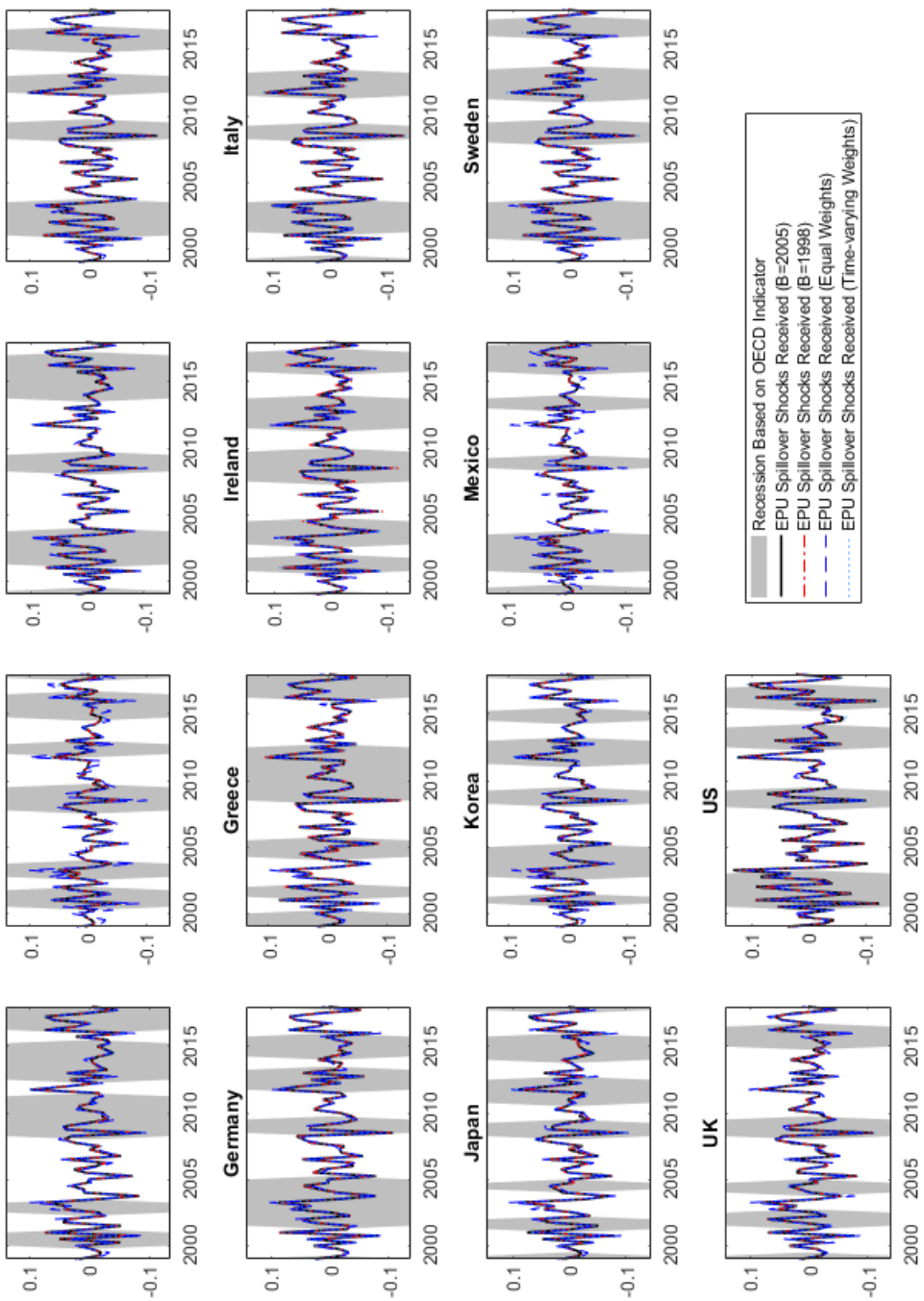


Figure A1: EPU Spillover Shocks

Figure A2: Impulse Responses with Base Year = 1998

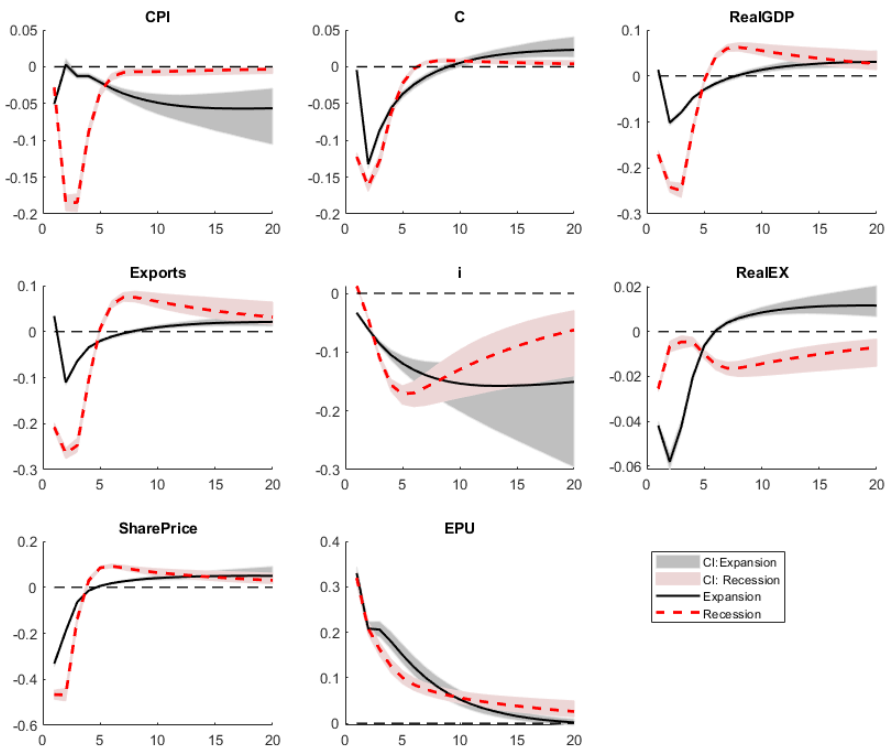


Figure A3: Impulse Responses with Equal Weights

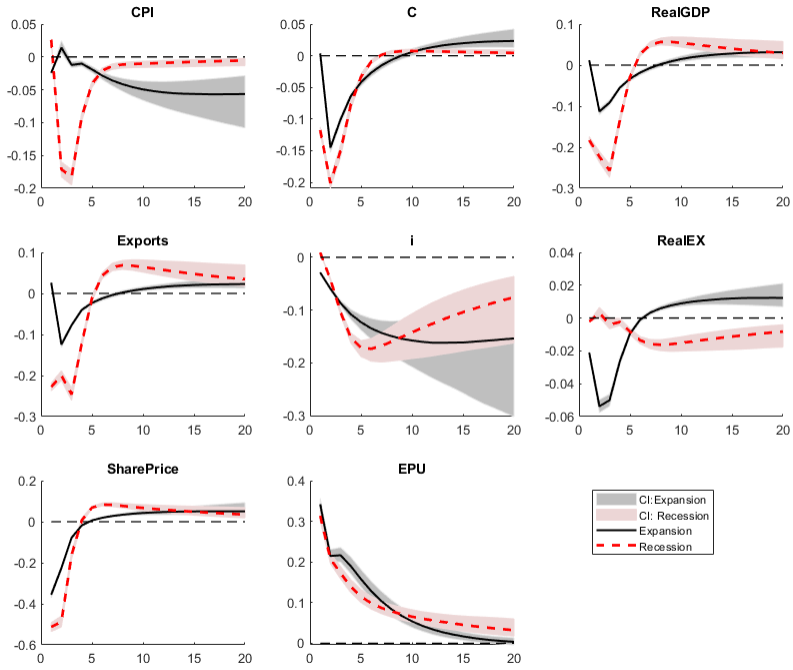


Figure A4: Impulse Responses with Time Varying Weights

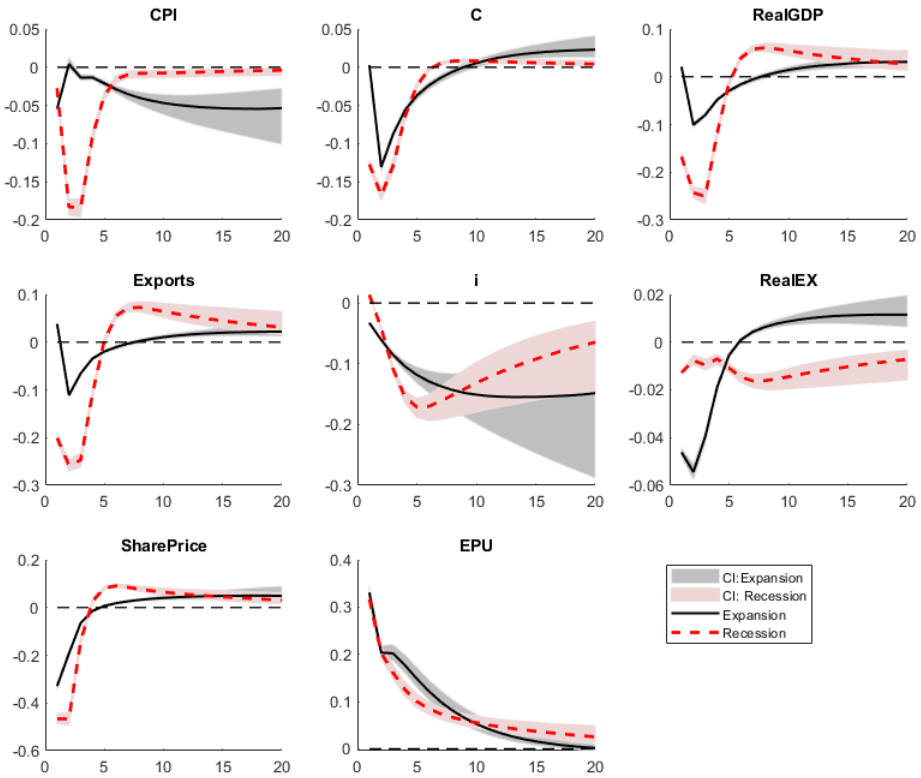


Figure A5: Effects of EPU Spillover Shocks during Recessions and Expansions (Alternative Ordering)

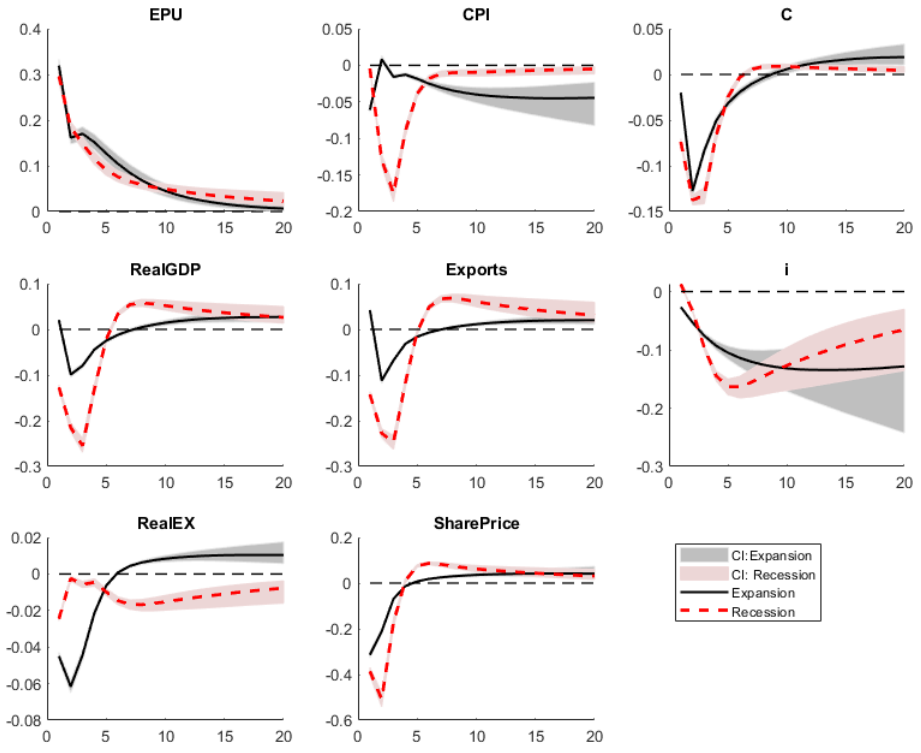


Figure A6: Domestic EPU Channel (Alternative Ordering)

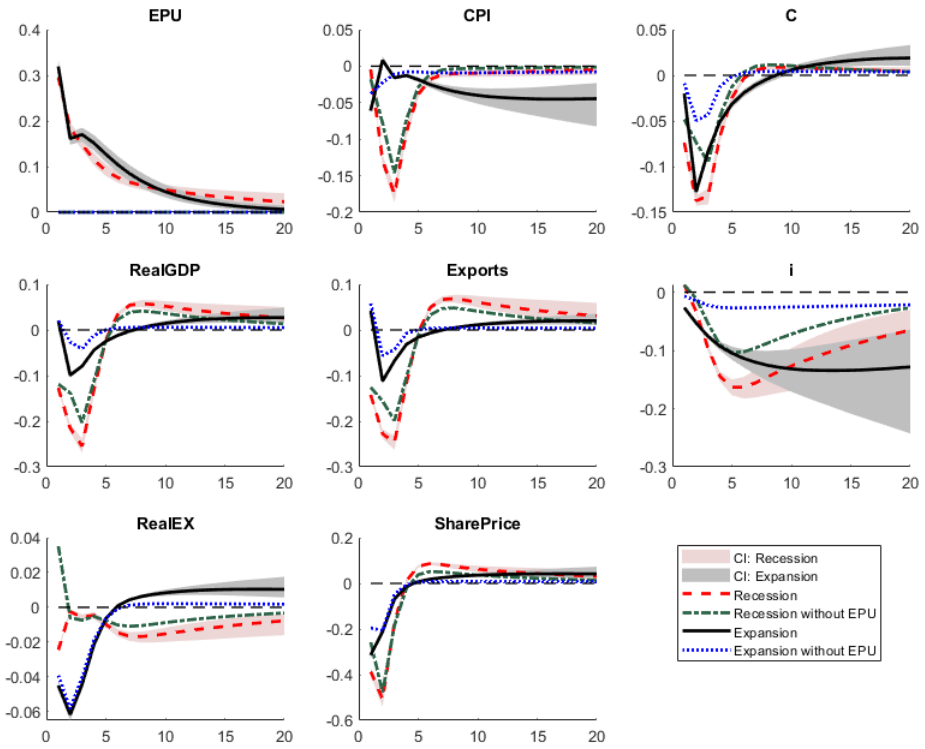


Figure A7: Financial Channel (Alternative Ordering)

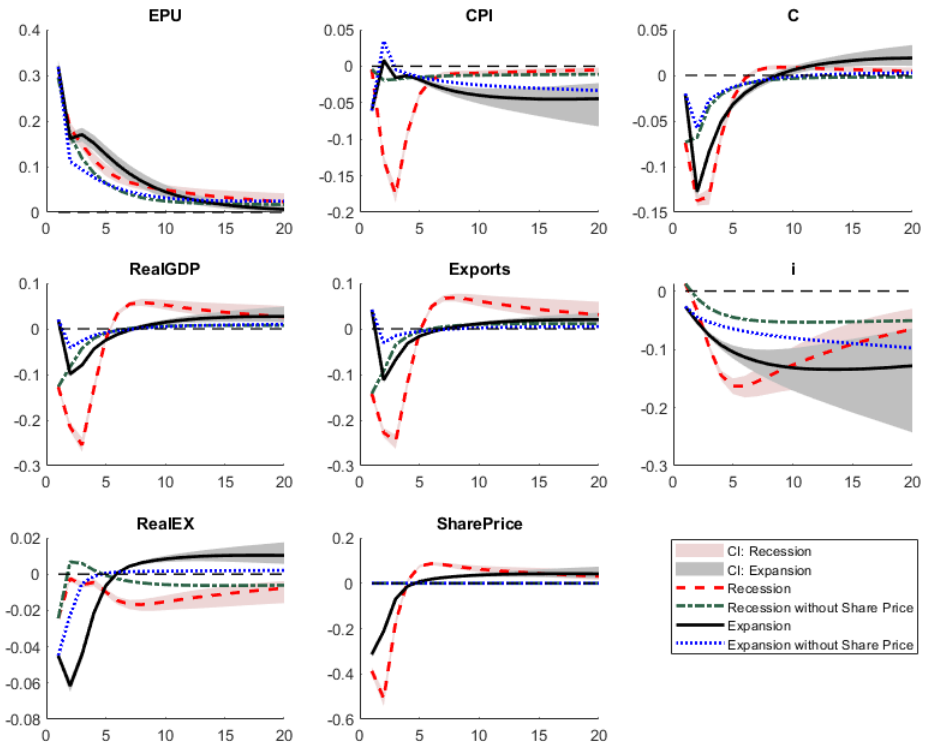


Figure A8: Trade Channel (Alternative Ordering)

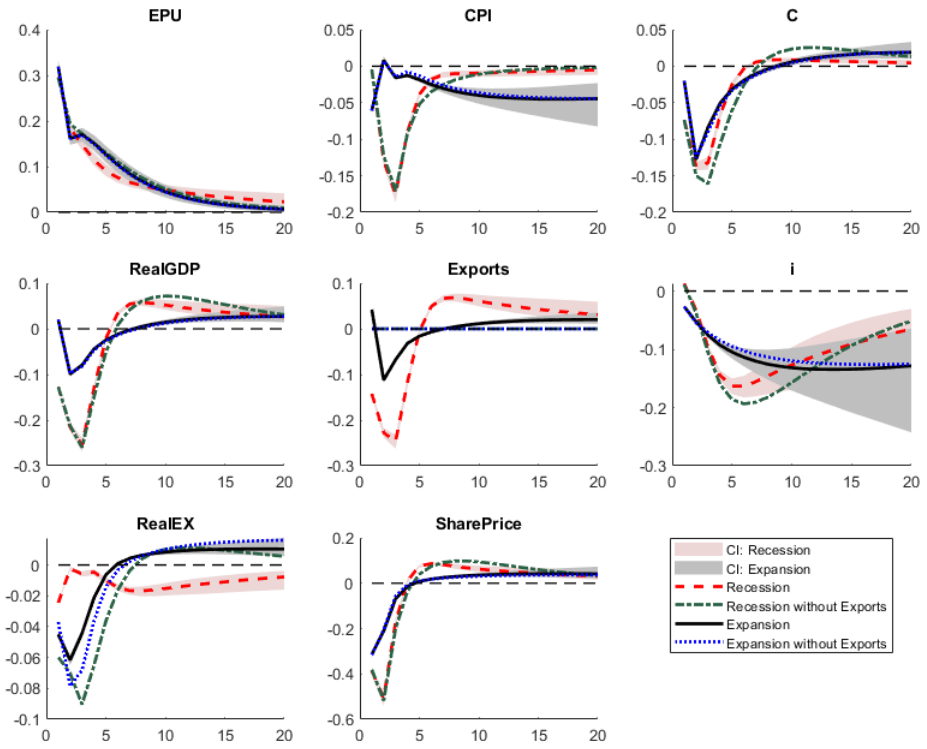


Figure A9: Confidence Channel (Alternative Ordering)

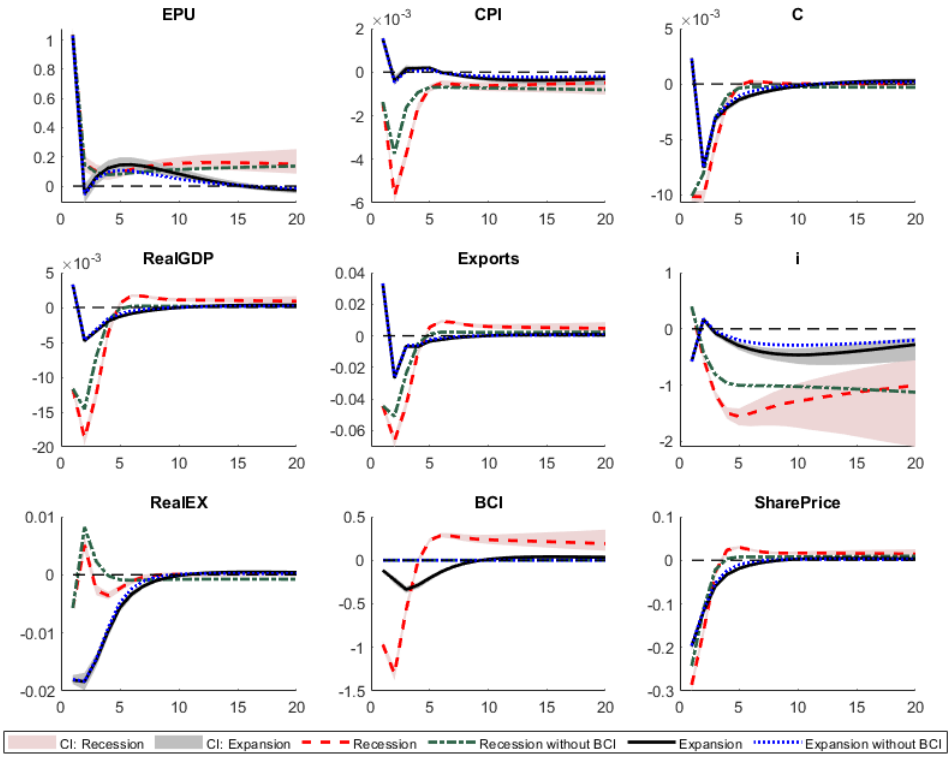


Figure A10: Transition Probabilities under Alternative Specification

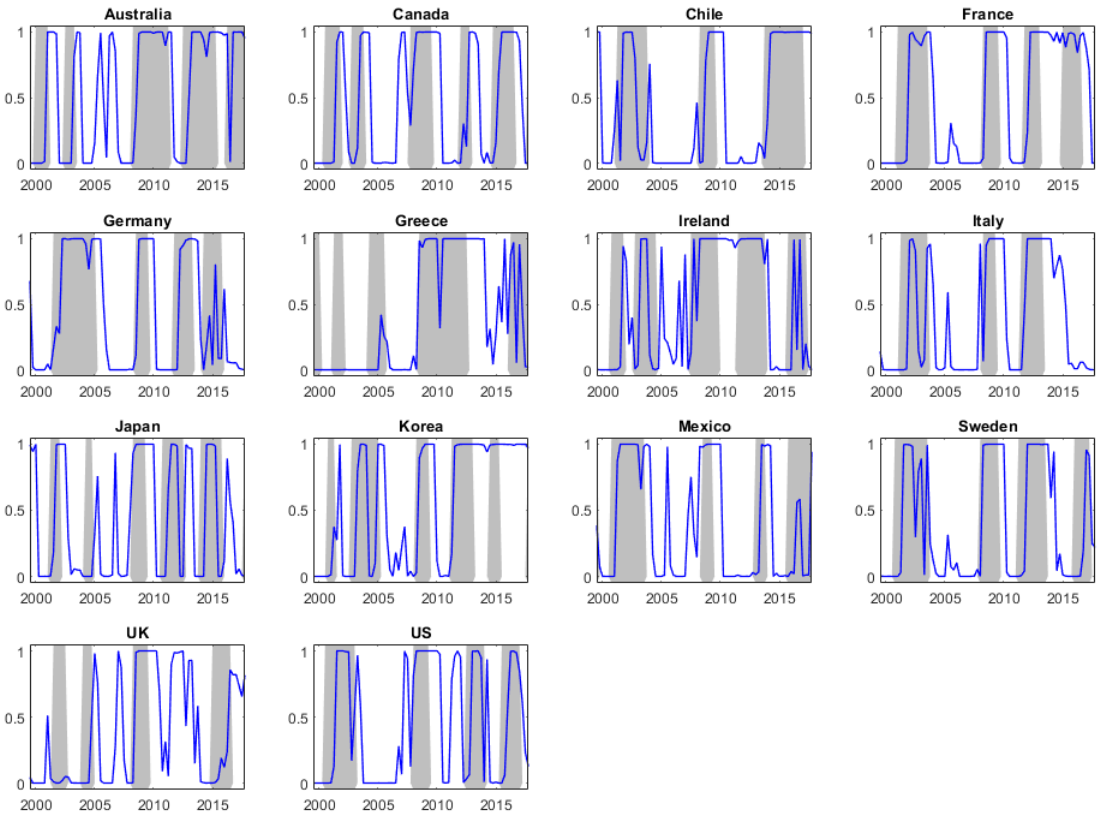


Figure A11: Impulse Responses with Alternative Transition Indicator

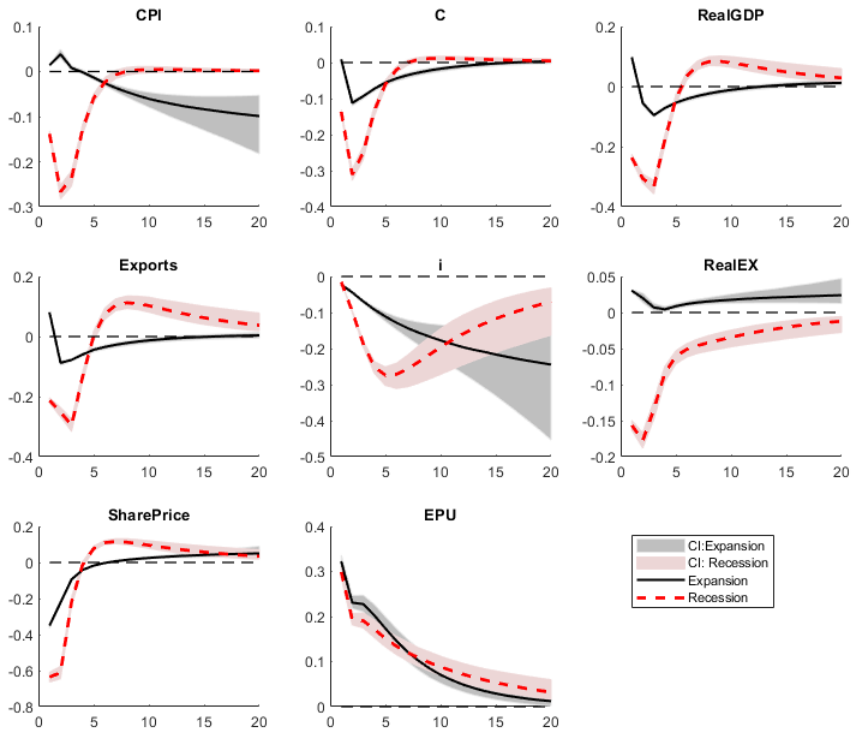


Figure A12: Impulse Responses after Removing Imports

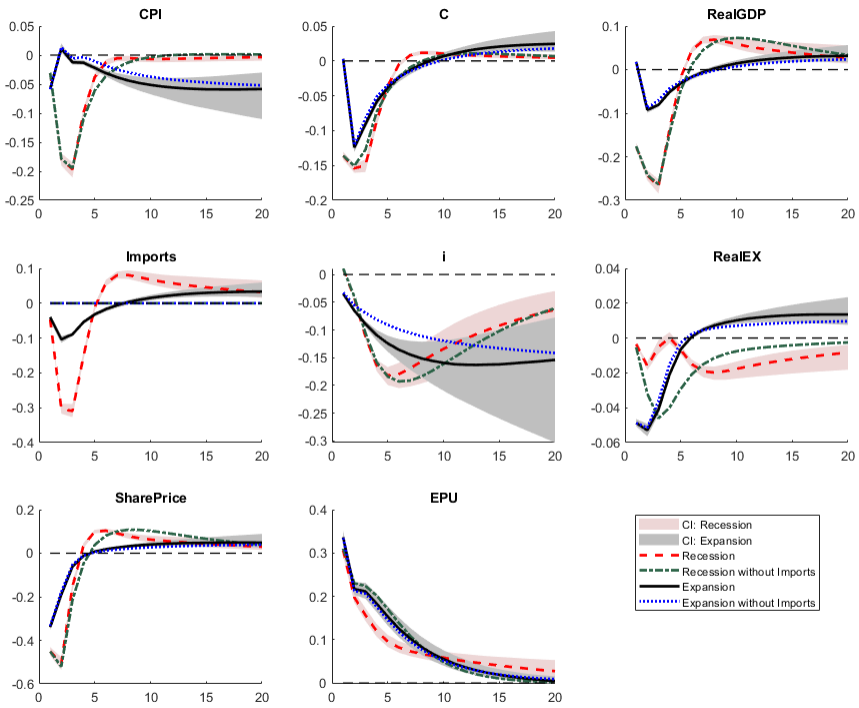
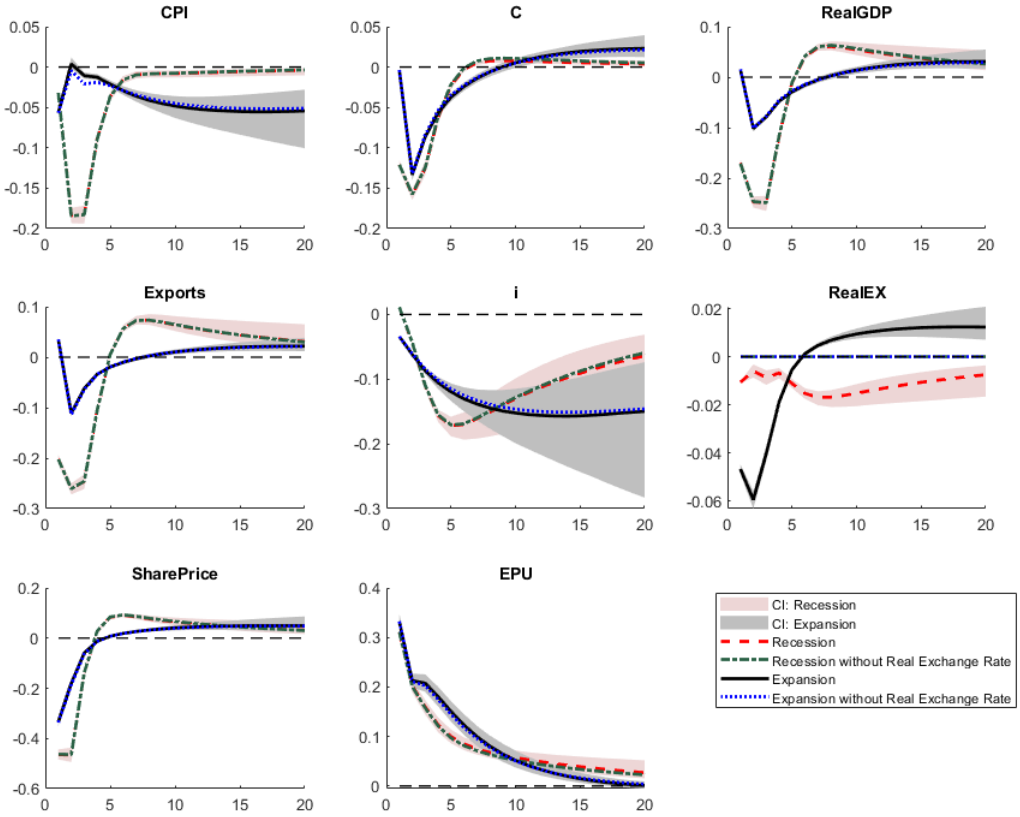


Figure A13: Impulse Responses after Removing the Real Exchange Rate



5 References

Chernozhukov, Victor, and Han Hong (2003) An MCMC approach to classical estimation. *Journal of Econometrics*, 115(2), 293-346.