

A Online Appendix: Figures

In this appendix, we present impulse response diagrams as described in the robustness section. For these robustness checks, we use our five-variable baseline models that employ both the state variables similar to the baseline case, unless otherwise indicated.

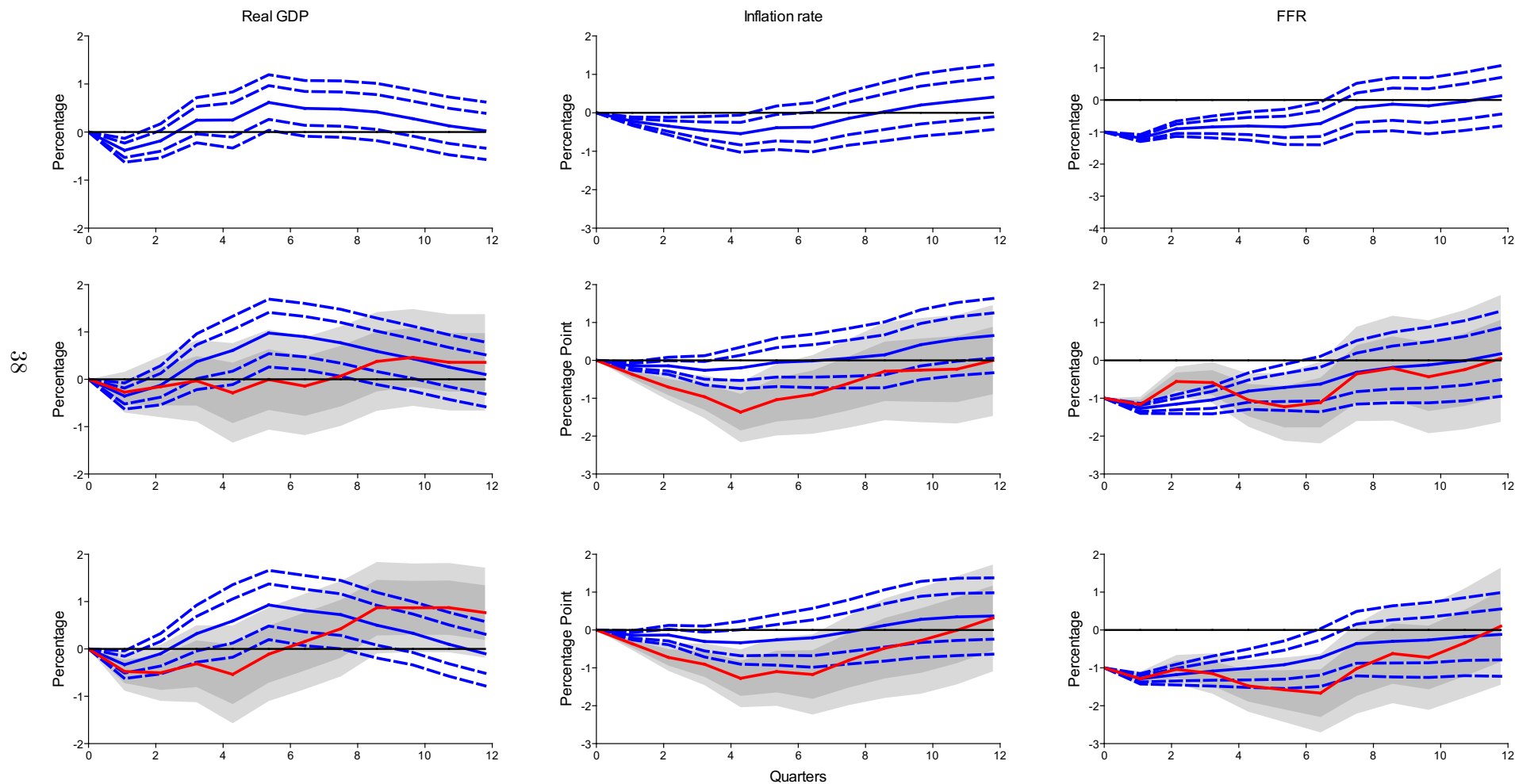


Figure A.1: IRFs of the three-variable model. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

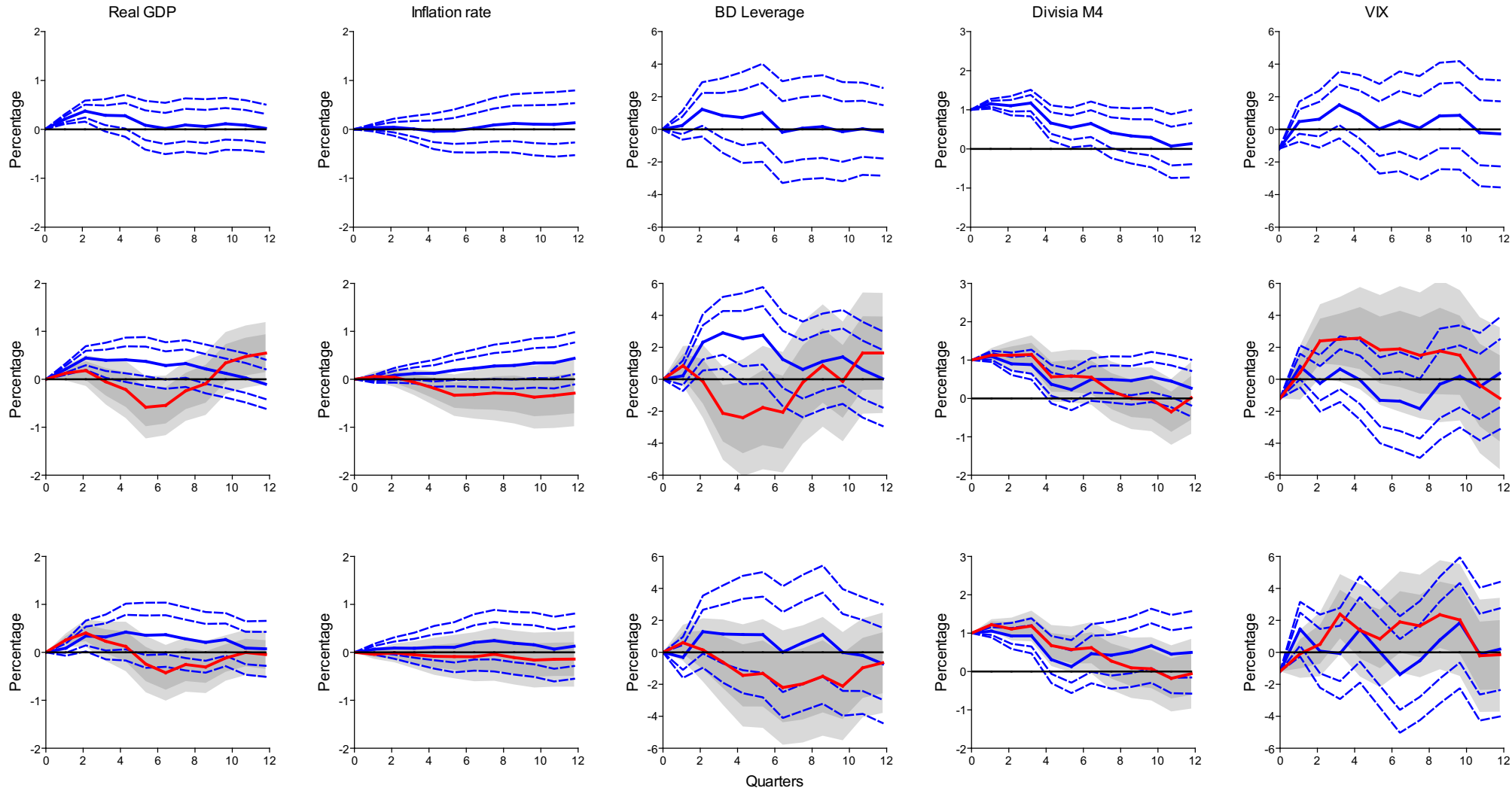


Figure A.2: IRFs of the five-variable model using the Divisia M4 to identify the monetary policy shocks. Five lags are used based on AIC. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

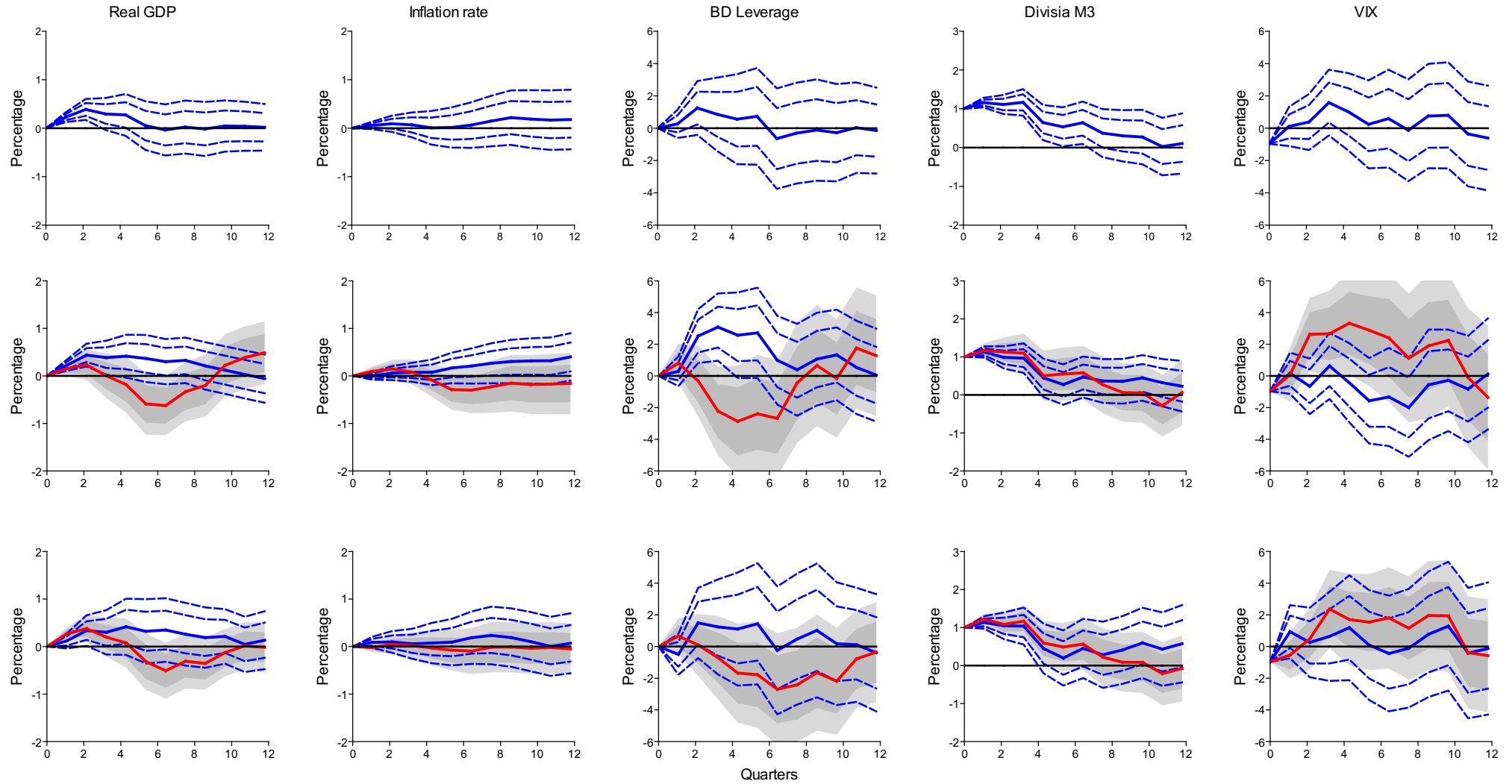


Figure A.3: IRFs of the five-variable model using the Divisia M3 to identify the monetary policy shocks. Five lags are used based on AIC. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

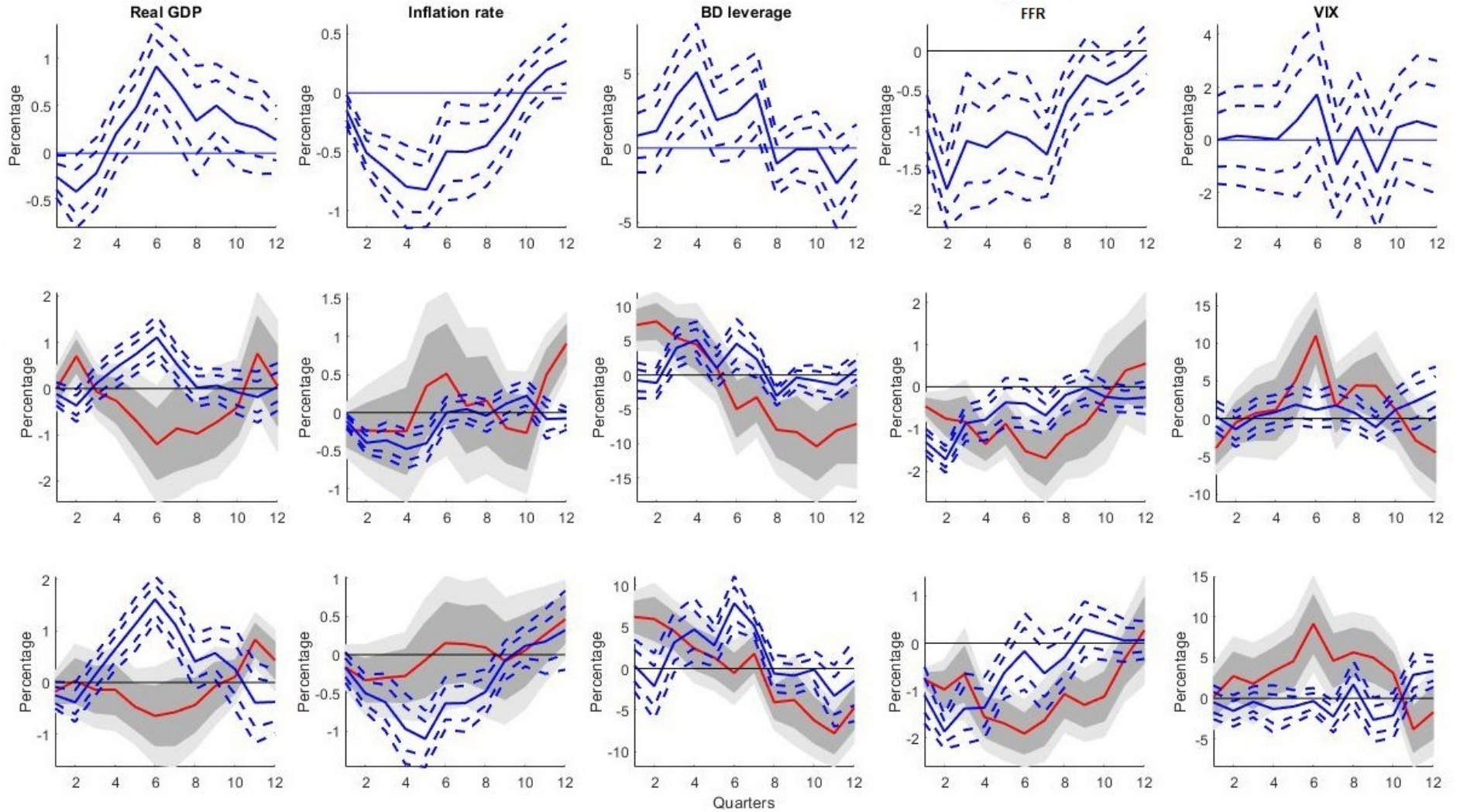


Figure A.4: IRFs of the five-variable model using the Romer and Romer (2004) monetary policy shocks. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

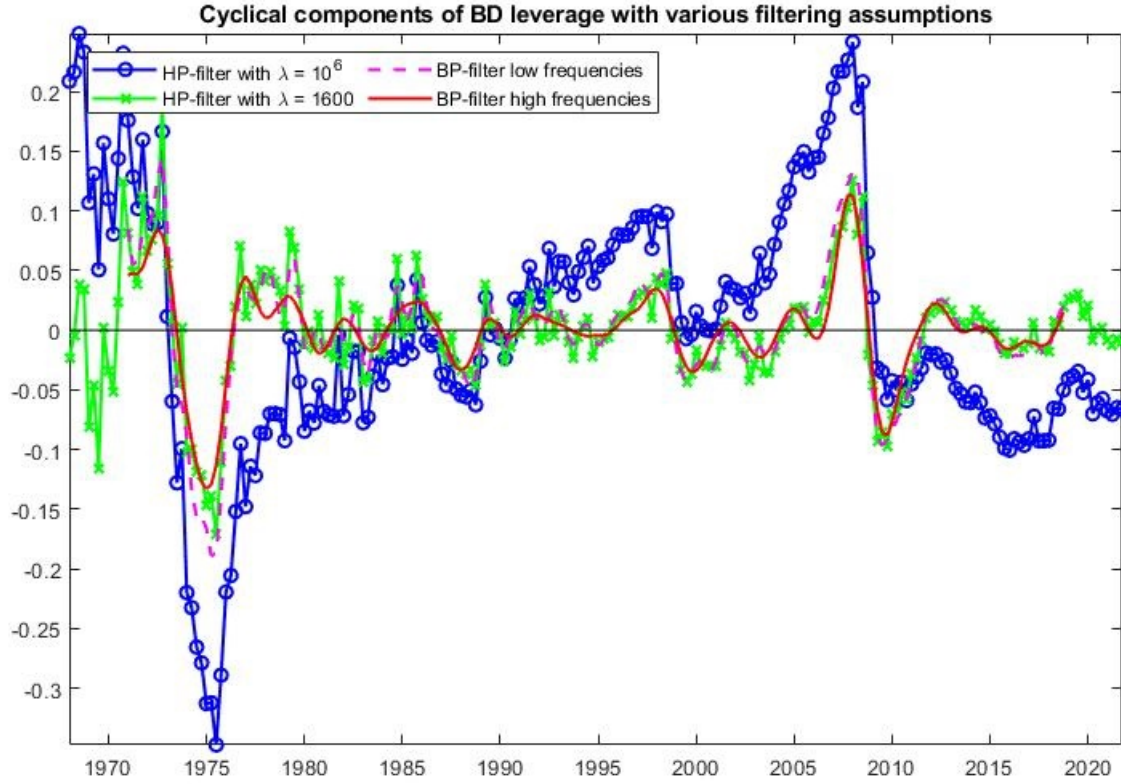


Figure A.5: Cyclical components of BD leverage using alternative filtering models. These include two HP filter smoothing parameters, ($\lambda = 1600$) and ($\lambda = 10^6$), and two [Baxter and King \(1999\)](#) bandpass filter models. The HP filter with ($\lambda = 10^6$) is consistent with [Bernardini and Peersman \(2018\)](#), who recommend a high smoothing parameter for HP detrending because credit cycles are twice as long as business cycles. For the bandpass filter, frequencies between 8 and 32 quarters as well as between 4 and 64 quarters are isolated. The 8 and 32 quarter filter is consistent with business cycle frequencies, while the 4 and 64 are consistent with the credit cycle frequencies.

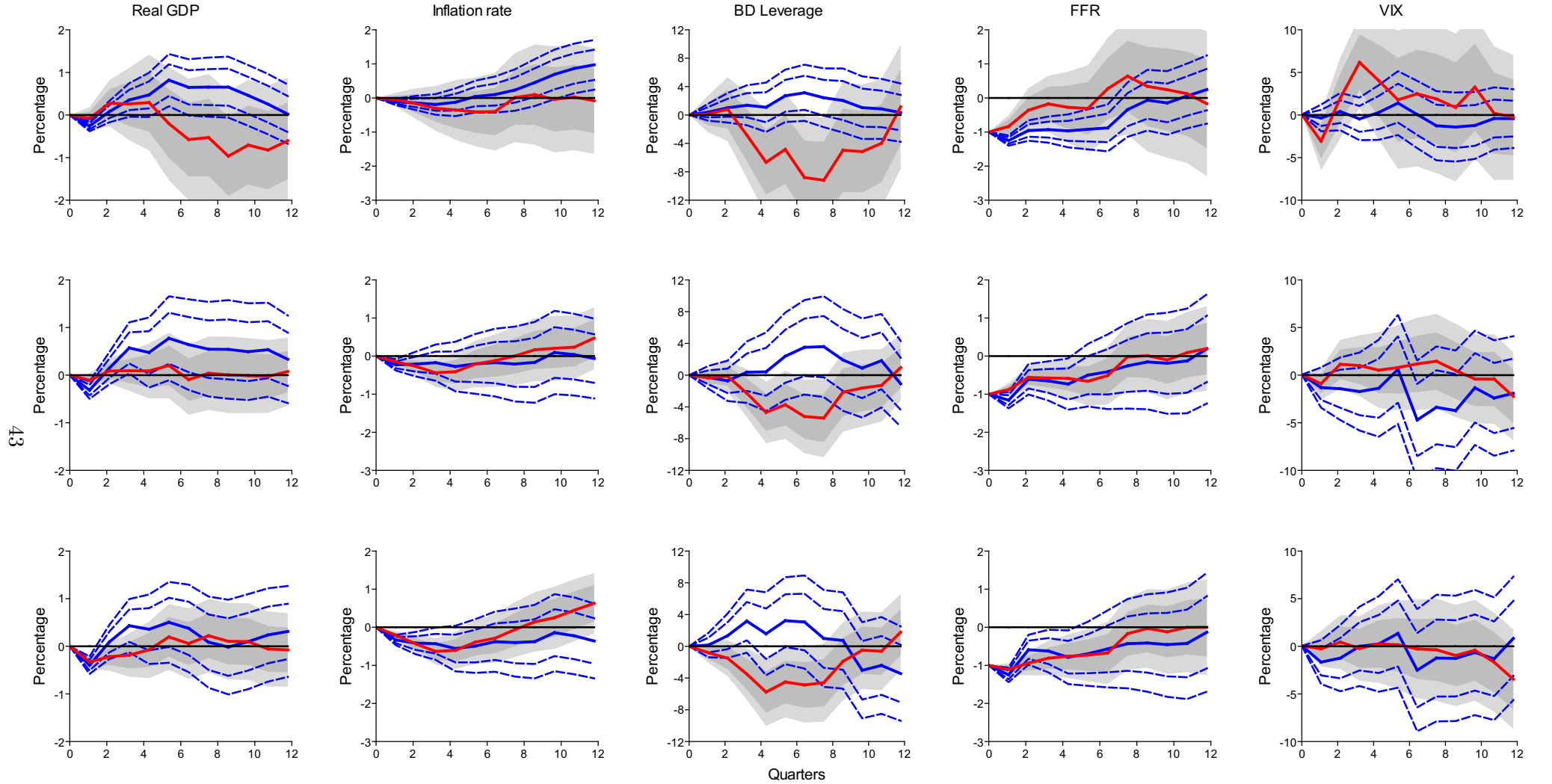


Figure A.6: IRFs of the five-variable model with alternative filtering assumptions. The top horizontal panel shows the IRFs of the threshold model where the state variable comes from using the HP filter with $\lambda = 10^6$. The second horizontal panel shows IRFs where the bandpass filter is used along with 4 to 64 quarters to define the state variable. The third horizontal panel shows IRFs the bandpass filter with 8 to 32 quarters. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

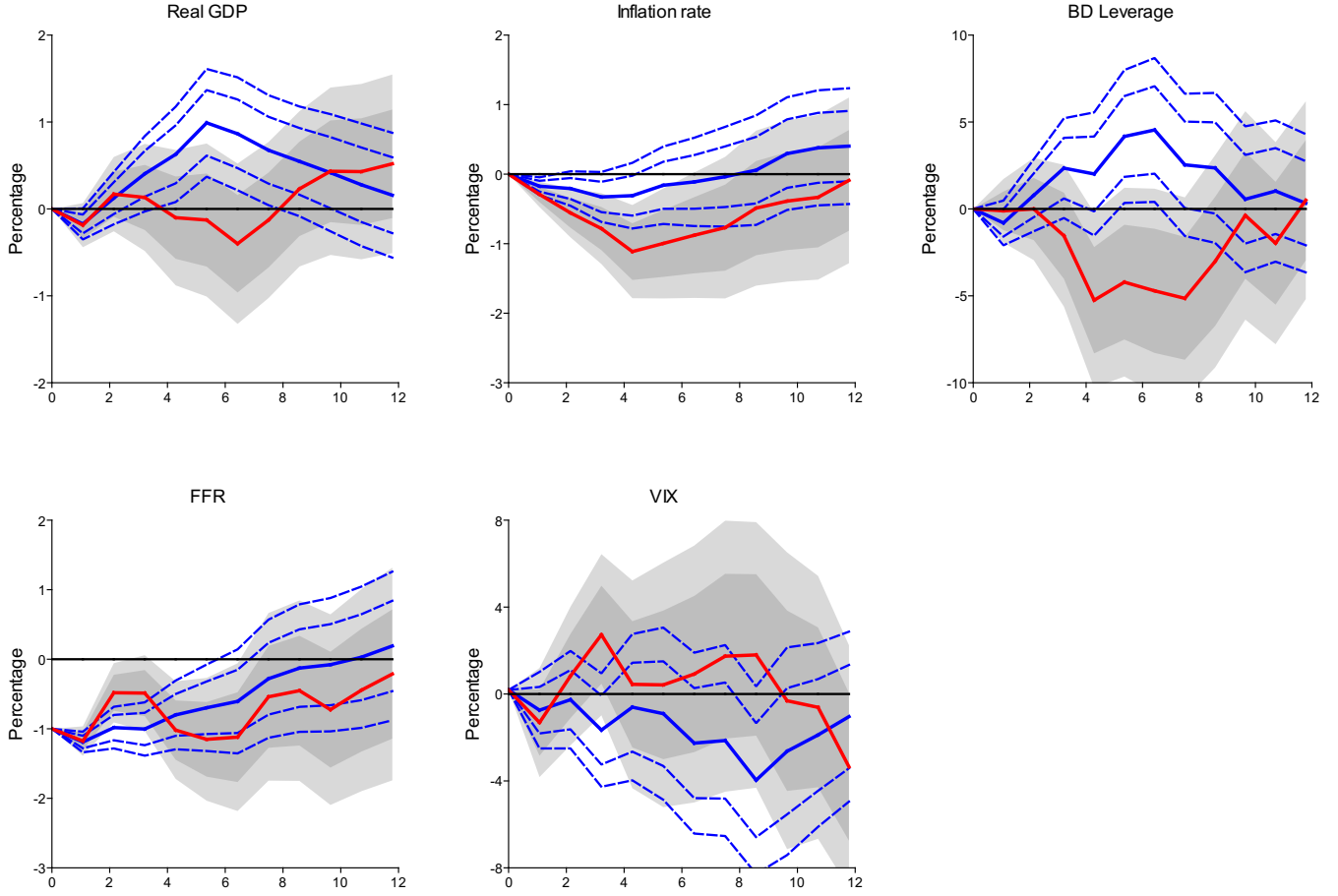


Figure A.7: IRFs of the five-variable threshold model where a truncated sample from the HP detrended leverage series is used to construct the threshold indicator to address the endpoint problem of the HP filter. Twelve-quarters each from the start and the end data points of the baseline sample are excluded. Blue solid lines reflect the IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models, and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

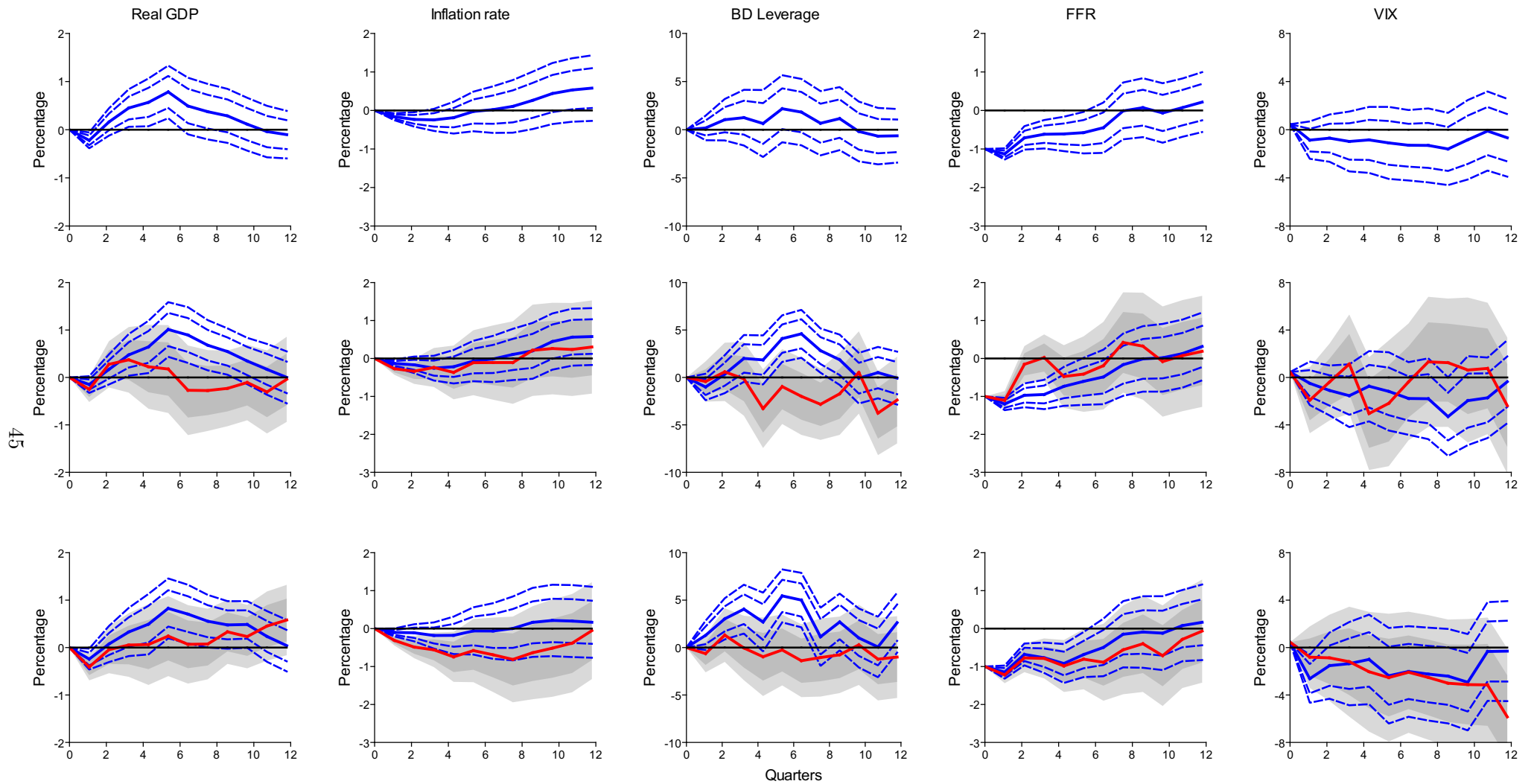


Figure A.8: IRFs of the five-variable model using a sample ending in 2008:Q3. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

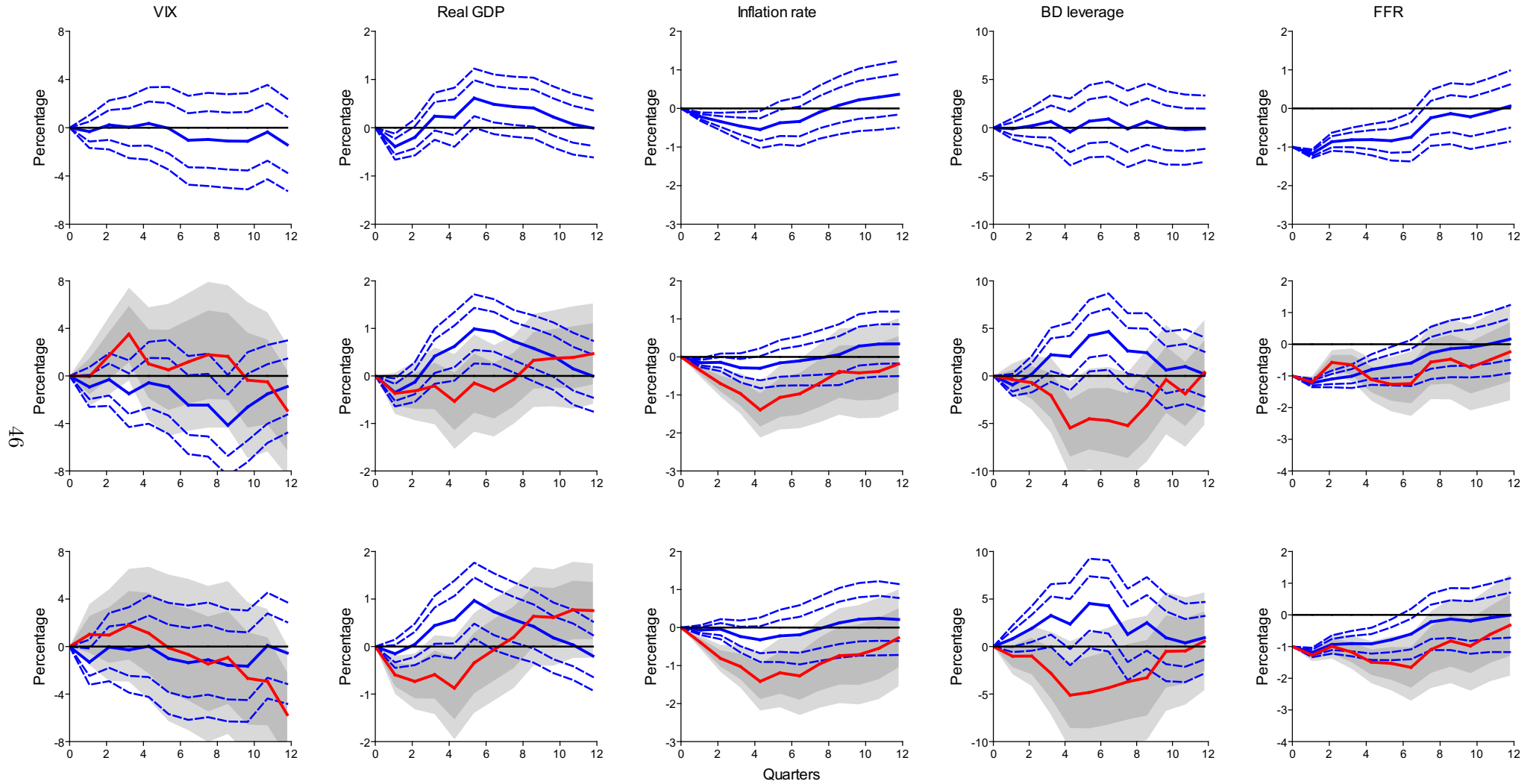


Figure A.9: IRFs of the five-variable model in which the VIX index is ordered first, followed by output, the inflation rate, BD leverage, and the fed funds rate. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

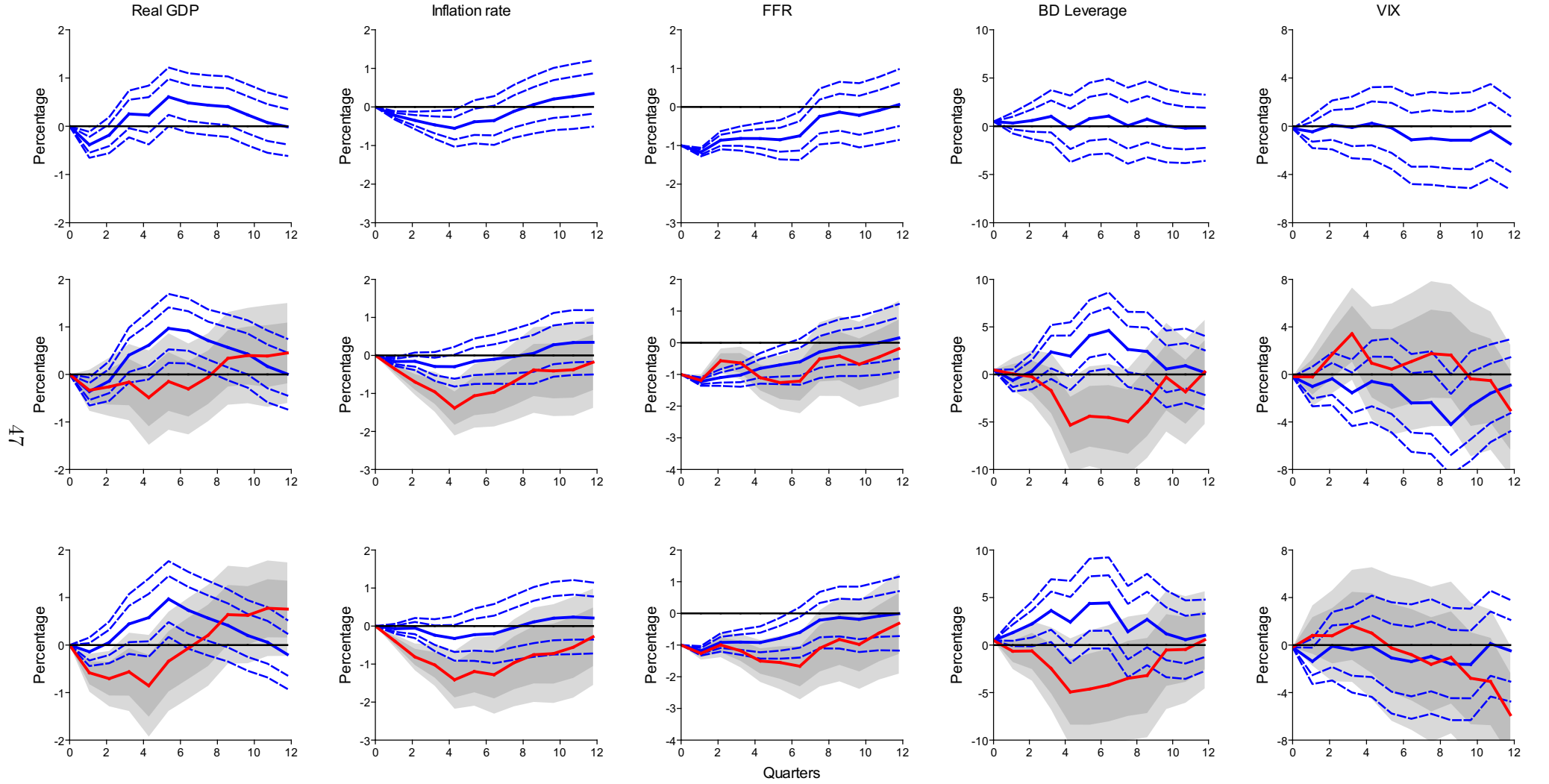


Figure A.10: IRFs of the five-variable model using an alternative ordering in which the FFR is ordered before BD leverage. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

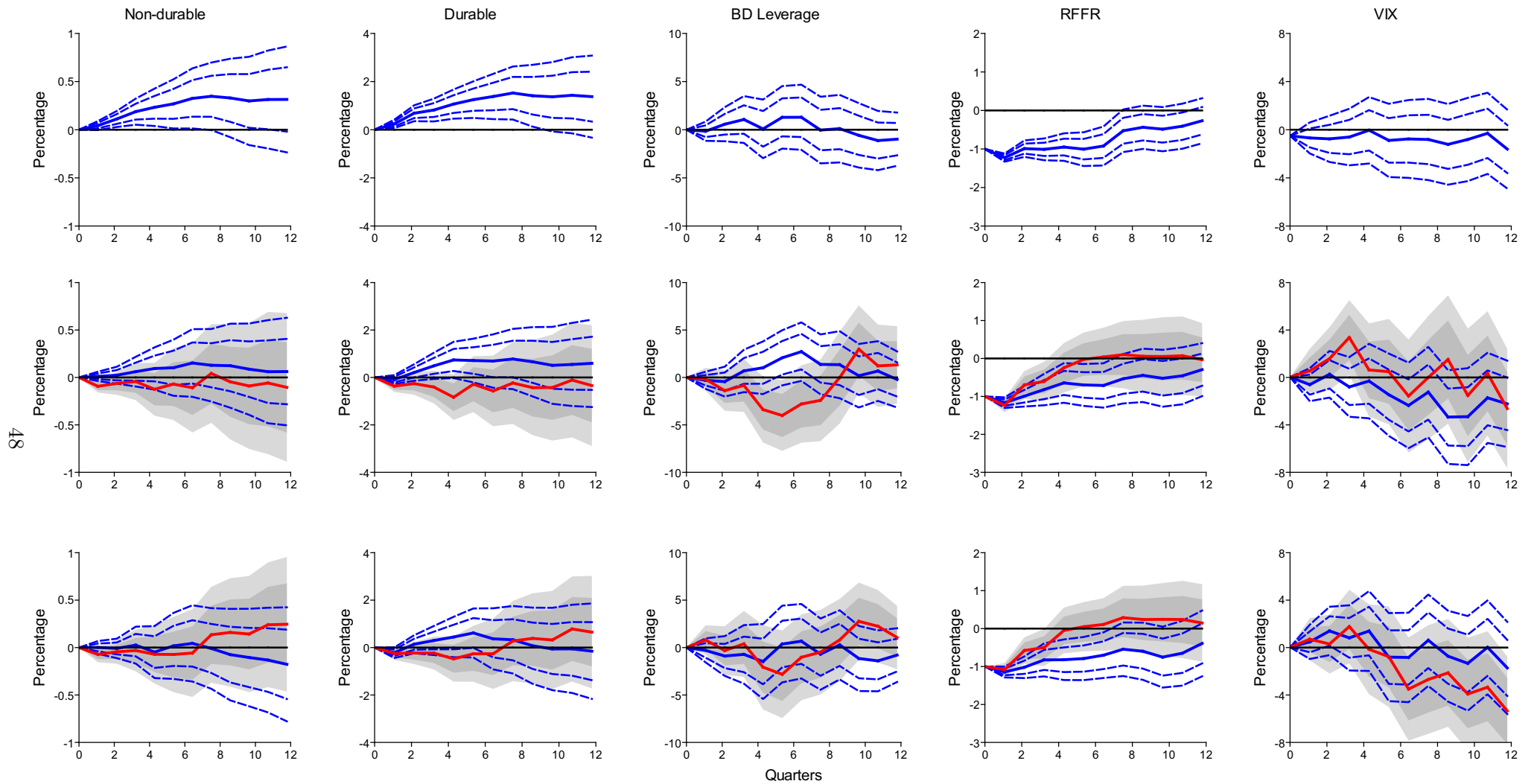


Figure A.11: IRFs of the five-variable model using an alternative economic specification. We replaced the variables of the baseline model by including consumption of non-durable and durable goods. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

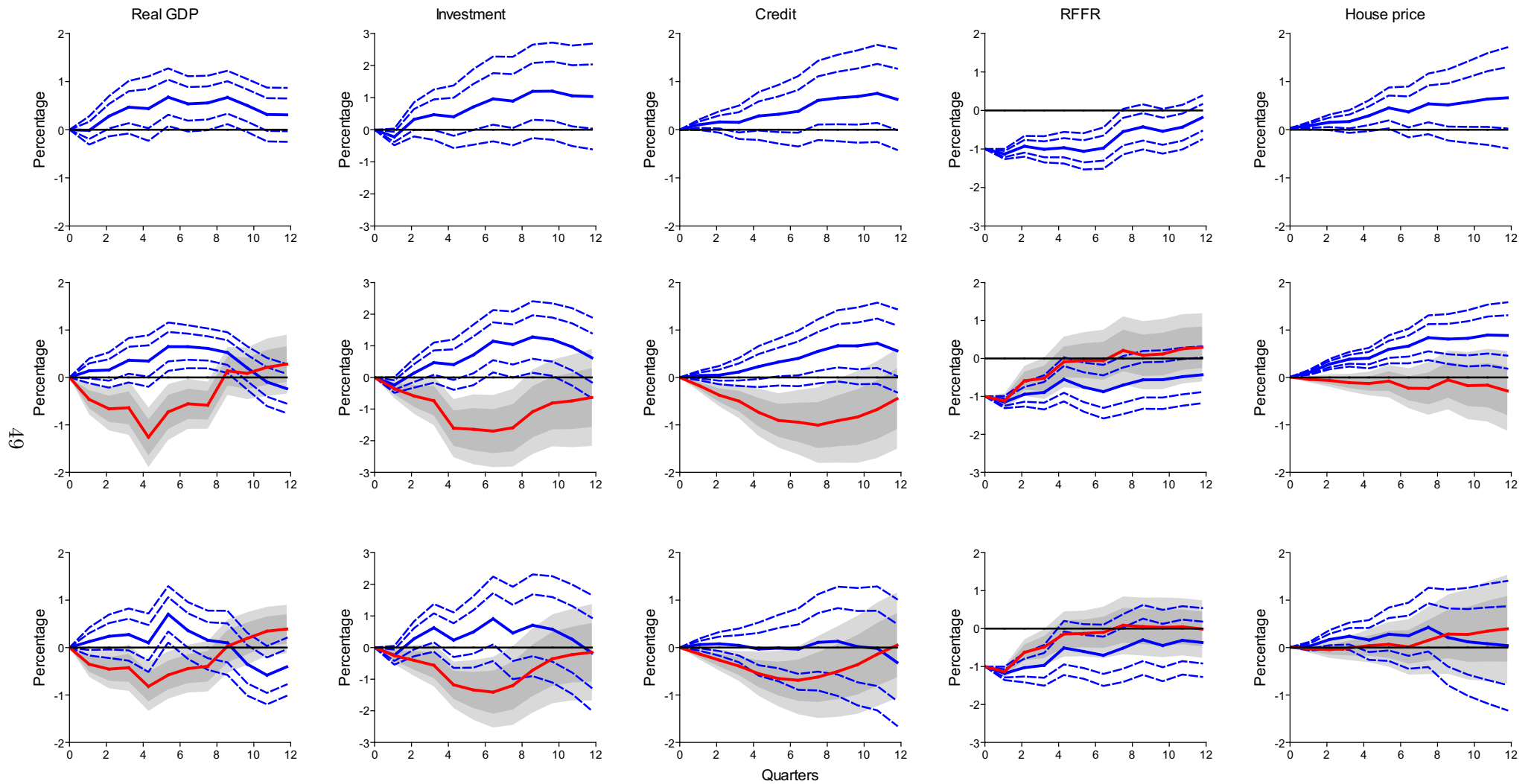


Figure A.12: IRFs of the five-variable model using an alternative economic specification. Here, some variables of the baseline model were swapped for other variables. This model includes real investment, credit to the private sector, and a housing price index. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

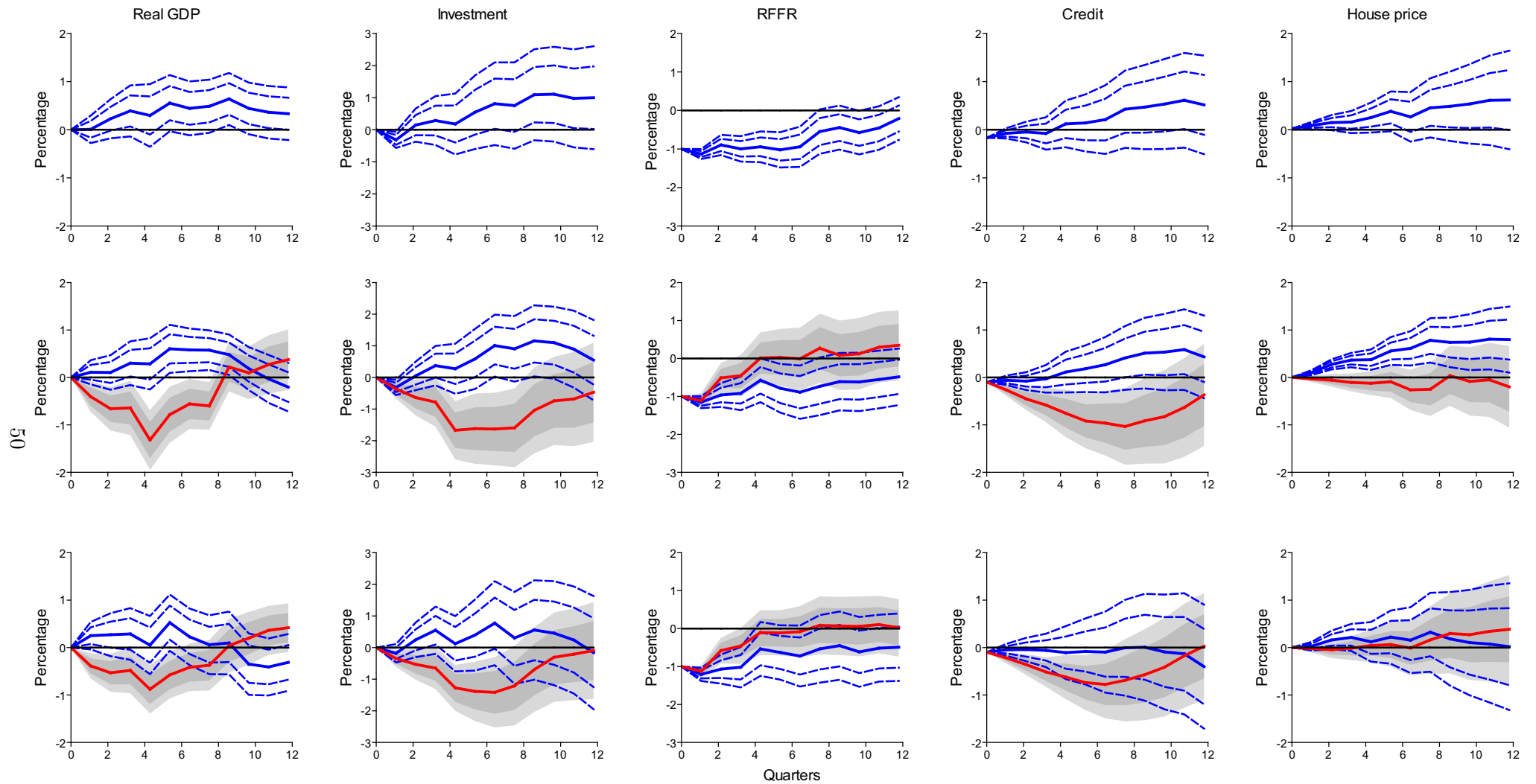


Figure A.13: IRFs of the five-variable model using an alternative economic specification with an alternative ordering. We changed the ordering of the model's variables in Figure A.12 by putting credit after the fed funds rate. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

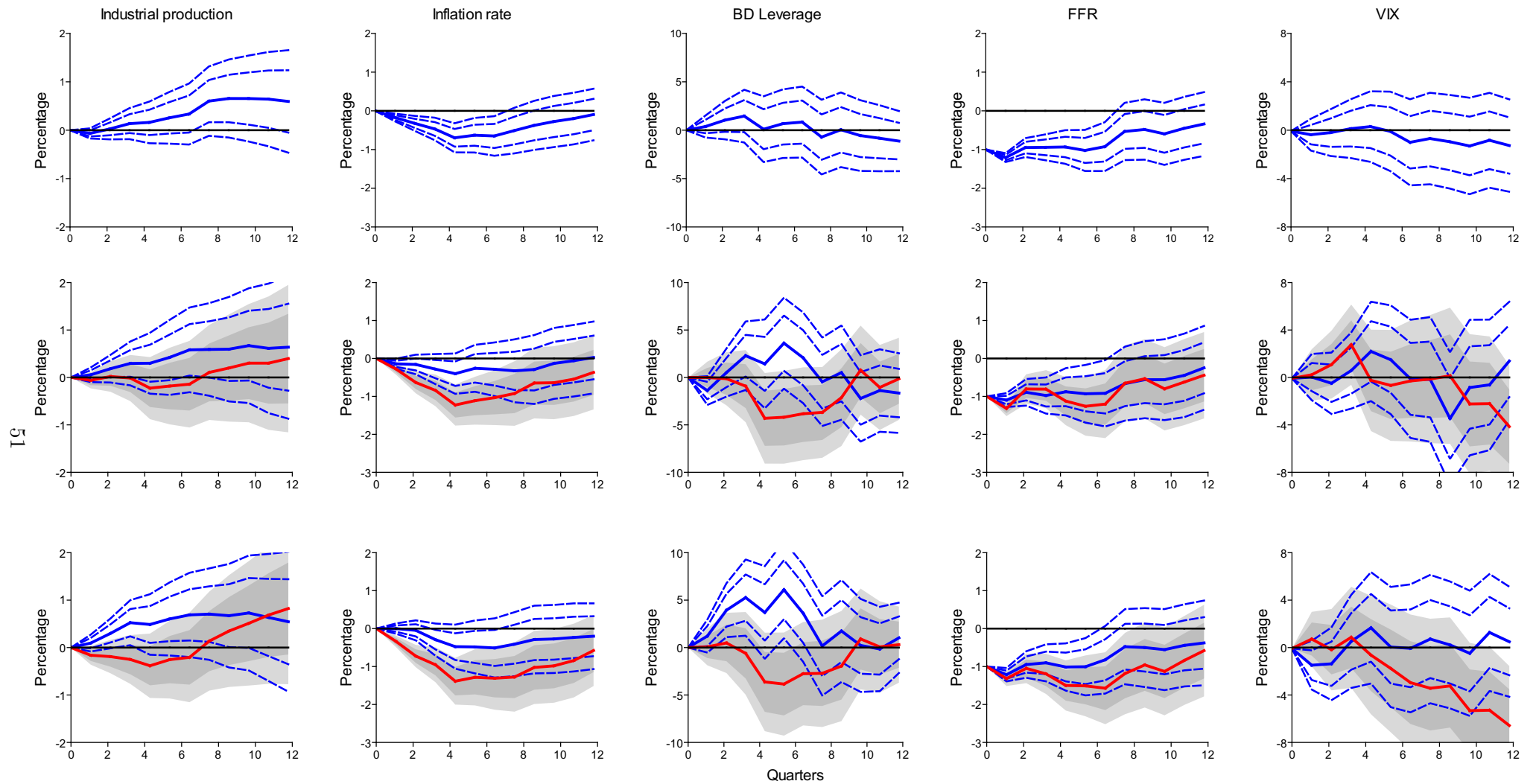


Figure A.14: IRFs of the five-variable model using an alternative business cycle variable. Here, real GDP is replaced with industrial production. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models, respectively, using HP detrended leverage and the quarterly growth rate of leverage as threshold indicators. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

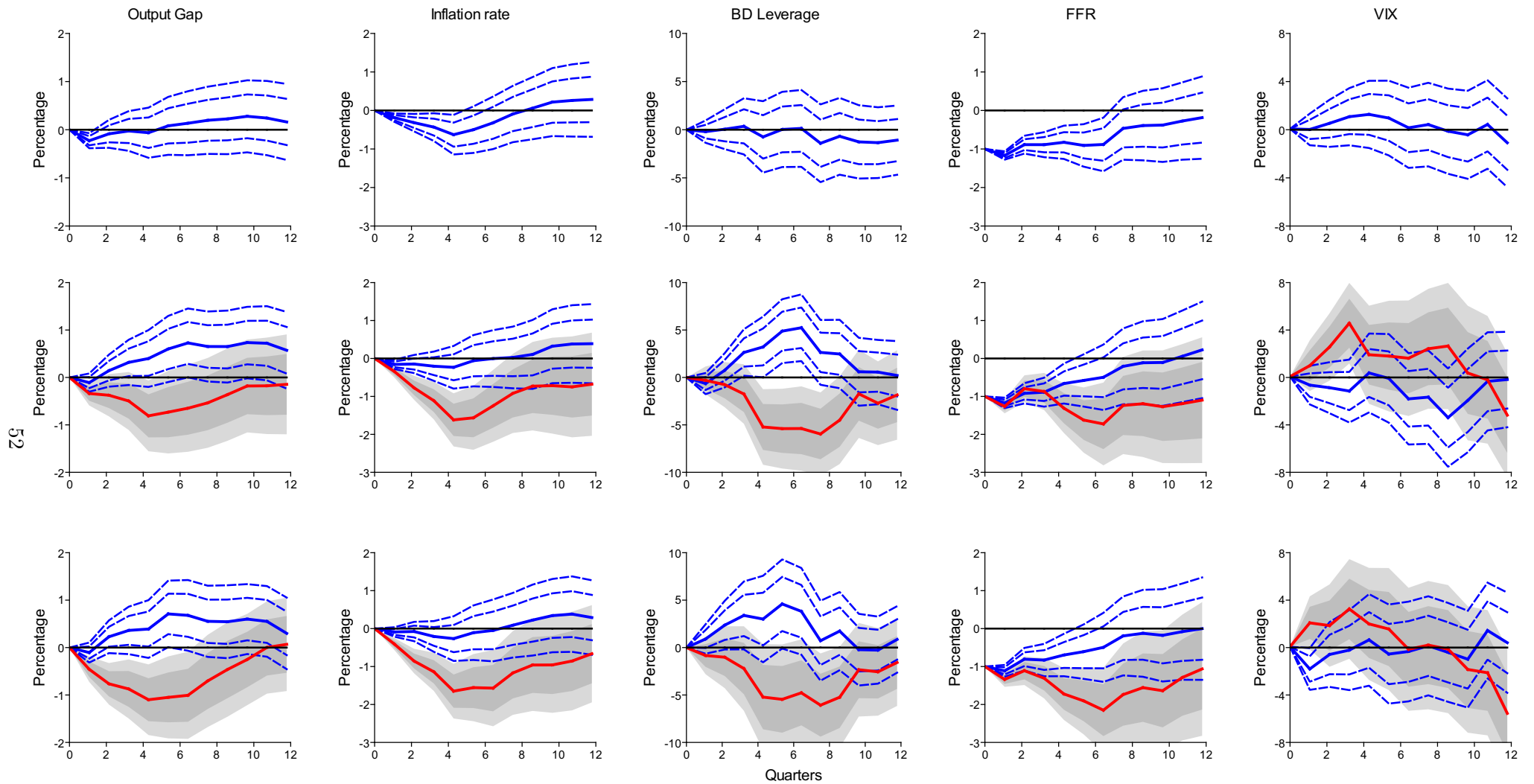


Figure A.15: IRFs of the five-variable model using an alternative business cycle variable. Here, real GDP is replace with the output gap. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

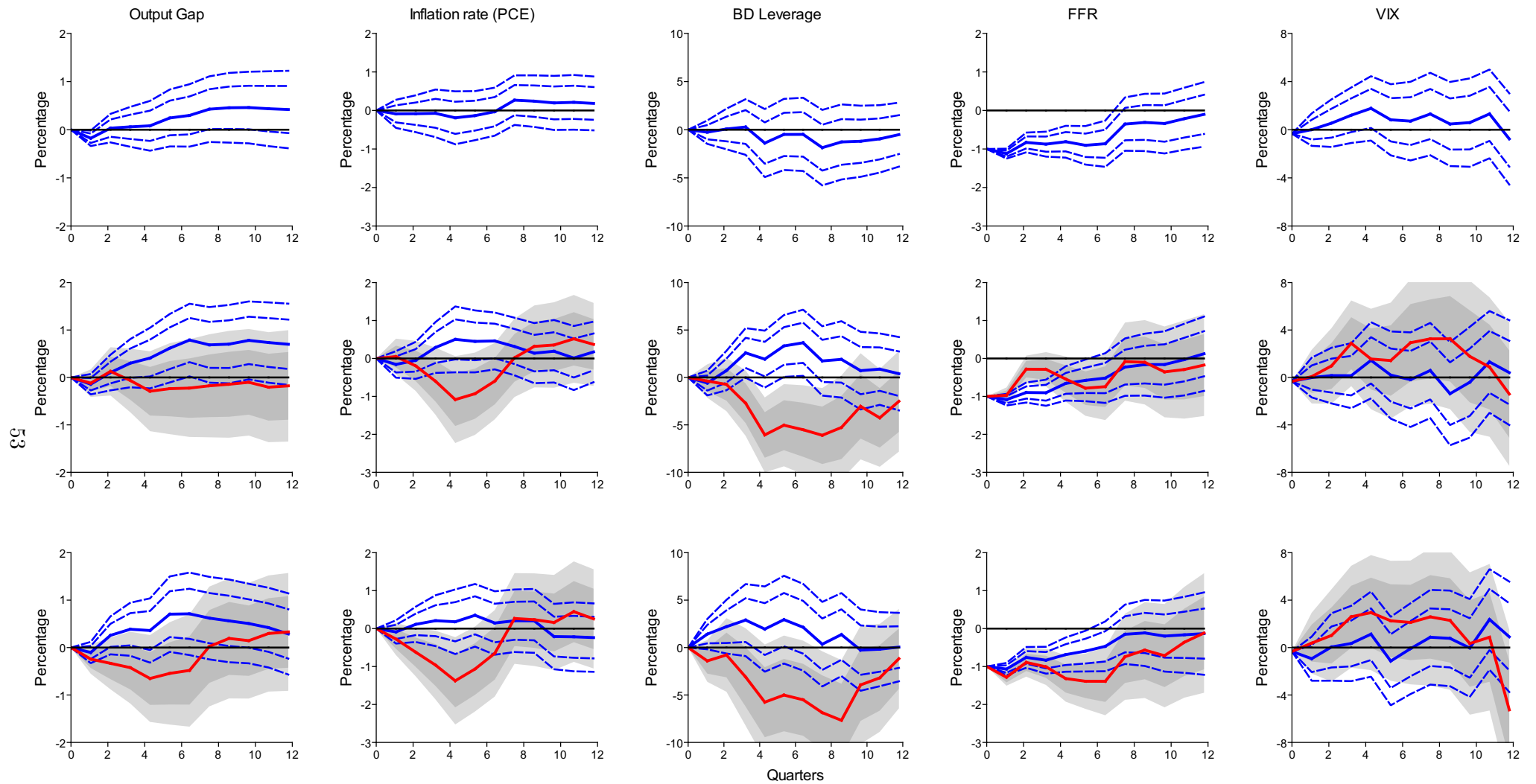


Figure A.16: IRFs of the five-variable model using an alternative price index to measure inflation. Here, inflation computed from personal consumption expenditure index was swapped in. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

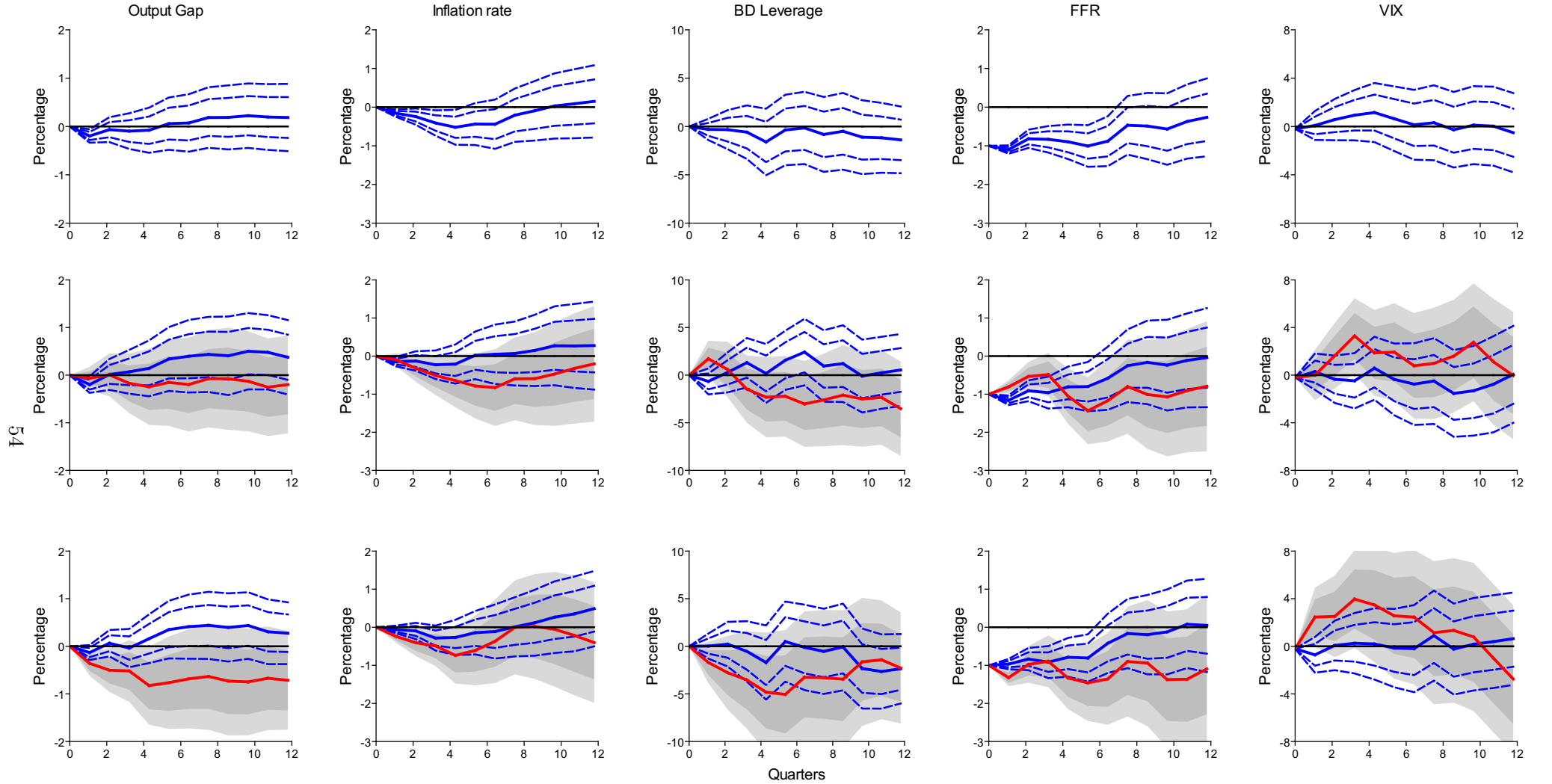


Figure A.17: IRFs of the five-variable model using an alternative lag specification. Here, a two lag projection model, which is based on the BIC, is used instead of the four lags used in the baseline model. The top horizontal model shows the IRFs of the linear model. The second and third horizontal panels show the IRFs of the threshold models using HP and Hamilton detrended leverage as threshold indicators respectively. Blue solid lines reflect IRFs of the linear model and the below trend leverage state of the threshold models. The dashed lines are 68% (inner) and 90% (outer) confidence bands around the IRFs of the linear model and the below trend state of the threshold models. Solid red lines show the above trend IRFs for the two threshold models and dark and light shaded regions are 68% (dark-shade) and 90% (light-shade) confidence bands around the IRFs for the above trend leverage state.

Data description

Variable name with explanation	Source
Real GDP (GDPC1) year over year percentage change	Federal Reserve Economic Data (FRED)
Output gap	Federal Reserve Economic Data (FRED)
Real GDP (GDPC1)	Federal Reserve Economic Data (FRED)
Industrial Production: Total Index (INDPRO)	Federal Reserve Economic Data (FRED)
Federal Funds Effective Rate (FEDFUNDS)	Federal Reserve Economic Data (FRED)
Consumer Price Index for All Urban Consumers: All Items in U.S. City Average (CPIAUCSL) (Year-over-year percentage)	Federal Reserve Economic Data (FRED)
Broker dealer total financial liabilities (FL664190005.Q)	Board of Governors of the Federal Reserve System,
Broker dealer total financial assets (FL664090005.q)	Board of Governors of the Federal Reserve System,
VIX (Uncertainty index)	Chicago Board of Options Exchange
Personal Consumption Expenditures: Durable Goods (PCEDG)	Federal Reserve Economic Data (FRED)
Personal Consumption Expenditures: Nondurable Goods (PCEND)	Federal Reserve Economic Data (FRED)
Inflation based on Personal Consumption Expenditures: Chain-type Price Index (PCEPI) (Year-over-year percentage)	Federal Reserve Economic Data (FRED)
Real Gross Private Domestic Investment (GPDIC1)	Federal Reserve Economic Data (FRED)
Total Credit to Private Non-Financial Sector, Adjusted for Breaks, for United States (CRDQUSAPABIS) (Year over year percentage change)	Federal Reserve Economic Data (FRED)
Divisia M4- year-over-year percentage growth rate	Center for Financial Stability: https://centerforfinancialstability.org/
Divisia M3 year-over-year percentage growth rate	Center for Financial Stability: https://centerforfinancialstability.org/
Federal funds rate with Wu-Xia Shadow Federal Funds Rate as a proxy for the Zero lower bound periods	Federal Reserve Bank of Atlanta
All-Transactions House Price Index for the United States (USSTHPI)	Federal Reserve Economic Data (FRED)
Romer and Romer monetary policy shocks	Available from Dr. Olivier Coibion
TED Spread (TEDRATE)	Federal Reserve Economic Data (FRED)
NBER based Recession Indicators for the United States from the Period following the Peak through the Trough (USREC)	Federal Reserve Economic Data (FRED)