Online Appendix for 'COVID-19-Induced Shocks and Uncertainty'

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A The Econometric Methodology

The Bayesian Algorithm. The baseline model is defined as:

$$Y_t = X_t\beta + \mu_t \tag{A.1}$$

where Y_t is $1 \times N$ matrix of endogenous variables, $\underbrace{X_t}_{1\times(NP+1)} = [X_{t-1}, .., X_{t-P}, 1]$ denotes the regressors in each equation and β is a $(NP+1) \times N$ matrix of coefficients. The error term is heteroscedastic:

$$\mu_t \tilde{} N\left(0, \Sigma_H\right) \text{ periods of CIU events}$$
$$\mu_t \tilde{} N\left(0, \Sigma_L\right) \text{ all other periods}$$

We use a natural conjugate prior for the VAR parameters implemented via dummy observations,see Bańbura et al. (2010):

$$Y_{D,1} = \begin{pmatrix} \frac{diag(\gamma_1\sigma_1 ... \gamma_N\sigma_N)}{\tau} \\ 0_{N\times(P-1)\times N} \\ ..... \\ diag\left(\sigma_1 ... \sigma_N\right) \\ ..... \\ 0_{1\times N} \end{pmatrix}, and\ X_{D,1} = \begin{pmatrix} \frac{J_P \otimes diag(\sigma_1 ... \sigma_N)}{\tau} & 0_{NP\times 1} \\ 0_{N\times NP+1} \\ ..... \\ 0_{1\times NP} & I_1 \times c \end{pmatrix} \tag{A.2}$$

where γ_1 to γ_N denote the prior mean for the coefficients on the first lag, τ is the tightness of the prior on the VAR coefficients and c is the tightness of the prior on the constant. In our application, the prior means are chosen as the OLS estimates of the coefficients of an AR(1) regression estimated for each endogenous variable. We set $\tau = 0.1$. The scaling factors σ_i are set using the standard deviation of the error terms from these preliminary AR(1) regressions. Finally we set $c = 1/10000$ in our implementation indicating a flat

prior on the constant. We also introduce a prior on the sum of the lagged dependent variables by adding the following dummy observations:

$$Y_{D,2} = \frac{diag\left(\gamma_1\mu_1 ... \gamma_N\mu_N\right)}{\lambda},\ X_{D,2} = \begin{pmatrix} \frac{(1_{1\times p})\otimes diag(\gamma_1\mu_1 ... \gamma_N\mu_N)}{\lambda} & 0_{N\times 1} \end{pmatrix} \tag{A.3}$$

where μ_i denotes the sample means of the endogenous variables calculated using AR(1) preliminary regressions. We set a loose prior of $\lambda = 10000\tau$.

The baseline VAR model is estimated via Gibbs sampling. Conditional on Σ_H and Σ_N, the posterior distribution of $b = vec\left(\beta\right)$ is normal with mean M^* and variance V^* where

$$V^* = \left(\sum_{t=1}^{T}\left(R_t^{-1}\otimes X_t X_t'\right) + S_0^{-1}\right)^{-1} \tag{A.4}$$

$$M^* = V^*\left(vec\left(\sum_{t=1}^{T}\left(X_t Y_t' R_t^{-1}\right)\right) + S_0^{-1}\tilde{\beta}_0'\right) \tag{A.5}$$

where $R_t = \Sigma_H$ over periods characterized by the financial shock and $R_t = \Sigma_N$, otherwise. The prior for the VAR coefficients based on dummy observations is $N\left(\tilde{B}_0, S_0\right)$. Conditional on a draw for β, the conditional posterior for $\Sigma_i, i = 0, 1$ is inverse Wishart: $IW\left(\mu_i'\mu_i + s_0, T + t_0\right)$ where μ_i denotes the residuals associated with period of CIU shock when $i = 1$ and all other periods when $i = 0$. The prior for the VAR error covariance implied by the dummy observations is $IW\left(s_0, t_0\right)$.

The estimation of the three identification approaches in Section 5 relies as well on Bayesian techniques. Specifically, for the PF and Choleski approaches we follow Caldara et al. (2016) and impose Minnesota priors choosing optimally the hyperparameters that maximize the marginal data density. In the sign restriction scheme we impose a standard tightness of the Minnesota prior of 0.1 as in the statistical approach. The lag is set to 10 in all specifications.

B Description of the Data

1. **Daily Financial Data**

   - the S&P500 index at daily frequency, transformed in logs. FRED link https://fred.stlouisfed.org/series/SP500
   - the VIX index at daily frequency, transformed in logs. FRED link https://fred.stlouisfed.org/series/VIXCLS.
   - the DGS1 index is the 1-year Treasury Constant Maturity Rate, FRED link https://fred.stlouisfed.org/series/DGS1
   - the MSCI world index is a cap-weighted world stock market index, FRED link https://uk.finance.yahoo.com/quote/MSCI/history?p=MSCI
   - the TED spread is the difference between the three month Treasury bill and the three-month LIBOR based index, FRED link https://fred.stlouisfed.org/series/TEDRATE
   - the BAA Spread isMoody's Seasoned Baa Corporate Bond Yield Relative to Yield on 10-Year Treasury Constant Maturity, FRED link https://fred.stlouisfed.org/series/BAA10Y
   - the EPU index is the economic policy uncertainty index by Baker et al. (2016), transformed in logs. Link https://www.policyuncertainty.com

2. **Daily Economic indicator**, tracktherecovery.org

   (a) Spending data from Affinity Solutions: Aggregated and anonymized purchase data from consumer credit and debit card spending. Spending is reported based on the ZIP code where the cardholder lives, not the ZIP code where transactions occurred.

      - Aggregate Spending: Seasonally adjusted credit/debit card spending relative to January 4-31 2020 in all merchant category codes, 7 day moving

average.

- Spending in 'accomodation and food service' category: Seasonally adjusted credit/debit card spending relative to January 4-31 2020 in accomodation and food service (ACF) MCCs, 7 day moving average, 7 day moving average.
- Spending in arts et cetera: Seasonally adjusted credit/debit card spending relative to January 4-31 2020 in arts, entertainment, and recreation (AER) MCCs, 7 day moving average.
- Spending in general merchandising stores: Seasonally adjusted credit/debit card spending relative to January 4-31 2020 in general merchandise stores (GEN) and apparel and accessories (AAP) MCCs, 7 day moving average.
- Spending in grocery and food store: Seasonally adjusted credit/debit card spending relative to January 4-31 2020 in grocery and food store (GRF) MCCs, 7 day moving average.
- Spending in health care services: Seasonally adjusted credit/debit card spending relative to January 4-31 2020 in health care and social assistance (HCS) MCCs, 7 day moving average.
- Spending in transportation and warehousing: Seasonally adjusted credit/debit card spending relative to January 4-31 2020 in transportation and warehousing (TWS) MCCs, 7 day moving average.
- Spending high income households: Seasonally adjusted credit/debit card spending by consumers living in ZIP codes with high (top quartile) median income, relative to January 4-31 2020 in all merchant category codes (MCC), 7 day moving average.
- Spending middle income households: Seasonally adjusted credit/debit card spending by consumers living in ZIP codes with middle (middle two quartiles) median income, relative to January 4-31 2020 in all merchant cat-

egory codes (MCC), 7 day moving average.

- Spending low income households: Seasonally adjusted credit/debit card spending by consumers living in ZIP codes with low (bottom quartiles) median income, relative to January 4-31 2020 in all merchant category codes (MCC), 7 day moving average.

(b) Employment data from Paychex, Intuit, Earnin and Kronos: Number of active employees, aggregating information from multiple data providers. This series is based on firm-level payroll data from Paychex and Intuit, worker-level data on employment and earnings from Earnin, and firm-level timesheet data from Kronos. All data is daily, presented as a 7-day moving average, as percent deviation relative to January 4-31 2020.

- Aggregate employmeny: Employment level for all workers.
- Empoyment low income households: Employment level for workers in the bottom quartile of the income distribution (incomes approximately under $ 27,000).
- Empoyment middle income households: Employment level for workers in the middle two quartiles of the income distribution (incomes approximately $27,000 to $60,000).
- Empoyment high income households: Employment level for workers in the top quartile of the income distribution (incomes approximately over $60,000).
- Employmeny NAICS supersector 40: Employment level for workers in trade, transportation and utilities.
- Employmeny NAICS supersector 60: Employment level for workers in professional and business services .
- Employmeny NAICS supersector 65: Employment level for workers in education and health services.

- Employmeny NAICS supersector 70: Employment level for workers in leisure and hospitality.

(c) Small business openings and revenue data from Womply. Small business transactions and revenue data aggregated from several credit card processors. Transactions and revenue are reported based on the ZIP code where the business is located. Number of small businesses open, as defined by having had at least one transaction in the previous 3 days.

- Small business openings, aggregate: Percent change in number of small businesses open calculated as a seven-day moving average seasonally adjusted and indexed to January 4-31 2020.
- Small business openings, high income areas: Percent change in number of small businesses open calculated as a seven-day moving average seasonally adjusted and indexed to January 4-31 2020 in high income (quartile 4 of median income) ZIP codes.
- Small business openings, middle income areas: Percent change in number of small businesses open calculated as a seven-day moving average seasonally adjusted and indexed to January 4-31 2020 in middle income (quartiles 2 3 of median income) ZIP codes.
- Small business openings, low income areas: Percent change in number of small businesses open calculated as a seven-day moving average seasonally adjusted and indexed to January 4-31 2020 in low income (quartile 1 of median income) ZIP codes.
- Small business openings, NAICS supersector 40: Percent change in number of small businesses open calculated as a seven-day moving average seasonally adjusted and indexed to January 4-31 2020 in transportation.
- Small business openings, NAICS supersector 60: Percent change in number of small businesses open calculated as a seven-day moving average

seasonally adjusted and indexed to January 4-31 2020 in professional and business services.

- Small business openings, NAICS supersector 65: Percent change in number of small businesses open calculated as a seven-day moving average seasonally adjusted and indexed to January 4-31 2020 in education and health services .
- Small business openings, NAICS supersector 70: Percent change in number of small businesses open calculated as a seven-day moving average seasonally adjusted and indexed to January 4-31 2020 in leisure and hospitality.
- Small business revenues, aggregate: percent change in net revenue for small businesses, calculated as a seven-day moving average, seasonally adjusted, and indexed to January 4-31 2020.
- Small business revenues, high income areas: Percent change in net revenue for small businesses, calculated as a seven-day moving average, seasonally adjusted, and indexed to January 4-31 2020 in high income (quartile 4 of median income) zipcodes.
- Small business revenues, middle income areas: Percent change in net revenue for small businesses, calculated as a seven-day moving average, seasonally adjusted, and indexed to January 4-31 2020 in middle income (quartiles 2 3 of median income) zipcodes.
- Small business revenues, low income areas: Percent change in net revenue for small businesses, calculated as a seven-day moving average, seasonally adjusted, and indexed to January 4-31 2020 in low income (quartile 1 of median income) zipcodes.
- Small business revenues, NAICS supersector 40: Percent change in net revenue for small businesses, calculated as a seven-day moving average, sea-

sonally adjusted, and indexed to January 4-31 2020 in transportation.

- Small business revenues, NAICS supersector 60: Percent change in net revenue for small businesses, calculated as a seven-day moving average, seasonally adjusted, and indexed to January 4-31 2020 in professional and business services.
- Small business revenues, NAICS supersector 65:: Percent change in net revenue for small businesses, calculated as a seven-day moving average, seasonally adjusted, and indexed to January 4-31 2020 in education and health services.
- Small business revenues, NAICS supersector 70: Percent change in net revenue for small businesses, calculated as a seven-day moving average, seasonally adjusted, and indexed to January 4-31 2020 in leisure and hospitality.

3. **Other Series**

- Sentiment index is the Daily News Sentiment Index, a high frequency measure of economic sentiment based on lexical analysis of economics-related news articles, see Shapiro et al. (2020), link https://www.frbsf.org/daily-news-sentiment-index/.
- Stock market jumps is a collection of events about jumps of the S&P 500 index as reported and descripbed by Baker et al. (2020), link https://www.stockmarketjumps.com/data/.

C Tables and Figures, COVID-19-Induced Shock

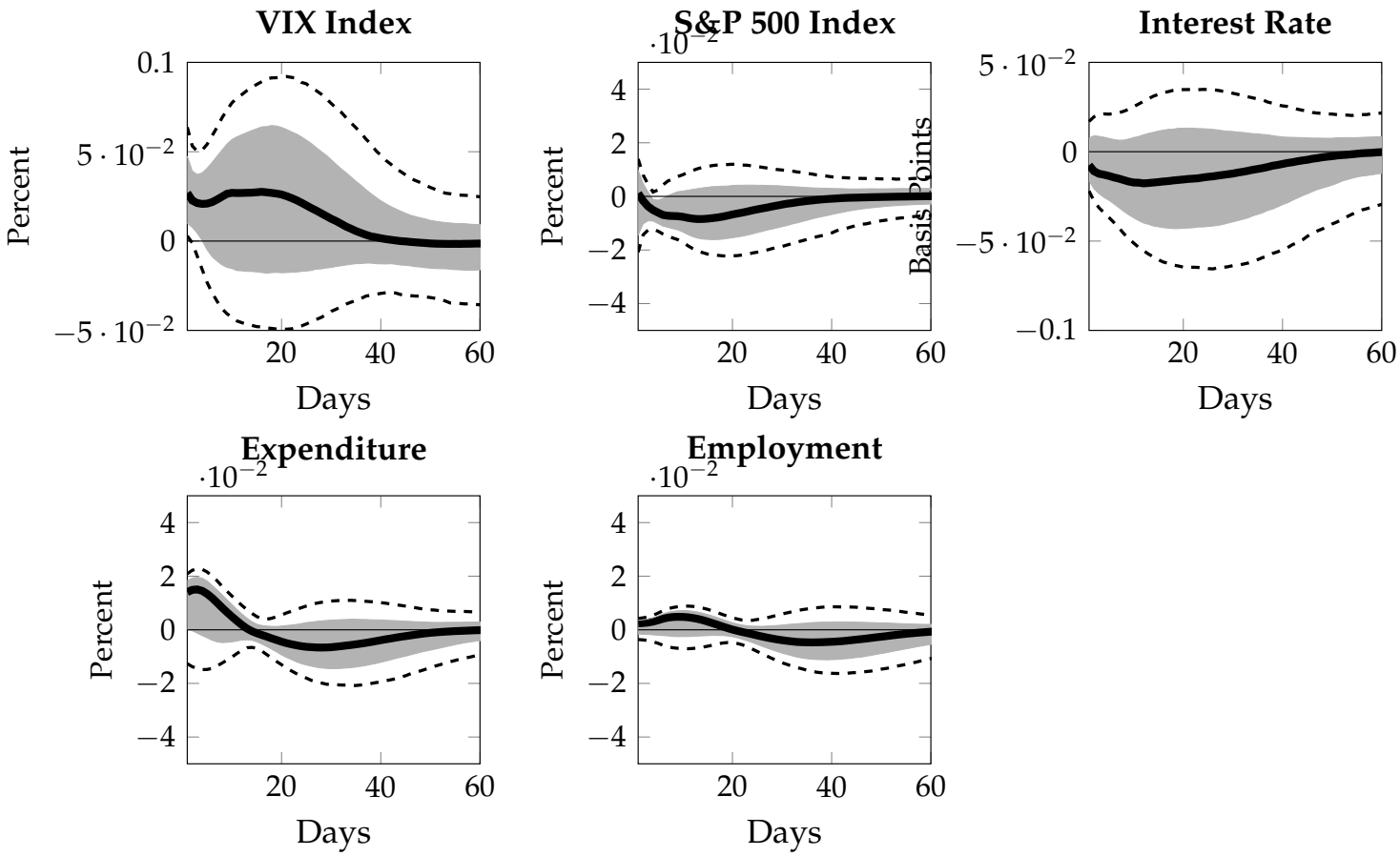

Figure C.1 – IRFs to a COVID-19-induced shock, random event dates. Solid black lines represent the median while shaded areas and broken lines represent the 68 and 90 percent credibility sets, respectively.

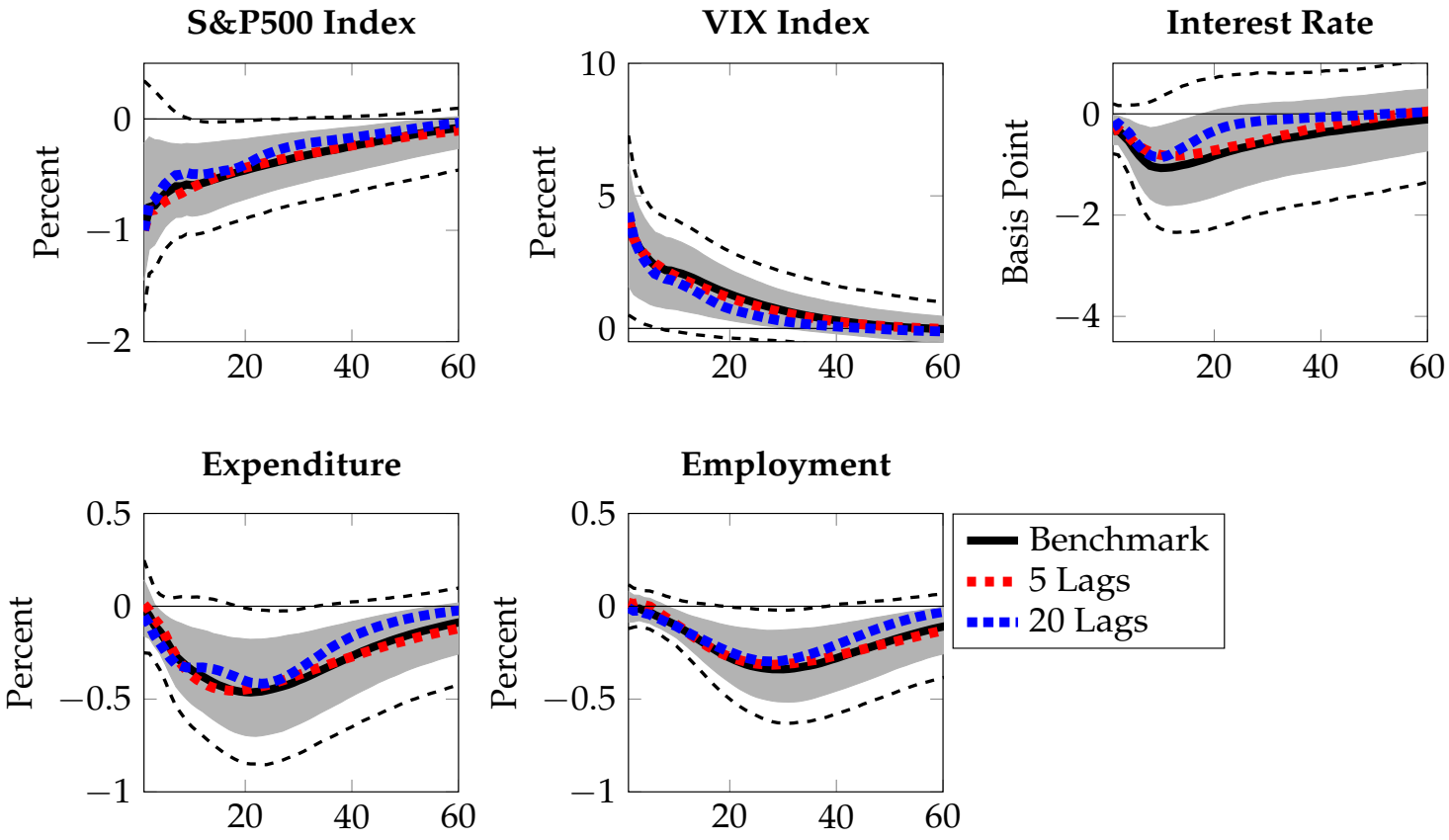

Figure C.2 – IRFs to a COVID-19-induced shock lowering S&P 500 by 1 percent. Different lag structure. Solid black line, median. Red dashed line, median 5 lags. Blue dashed line, median 21 lags. Shaded areas and dotted lines are the 68 and 90 credibility sets of the benchmark, respectively.

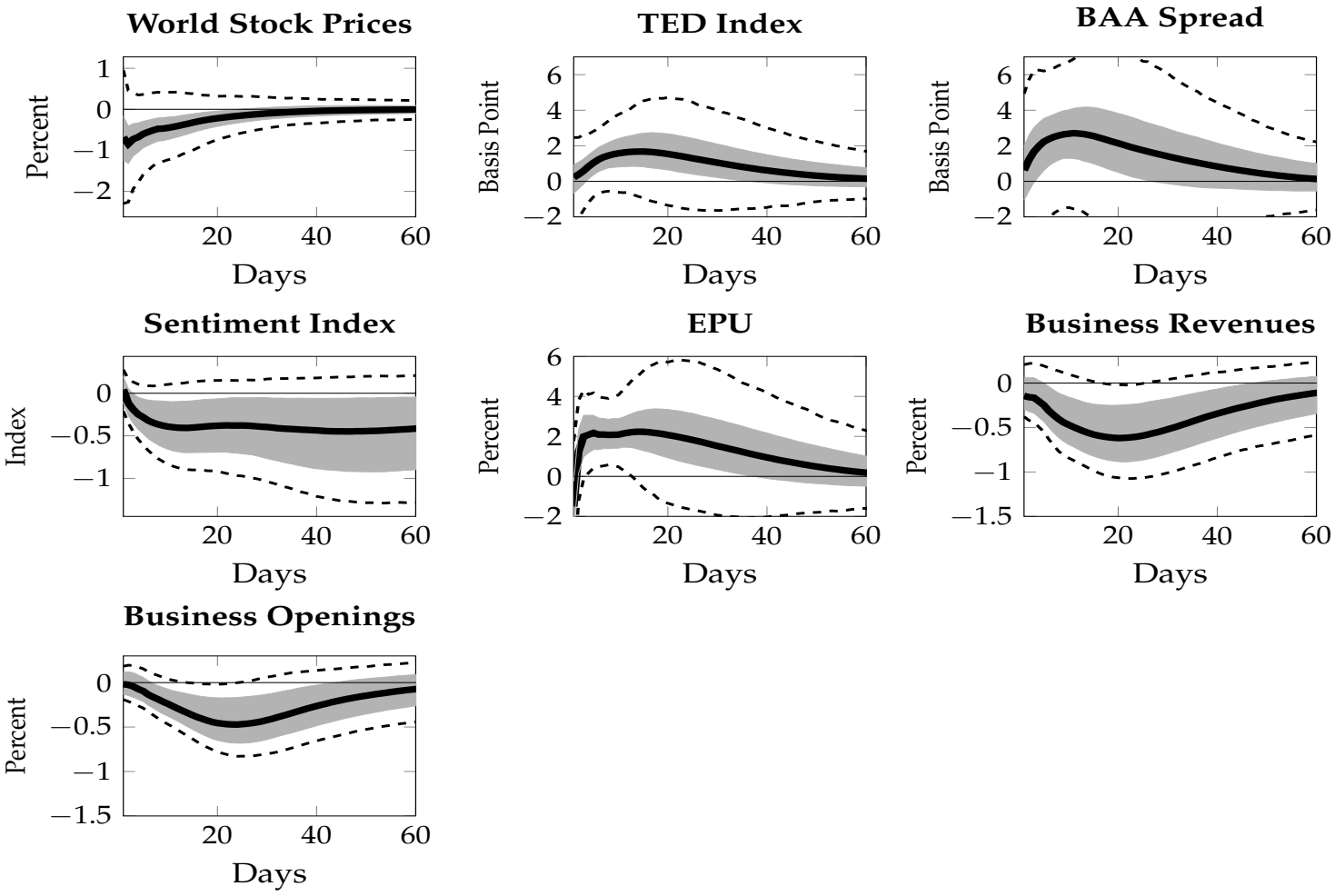

Figure C.3 – IRFs to a COVID-19-induced shock that lowers the S&P 500 Index by 1 pc. Black solid lines represent the median response. Shaded areas and dashed-lines represent the 68 and 90 percent credibility interval, respectively.

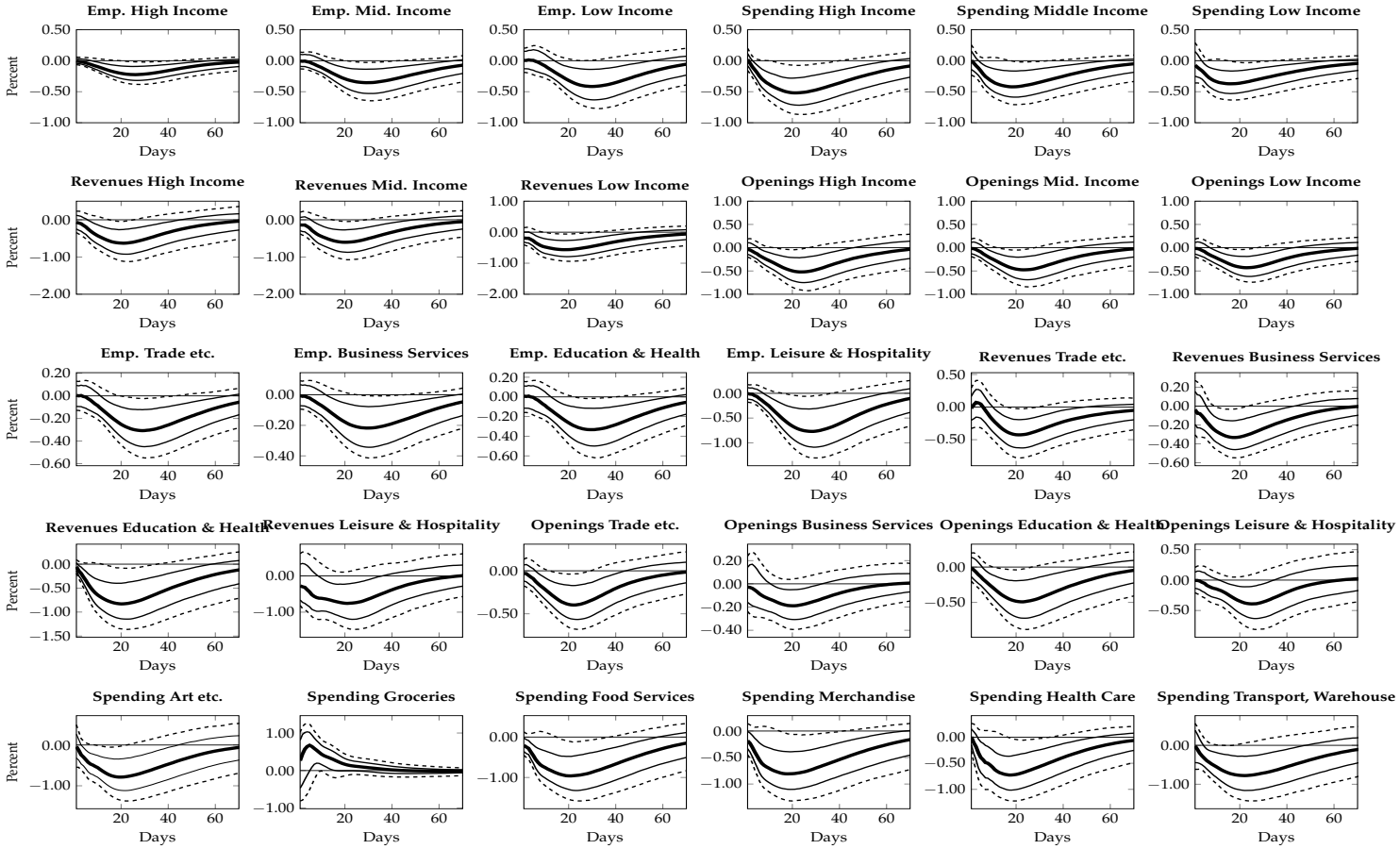

Figure C.4 – IRFs to a COVID-19-induced shock that increases reduces S&P500 by 1 percent. Solid and dashed lines represent the 68 and 90 percent credibility interval, respectively.

D Tables and Figures, Uncertainty Shock

Table C.1 – Peak Effects on Distributional and Sectoral Variables, Various Models. Asterisks * and ** mean 68 and 90 percent significance, respectively.

Part A: Distribution

Variable	**Peak Effect** *baseline*	**Peak Effect** *with feedbacks*	**Period** (in weeks)
Employment, Aggregate	-0.34**	-0.34**	6
Employment, High Income	-0.23**	-0.17*	5
Employment, Mid Income	-0.34**	-0.28*	6
Employment, Low Income	-0.40**	-0.35*	6
Expenditure, Aggregate	-0.47**	-0.47**	5
Expenditure, High Income	-0.58**	-0.53*	5
Expenditure, Mid Income	-0.45**	-0.43*	5
Expenditure, Low Income	-0.39*	-0.38*	6
Small Business Revenue, Aggregate	-0.63**	-0.63**	5
Small Business Revenue, High Income	-0.64**	-0.56*	5
Small Business Revenue, Mid Income	-0.63**	-0.48*	5
Small Business Revenue, Low Income	-0.64**	-0.42*	4
Small Business Openings, Aggregate	-0.49**	-0.49**	6
Small Business Openings, High Income	-0.53**	-0.48*	6
Small Business Openings, Mid Income	-0.49**	-0.43*	6
Small Business Openings, Low Income	-0.44**	-0.38*	6

Part B: Sectors

Variable	**Peak Effect** *baseline*	**Peak Effect** *wit feedbacks*	**Period** (in weeks)
Employment,Trade, Transportation and Utilities	-0.31**	-0.30*	6
Employment, Professional and Business Services	-0.20**	-0.19*	6
Employment, Education and Health Services	-0.31**	-0.30*	6
Employment, Leisure and Hospitality	-0.82**	-0.78*	6
Revenues, Trade, Transportation and Utilities	-0.48**	-0.39*	6
Revenues, Professional and Business Services	-0.36**	-0.32*	5
Revenues, Education and Health Services	-0.94**	-0.81*	6
Revenues, Leisure and Hospitality	-0.72**	-0.77*	5
Business Openings,Trade, Transportation and Utilities	-0.43*	-0.33	5
Business Openings, Professional and Business Services	-0.18*	-0.16*	2
Business Openings, Education and Health Services	-0.50**	-0.43	5
Business Openings, Leisure and Hospitality	-0.39*	-0.35*	5

Part C: Expenditure Categories

Variable	**Peak Effect** *baseline*	**Peak Effect** *with feedbacks*	**Period** (in weeks)
Accommodation and Food Service	-1.78**	-0.70**	5
Arts, Entertainment, and Recreation	-0.87**	-0.49	5
General Merchandise Stores	-1.48**	-1.12**	5
Grocery and Food Store	0.75*	0.54*	1
Health Care and Social Assistance	-0.91**	-0.68*	5
Transportation and Warehousing	-0.79*	-0.52*	5

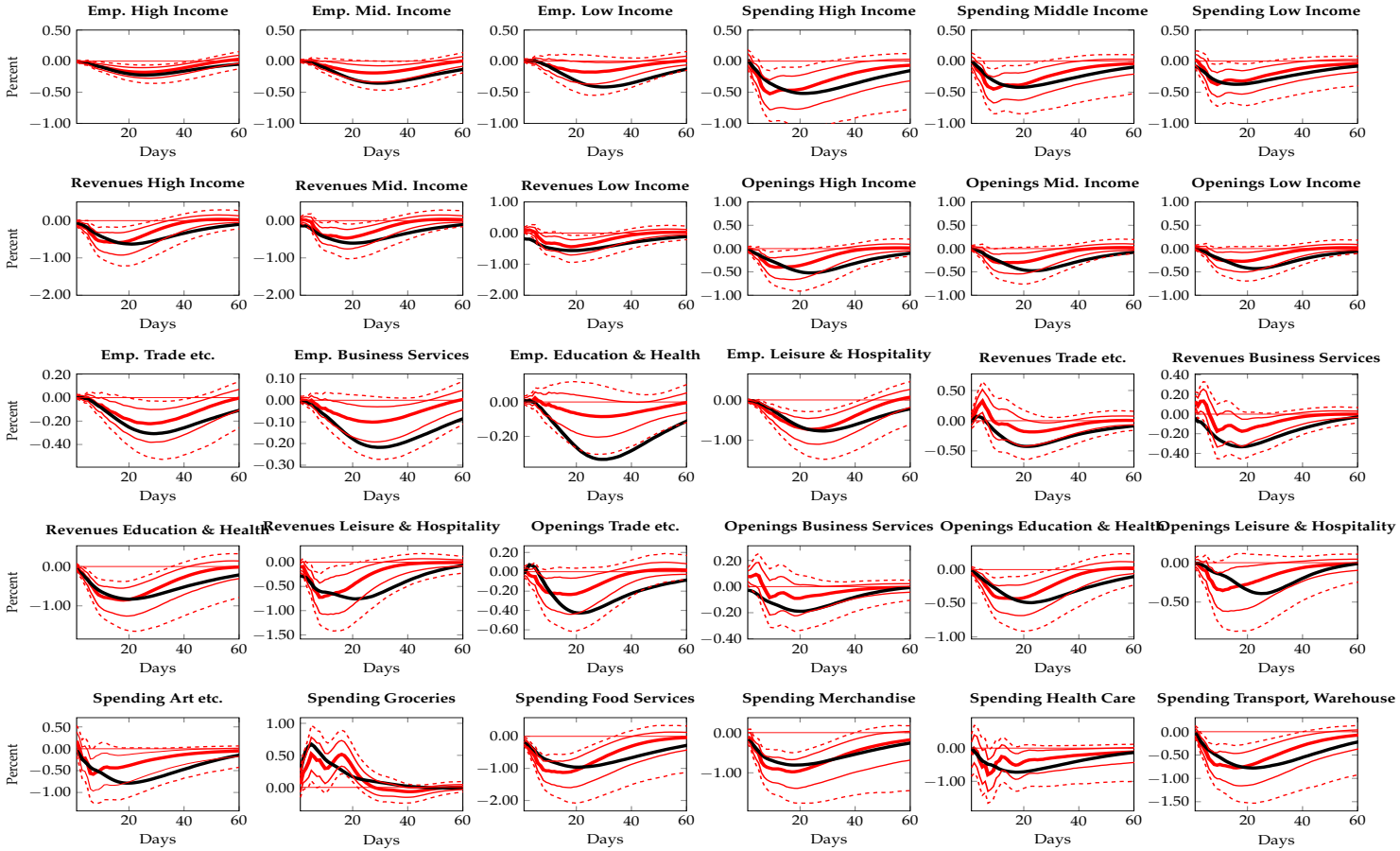

Figure D.1 – IRFs to a Uncertainty Shock that reduces S&P500 by 1 percent, Cholesky identification. Red solid and dashed lines represent the 68 and 90 percent credibility interval, respectively. Black thick lines represent the posterior median response from the statistical models, see Figure C.4.

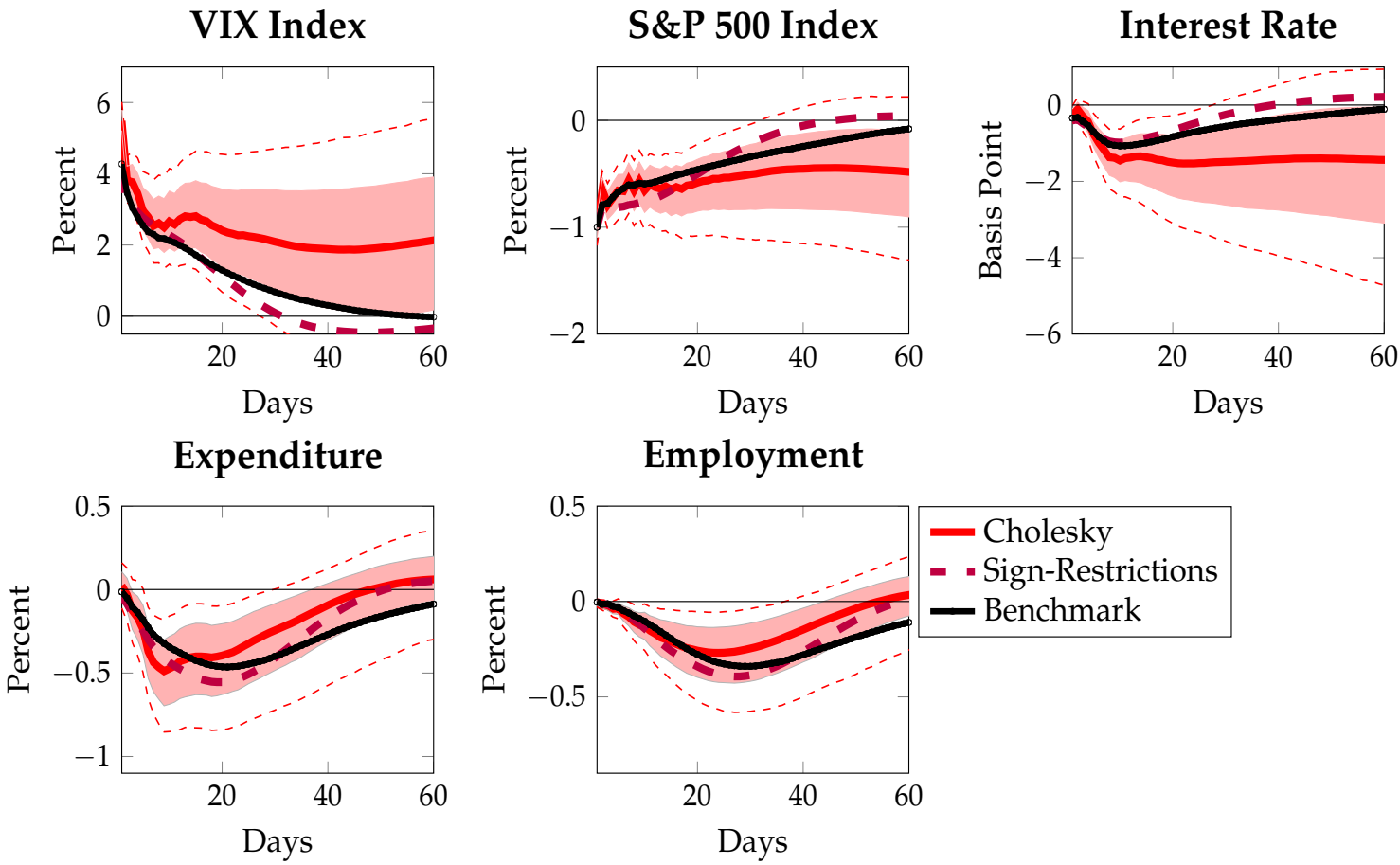

Figure D.2 – IRFs to an uncertainty shock lowering S&P 500 by 1 percent, Cholesky, Sign-Restrictions and benchmark identifications. Solid red lines identify the median for the Cholesky identification, while shaded areas and broken lines represent the 68 and 90 percent credibility set from the same scheme, respectively.

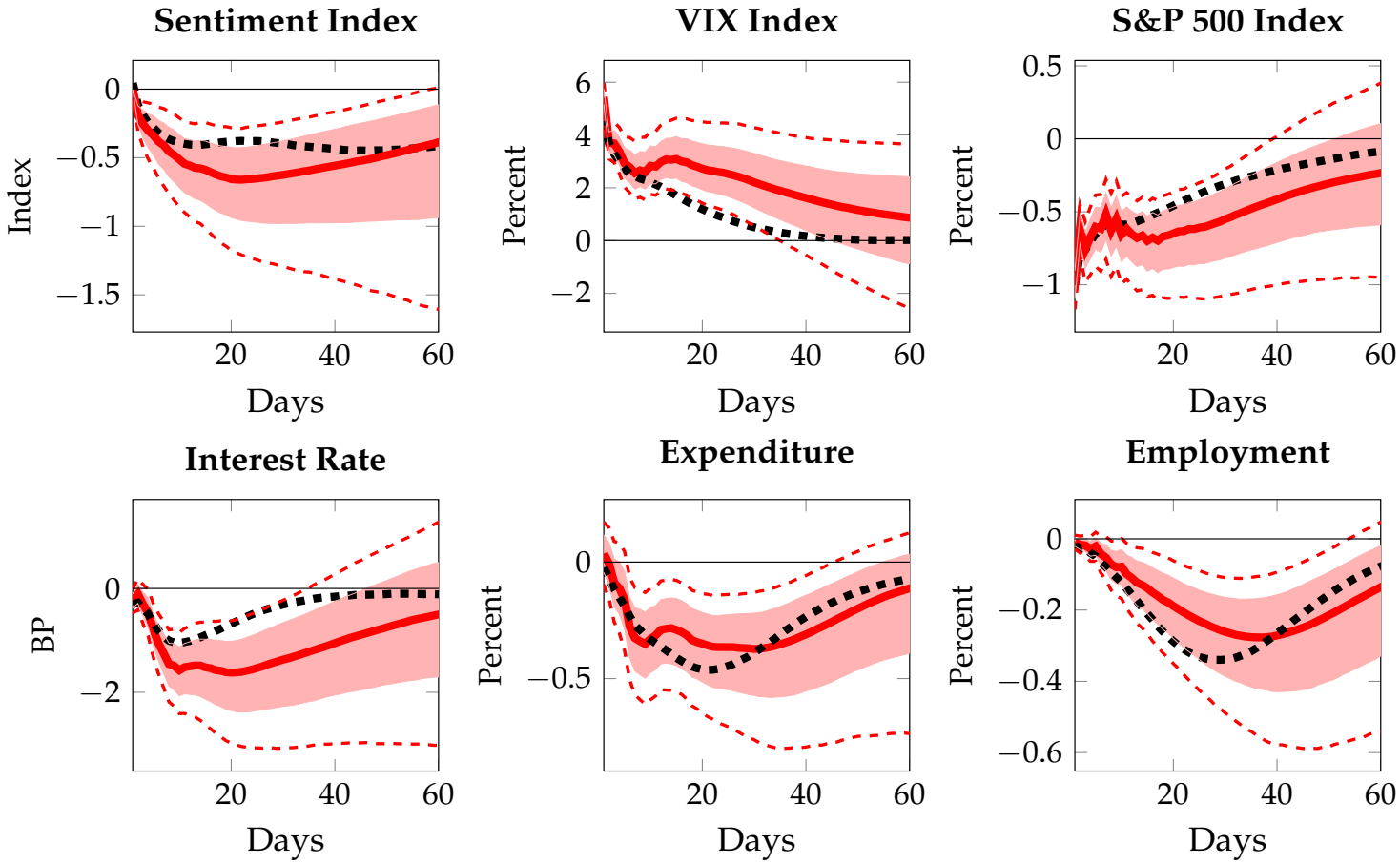

Figure D.3 – IRFs to an uncertainty shock lowering S&P 500 by 1 percent, ncertainty shock sequentially ordered after sentiment shock, Cholesky Identification. Red solid lines identify the median while shaded areas and broken lines represent the 68 and 90 percent credibility sets, respectively. Thick, dashed black line, median of the benchmark statistical identification, extended model, i.e. Baseline plus the Sentiment Index.

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