Appendix 1: Outstanding Debts of Oil Companies in USD million

Firm/Type	Senior Unsec. Debt	Total Debt	Market Capitalization	Debt to Equity
INTEGRATED				
Royal Ducth Shell	63,551.75	63,551.75	94,581.81	67%
Exxon Mobil	44,451.90	46,179.55	141,011.58	33%
Lukoil OSJS	5,031.30	5,500.00	38,302.78	14%
GAZPROM	12,883.02	13,944.20	50,221.85	28%
Equinor	31,253.28	31,253.28	44,613.29	70%
Chevron	22,300.00	22,300.00	136,560.70	16%
Total SA	7,550.00	18,866.14	84,808.39	22%
Rosneft	40,036.66	51,771.32	51,947.09	100%
BP	71,785.22	81,852.55	52,822.95	155%
Eni S.P.A	11,106.28	23,861.49	26,828.34	89%
PTT Plc	3,952.64	4,172.23	29,466.64	14%
Occidental Pet. Corp	35,207.01	37,241.71	8,799.14	423%
Petroleo Brasilerio SA	34,514.59	53,442.36	46,899.87	114%
Suncor Energy	11,333.49	11,333.49	18,302.73	62%
Reposol SA	6,868.94	10,310.84	10,459.79	99%
Husky Energy	5,888.13	7,288.13	3,817.03	191%
Galp Energia	1,776.45	2,077.26	7,228.13	29%
Total	**409,490.66**	**484,946.30**	**846,672.11**	**57%**
UPSTREAM				
Conocco Phillips	9,803.81	10,086.31	32,316.36	31%
CNOOC Ltd	15,940.00	15,940.00	42,400.68	38%
EOG Resources Inc	5,640.00	5,640.00	20,133.98	28%
Canadian Natural Resources	10,575.37	15,479.07	19,309.48	80%
Woodside Petroleum	5,393.31	5,993.31	12,223.99	49%
Pioneer Natural Resources	3,547.91	3,547.91	13,777.64	26%
Marathon Oil Corp	4,200.00	6,200.00	3,260.00	190%
Ovintiv	7,607.30	9,597.30	2,408.91	398%
Continental Resources	5,299.00	5,946.00	4,717.47	126%
Devon Energy	4,348.29	4,348.29	3,326.53	131%
Murphy Oil Corp	2,809.71	2,979.70	1,228.79	242%
Apache Corp	8,905.97	9,470.97	3,149.89	301%
Antero resources corp	2,472.38	3,398.38	982.89	346%
Freeport-McMoRan inc	9,212.37	9,212.37	25,733.31	36%
Hess Corp	5,438.29	6,438.29	11,487.20	56%
Kinder Morgan Energy Inc	32,494.06	32,871.86	27,550.37	119%
Noble Energy	963.45	2,669.43	4,100.00	65%
Total	**134,651.22**	**149,819.19**	**228,107.49**	**66%**
Down Stream				
Valero Energy Co	11,950.00	12,550.00	15,600.79	80%
Reliance Industries	13,275.29	27,482.13	181,617.61	15%
SK Innovation Co Ltd	8,195.21	8,195.21	10,649.60	77%
OJS Transneft	3,609.25	3,609.25	2,701.15	134%
Plains All American Pipeline LP	9,750.00	12,327.26	4,681.69	263%
Energy Transfer LP	37,876.85	50,708.33	15,231.53	333%
Enbridge Inc	36,533.88	55,176.54	57,270.47	96%
Kinder Morgan Inc	32,490.99	32,868.85	27,550.37	119%
ONEOK Inc	14,572.40	14,572.40	13,024.00	112%
Megellan Midstream Partners LP	4,700.00	4,700.00	8,059.27	58%
Snam S.P.A	9,233.72	10,058.72	14,253.25	71%
The Williams Companies Inc	21,424.46	21,424.46	23,567.31	91%
Nipoil JXTG	2,336.45	3,481.05	11,107.40	31%
Total	**205,948.50**	**257,154.20**	**385,314.44**	**67%**
Industry Total	**750,090.38**	**891,919.69**	**1,460,094.04**	**61%**

Note: We used classification provided in the Bloomberg data base which is consistent with industry classification.

Appendix 2: Variables (weekly) and Definition.

Variable	Definition
Dependent Variable	
DCDS	The weekly changes of the CDS spread.
DUSD	The weekly changes of the USD index.
DWTIC	The weekly changes of the oil price.
Covariates	
Firm-Level factors	
Stock Return	Individual stock return over a 180-day window
Volatility	Individual historical volatility of the annualized stock return over a 180-day window.
Illiquidity	The bid-ask spread of CDS quotes at the end of the week.
Leverage	The market-based leverage ratio of the firm.
Common factors	
Spot	10-year treasury yield rate of home country at the end of the week.
Slope	Term structure slope at the end of the week, the difference between 10-year treasury yield rate and 2-year treasury yield rate of home country.
Market Return	Annualized return of the corresponding market index over 180-day window. For companies from North America, Europe, Britain, Japan, India, Thailand, Russia and Australia, this research used the 180-day return of the SP500 stock market index, EURONEXT100 stock market index, FTSE 100 stock market index, Nikkei 225 stock market index, NIFTY50 stock market index, SET stock market index, IMOEX stock market index, and AORD stock market index, respectively.
Market Vol	Historical volatility of the annualized corresponding market index return over a 180-day window.

Source: Bloomberg market data terminal

Appendix 3: Robustness Test

Table A1 Addition results: Alternative panel regression.

This table presents the panel regression results as discussed in section 6.3. GFC is the dummy variable which equals 1 for the period January 1, 2007 to June 30, 2009 and zero otherwise. OIL is the dummy variable which equals 1 for the period July 1, 2014 to December 31, 2017 and zero otherwise. COVID is the dummy variable which equals 1 for the period January 20, 2020 to August 31, 2020 and zero otherwise. GFC_DWTIC, OIL_DWTIC, COVID_DWTIC are the interaction terms between the corresponding dummy variable and DWTIC, respectively. GFC_DUSD, OIL_DUSD, COVID_DUSD are the interaction terms between the corresponding dummy variable and DUSD, respectively. Δ represents the first-difference transformation. Firm fixed effects are controlled. We report the standardized beta coefficient in the table to eliminate scalar issues. Standard errors are clustered at firm level and presented in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

	(1)	(2)	(3)
	DCDS	DCDS	DCDS
DWTIC	-0.062***	-0.114***	-0.060***
	(0.0806)	(0.125)	(0.0758)
DUSD	0.042***	0.026*	0.047***
	(0.257)	(0.283)	(0.275)
GFC	-0.011	-0.010	-0.009
	(0.483)	(0.503)	(0.477)
OIL	-0.022***	-0.011**	-0.018***
	(0.202)	(0.205)	(0.203)
COVID	-0.049***	-0.019*	-0.045***
	(1.571)	(1.204)	(1.649)
GFC_DWTIC	0.016**		0.012
	(0.0703)		(0.0819)
OIL_DWTIC	-0.101***		-0.107***
	(0.267)		(0.278)
COVID_DWTIC	-0.119***		-0.103***
	(0.837)		(0.859)
GFC_DUSD		-0.020*	-0.008
		(0.565)	(0.642)
OIL_DUSD		-0.014	-0.038***
		(0.351)	(0.390)
COVID _DUSD		0.095***	0.076***
		(2.026)	(2.125)
Stock Return	-0.013	-0.013	-0.012
	(0.695)	(0.709)	(0.692)
ΔVolatility	0.114**	0.148***	0.121**
	(1163.5)	(1252.8)	(1150.8)

Δilliquidity	0.264***	0.273***	0.264***
	(0.185)	(0.183)	(0.184)
ΔLeverage	0.026***	0.029***	0.028***
	(36.37)	(36.68)	(35.82)
Market Return	0.008	0.020	0.007
	(0.889)	(0.928)	(0.866)
ΔMarket Vol	0.040	0.035	0.023
	(1473.0)	(1300.1)	(1322.4)
ΔSlope	0.001	-0.001	0.001
	(0.399)	(0.410)	(0.407)
ΔSpot	0.010	0.014	0.008
	(3.535)	(3.654)	(3.594)
No. of obs	23,431	23,431	23,431
Adj. R^2	0.165	0.156	0.172

Table A2 Addition results during normal period

This table presents the results of the PVAR models during a normal time period. The VAR model is estimated by GMM, firm fixed effects are removed by Helmert transformation prior to estimation. Standard errors are clustered at firm level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

Response to	Response of		
	(1) CDS	(2) USD	(3) WTIC
CDS(t-1)	0.077**	-0.001*	0.003
	(0.035)	(0.000)	(0.002)
CDS(t-2)	-0.010	0.001***	-0.005**
	(0.023)	(0.000)	(0.002)
CDS(t-3)	0.002	-0.001*	-0.001
	(0.023)	(0.000)	(0.001)
USD(t-1)	0.118	-0.008***	0.302***
	(0.178)	(0.003)	(0.017)
USD(t-2)	0.443***	0.090***	-0.048***
	(0.155)	(0.005)	(0.012)
USD(t-3)	-0.097	-0.090***	-0.151***
	(0.153)	(0.004)	(0.018)
WTIC(t-1)	-0.120***	0.005***	0.045***
	(0.042)	(0.001)	(0.003)
WTIC(t-2)	-0.042	0.026***	-0.027***
	(0.058)	(0.001)	(0.004)
WTIC(t-3)	-0.062	-0.025***	-0.068***
	(0.050)	(0.001)	(0.003)
Control Variables	Yes	Yes	Yes
No. of obs		13,444	
No. of firms		48	
Ave. no. of T		280	

Table A3 Addition results: Alternative panel regression using the full sample and the subsample during the normal period.

This table presents the panel regression results using the full sample and the subsample in a time normal period. Column (1) presents the panel regression results using the full sample while column (2) presents the panel regression results using the subsample during a normal time period. Δ represents the first-difference transformation. Firm fixed effects are controlled-for. We report the standardized beta coefficient in the table to eliminate scalarity issues. Standard errors are clustered at firm level and presented in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

	(1) DCDS	(2) DCDS
DWTIC	-0.118***	-0.065***
	(0.124)	(0.0700)
DUSD	0.037***	0.065***
	(0.258)	(0.278)
Stock Return	-0.012	-0.006
	(0.740)	(0.637)
ΔVolatility	0.097**	0.014
	(1236.0)	(410.7)
Δilliquidity	0.298***	0.334***
	(0.184)	(0.379)
ΔLeverage	0.032***	0.033***
	(36.22)	(35.25)
Market Return	0.028***	-0.009
	(0.797)	(0.764)
ΔMarket Vol	0.049*	0.036***
	(1474.0)	(630.9)
ΔSlope	-0.002	-0.004
	(0.407)	(0.487)
ΔSpot	0.021	0.014
	(3.635)	(2.747)
No. of obs	23,431	13,884
Adj. R^2	0.147	0.132

Table A4 Addition results: controlling the spread of the home country 10-year government bond yield relative to the 10-year U.S.

This table presents the results of the PVAR model as in equation (2). We drop US firms and control for the spread of the home country 10-year government bond yield relative to the 10-year U.S. Treasury yield. The PVAR model is estimated by GMM, firm fixed effects are removed by Helmert transformation prior to estimation. Standard errors are clustered at firm level and reported in parentheses. ***, **, and * denote significance at the 1%, 5%, and 10% level, respectively.

Response to	Response of		
	(1) CDS	(2) USD	(3) WTIC
CDS(t-1)	0.019 (0.013)	0.000 (0.001)	-0.003** (0.001)
CDS(t-2)	0.036 (0.023)	0.002** (0.001)	-0.005** (0.002)
CDS(t-3)	0.007 (0.014)	-0.002*** (0.001)	-0.004*** (0.002)
USD(t-1)	0.258 (0.178)	0.015* (0.009)	0.048 (0.039)
USD(t-2)	0.277** (0.140)	-0.022* (0.011)	0.130*** (0.027)
USD(t-3)	-0.183 (0.229)	-0.086*** (0.004)	-0.200*** (0.012)
WTIC(t-1)	-0.226** (0.092)	-0.001 (0.001)	-0.044*** (0.012)
WTIC(t-2)	-0.097 (0.080)	0.000 (0.003)	0.046*** (0.006)
WTIC(t-3)	0.028 (0.106)	-0.037*** (0.002)	0.034*** (0.008)
Control Variables	Yes	Yes	Yes
No. of obs		7,485	
No. of firms		16	
Ave. no. of T		468	

Figure A1 Cumulative impulse responses for the model: the entire sample

This figure presents the cumulative impulse responses for the model (1). Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.

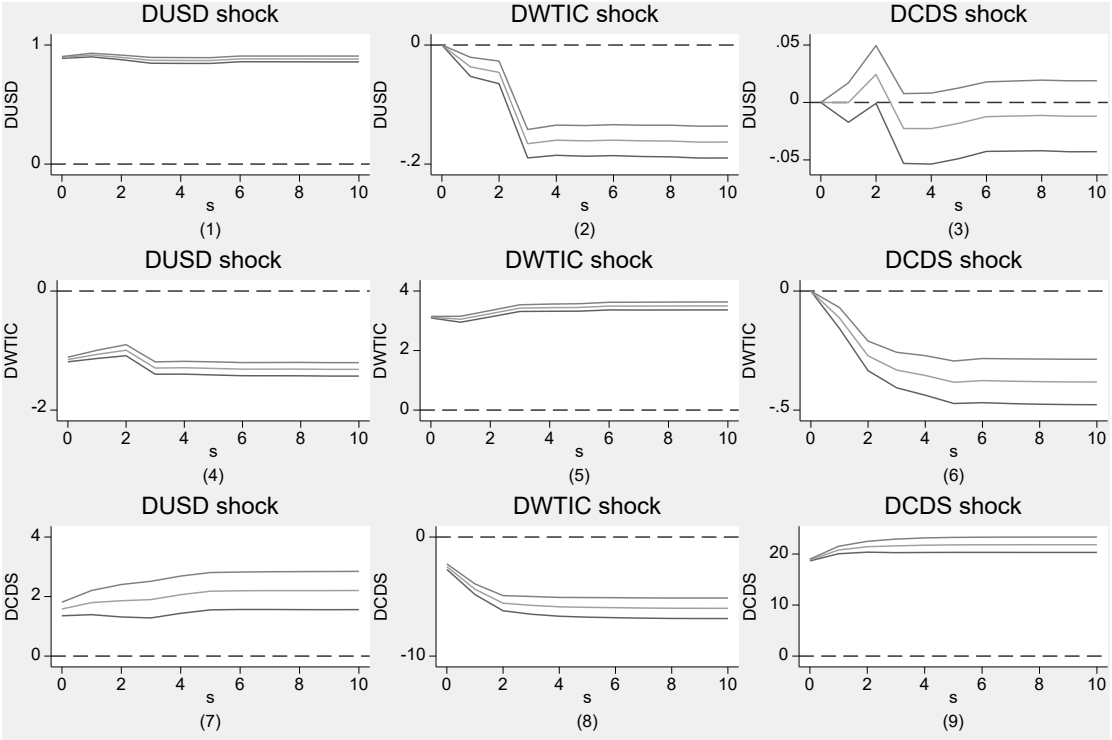
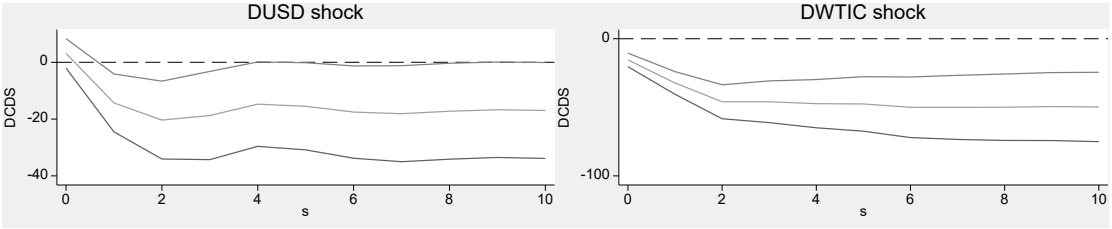
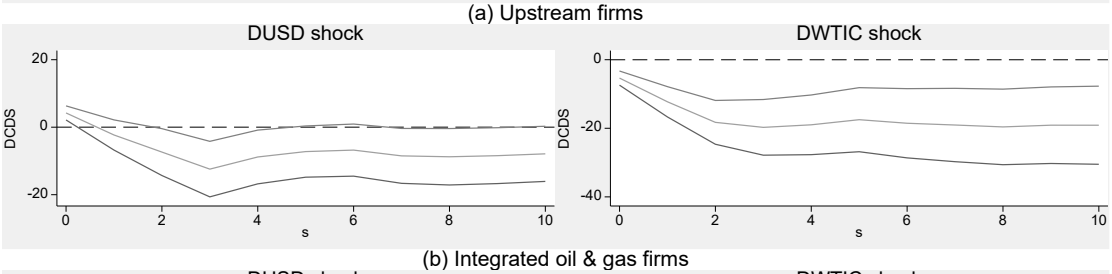


Figure A2 Cumulative impulse responses for the model: different types of firms during the COVID-19 crisis

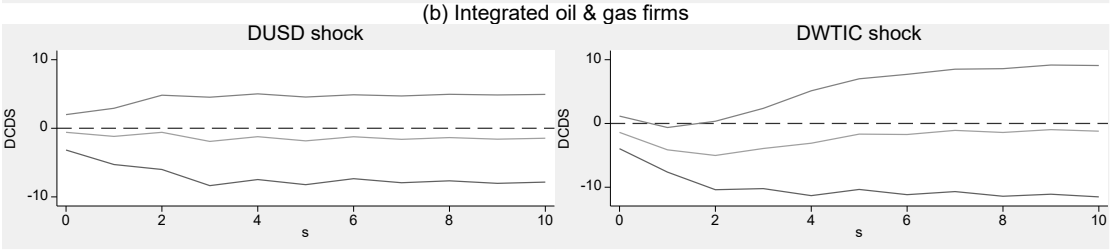
This figure presents the cumulative impulse responses for the model (1) using samples during the COVID-19 crisis. We further split the sample into three groups: upstream firms, integrated oil and gas firms, and downstream firms. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(a) Upstream firms



(b) Integrated oil & gas firms



(c) Downstream firms

Figure A3 Robustness: Impulse responses for the full sample using alternative Cholesky ordering.

This figure presents the impulse responses for the 3-order PVAR model as in equation (2) using alternative Cholesky ordering (DWTIC→DUSD→DCDS). Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.

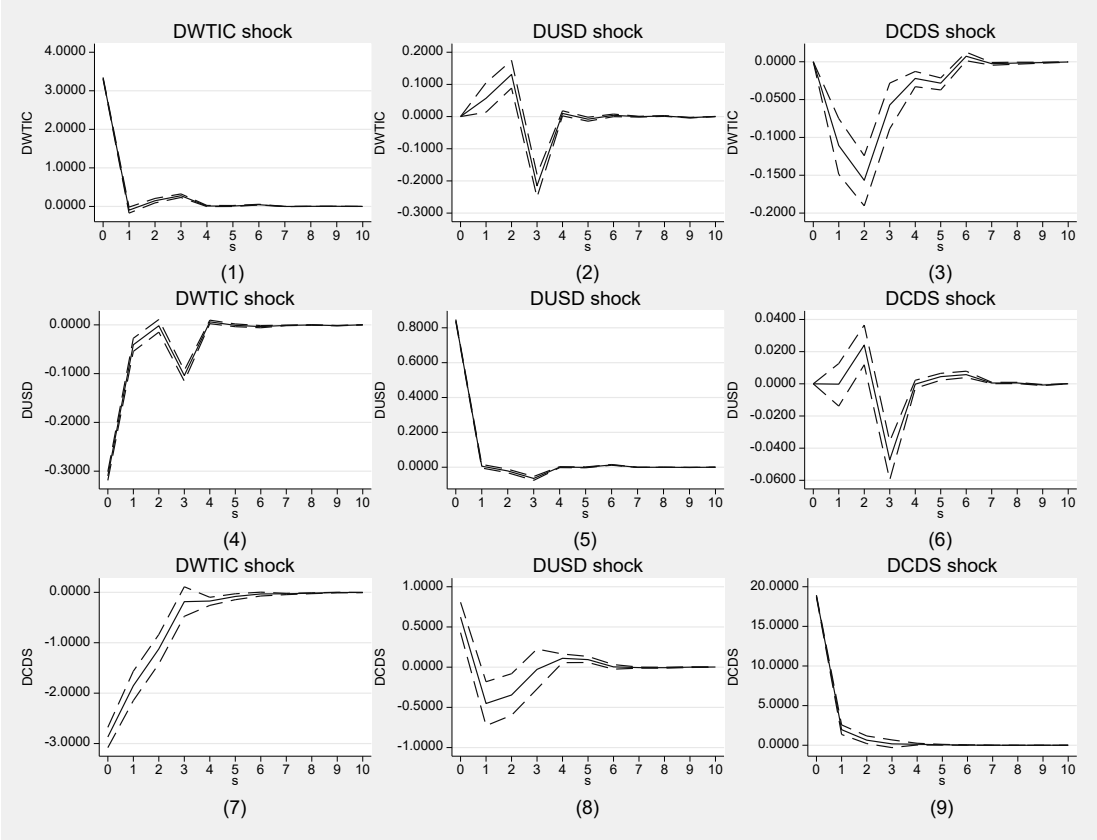
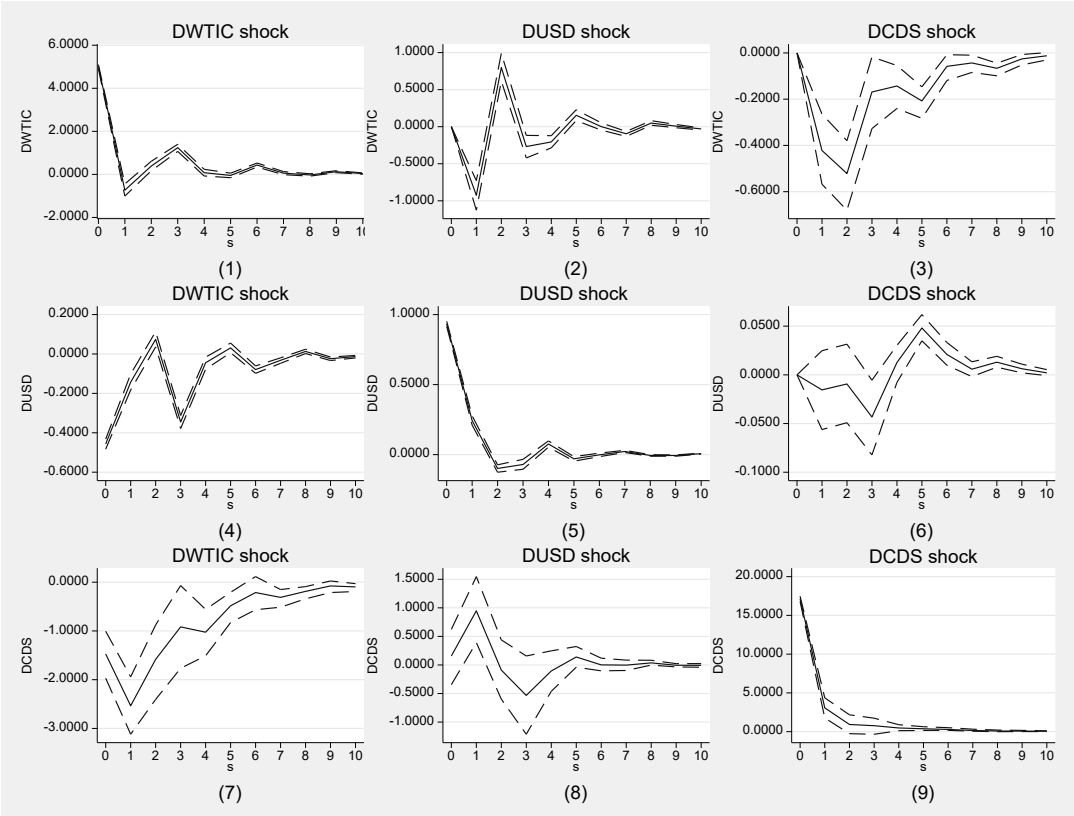
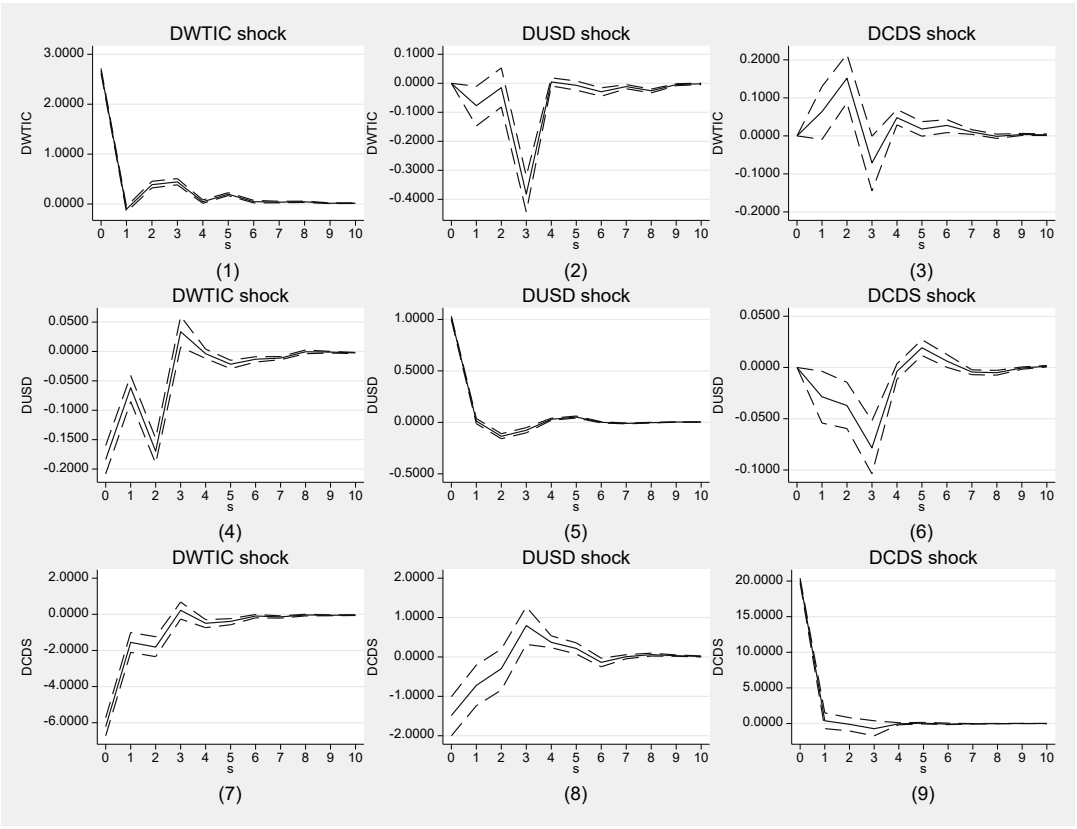


Figure A4 Robustness: impulse responses for different crisis period using alternative Cholesky ordering.

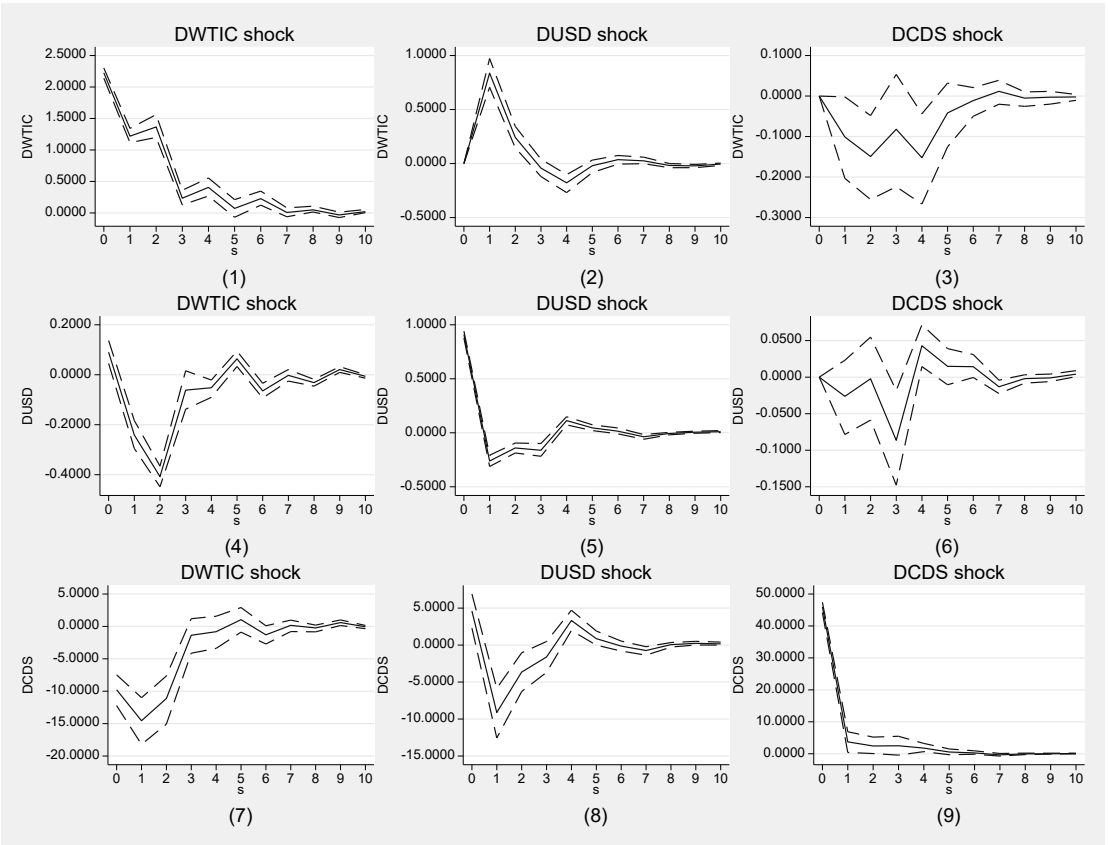
This figure presents the impulse-responses for the 3-order PVAR model as in equation (2) for different crisis periods using alternative Cholesky ordering (DWTIC→DUSD→DCDS). Figure (a) estimates the model using the sample of the GFC period (from Jan 1, 2007 to July 1, 2009). Figure (b) estimates the model using the sample of the 2014-2016 oil-price-plunge period (from July 1, 2014 to December 31, 2016). Figure (c) estimates the model using the sample during the COVID-19 crisis (from Jan 20, 2020 to August 20, 2020). Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(a) GFC crisis



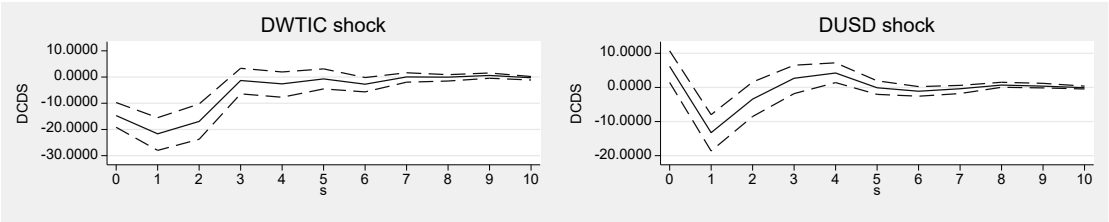
(b) oil price plunge



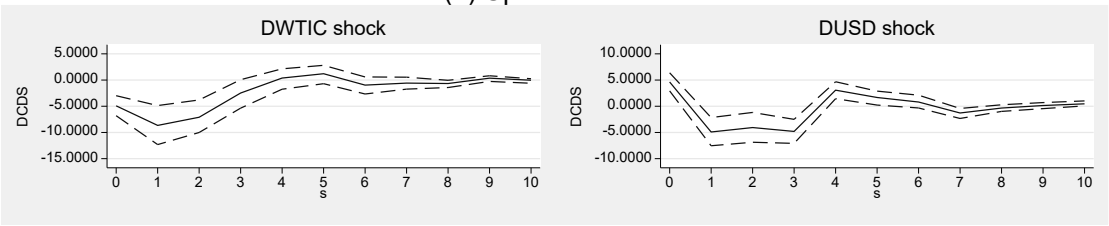
(c) COVID-19

Figure A5 Robustness: Impulse response for different types of oil-related firms during COVID-19

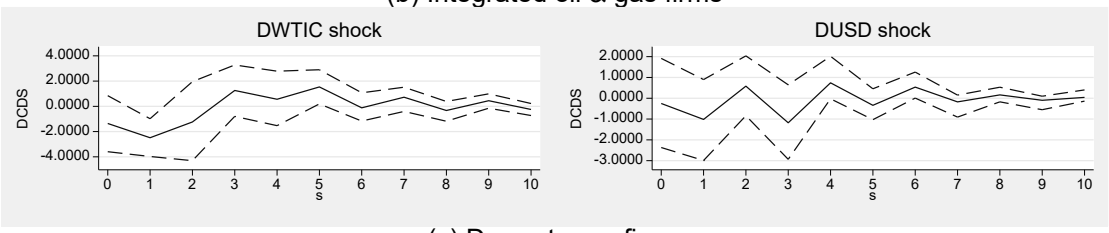
This figure presents the impulse-responses for different types of oil-related firms during COVID-19 based on equation (2) using alternative Cholesky ordering (DWTIC → DUSD → DCDS). Figure (a) estimates the model using the sample of upstream firms. Figure (b) estimates the model using the sample of integrated oil and gas firms. Figure (c) estimates the model using the sample of downstream firms. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(a) Upstream firms



(b) Integrated oil & gas firms



(c) Downstream firms

Figure A6 Robustness: Impulse responses for normal periods

This figure presents the impulse responses for the 3-order PVAR model as in equation (2) using the subsample during normal time periods. Observations from the year 2007-2009, 2014-2016, and 2020 are dropped. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.

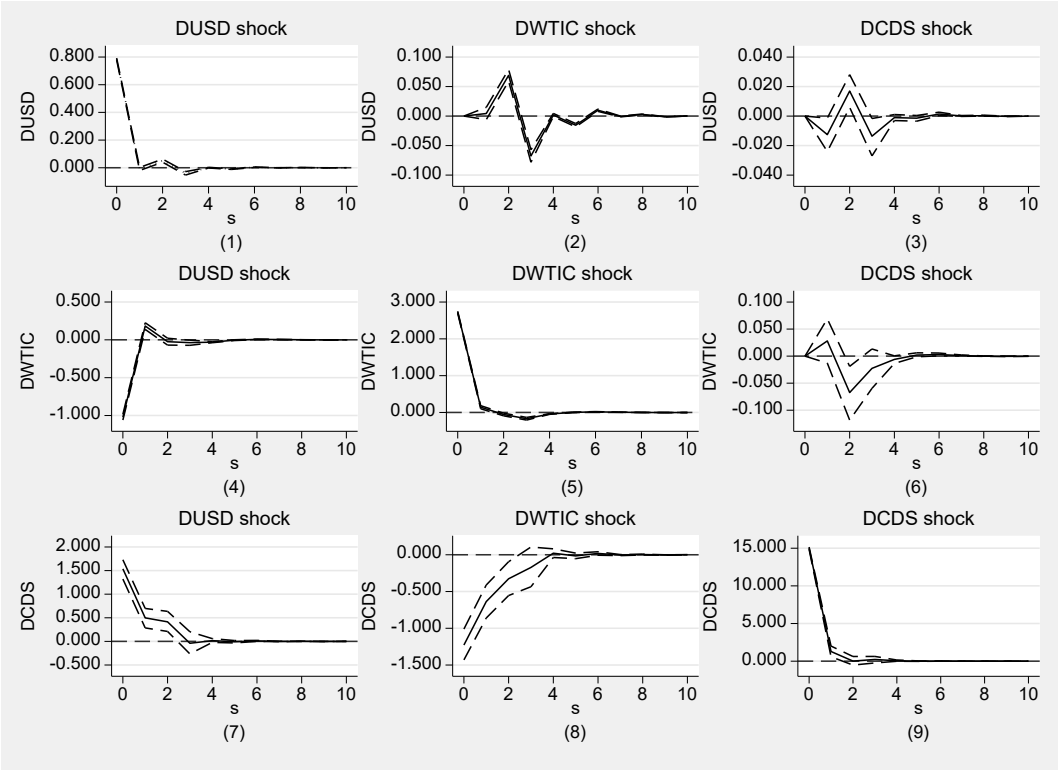
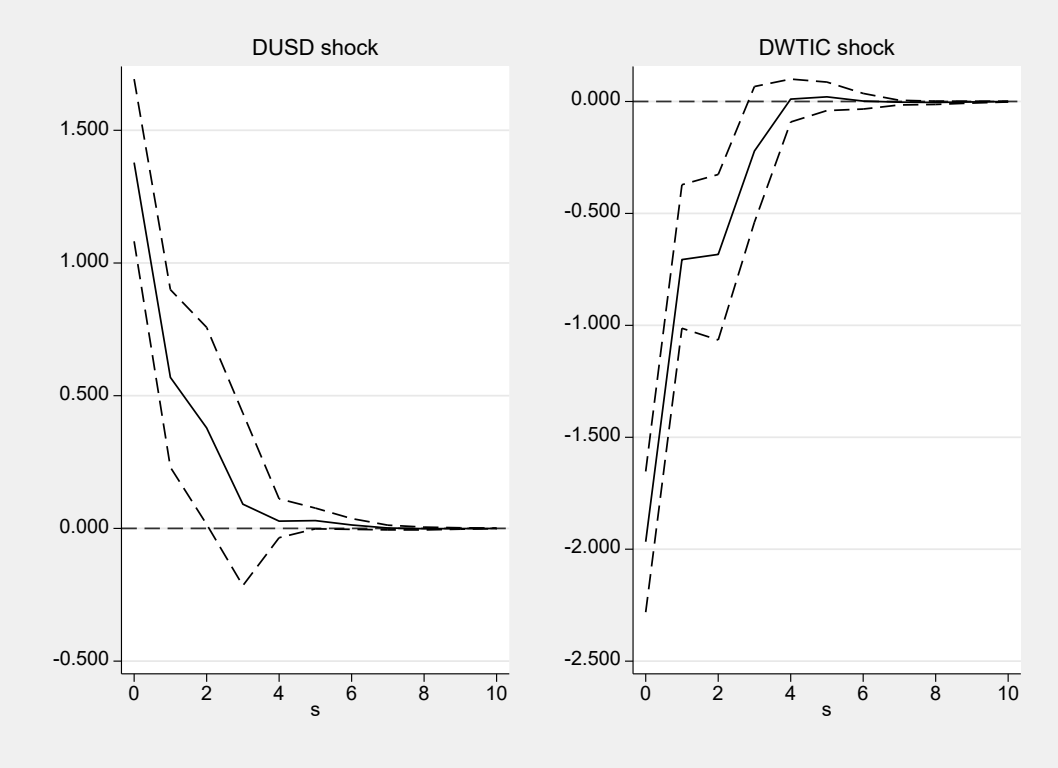
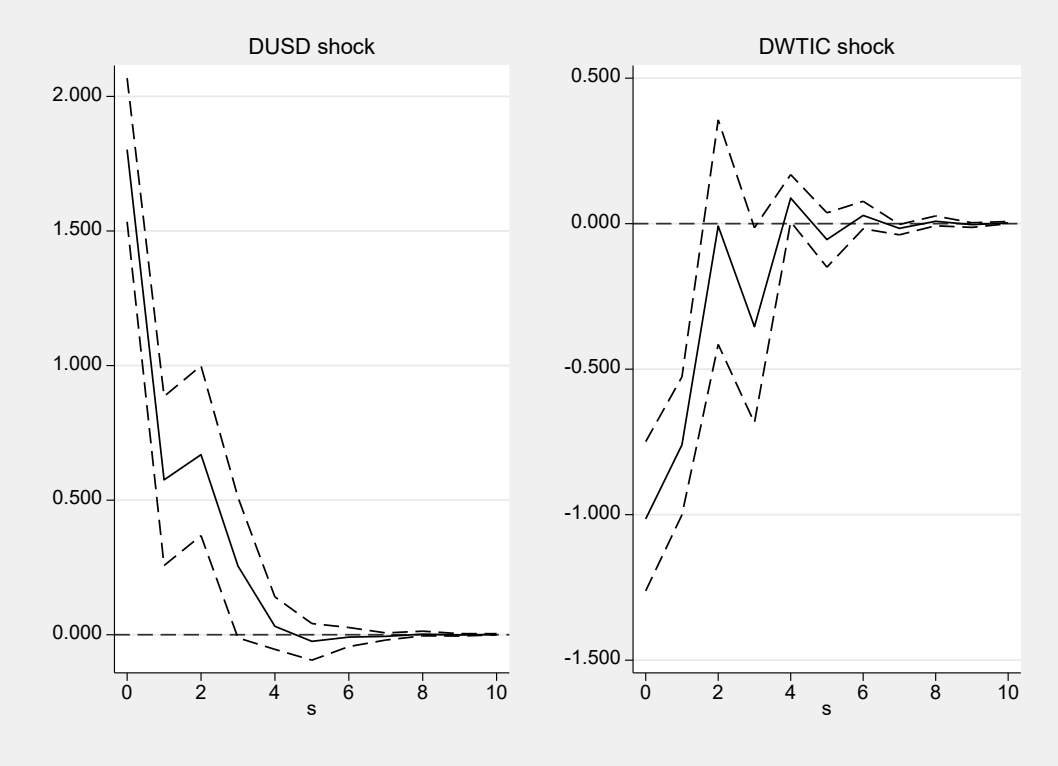


Figure A7 Robustness: Impulse response for different types of oil-related firms during the normal time

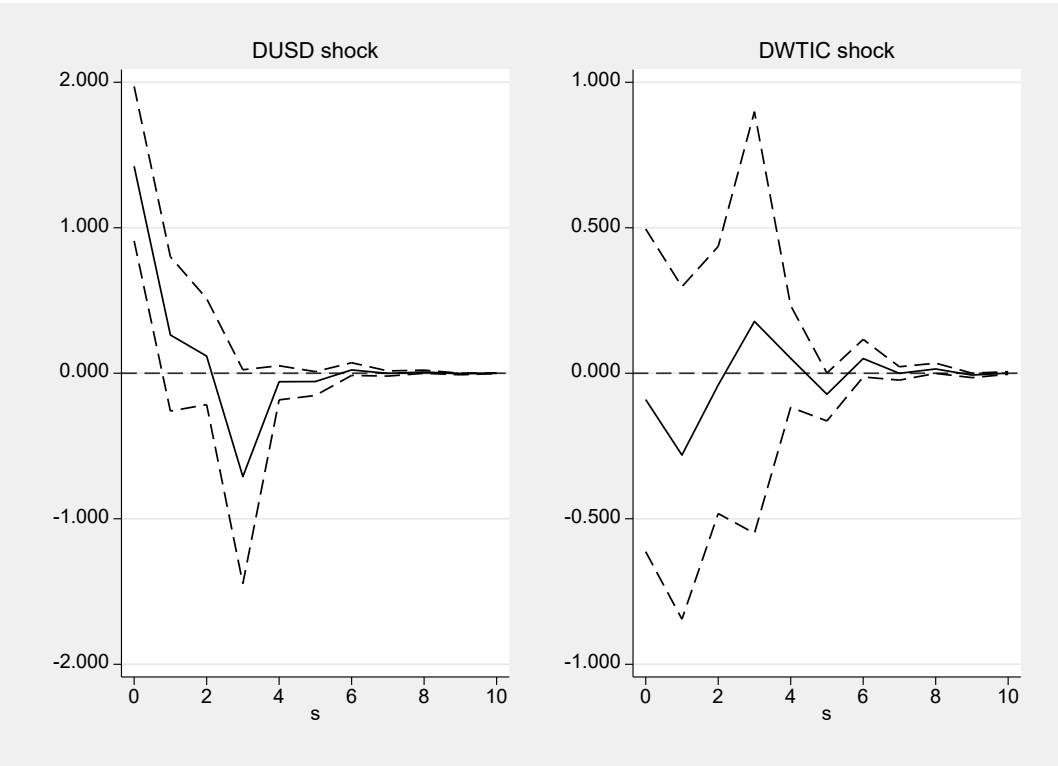
This figure presents the impulse responses for different types of oil-related firms during a normal time period based on equation (2). Figure (a) estimates the model using the sample of upstream firms. Figure (b) estimates the model using the sample of integrated oil firms. Figure (c) estimates the model using the sample of downstream firms. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(a) Downstream



(b) Integrated



(c) Downstream

Figure A8 Impulse responses for subsample outside US: controlling the spread of the home country 10-year government bond yield relative to the 10-year U.S.

This figure presents the impulse responses for the 3-order PVAR model as in equation (2). We drop the US firms and control for the spread of the home country 10-year government bond yield relative to the 10-year U.S. Treasury rate. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.

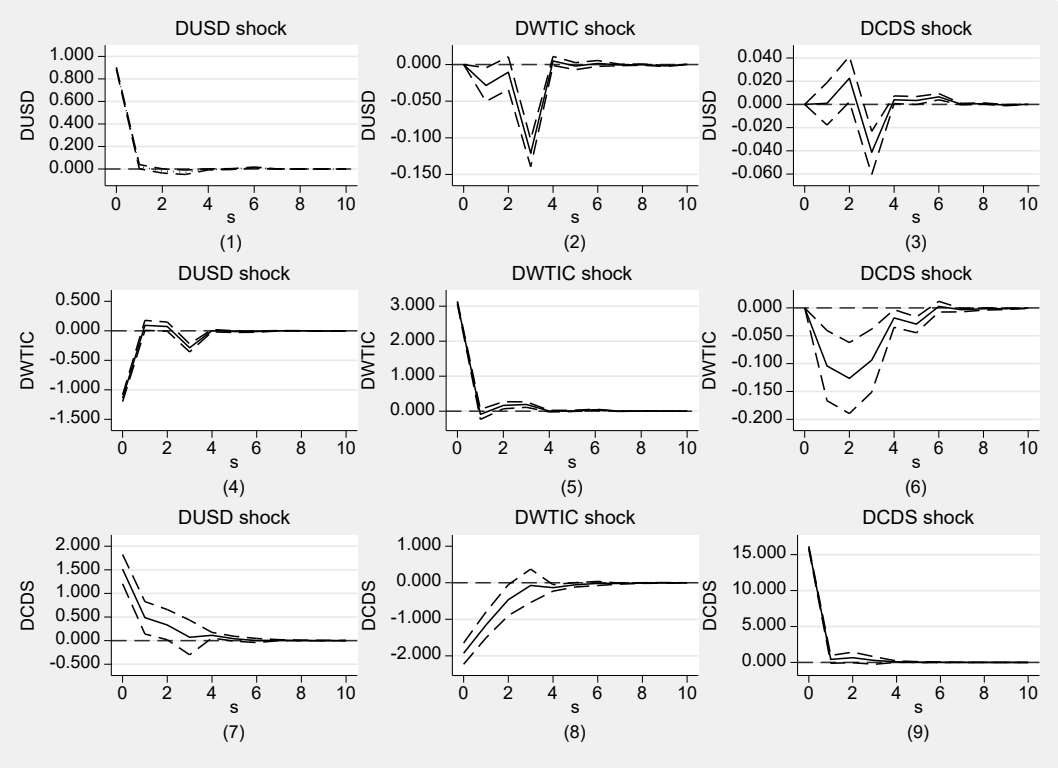
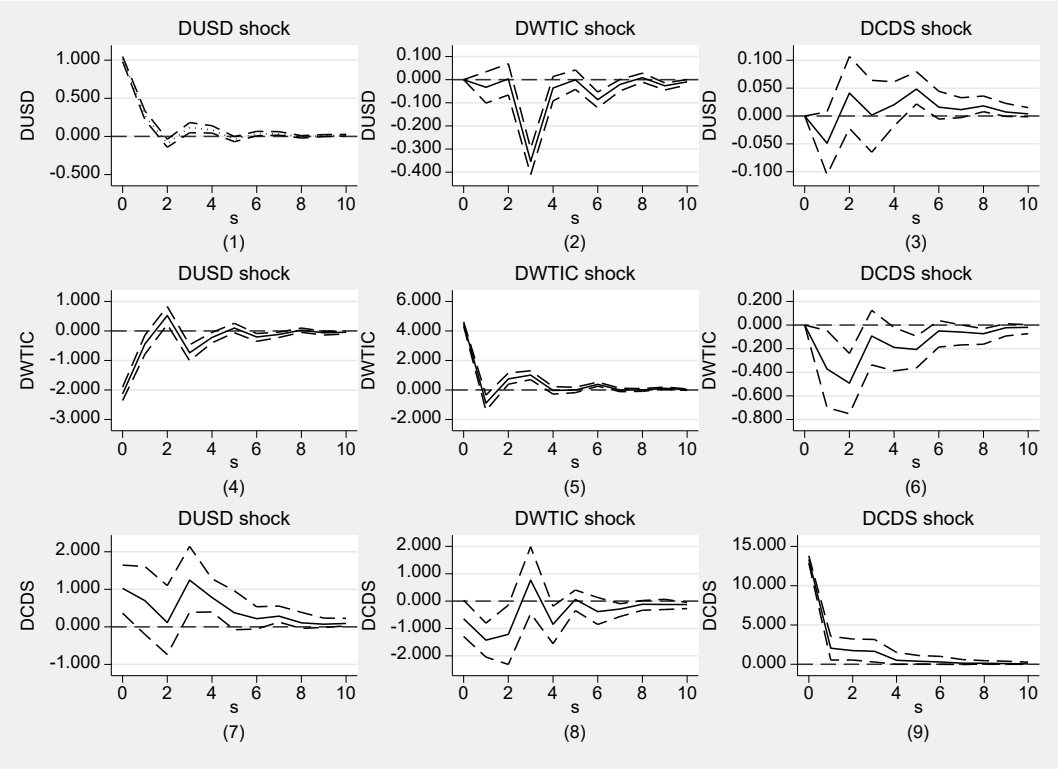
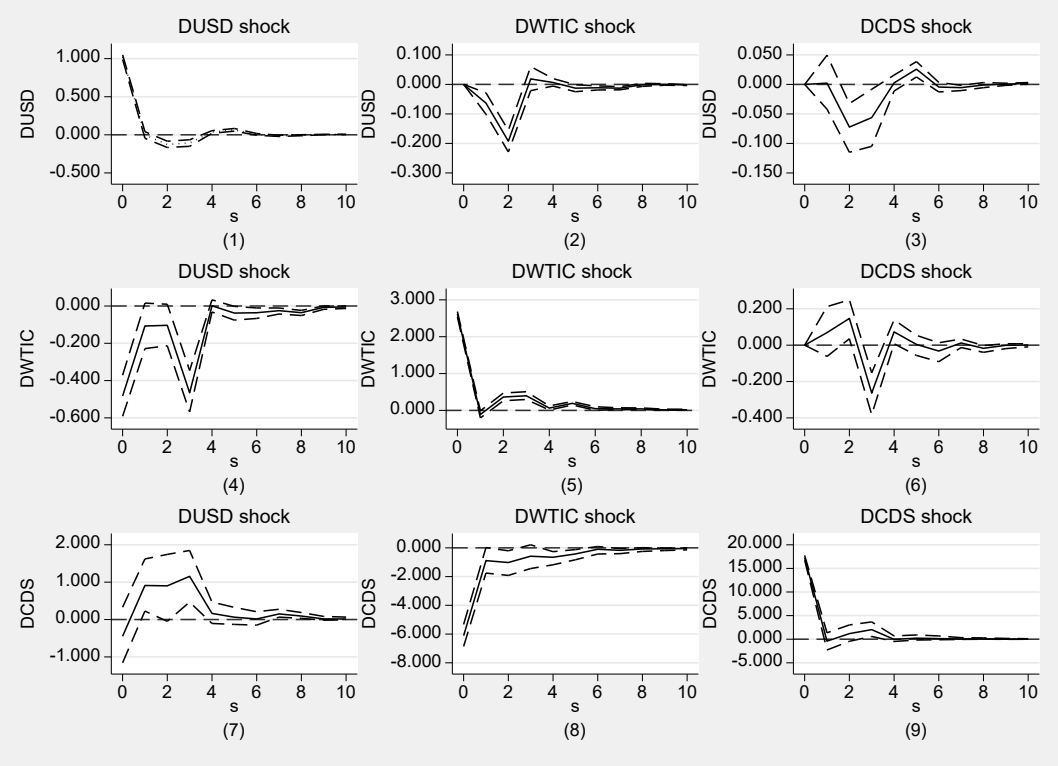


Figure A9 Impulse responses for different crisis: controlling the spread of the home country 10-year government bond yield relative to the 10-year U.S.

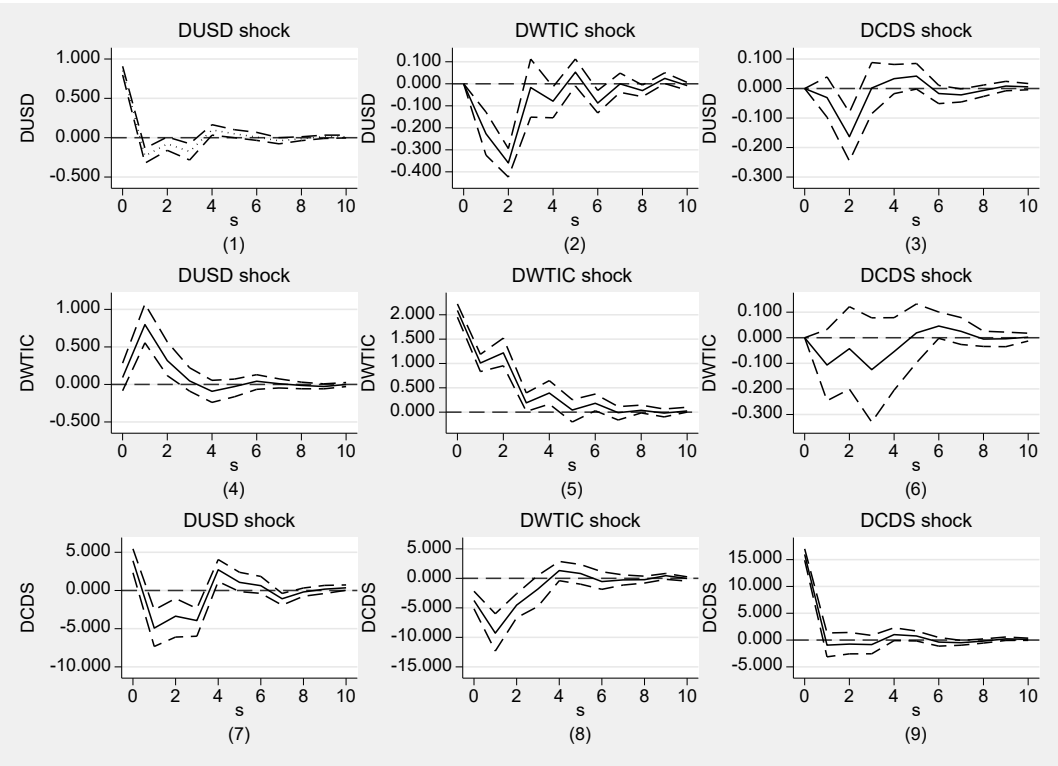
This figure presents the impulse-responses for the 3-order PVAR model as in equation (2) for different crises periods using log-differences of variables. We drop US firms and control for the spread of the home country 10-year government bond yield relative to the 10-year U.S. Treasury yield. Figure (a) estimates the model using the sample of the GFC period (from Jan 1, 2007 to July 1, 2009). Figure (b) estimates the model using the sample of the 2014-2016 oil-price plunge period (from July 1, 2014 to December 31, 2016). Figure (c) estimates the model using the sample during the COVID-19 crisis (from Jan 20, 2020 to August 20, 2020). Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(a) GFC crisis



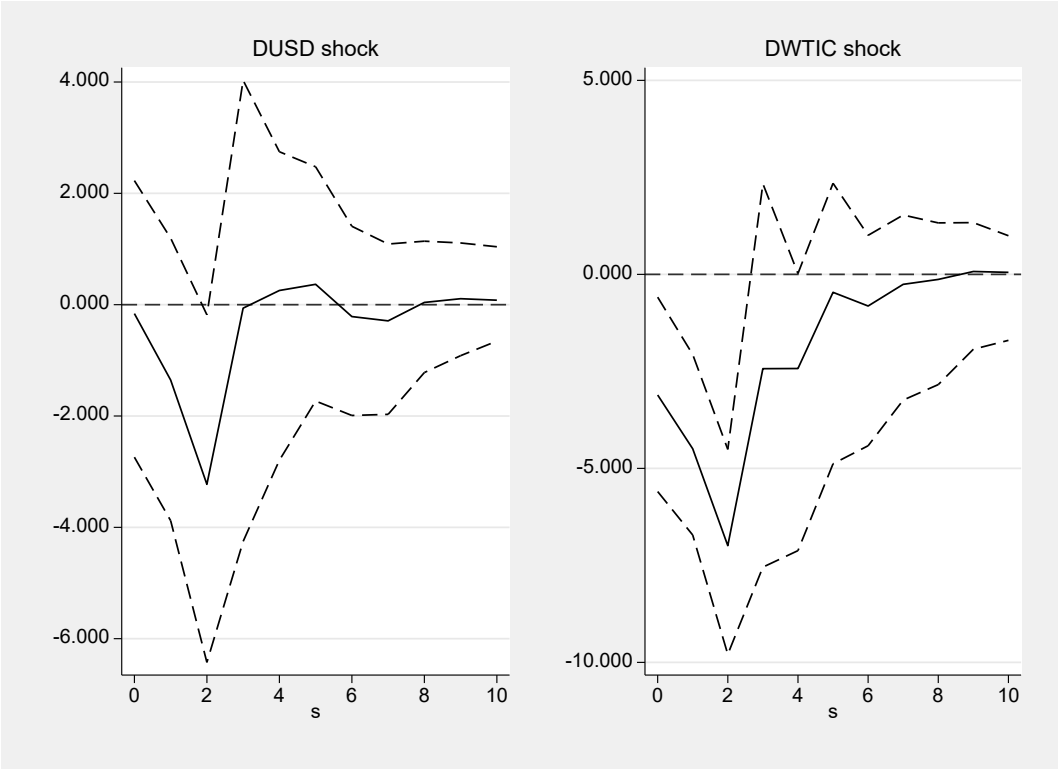
(b) Oil price plunge



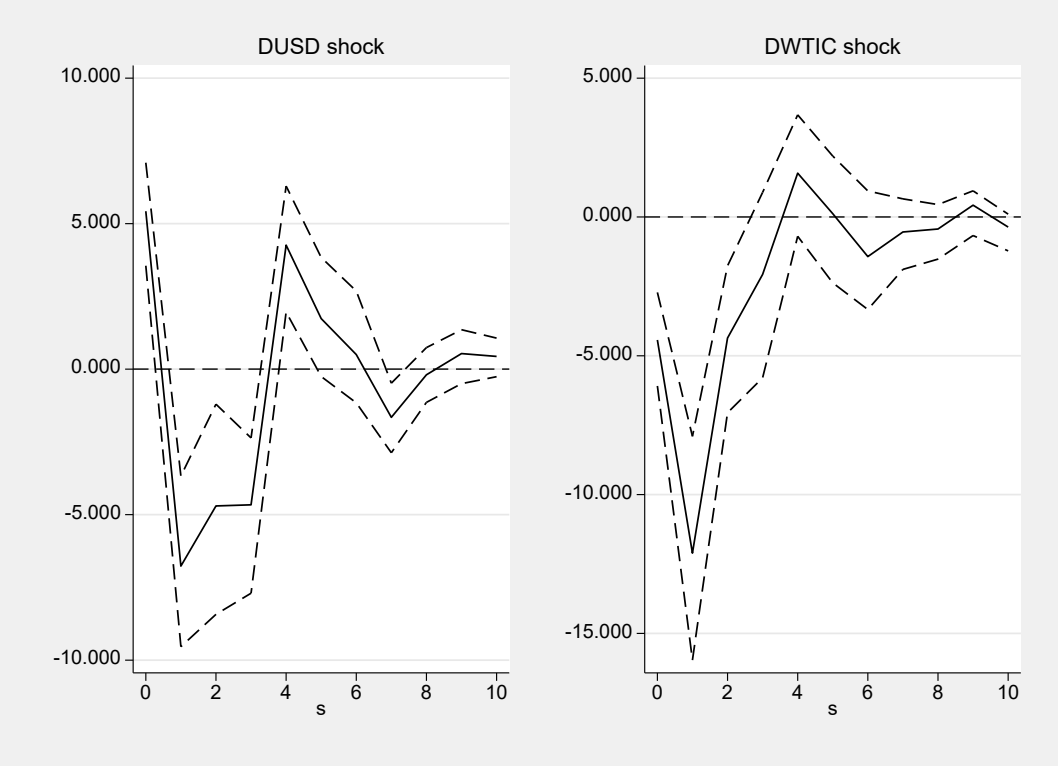
(c) Covid-19

Figure A10 Impulse response for different types of oil-related firms during COVID-19: controlling the spread of the home country 10-year government bond yield relative to the 10-year U.S.

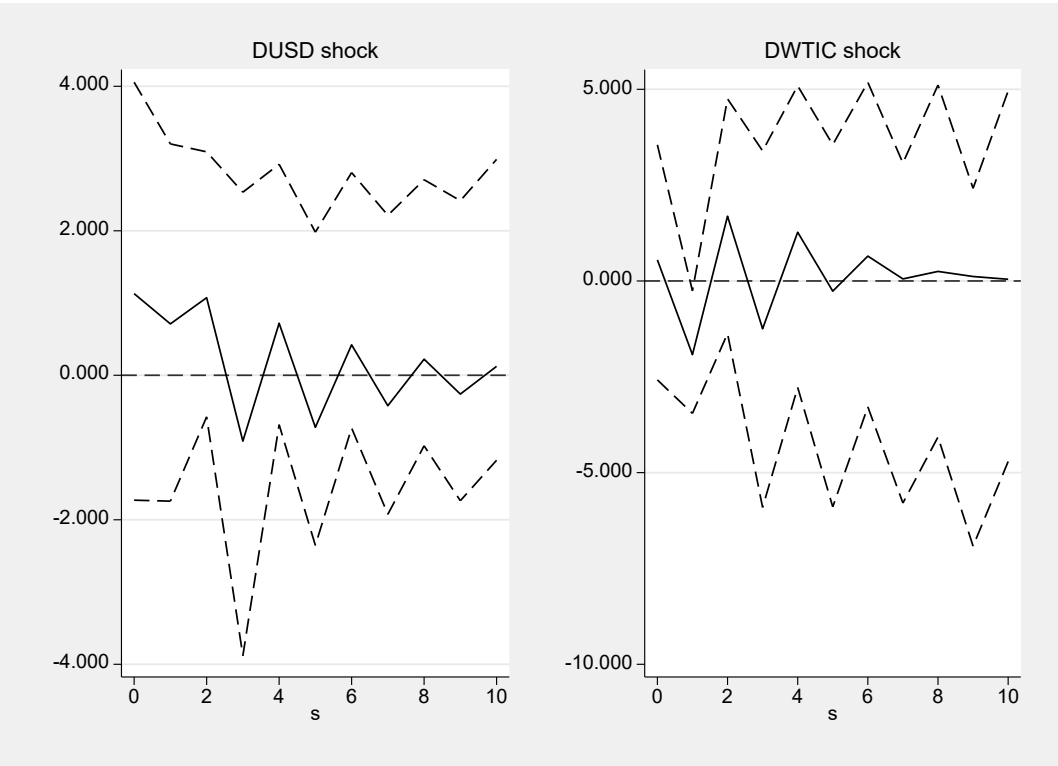
This figure presents the impulse-responses for different oil related firms depending on the production cycle during COVID-19 pandemic based on equation (1). We drop US firms and control for the spread of the home country 10-year government bond yield relative to the 10-year U.S. Treasury yield. Figure (a) estimates the model using the sample of upstream firms. Figure (b) estimates the model using the sample of integrated oil firms. Figure (c) estimates the model using the sample of downstream firms. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(a) Upstream firms



(b) Integrated oil & gas firms



(c) Downstream firms

Figure A11 Robustness: Impulse responses for full sample using log-differences

This figure presents the impulse responses for the 3-order PVAR model as in equation (1) using log-differences variables for the full sample. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates. D.ln(USD), D.ln(WTIC), D.ln(CDS) represent the log-differences of USD index, crude oil price and credit spread, respectively.

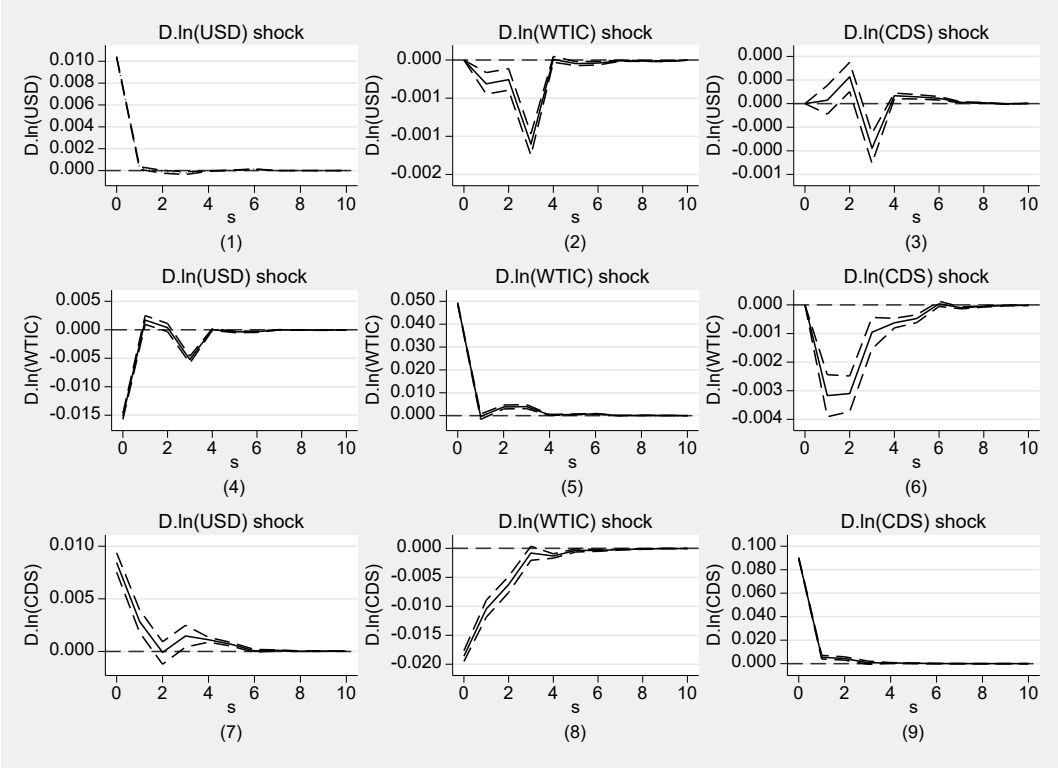
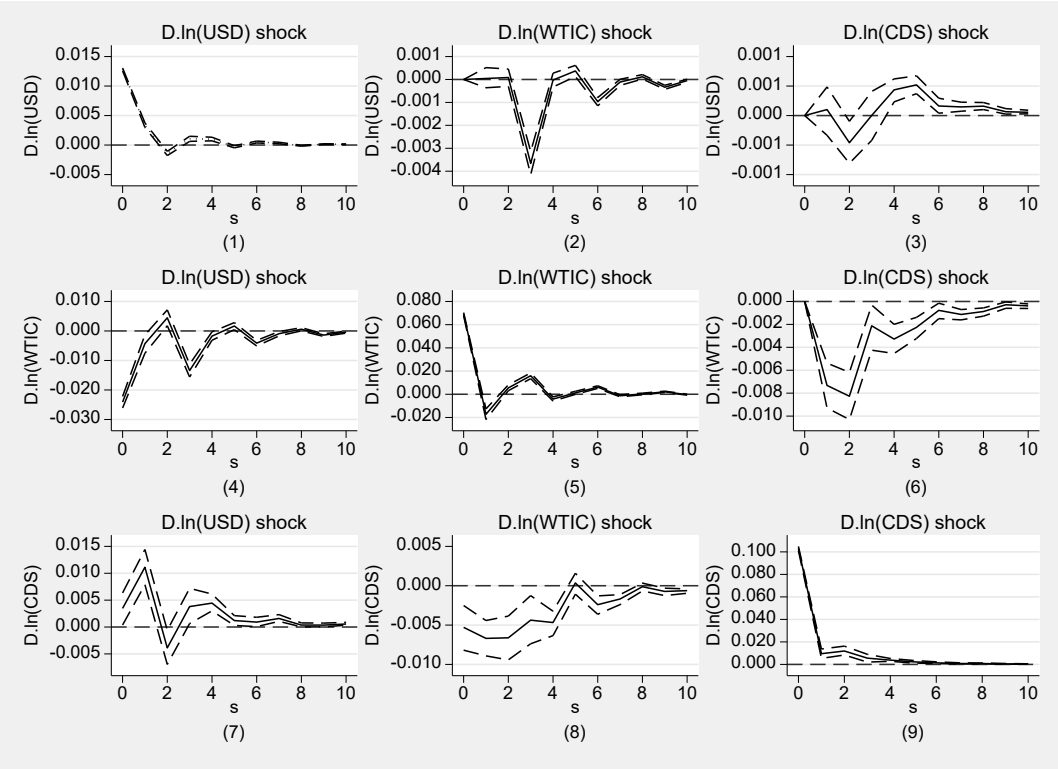
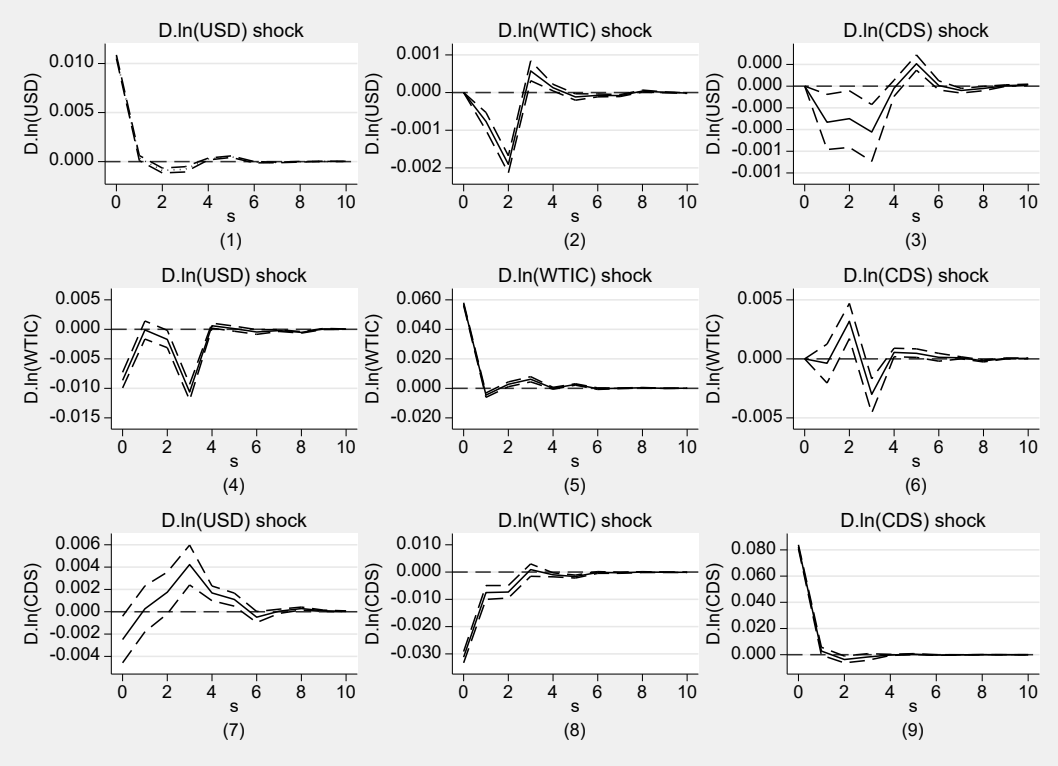


Figure A12 Robustness: Impulse responses for different crisis periods using log-differences

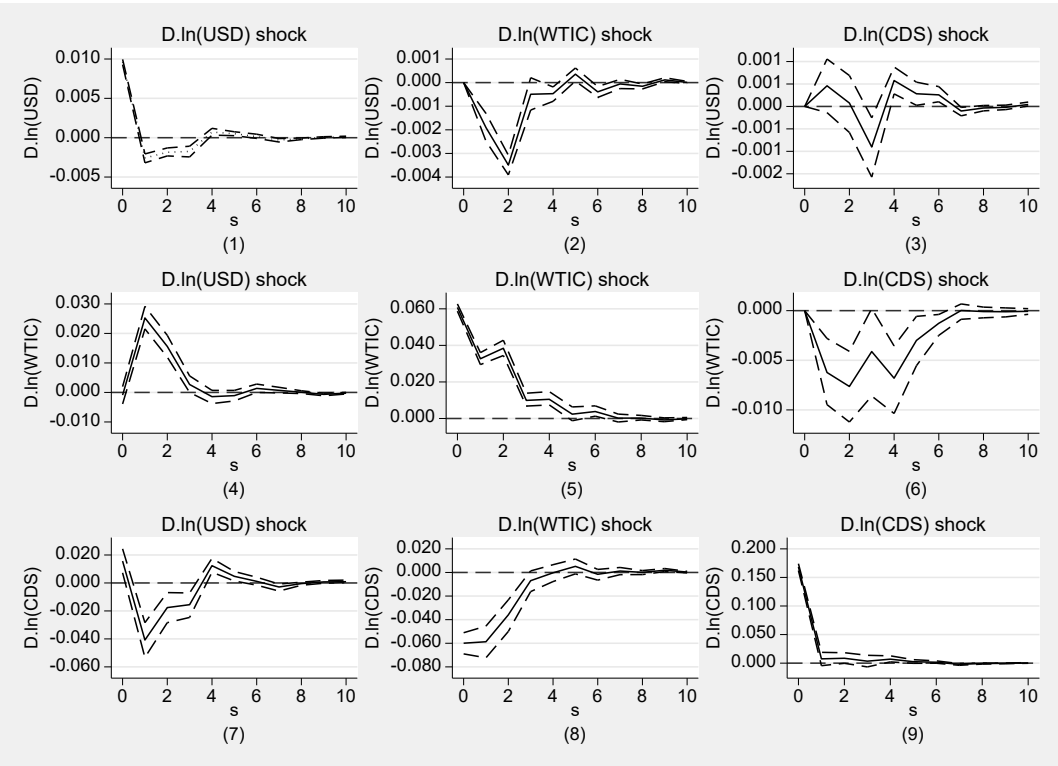
This figure presents the impulse-responses for the 3-order PVAR model as in equation (2) for different crises periods using log-differences of variables. D.ln(USD), D.ln(WTIC), D.ln(CDS) represent the log-differences of USD index, crude oil price and credit spreads, respectively. Figure (a) estimates the model using the sample of the GFC period (from Jan 1, 2007 to July 1, 2009). Figure (b) estimates the model using the sample of the 2014-2016 oil-price plunge period (from July 1, 2014 to December 31, 2016). Figure (c) estimates the model using the sample during the COVID-19 crisis (from Jan 20, 2020 to August 20, 2020). Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(a) GFC crisis



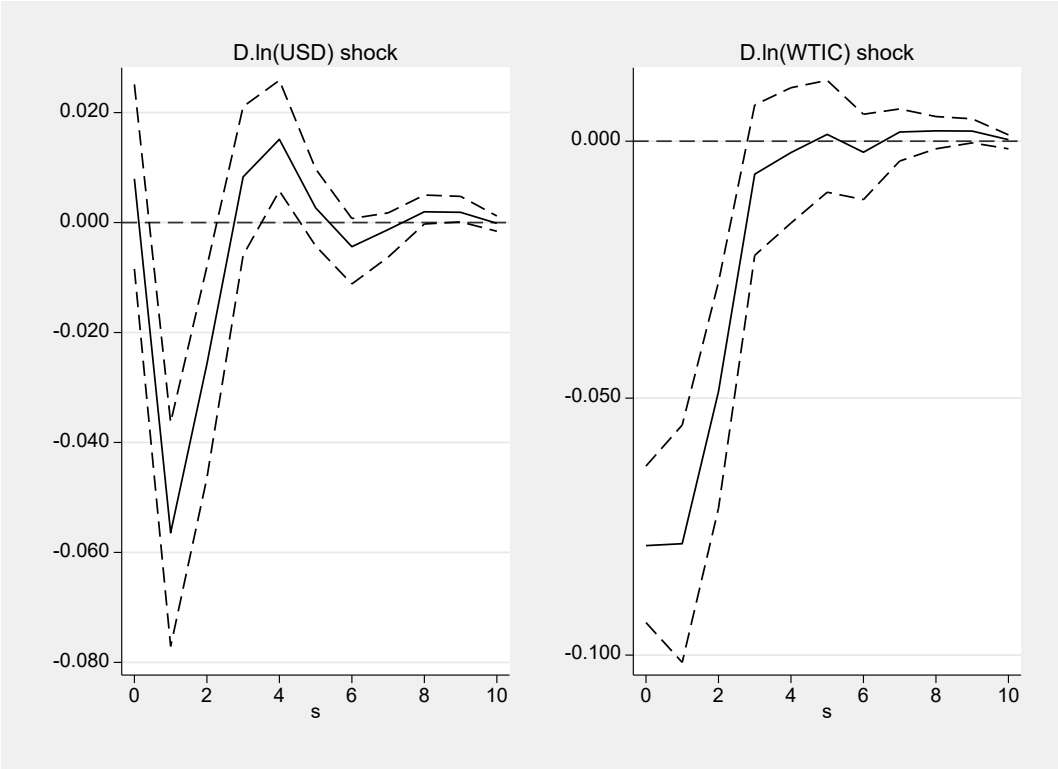
(b) Oil price plunge



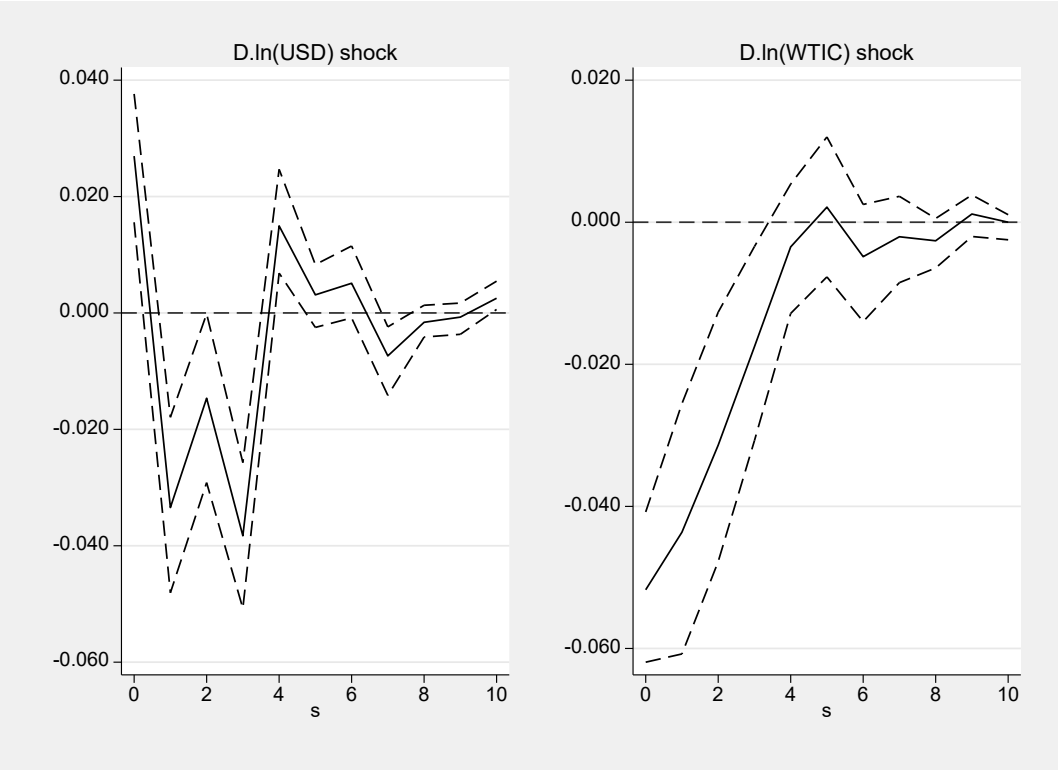
(c) Covid-19

Figure A13 Robustness: Impulse response for different types of oil-related firms during COVID-19 using log-differences

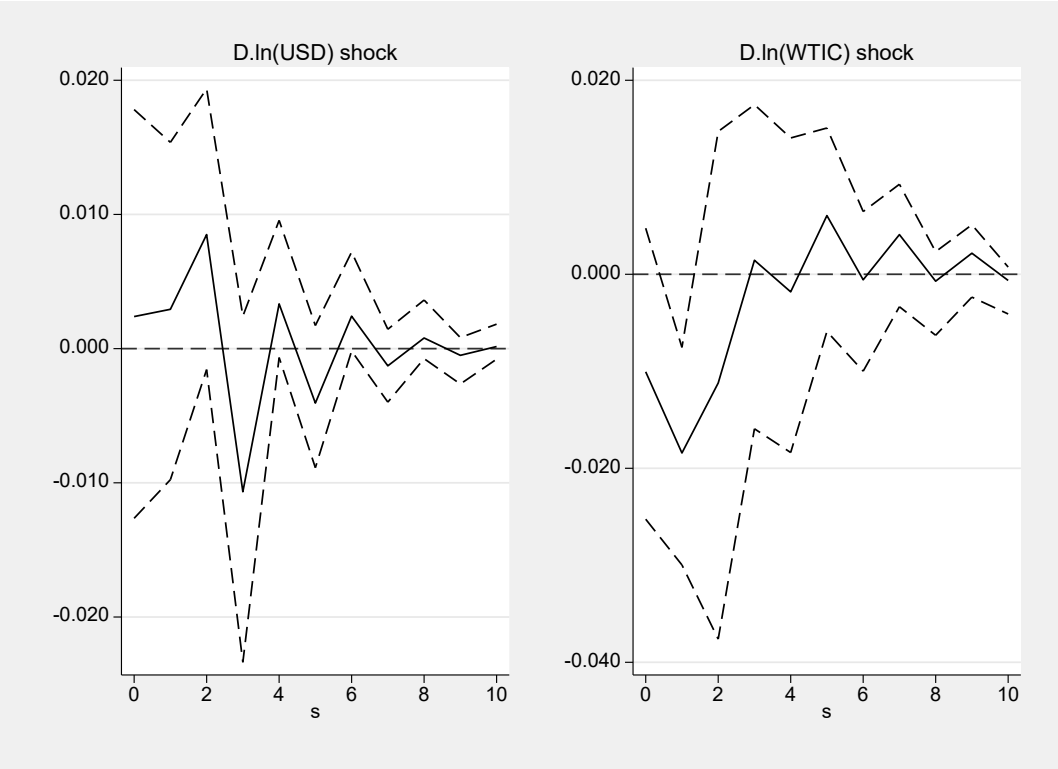
This figure presents the impulse-responses for different oil related firms depending on the production cycle during COVID-19 pandemic based on equation (1). All variables are in log-diffences. D.ln(USD), D.ln(WTIC), D.ln(CDS) represent the log-differences of USD index, crude oil price and credit spreads, respectively. Figure (a) estimates the model using the sample of upstream firms. Figure (b) estimates the model using the sample of integrated oil firms. Figure (c) estimates the model using the sample of downstream firms. Error bands are 5% on each side generated by Monte-Carlo with 1000 replicates.



(b) Upstream firms



(b) Integrated firms



(c) Downstream firms