**Online Appendices**

**Appendix A**

Table A.1 Basis for the selection of news

|  |  |  |
| --- | --- | --- |
| Keyword Type | English | Chinese |
| Climate | Climate, climate change, | 气候，气候变化 |
|  | Carbon dioxide, low carbon，  carbon emission, greenhouse gas, emission, carbon trading | 二氧化碳，低碳，碳排放，温室气体，排放，碳交易 |
|  | Global warming | 全球变暖 |
|  | Green energy | 绿色能源 |
|  | Renewable energy | 可再生能源 |
|  | Environmental/environment | 环境 |
|  | New energy | 新能源 |
| Uncertainty | Uncertainty/uncertain | 不确定、不明确 |
|  | Volatile | 波动，震荡，动荡 |
|  | Unstable/unclear | 不稳，未明，不明朗，不清晰，未清晰 |
|  | unpredictable | 难料，难以预料，难以预测，难以预计，难以估计，无法预料，无法预测，无法预计，无法估计，不可预料，不可预测，不可预计，不可估计 |
| Policy | Policy/measures | 政策，制度，体制，战略，措施，规章，规例，条例 |
|  | Politics | 政治，执政 |
|  | Government/authority | 政府，政委，国务院，人大，人民代表大会，中央 |
|  | President | 国家主席，总书记，国家领导人 |
|  | Prime minister | 总理 |
|  | Reform | 改革，整改 |
|  | Regulation | 整治，规管，监管 |
|  | Environmental protection Tax | 环境保护税，环保税 |
|  | People’s bank of China/PBOC | 人民银行，央行 |
|  | Carbon neutral, carbon peak | 碳中和，碳达峰 |
|  | Sustainable/sustainability | 可持续,可持续性 |

Note: the keywords in the type of uncertainty are from Huang and Luk (2020). Based on Gavriilidis (2021) and Huang and Luk (2020), there are some words that reveals climate policy with Chinses characteristic were added in the keyword type of policy and climate.

Table A.2 List of news source

|  |  |
| --- | --- |
| News source |  |
| 21st Century Business Herald | National Business Daily |
| China Business Network | People’s Daily |
| China Economic Network | People’s Daily Online |
| China’s National Online News Service-Finance | Shanghai Securities News |
| China News Network | Xinhua Daily |
| China Securities Journal | Xinhua News Agency |
| China Stock Network | Xinhua Net |
| Economic Information Daily | Securities Daily |
| Economic Observer | Security Times |
| Economic Daily | Southern Metropolis Daily |
| International Finance News |  |

**Appendix B**

* **Stationary test and lag selection.**

Table B.1 Stationary test.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Index | *Coal* | *CPU* | *Carbon* | *DCoal* | *DCPU* | *DCarbon* |
| ADF Test | -3.634 | -3.417\*\* | -2.534\*\* | -14.245\*\*\* | -14.006\*\*\* | -13.205\*\*\* |

Note: \*\*\*, \*\* and \* respectively indicate the 1%, 5% and 10% significance levels.

Table B.2 Lag selection analysis.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Lag | LogL | LR | FPE | AIC |
| 0 | -7109.669 | NA | 142416.3 | 20.38014 |
| 1 | -6960.880 | 295.8740 | 95412.68 | 19.97960 |
| 2 | -6908.392 | 103.9219 | 84234.76 | 19.85499 |
| 3 | -6872.886 | 69.99472 | 78074.46 | 19.77904 |
| 4 | -6856.971 | 31.23761 | 76543.22 | 19.75923 |
| 5 | -6846.040 | 21.36147 | 76121.66 | 19.75370 |
| 6 | -6818.240 | 54.08602 | 72130.84 | 19.69983 |
| 7 | -6808.849 | 18.18957 | 72051.73 | 19.69871 |
| 8 | -6796.046 | 24.68893\* | 71272.94\* | 19.68781\* |
| 9 | -6787.284 | 16.82139 | 71324.18 | 19.68849 |
| 10 | -6783.543 | 7.149250 | 72410.48 | 19.70356 |

Note: \* denotes the optimal lag order for each evaluation approach at 5% level.

The augmented Dickey-Fuller (ADF) test is utilized to examine the series stationarity. As shown in Table B.1, the series of both climate policy uncertainty (*CPU*) and carbon price (*Carbon*) pass the ADF test at 5% significance level, but the series of coal price (*Coal*) is not. Their first differenced series (i.e., *DCPU, DCoal*, and *DCarbon*) pass the ADF test at 1% significance level. To sum up, the results above demonstrate that the model is stable and the parameter estimation is valid.

Turning to the lag length selection in the TVP-VAR model, we selected the optimal lag length based on the sequential modified LR test statistic (HR), the final prediction error (FPE) criterion and the Akaike information criterion (AIC). Table B.2 shows the optimal lag selection results, suggesting that the optimal lag order is 8.

* **The coefficient of auto correlation, sample path and the posterior distribution of estimated parameter.**

图示

描述已自动生成

Fig.B.1. The coefficient of auto correlation, sample path and the posterior distribution of estimated parameter.

Fig.B.1 shows the coefficient of auto correlation (row 1), sample path (row 2) and posterior distribution (row 3) of each estimated parameter. As shown in Fig.B.1, the coefficient of auto correlation for each parameter falls to 0 after iteration sampling, which reveals that the iterations can eliminate the auto correlation caused by sampling. Meanwhile, the sample path of each parameter obeys the form of white noise. Besides, the posterior distribution of each parameter follows the characteristic of normal distribution.

* **The spikes/jumps in the impulse responses of *Carbon* to *CPU* shocks.**

**图表, 折线图

描述已自动生成**

(a) (b)

Fig.B.2. The impulse responses of *Carbon* to *CPU* shocks and *Coal* shocks at different lag periods.

In Fig.B.2(a), there are three spikes/jumps at the period horizon. First, the impulse response reaches its height at the end of December 2019. A policy called interim provisions on the accounting treatment regarding carbon trading has been issued before and has been carried out since January 1, 2020, which is a crucial policy that ensures effective supervision of corporate carbon emissions in China. The second spike is related to June 7, 2021; Notice of the NDRC on Matters Related to the Renewable Electricity Feed-in Tariff Policy in 2021 was issued[[1]](#footnote-1). The third spike is on January 5, 2020; a guideline on carbon peaking and carbon neutrality was issued by Hebei province[[2]](#footnote-2). According to the guideline, Hebei will actively establish the Xiongan Green Exchange and strive for the establishment of a national China Certified Emission Reduction (CCER) trading market by Beijing and Xiongan jointly.

* **The impulse responses of specific time points**

**图表

描述已自动生成**(a) (b)

Fig.B.3. The impulse responses at specific time points.

Three specific events are chosen for examining the time-varying impact of *CPU* and *Coal* on *Carbon.* Each event refers to a specific day of issuing a carbon-related policy, which is crucial to the carbon market. The first one is September 25, 2019. An implementation plan for carbon emissions quota allocation of key emitters in the power generation industry was issued by the Chinese Ministry of Ecology and Environment, which specifies the definition, classification and quota allocation method of carbon dioxide emission quota. The second one is December 31, 2020. The Ministry of Ecology and Environment released the measures for the management of Carbon Emission Trading, which is a national strategy to tackle climate change. The third one is October 26, 2021. The state council issued the first “N” policy in the “1+N” policy framework for climate change, namely the action plan for reaching carbon peak before 2030. This action plan mentions the goal of reducing coal consumption and ten actions of realizing carbon peak.

Fig.B.3(a) describes the impulse responses of *Carbon* to *CPU* shocks at these three specific events. Overall, the reaction of *Carbon* follows a positive and negative alternating trend in each specific event and the shock effect lasts for nine periods. The time-varying effect of the first period is found to be the most significant for the first event, suggesting that the implementation plan has intensified this time-varying effect. However, the response of *Carbon* ranged from -0.1 to 0 in the first period in each event, indicating that the negative effect is small.

The impulse responses of *Carbon* to *Coal* shocks are shown in Fig.B.3(b). The dynamic spillover effects of *Coal* shocks on *Carbon* also depicts a positive and negative alternating trend and these shock effects last for eight periods. The response of *Carbon* is also the strongest on September 25, 2019. This is mainly because the first event has a strong impact on the coal-fired industry, resulting in more volatile fluctuations.

**Appendix C**

Table C.1 The mean square equation of VAR(8)-BEKK-GARCH model.

|  |  |  |  |
| --- | --- | --- | --- |
|  | *DCarbon* | *DCoal* | *DCPU* |
| *DCarbon(-1)* | -0.1213\*\* | -0.4141 | 0.1879 |
| *DCarbon(-2)* | -0.0349\*\* | 0.3357 | 0.1595 |
| *DCarbon(-3)* | -0.0658\*\* | -0.3817 | 0.1144 |
| *DCarbon(-4)* | -0.0036\*\* | 0.1839 | 0.2035 |
| *DCarbon(-5)* | -0.0792\*\* | -0.4401 | 0.1394 |
| *DCarbon(-6)* | -0.0743\*\* | 0.6162 | -0.0944 |
| *DCarbon(-7)* | -0.0719\*\* | -0.3028 | -0.0293 |
| *DCarbon(-8)* | -0.0797\*\* | 0.6633 | 0.0912 |
| *DCoal(-1)* | -0.0018\*\*\* | 0.2449\*\* | 0.0188\*\* |
| *DCoal(-2)* | 0.0027\*\*\* | 0.0818\*\* | -0.0163\*\* |
| *DCoal(-3)* | -0.0041\*\*\* | 0.0624\*\* | 0.0398\*\* |
| *DCoal(-4)* | 0.0013\*\*\* | -0.0222\*\* | -0.0216\*\* |
| *DCoal(-5)* | 0.0062\*\*\* | 0.1200\*\* | 0.0484\*\* |
| *DCoal(-6)* | -0.0030\*\*\* | -0.1505\*\* | -0.0671\*\* |
| *DCoal(-7)* | -0.0039\*\*\* | -0.0163\*\* | -0.0135\*\* |
| *DCoal(-8)* | 0.0019\*\*\* | -0.0563\*\* | -9.73E-5\*\* |
| *DCPU (-1)* | -0.0051\*\*\* | 0.2160\* | -0.8560\*\* |
| *DCPU (-2)* | -0.0051\*\*\* | 0.3201 | -0.6926\* |
| *DCPU (-3)* | -0.0090\*\*\* | 0.2917 | -0.5476\* |
| *DCPU (-4)* | -0.0071\*\* | -0.0003 | -0.3859\* |
| *DCPU (-5)* | -0.0077\*\* | 0.1227 | -0.3055\* |
| *DCPU (-6)* | -0.0073\*\*\* | 0.1911 | -0.1935\* |
| *DCPU (-7)* | 0.0013\*\*\* | 0.2556 | -0.1002\* |
| *DCPU (-8)* | -0.0085\*\*\* | -0.0031 | -0.1477\*\* |
| *Constant* | 0.0423\* | 0.2400 | 0.2392 |

Note: \*\*\*, \*\*, \* represent 1%,5%,10% significance, respectively.

**Appendix D**

图示, 工程绘图

描述已自动生成

Fig.D.1. Total directional connectedness to others (TDC-TO)

图形用户界面

描述已自动生成

Fig.D.2. Total directional connectedness from others (TDC-FROM).

图示

描述已自动生成

Fig.D.3. Net total directional connectedness.

社交网站的手机截图

描述已自动生成

Fig.D.4. Net pairwise directional connectedness.

社交网站的手机截图

中度可信度描述已自动生成

Fig.D.5. Dynamic pairwise connectedness.

Fig.D.1 shows TDC-TO among *CPU*, *Coal* and *Carbon*. It is evident that the TDC-TO of *Coal* is the strongest among others, indicating that *Coal* plays a crucial role in volatility transmission. Fig.D.2 depicts TDC-FROM effects among *CPU, Coal* and *Carbon*. Consistent with Fig.D.1, *Carbon* presents a leading role in receiving volatility spillover effect, followed by *CPU* and *Coal*. Fig.D.3 shows the net total directional volatility spillovers among *CPU, Coal* and *Carbon*. *Coal* is mainly a net shock transmitter over the sampling period. *CPU* and *Carbon* are mostly net shock receiver. The net pairwise directional connectedness was plotted in Fig.D.4. *CPU* and *Carbon* are respectively dominated by *Coal* in most cases. *CPU* dominates *Carbon* until the beginning of 2021 when *CPU* becomes a net pairwise receiver. Fig.D.5 shows the dynamic pairwise connectedness.

1. <https://chinaenergyportal.org/en/notice-on-matters-related-to-the-renewable-electricity-feed-in-tariff-policy-in-2021/> [↑](#footnote-ref-1)
2. <https://www.stcn.com/xw/news/202201/t20220105_4045106.html> [↑](#footnote-ref-2)