# Impact of work resumption on air quality after subsiding of COVID-19: evidence from China

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# ONLINE APPENDIX

**Table A1.** Lockdown of cities in Hubei province and the number of infected cases

| City | Lockdown Date | Accumulated Cases | Death Cases |
|---|---|---|---|
| Wuhan | 2020/1/23 | 49978 | 2423 |
| Huanggang | 2020/1/23 | 2907 | 125 |
| Ezhou | 2020/1/23 | 1394 | 54 |
| Jingmen | 2020/1/24 | 928 | 39 |
| Xiantao | 2020/1/24 | 575 | 22 |
| Qianjiang | 2020/1/24 | 198 | 179 |
| Enshi | 2020/1/24 | 252 | 9 |
| Shiyan | 2020/1/24 | 672 | 8 |
| Xianning | 2020/1/24 | 836 | 14 |
| Suizhou | 2020/1/24 | 1307 | 44 |
| Yichang | 2020/1/24 | 931 | 35 |
| Huangshi | 2020/1/24 | 1015 | 38 |
| Xiaogan | 2020/1/24 | 3518 | 126 |
| Jingzhou | 2020/1/24 | 1580 | 49 |
| Tianmen | 2020/1/24 | 496 | 15 |
| Xiangyang | 2020/1/28 | 1175 | 38 |
| Shennongjialinqu | | 11 | 0 |
| Total | | 67773 | 3162 |

*Source*: https://voice.baidu.com/act/newpneumonia/newpneumonia. The raw data of the number of COVID-19 infected cases are taken from the Chinese Center for Disease Control and Prevention.

**Table A2.** Schedules for work resumption

| Province or City | Code | Date | Primary Response Date |
|---|---|---|---|
| Zhejiang | 33 | 2/10/2020 | 1/23/2020 |
| Yunnan | 53 | 2/10/2020 | 1/24/2020 |
| Xizang (Tibet) | 54 | 2/10/2020 | 1/28/2020 |
| Xinjiang | 65 | 2/10/2020 | 1/25/2020 |
| Tianjin | 12 | 2/10/2020 | 1/24/2020 |
| Shanxi | 14 | 2/10/2020 | 1/25/2020 |
| Shanxi | 61 | 2/10/2020 | 1/25/2020 |
| Shanghai | 31 | 2/10/2020 | 1/24/2020 |
| Shandong | 37 | 2/10/2020 | 1/24/2020 |
| Ningxia | 64 | 2/10/2020 | 1/25/2020 |
| Neimenggu | 15 | 2/10/2020 | 1/25/2020 |
| Liaoning | 21 | 2/10/2020 | 1/25/2020 |
| Jilin | 22 | 2/10/2020 | 1/25/2020 |
| Jiangxi | 36 | 2/10/2020 | 1/24/2020 |
| Jiangsu | 32 | 2/10/2020 | 1/24/2020 |
| Hunan | 43 | 2/10/2020 | 1/23/2020 |
| Henan | 41 | 2/10/2020 | 1/25/2020 |
| Heilongjiang | 23 | 2/10/2020 | 1/25/2020 |
| Hebei | 13 | 2/10/2020 | 1/24/2020 |
| Hainan | 46 | 2/10/2020 | 1/25/2020 |
| Guizhou | 52 | 2/10/2020 | 1/24/2020 |
| Guangxi | 45 | 2/10/2020 | 1/24/2020 |
| Guangdong | 44 | 2/10/2020 | 1/23/2020 |
| Gansu | 62 | 2/10/2020 | 1/25/2020 |
| Fujian | 35 | 2/10/2020 | 1/24/2020 |
| Chongqing | 50 | 2/10/2020 | 1/24/2020 |
| Beijing | 11 | 2/10/2020 | 1/24/2020 |
| Sichuan | 51 | 2/10/2020 | 1/24/2020 |
| Qinghai | 63 | 2/10/2020 | 1/25/2020 |
| Anhui | 34 | 2/10/2020 | 1/24/2020 |
| **Wenzhou** | **3303** | **2/17/2020** | |
| **Shihezi** | **6590** | **2/15/2020** | |
| **Hubei** | **42** | **3/11/2020** | 1/24/2020 |

*Notes:* In the baseline sample, we exclude the observations of Wenzhou and Shihezi. Primary response date indicates the date when the first-level public health emergency response was launched.

**Table A3.** The definition of wind orientation

| wind angle | latitude condition | longitude condition | wind orientation | value |
|---|---|---|---|---|
| 0<=angle<90 | lat(A)>lat(W) | lon(A)>lon(W) | upwind | -1 |
| 0<=angle<90 | lat(A)<lat(W) | lon(A)<lon(W) | downwind | 1 |
| 0<=angle<90 | None of the above | | otherwise | 0 |
| 90<=angle<180 | lat(A)<lat(W) | lon(A)>lon(W) | upwind | -1 |
| 90<=angle<180 | lat(A)>lat(W) | lon(A)<lon(W) | downwind | 1 |
| 90<=angle<180 | None of the above | | otherwise | 0 |
| 180<=angle<270 | lat(A)>lat(W) | lon(A)<lon(W) | upwind | -1 |
| 180<=angle<270 | lat(A)<lat(W) | lon(A)>lon(W) | downwind | 1 |
| 180<=angle<270 | None of the above | | otherwise | 0 |
| 270<=angle<360 | lat(A)>lat(W) | lon(A)>lon(W) | upwind | -1 |
| 270<=angle<360 | lat(A)<lat(W) | lon(A)<lon(W) | downwind | 1 |
| 270<=angle<360 | None of the above | | otherwise | 0 |

*Notes:* The angle, which is measured in a clockwise direction, between the north and the direction from which the wind is blowing, such as north (0), east (90), and west (270). The lat (A) and lat (W) indicate the latitude of the air quality monitoring station and weather station respectively. The lon (A) and lon (W) represent the longitude of the air quality monitoring station and weather station, respectively.

**Table A4.** The effects of work resumption on air quality (robustness)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| **Dependent Variable =** | **AQI** | **PM2.5** | **PM10** | **$NO_2$** |
| Treat×post | 7.027* | 5.084* | 6.057* | 4.505*** |
| | (3.603) | (2.891) | (3.426) | (0.673) |
| Temperature | 0.604** | 0.414* | 0.800*** | 0.0380 |
| | (0.257) | (0.219) | (0.257) | (0.0746) |
| Barometric pressure | -0.536** | -0.646*** | -0.358* | -0.381*** |
| | (0.225) | (0.177) | (0.192) | (0.0462) |
| Wind orientation | **0.678** | **0.586** | **0.599** | **0.00415** |
| | **(0.586)** | **(0.474)** | **(0.603)** | **(0.164)** |
| Wind velocity | -4.277*** | -4.651*** | -2.928*** | -2.693*** |
| | (0.753) | (0.554) | (0.697) | (0.204) |
| Cloudage | -0.811 | -0.183 | -0.340 | -1.468*** |
| | (2.812) | (2.175) | (2.621) | (0.503) |
| Constant | 615.6*** | 709.6*** | 424.9** | 413.7*** |
| | (232.7) | (183.1) | (198.9) | (47.78) |
| Site FE | Yes | Yes | Yes | Yes |
| Daily FE | Yes | Yes | Yes | Yes |
| Observations | 44814 | 44701 | 44722 | 44956 |
| Sites | 1012 | 1012 | 1011 | 1011 |
| $R^2$ | 0.437 | 0.451 | 0.446 | 0.606 |

*Notes:* The only difference between this table and table 2 is that we change the variables from wind direction to wind orientation. The definition of wind orientation for upwind and downwind is shown in appendix table A3. Standard errors are clustered by city. *, ** and *** denote significance levels at 10%, 5%, and 1% respectively.

**Table A5.** Summary statistics with treatment group and control group

| | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| | treat=0 | | treat=1 | | difference | p-value |
| | N | mean | N | mean | | |
| AQI | 549 | 80.88 | 16136 | 73.10 | 7.522 | 0.263 |
| PM2.5 | 549 | 59.31 | 16129 | 50.91 | 8.181 | 0.124 |
| PM10 | 549 | 64.57 | 16210 | 65.18 | -0.820 | 0.860 |
| $NO_2$ | 545 | 16.24 | 16327 | 18.65 | -2.449 | 0.124 |
| Temperature | 549 | 5.330 | 16598 | 2.178 | 3.158*** | 0.000 |
| Barometric pressure | 549 | 1027.41 | 16598 | 1026.51 | 0.943*** | 0.008 |
| Wind direction | 549 | 166.6 | 16598 | 169.7 | -3.328 | 0.801 |
| Wind velocity | 549 | 1.965 | 16598 | 2.316 | -0.347** | 0.024 |
| Cloudage | 549 | 0.457 | 16598 | 0.437 | 0.019 | 0.773 |
| Within-City Flow Intensity | 549 | 1.883 | 16563 | 2.613 | -0.789*** | 0.002 |
| Inflow Index | 549 | 0.342 | 16563 | 0.838 | -0.535*** | 0.000 |
| Outflow Index | 549 | 0.331 | 16563 | 0.708 | -0.408*** | 0.001 |

*Notes:* In column (5), ** and *** respectively denote significance levels at 5% and 1%. The differences of all variables are presented in the presence of daily fixed effects in column (5).

**Table A6.** The comparison of population and industry structure between control group and treatment group

| | treat=0 | | treat=1 | | whole sample | |
|---|---|---|---|---|---|---|
| | N | median | N | median | N | median |
| Population | 479 | 646.35 | 16011 | 537.1 | 16490 | 537.14 |
| Structure | 479 | 47.47 | 16092 | 46.57 | 16571 | 46.58 |

*Notes:* Population is the number of resident population of a city (i.e., those who have been living in that city for more than six months). Structure is the value-added of secondary industry as a share of GDP.

**Table A7.** Mechanisms of the effect of work resumption on air quality without outliers

| **Dependent Variable =** | **(1)**<br>**Within-City Flow Intensity** | **(2)**<br>**Inflow Index** | **(3)**<br>**Outflow Index** |
|---|---|---|---|
| Treat×post | 0.875*** | -0.0673 | 0.00986 |
| | (0.0741) | (0.0489) | (0.0286) |
| Control Vars | Yes | Yes | Yes |
| Site FE | Yes | Yes | Yes |
| Daily FE | Yes | Yes | Yes |
| Observations | 43707 | 43707 | 43707 |
| Sites | 1009 | 1009 | 1009 |
| $R^2$ | 0.849 | 0.852 | 0.763 |

*Notes:* Robust standard errors are shown in parentheses. Standard errors are clustered by city. *** denotes significance level at 1%.

**Table A8.** Counterfactual test of the effect of work resumption on air quality

| **Dependent Variable =** | **(1)**<br>**-7 days**<br>**AQI** | **(2)**<br>**5 days**<br>**AQI** | **(3)**<br>**7 days**<br>**AQI** | **(4)**<br>**14 days**<br>**AQI** |
|---|---|---|---|---|
| Treat×post | 3.965 | 2.066 | 2.437 | -0.600 |
| | (4.289) | (2.868) | (2.147) | (1.726) |
| Control Vars | Yes | Yes | Yes | Yes |
| Sites FE | Yes | Yes | Yes | Yes |
| Day FE | Yes | Yes | Yes | Yes |
| Observations | 44814 | 44814 | 44814 | 44814 |
| Sites | 1012 | 1012 | 1012 | 1012 |
| $R^2$ | 0.437 | 0.437 | 0.437 | 0.437 |

*Notes:* Columns (1)–(4) report the results of the treatment effect on air quality in which the date of resumption of work is assumed to shift a week earlier, 5 days later, a week later, and two weeks later, respectively. Regression specification follows table 2. Robust standard errors are shown in parentheses. Standard errors are clustered by city.

**Table A9.** The resumption index of work on March 10, 2020

| Province or City | Code | Resumption Index |
|---|---|---|
| Zhejiang | 33 | 65.59% |
| Yunnan | 53 | 73.16% |
| Xizang | 54 | 75.82% |
| Xinjiang | 65 | 52.33% |
| Tianjin | 12 | 58.45% |
| Shanxi | 14 | 67.05% |
| Shanxi | 61 | 63.66% |
| Shanghai | 31 | 63.91% |
| Shandong | 37 | 67.30% |
| Ningxia | 64 | 64.83% |
| Neimenggu | 15 | 69.41% |
| Liaoning | 21 | 72.49% |
| Jilin | 22 | 72.68% |
| Jiangxi | 36 | 62.29% |
| Jiangsu | 32 | 66.10% |
| Hunan | 43 | 66.55% |
| Henan | 41 | 60.19% |
| Heilongjiang | 23 | 56.15% |
| Hebei | 13 | 62.75% |
| Hainan | 46 | 63.53% |
| Guizhou | 52 | 70.60% |
| Guangxi | 45 | 68.80% |
| Guangdong | 44 | 66.70% |
| Gansu | 62 | 73.60% |
| Fujian | 35 | 67.90% |
| Chongqing | 50 | 57.32% |
| Beijing | 11 | 53.47% |
| Sichuan | 51 | 67.90% |
| Qinghai | 63 | 78.39% |
| Anhui | 34 | 64.23% |
| **Hubei** | **42** | **30.80%** |

*Notes:* The resumption of work is defined as the ratio of the cumulative active working population after the Spring Festival (Feb 1, 2020) to the active working population in December 2019. *Source:* The Map of Baidu, see https://www.sohu.com/a/381034555_114731.


**Figure A1.** Accumulated confirmed COVID-19 cases in cities in Hubei Province on March 10, 2020.

*Notes:* This figure presents the geographical distribution of accumulated confirmed cases in Hubei Province on March 10, 2020. The map is plotted with ArcGIS 10.7.

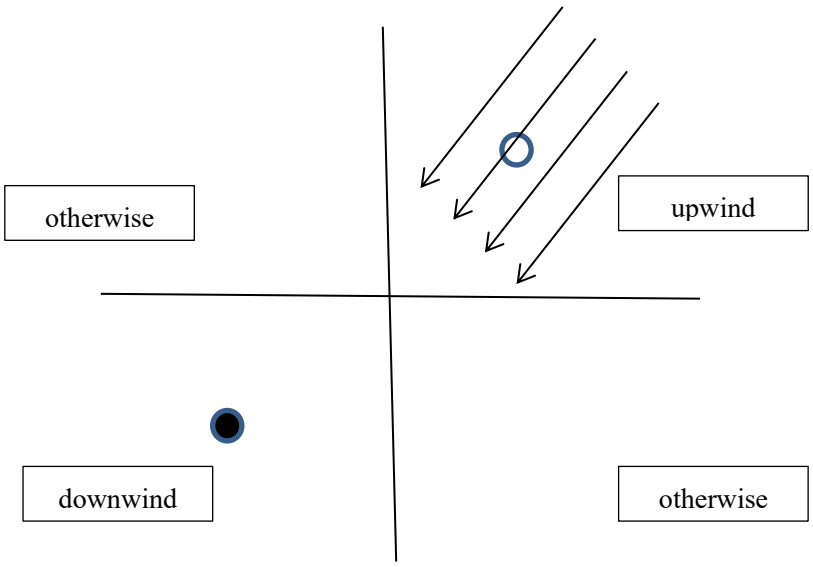


**Figure A2.** Wind direction diagram.

*Notes:* The solid circle is the location of the weather station. The hollow circle is the location of the air quality monitoring station. The black arrows indicate the wind direction.