**Online Appendix**

**for “Curbing Elite Capture or Enhancing Resources”**

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# Section I: Data and Method

## 1-1: Vertical Reform

China's local environmental enforcement has been decentralized for a long time. Local environmental enforcement agencies are constituent departments of the local government and are therefore supervised and funded by the local government. Several issues have arisen from this structure of environmental enforcement. First, local enforcement cannot be conducted independently without local intervention. Second, the local enforcement agencies are disconnected from the environmental agencies at higher levels, resulting in insufficient resources and expert support for their local enforcement. Lastly, because local enforcement agencies report only to their corresponding local government, addressing environmental problems that require inter-regional coordination is usually difficult.

To address these problems, China began planning for a "vertical reform" of environmental enforcement. In October 2015, President Xi Jinping announced that China should aim to complete the vertical reform within the 13th Five-Year Plan period. The initial plan for the vertical reform was issued in late 2016. Specifically, the vertical reform would recentralize environmental enforcement from the county level to the city level. The environmental agencies at the city government level will directly supervise and fund all enforcement forces at the county level. As a result of the vertical reform, local enforcement officials are no longer managed by the county government. Instead, they are directly supervised by the city government. The city fiscal budget is responsible for the resources needed for local enforcement, and the city government is responsible for managing the personnel issues of local enforcement teams. The local environmental enforcement agencies, although still working at each county, become delegates of the city environmental agency. The graph below briefly demonstrates the structure of China's government and the supervision of environmental agencies, and how the vertical reform recentralizes local enforcement at the county level.

The vertical reform was initially launched in Chongqing and Hebei as a pilot stage. After this stage, the vertical reform was gradually implemented across all provincial regions in China. In this study, the year each provincial region started its vertical reform was identified based on the official document of the vertical reform in each province. Documents from some provinces are publicly available, so we directly collected them. For those provinces whose official documents are not available, our research team submitted an information disclosure request to each of them to obtain such information. Table A1 presents the year each province adopted the vertical reform. Please note that, because our study period is from 2015 to 2018, all provinces that started the vertical reform in 2019 are regarded as "non-reform" in our study. In technical terms, only those provinces that started the vertical reform before 2019 are in the "treatment group" in our Difference in Differences (DID) setting.

Because there is no specific schedule for each city within one province to adopt the reform, all cities in one province are regarded to start their vertical reform in the same year that the province starts the reform. For example, all cities in Hebei provinces are regarded to have their vertical reform in 2017.

We collect the time based on openly available data. For those provinces without open information, we sent official information requests to obtain this date. We excluded the four centrally administered municipalities (Beijing, Shanghai, Tianjin, and Chongqing) because they are not comparable with ordinary provincial regions. Tibet, Guizhou, Ningxia, and Xinjiang are also excluded because they did not provide relevant information.

**Table A1 Schedule of the Vertical Reform Across Provinces in China**

|  |  |  |
| --- | --- | --- |
| **Provincial Region** | **Vertical Reform Starting Year** | **Note** |
| Hebei | 2017 |  |
| Jiangsu | 2018 |  |
| Fujian | 2018 |  |
| Hubei | 2018 |  |
| Jiangxi | 2018 |  |
| Qinghai | 2018 |  |
| Shandong | 2018 |  |
| Shaanxi | 2018 |  |
| Gansu | 2019 |  |
| Guangdong | 2019 |  |
| Guangxi | 2019 |  |
| Hainan | 2019 |  |
| Henan | 2019 |  |
| Heilongjiang | 2019 |  |
| Hunan | 2019 |  |
| Jilin | 2019 |  |
| Liaoning | 2019 |  |
| Neimenggu (Inner Mogolia) | 2019 |  |
| Ningxia | 2019 |  |
| Shanxi | 2019 |  |
| Sichuan | 2019 |  |
| Yunnan | 2019 |  |
| Zhejiang | 2019 |  |
| Anhui | NA | No reply yet |
| Beijing | NA | Excluded |
| Guizhou | NA | No reply yet |
| Shanghai | NA | Excluded |
| Tianjin | NA | Excluded |
| Xinjiang | NA | No reply yet |
| Chongqing | NA | Excluded |

Beijing, Shanghai, Tianjin, and Chongqing are excluded because they are not comparable with other cities. Three provinces (Anhui, Xinjiang, and Guizhou) have not replied to our requests yet.

## 1-2: Pollution Data

Pollution data is collected from the China City Statistical Yearbook for 2015-2018. We choose three major figures of industrial emission as our measurement of pollution enforcement quality: the SO2, the Industrial Dust, and the Industrial Wastewater. We have the following considerations in selecting these three figures.

First, the major task of local environmental enforcement is to reduce pollution emissions. Therefore, the measurement of key emission data should be more accurate in reflecting the quality of local enforcement.

Second, we focus on industrial pollution because industrial pollution is the major source of environmental pollution. It is also the major focus of the local environmental enforcement. Therefore, we believe figures on industrial pollution are more appropriate in measuring the quality of enforcement.

Third, we focus on two types of pollution: air pollution (SO2 and Dust) because these two are the common types of pollution in daily environmental works.

Lastly, the data of these three figures is relatively complete across all cities. Some other pollution measures are not complete in all cities in the time period we studied. Therefore, these three figures are the most feasible options we have given the data availability.

The average level of these three figures in each year is shown as follows.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **2015** | **2016** | **2017** | **2018** |
| **SO2 (Kt)** | 47.43 | 25.56 | 18.19 | 14.26 |
| **Dust (Kt)** | 48.04 | 24.43 | 17.90 | 15.24 |

## 1-3: Investigation Data

Investigation data was shared by the relevant government departments with the research team. The data contains five types of investigations: Penalty, Impound, Production Suspension and Limits, Detention, and Criminal Prosecution. The local government reported the investigation data to the Central Government. The research team received the raw data reported and then cleaned this data for research activities. For the data on penalty-related investigations, we collected further data based on the written decision to identify the types of pollution (air-related or not).

Our data comes from 294 cities and municipalities in China. There were 333 municipal-level administrations in China by the end of 2019. However, only 285 cities have the socioeconomic data available, and this study cannot be conducted without city-level socioeconomic statistics. We further excluded Lhasa, the capital city of Tibet, because no data was reported from Lhasa. As a result, 284 cities are included. In addition, the four Direct-controlled municipalities (Beijing, Shanghai, Tianjin, and Chongqing) are excluded since they are provincial-level administrative regions and cannot be directly compared with other city-level regions. For obvious reasons, data from Hong Kong, Macau, and Taiwan is not included as well.

We acknowledge the possibility that the self-reported data might be inaccurate as local officials may fake the data. However, we believe it is not a serious problem in our studies, for the following reasons.

First, the investigatory data are shared by the Ministry of Ecology and Environment from its internal system. The system is, in fact, an “investigation case registration system”. In this system, the local agency not merely reports a total number but also needs to report many details of each investigation conducted (e.g., investigation type, polluter’s name and identity, time, location, scale of the pollution, detailed evidence). It is very difficult to fake an investigation case entirely and create so many details to be reported in the internal system.

Second, the Ministry collects a broad range of data from different local agencies and sources, which allows the ministry to cross-check the accuracy of the data across different types of data. If one local government wants to fake investigatory data, it needs to fake many other types of data accordingly to ensure that there is no inconsistency. We believe that this process is very costly and therefore unlikely to occur.

Nevertheless, we understand that there is still some possibility of inaccurate self-reports. However, we want to point out that the number of investigations is the KPI of the local investigatory agencies that determines their performance evaluation. Therefore, even if there is inaccurate reporting, it is more likely that local agencies overreport the number of investigations rather than underreporting. However, our findings indicate that the vertical reform did not increase the total number of investigations. Therefore, even if we consider the possibility of overreporting the number of investigations, our findings are still likely to be valid.

Furthermore, because the internal registration system requires so many details in each investigatory case, it is very unlikely for local agencies to overreport non-existing investigatory cases. In fact, our research team worked with the ministry to screen the reported investigatory cases. We found that less than 0.1% of the investigatory cases were suspected nonexistent cases (overreports). In this sense, we believe that our data are accurate and reliable.

## 1-4: Other Data

The socioeconomic data is collected from the China City Statistical Yearbook from 2015 to 2019. Besides the necessary logarithm transformation of some data, when necessary, we do not make any further changes to the socio-economic data.

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# Section II: Tables and Figures for Additional Analysis and Robustness Check

## Figures for Analysis in the Main Manuscript

### Figure A1 Effect of Reform (with additional control variables)



### Figure A2 Heterogeneous Effect: GDP and GDP per capita



## Tables for Analysis in Main Manuscript

### Table A2: Robustness Check: with additional control variables

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| DV | SO2 | Dust | Pollution | SO2 | Dust | Pollution | SO2 | Dust |
|  | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Reform | -9.529\*\*\* | -26.401 | -0.027\*\* | -9.596\*\*\* | -27.280 | -0.027\*\* | -9.596\*\*\* | -27.28 |
|  | (2.573) | (18.897) | (0.011) | (2.662) | (18.910) | (0.011) | -2.662 | -18.91 |
| GDP of City (Log) | 18.909\* | -5.789 | 0.026 | 22.967\* | -12.141 |  |  |  |
|  | (10.662) | (28.107) | (0.022) | (12.044) | (26.913) |  |  |  |
| GDP per Capita (Log) |  |  |  |  |  | 0.026 | 22.967\* | -12.141 |
|  |  |  |  |  |  | (0.022) | -12.044 | -26.913 |
| Area of City (Log) | 5.201 | 8.102 | 0.026 | 12.606 | 13.402 | 0.026 | 12.606 | 13.402 |
|  | (26.117) | (28.472) | (0.050) | (28.815) | (31.430) | (0.050) | -28.815 | -31.43 |
| Population of City (Log) | -17.585 | 29.161 | -0.021 | -23.561 | 26.696 | 0.004 | -0.594 | 14.556 |
|  | (29.007) | (40.937) | (0.064) | (33.788) | (47.134) | (0.063) | -35.511 | -47.468 |
| Total Expenditure of City (Log) | 0.710 | -43.102 | -0.022 | -0.813 | -42.046\* | -0.022 | -0.813 | -42.046\* |
|  | (11.568) | (27.348) | (0.022) | (11.995) | (23.358) | (0.022) | -11.995 | -23.358 |
| Urbanization rate | 1.165\*\*\* | -0.154 | 0.002\*\*\* | 1.191\*\*\* | 0.013 | 0.002\*\*\* | 1.191\*\*\* | 0.013 |
|  | (0.172) | (0.376) | (0.000) | (0.183) | (0.445) | (0.000) | -0.183 | -0.445 |
| FDI/GDP ratio |  |  | -0.004 | -1.263 | -5.248 | -0.004 | -1.263 | -5.248 |
|  |  |  | (0.007) | (2.720) | (8.353) | (0.007) | -2.72 | -8.353 |
| Ratio of the Industrial Sector |  |  | 0.000 | -0.116 | 0.528 | 0.000 | -0.116 | 0.528 |
|  |  |  | (0.001) | (0.289) | (1.033) | (0.001) | -0.289 | -1.033 |
| Constant | -223.912 | 540.092 | -0.129 | -296.556 | 573.125 | 0.108 | -85.027 | 461.305 |
|  | (279.286) | (428.381) | (0.487) | (290.643) | (474.143) | (0.378) | -227.949 | -307.027 |
| City Fixed Effect | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year Fixed Effect | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 988 | 986 | 932 | 936 | 935 | 932 | 936 | 935 |
| Number of city | 271 | 271 | 263 | 263 | 263 | 263 | 263 | 263 |

Seven cities are dropped because of their missing data in FDI and one is dropped for missing data in the Industrial sector. Total Investigation numbers also include investigations with detention and criminal prosecution. Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### Table A3: Heterogeneous Effect of Reform: Provincial Border Cities

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| VARIABLES | Overall Pollution | | SO2 | | Dust | |
| Provincial Border City | No | Yes | No | Yes | No | Yes |
| Reform | -0.019\*\* | -0.027\*\* | -11.201\*\* | -8.214\*\*\* | -6.474\*\* | -33.093 |
|  | (0.007) | (0.013) | (4.608) | (2.722) | (2.302) | (21.604) |
| GDP of City (Log) | 0.044\* | 0.030 | 30.521\* | 27.695\*\* | 3.532 | -16.495 |
|  | (0.024) | (0.026) | (14.711) | (12.634) | (10.360) | (39.062) |
| Area of City (Log) | 0.051 | -0.035 | 32.593 | -37.214 | 11.715 | 11.996 |
|  | (0.039) | (0.093) | (22.534) | (62.327) | (18.153) | (63.108) |
| Population of City (Log) | -0.044 | -0.083 | -33.400 | -50.772 | 3.352 | 4.469 |
|  | (0.045) | (0.087) | (27.013) | (60.050) | (19.163) | (81.955) |
| Total Public Expenditure of City (Log) | 0.004 | -0.044 | 4.276 | -4.651 | -4.543 | -71.075\* |
|  | (0.026) | (0.028) | (17.719) | (10.925) | (9.529) | (40.185) |
| Urbanization rate | 0.002\*\*\* | 0.009 | 1.451\*\*\* | -0.144 | -0.155 | 11.327 |
|  | (0.000) | (0.006) | (0.193) | (3.965) | (0.136) | (11.773) |
| FDI/GDP ratio | -0.025 | -0.001 | -12.884 | -0.501 | -15.542 | -1.736 |
|  | (0.025) | (0.007) | (14.855) | (2.608) | (9.418) | (7.758) |
| Ratio of the Industrial Sector | 0.000 | -0.000 | 0.291 | -0.480 | 0.005 | 0.649 |
|  | (0.001) | (0.001) | (0.327) | (0.334) | (0.306) | (1.596) |
| Year Fixed Effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | -0.926\* | 1.081 | -645.869\*\* | 342.201 | -78.995 | 1,211.116 |
|  | (0.452) | (0.797) | (284.659) | (388.054) | (193.033) | (786.018) |
| Observations | 306 | 626 | 307 | 629 | 307 | 628 |
| Number of citycode | 0.576 | 0.308 | 88 | 175 | 88 | 175 |

Total Investigation numbers also include investigations with detention and criminal prosecution. We separate our sample into cities bordering other provinces and cities not bordering other provinces. Robust standard errors in parentheses. Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### Table A4: Lagged Outcome Regression Results

|  |  |  |
| --- | --- | --- |
| DV | SO2 | Dust |
| Reform | -4.943\*\* | -7.609\*\* |
|  | (1.795) | (2.881) |
| SO2 (one-year lagged) | 0.129\*\*\* |  |
|  | (0.035) |  |
| Dust (one-year lagged) |  | 0.010\* |
|  |  | (0.005) |
| GDP of City (Log) | -15.252 | -8.076 |
|  | (10.004) | (12.287) |
| GDP per Capita (Log) | -15.907 | -73.046 |
|  | (33.662) | (66.971) |
| Area of City (Log) | 13.878 | 3.730 |
|  | (18.014) | (15.991) |
| Population of City (Log) | -3.000 | -9.825 |
|  | (6.775) | (7.393) |
| Total Expenditure of City (Log) | 1.607\* | 3.625 |
|  | (0.810) | (2.983) |
| Urbanization rate | -0.022 | -1.235 |
|  | (0.845) | (2.114) |
| FDI/GDP ratio | 0.127 | -0.303 |
|  | (0.264) | (0.347) |
| Ratio of the Industrial Sector | -4.943\*\* | -7.609\*\* |
|  | (1.795) | (2.881) |
| Constant | 377.233 | 975.517\* |
|  | (349.171) | (555.283) |
| City Fixed Effect | Yes | Yes |
| Year Fixed Effect | Yes | Yes |
| Observations | 648 | 649 |
| Number of city | 250 | 251 |

Seven cities are dropped because of their missing data in FDI and one is dropped for missing data in the Industrial sector. Total Investigation numbers also include investigations with detention and criminal prosecution. Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1

### Table A5: Marginal Effect Investigation on Pollution

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
| DV | so2 | dust | Pollution | so2 | dust | Pollution |
| Investigation (Penalty) | 0.217 | -0.239 | 0.001 | 0.171 | -0.223 | 0.001 |
|  | (0.452) | (0.211) | (0.001) | (0.457) | (0.208) | (0.001) |
| Reform | -8.521\*\*\* | -24.754 | -0.021\* | -8.717\*\*\* | -25.690 | -0.021\* |
|  | (2.614) | (18.501) | (0.010) | (2.690) | (18.596) | (0.010) |
| Reform##Investigation | -0.905\* | -1.639\*\*\* | -0.003\*\*\* | -0.852\* | -1.672\*\*\* | -0.003\*\*\* |
|  | (0.487) | (0.279) | (0.001) | (0.493) | (0.275) | (0.001) |
| GDP of City (Log) | 17.449\* | -6.343 | 0.017 | 21.147\* | -13.827 | 0.018 |
|  | (9.628) | (28.027) | (0.023) | (11.002) | (27.652) | (0.023) |
| Area of City (Log) | 7.358 | 16.836 | 0.018 | 14.881 | 22.484 | 0.030 |
|  | (24.425) | (25.578) | (0.043) | (26.993) | (29.872) | (0.047) |
| Population of City (Log) | -19.011 | 21.112 | -0.012 | -25.132 | 18.563 | -0.020 |
|  | (27.679) | (37.314) | (0.056) | (32.315) | (44.502) | (0.063) |
| Total Public Expenditure of City (Log) | 0.880 | -42.653 | -0.023 | -0.444 | -41.421\* | -0.023 |
|  | (11.519) | (27.269) | (0.021) | (12.054) | (23.242) | (0.021) |
| Urbanization rate | 1.155\*\*\* | -0.191 | 0.002\*\*\* | 1.184\*\*\* | -0.023 | 0.002\*\*\* |
|  | (0.169) | (0.338) | (0.000) | (0.181) | (0.410) | (0.000) |
| FDI/GDP ratio |  |  |  | -1.145 | -4.748 | -0.005 |
|  |  |  |  | (2.667) | (8.213) | (0.007) |
| Ratio of the Industrial Sector |  |  |  | -0.089 | 0.584 | 0.000 |
|  |  |  |  | (0.289) | (1.039) | (0.001) |
| Year Fixed Effect | Yes | Yes | Yes | Yes | Yes | Yes |
| City Fixed Effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | -214.240 | 508.600 | 0.032 | -285.234 | 552.802 | -0.034 |
|  | (257.750) | (399.106) | (0.480) | (268.187) | (456.977) | (0.470) |
| Observations | 988 | 986 | 983 | 936 | 935 | 932 |
| Number of citycode | 271 | 271 | 271 | 263 | 263 | 263 |
| Investigation for Model 1,2,4, and 5 are for air-related cases only; Investigation for Model 3 and 6 are for all cases. Robust standard errors in parentheses: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 | | | | | | |

# Section III: Extended Analysis

## 3-1: DID Setup and Robustness Check

In this study, we use a generalized DID model following Angrist and Pischke (2008) in our analysis. We have cities from one province (Hebei) receiving the treatment (the reform) in 2017 and 98 cities from seven other provinces receiving treatment in 2018. We acknowledge that our DID data is not ideal because it has too few post-treatment years and is not very balanced. Also, we understand that readers may be concerned that the cities that started the reform in 2018 may not have received the treatment sufficiently to be regarded as the “treatment group”. We attempt to address these concerns regarding our DID setup in this section.

First, we conducted a parallel trend assumption test and showed the results in Table A6. Note that the parallel trend assumption test can only be conducted when all treatments happened at the same time. In our case, cities from Hebei received the treatment one year earlier than other cities. We, therefore, excluded Hebei in our test. The results indicate that the parallel trend assumption is likely to hold.

Second, we try to address the data imbalance problem. Our data covers the period of 2015-2018, mostly due to data availability. We believe data from 2020 is not directly comparable because of the impacts of COVID-19. Therefore, we conducted an additional DID analysis repeating the main analysis we have in the main manuscript but adding the data from 2019 in order to have one more post-treatment year. The results are shown in Table A7-A9, and our main conclusions still hold. However, we would like to note that having data from 2019 would not completely solve the problems because we would have 13 provinces starting their vertical reform in 2019. Although adding the data from 2019 would give one more “post-treatment” year for the cities with original treatment, the cities in these 13 provinces would become new observations that have only one post-treatment year. However, the fact that our main conclusions remain the same after having the data from 2019 can make us more confident that our findings are robust and not subject to the unbalanced data.

In addition, we would like to note that, although some of the cities received the reform in 2018, they all started the reform in early 2018. Thus, we expect that they still received the treatment effect in the year of 2018, giving us one post-treatment year for our generalized DID. Therefore, we have cities from Hebei covered by the treatment for 2017 and 2018 (11 cities) and cities from seven other provinces (98 cities) covered by the treatment in 2018. It is possible that cities starting the reform in 2018 received a weaker treatment in 2018 because the reform just started. However, we believe this constitutes a conservative estimation because the treatment effect is weaker than it should have been if the full reform was launched.

### Table A6: DID analysis and Parallel Assumption Test

|  |  |  |  |
| --- | --- | --- | --- |
|  | Pollution | SO2 | Dust |
| Reform DID Effect | -0.013\*\* | -8.737\*\* | -4.717+ |
| **Parallel Assumption (F-test)** | 1.50 | 1.54 | 0.31 |
| No. of Cities in Control | 166 | 166 | 166 |
| No. of Cities in Treatment | 98 | 98 | 98 |

For the parallel Assumption Test, the null hypothesis is "the linear trends are parallel," and thus none of the analyses presented can reject the null hypothesis. +p<0.1 (one-tailed) \* p<0.1 \*\*p<0.05 \*\*\*p<0.01

### Table A7: Effect of Reform on Pollution (with 2019 Data)

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) |
| DV | Pollution | Pollution | Pollution | so2 | dust |
|  |  |  |  |  |  |
| Reform | -0.018\*\* | -0.018\*\* | -0.019\*\* | -7.218\*\*\* | -18.118 |
|  | (0.007) | (0.007) | (0.008) | (1.741) | (12.322) |
| GDP of City (Log) |  | 0.022 | 0.042\*\*\* | 14.263 | 6.570 |
|  |  | (0.016) | (0.014) | (9.468) | (12.614) |
| Area of City (Log) |  | 0.007 | 0.011 | 5.678 | -5.094 |
|  |  | (0.052) | (0.060) | (29.445) | (33.505) |
| Population of City (Log) |  | -0.015 | -0.018 | -24.405 | 38.027 |
|  |  | (0.057) | (0.068) | (29.354) | (46.422) |
| Total Public Expenditure of City (Log) |  | -0.017 | -0.021 | -1.010 | -31.508 |
|  |  | (0.017) | (0.017) | (9.479) | (21.836) |
| Urbanization rate |  | 0.002\*\*\* | 0.002\*\*\* | 1.075\*\*\* | 0.228 |
|  |  | (0.000) | (0.000) | (0.210) | (0.684) |
| FDI/GDP ratio |  |  | -0.000 |  |  |
|  |  |  | (0.000) |  |  |
| Ratio of the Industrial Sector |  |  | -0.001 |  |  |
|  |  |  | (0.001) |  |  |
| Year Fixed Effect | Yes | Yes | Yes | Yes | Yes |
| City Fixed Effect | Yes | Yes | Yes | Yes | Yes |
| Constant | 0.087\*\*\* | -0.003 | -0.258 | -85.618 | 233.167 |
|  | (0.005) | (0.420) | (0.392) | (258.306) | (302.937) |
| Observations | 1,201 | 1,197 | 1,128 | 1,202 | 1,200 |
| R-squared | 0.332 | 0.335 | 0.340 | 0.577 | 0.053 |
| Number of citycode | 283 | 283 | 271 | 283 | 283 |
| Robust standard errors in parentheses\*\*\* p<0.01, \*\* p<0.05, \* p<0.1 | | | | | |

### Table A8: Effect of Reform on Pollution Investigation (with 2019 Data)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
| VARIABLES | No. of Environment Investigation | Investigation (Penalty) | Investigation (Impound) | Investigation (Limits) | Investigation (Detention) | Investigation (Prosecution) |
|  |  |  |  |  |  |  |
| Reform | -14.761 | -0.864 | -3.227 | -7.900\*\* | -2.592 | -0.178 |
|  | (13.414) | (0.595) | (13.442) | (2.881) | (1.612) | (1.176) |
| GDP of City (Log) | 73.546\*\* | 4.502\* | 38.134 | 13.795 | 14.048\*\* | 3.066 |
|  | (34.664) | (2.198) | (25.437) | (9.278) | (6.269) | (2.577) |
| Area of City (Log) | 69.587 | 7.636 | -66.057 | 43.588\* | 65.697 | 18.724 |
|  | (181.768) | (7.323) | (77.333) | (21.431) | (130.609) | (13.818) |
| Population of City (Log) | 55.023 | -13.522\* | 153.670\* | -26.284 | -40.853 | -17.988 |
|  | (164.600) | (7.893) | (81.794) | (23.752) | (117.523) | (14.724) |
| Total Public Expenditure of City (Log) | -37.237 | 1.837 | 2.201 | -25.467 | -1.324 | -14.484 |
|  | (41.554) | (2.873) | (15.696) | (15.010) | (8.251) | (11.803) |
| Pollution Level Index (0-1) | -42.145 | 1.694 | -12.471 | 5.612 | -33.054\*\* | -3.926 |
|  | (38.180) | (4.508) | (26.251) | (10.556) | (14.187) | (2.695) |
| Urbanization rate | 1.980\*\* | -0.093 | 0.023 | 1.087\*\* | 0.383 | 0.579\*\*\* |
|  | (0.725) | (0.107) | (0.729) | (0.453) | (0.252) | (0.104) |
| FDI/GDP ratio | -0.004 | 0.000 | -0.002\* | -0.001 | -0.000 | 0.000 |
|  | (0.002) | (0.000) | (0.001) | (0.001) | (0.001) | (0.000) |
| Ratio of the Industrial Sector | -1.297\*\* | -0.065 | -0.192 | -0.575\*\*\* | -0.247 | -0.219 |
|  | (0.555) | (0.050) | (0.376) | (0.194) | (0.171) | (0.142) |
| Year Fixed Effect | 28.789\*\*\* | 0.642 | 15.845\*\*\* | 7.302\* | 3.851\*\*\* | 1.149 |
| City Fixed Effect | (9.154) | (0.481) | (4.893) | (4.162) | (1.170) | (0.978) |
| Constant | -1,540.483 | -87.900\* | -937.849\*\* | -64.342 | -562.867 | 112.475 |
|  | (993.305) | (49.633) | (377.217) | (175.329) | (656.435) | (182.054) |
| Observations | 1,128 | 1,128 | 1,128 | 1,128 | 1,128 | 1,128 |
| R-squared | 0.218 | 0.074 | 0.163 | 0.122 | 0.121 | 0.094 |
| Number of citycode | 271 | 271 | 271 | 271 | 271 | 271 |
| Robust standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 | | | | | | |

### Table A9: Effect of Reform on Pollution Investigation (with 2019 Data)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | (1) | (2) | (3) | (4) | (5) | (6) |
| DV | so2 | dust | Pollution | so2 | dust | Pollution |
| Investigation (Penalty) | 0.412 | -0.149 | 0.001\* | 0.322 | -0.205 | 0.001 |
|  | (0.453) | (0.232) | (0.001) | (0.436) | (0.252) | (0.001) |
| Reform | -6.300\*\*\* | -17.046 | -0.014\*\* | -6.606\*\*\* | -17.511 | -0.015\* |
|  | (1.762) | (12.285) | (0.006) | (1.963) | (13.361) | (0.007) |
| Reform##Investigation | -0.894\* | -1.254\*\*\* | -0.002\*\*\* | -0.780 | -1.158\*\*\* | -0.002\*\*\* |
|  | (0.481) | (0.303) | (0.001) | (0.469) | (0.366) | (0.001) |
| GDP of City (Log) | 12.859 | 6.277 | 0.018 | 22.386\*\* | 18.492\*\* | 0.035\*\* |
|  | (8.696) | (12.552) | (0.015) | (9.217) | (8.497) | (0.014) |
| Area of City (Log) | 6.166 | -0.334 | 0.007 | 12.262 | -7.437 | 0.011 |
|  | (28.510) | (31.749) | (0.050) | (31.994) | (38.341) | (0.058) |
| Population of City (Log) | -24.215 | 32.984 | -0.009 | -30.691 | 44.254 | -0.011 |
|  | (28.711) | (44.577) | (0.058) | (33.650) | (53.838) | (0.069) |
| Total Public Expenditure of City (Log) | -0.408 | -29.965 | -0.017 | -2.831 | -31.754 | -0.020 |
|  | (9.386) | (21.664) | (0.017) | (9.209) | (22.446) | (0.017) |
| Urbanization rate | 1.078\*\*\* | 0.206 | 0.002\*\*\* | 1.075\*\*\* | 0.348 | 0.002\*\*\* |
|  | (0.199) | (0.666) | (0.000) | (0.190) | (0.799) | (0.000) |
| FDI/GDP ratio |  |  |  | -0.000 | -0.004 | -0.000 |
|  |  |  |  | (0.000) | (0.003) | (0.000) |
| Ratio of the Industrial Sector |  |  |  | -0.322 | -0.246 | -0.000 |
|  |  |  |  | (0.239) | (0.736) | (0.001) |
| Year Fixed Effect | Yes | Yes | Yes | Yes | Yes | Yes |
| City Fixed Effect | Yes | Yes | Yes | Yes | Yes | Yes |
| Constant | -77.414 | 200.451 | 0.023 | -202.092 | 35.237 | -0.208 |
|  | (244.313) | (286.523) | (0.398) | (257.134) | (296.620) | (0.376) |
| Observations | 1,202 | 1,200 | 1,197 | 1,132 | 1,131 | 1,128 |
| Number of citycode | 283 | 283 | 283 | 271 | 271 | 271 |
| Investigation for Model 1,2,4, and 5 are for air-related cases only; Investigation for Model 3 and 6 are for all cases. Robust standard errors in parentheses: \*\*\* p<0.01, \*\* p<0.05, \* p<0.1 | | | | | | |

## 3-2: Heterogeneity Analysis

We test the heterogeneity in the effect of the vertical reform by city economic level. Cities with lower economic development should be more susceptible to severe local protectionism because they should prioritize economic growth. Thus, our theory predicts that the vertical reform, which reduced elite capture, should be more effective in areas with lower economic development. We use GDP and GDP per capita for this analysis. The results support our prediction.

We test the heterogeneity in the effect of the reform on cities that are adjacent to other provinces and cities that are not. We argue that cities adjacent to another province should pay more attention to environmental protection because it is more difficult to deal with disputes with cities in other provinces. In contrast, the spread of pollution within one province is relatively easier to address, as the response can be coordinated by the provincial government. Therefore, we should expect less severe local protectionism in cities at provincial borders and, therefore, smaller pollution reductions from the reform in those cities if the reform’s main target was elite capture. The results again confirm our prediction.

## 3-3: Variation in the Timing of Adopting the Reform

In this section, we aim to provide preliminary evidence to show that the timing of reforms implemented in different regions is related to factors such as the capabilities of relevant personnel and the efficiency of relevant departments. We then attempt to demonstrate that there is no significant correlation between the timing of the reform and the level of regional economic development, the degree of emphasis on environmental protection, or the current pollution situation.

According to the “Regulations on Handling Documents of Party and Government Organizations” issued by the General Office of the Communist Party of China Central Committee and the General Office of the State Council in 2012 (Document No. [2012] 14), the implementation plans for vertical reform issued by various provinces fall under the category of “notifications” in official documents. In China’s local government, the formulation and announcement of notifications involve three stages:

(1) Drafting: The drafting of official documents requires a clear theme, concise wording, and standardized format. This involves the capabilities of relevant personnel and the allocation of human, financial, and material resources by relevant departments. In addition, the drafting of official documents requires in-depth investigations and solicitation of opinions from relevant regions and departments. The corresponding provincial leaders need to be committed to providing resources for conducting investigations and soliciting opinions.

(2) Review: If the reviewing authority believes that the drafted official document needs further research and modification, it should be returned for revision. This means that the publication time of notifications may also be influenced by the review process.

(3) Issuance: Notifications are joint documents issued by the provincial party committee and the provincial government, and issuing such a document requires the joint approval of the responsible persons of the provincial party committee and the provincial government.

In conclusion, we believe that the publication of vertical reform documents in different regions is more akin to a random event subject to the bureaucratic capacity and the corresponding provincial leaders’ level of commitment. To further test this viewpoint, we divided the 26 provincial-level administrative regions into four groups based on the year of publication of the reform documents and examined whether there were significant differences among the groups in terms of economic development level (measured by per capita GDP in 2016), emphasis on environmental protection (measured by the proportion of environmental investment to GDP in 2016), and pollution level (measured by sulfur dioxide emissions and wastewater discharge in 2016). The detailed results of the examination are as follows. From the results below, we can clearly see that provinces adopting reforms in different years do not have any significant difference in their economic level, their commitment to the environmental protection, and their current pollution level.

**Table A10: Comparison of Provinces in different Batch of Reform-Starting Years**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | GDP Capita | Enviro. Investment | SO2 | Water Discharge |
| 2016 | Baseline | | | |
| 2017 | 14796.3 | 0.32 | 3.844 | 68636.2 |
|  | (0.70) | (0.46) | (0.24) | (0.41) |
| 2018 | 31656.8 | -0.0850 | -22.00 | -86536.4 |
|  | (1.41) | (-0.12) | (-1.28) | (-0.48) |
| 2019 | 3591.1 | 0.410 | -4.232 | 10867.0 |
|  | (2064) | (1.72) | (-0.28 | (0.07) |
| Constant | 48507.5\* | 1.030 | 34.05\* | 245428 |
|  | (2.64) | (1.72) | (2.43) | (1.67) |
| N | 26 | 26 | 26 | 26 |
| F-Test is conducted. \*<0.1, \*\*<0.05, \*\*\*<.01 | | | | |

## 3-4: Investigations without Penalties

In this section, we provide further discussions on how it will affect our main conclusions if some investigatory actions did not lead to penalty decisions.

First, an investigation is recorded only when it is filed with consequences (penalties). In this sense, it is not counted as an “investigation” if no penalty is issued (mostly this means no fault is found). In each case, the local agencies may conduct multiple investigatory actions to obtain sufficient evidence for issuing the penalty. However, they do not record and report how many investigatory actions they conducted. All the investigatory actions lead to one final penalty, which is then recorded as one investigation case. Therefore, we do not know the exact number of investigatory actions.

Second, local officials have no incentive to conduct more investigatory actions without issuing penalties. As we explain, the investigation case is filed only if it issues a penalty in the internal system, and the number of recorded cases is a KPI to evaluate the performance of local officials. Therefore, local officials have incentives to have more investigation cases (with penalties) recorded in the system. Conducting investigatory actions without penalty, however, does not bring any explicit benefits to local officials, as it does not count toward their KPI. Since local officials have no incentive to perform investigatory actions without issuing penalties, we should see that the number of investigations with penalties also increases if more investigatory actions are taken.

Given that local officials have limited time and resources, it is natural for local officials to conduct investigatory actions only for cases they believe should be serious enough to warrant a penalty. Therefore, if the vertical reform provides more resources for local officials to conduct more investigatory actions, we should expect them to be able to find stronger evidence to issue penalties to polluters, which should also increase the number of penalty cases they report.

Reference

Angrist, Joshua D, and Jörn-Steffen Pischke. 2008. *Mostly harmless econometrics: An empiricist's companion*: Princeton university press.