## Appendix A: Data Descriptions and Sources

### A.1 Data Sources and Limitations for Hydropower Variables

Data of hydropower stations are primarily collected from the following four sources: (1) Chinese Hydropower Database (CHD, 2021); (2) Global Reservoir and Dam Database (GRanD, 2011, version 2019); (3) *Almanac of China's Water Power*; and (4) provincial electric power industry chronicles. In this section, the data structure, quality, and limitations of different data sources are described.

First, the Chinese Hydropower Database serves as the primary source for the dataset in this study, as it covers data on 3,701 hydropower stations across China (with a total of 3,510 commissioned before the end of 2019) and includes geographic coordinates of these stations. Regarding the features interested in this study, CHD contains information on the location (province, county, and longitude and latitude), name (in English and in Chinese), installed capacity (nominal and actual), commission status (commission year), and river region of hydropower stations. However, CHD has two significant limitations: (1) Missing records for small-size hydropower stations. There are substantial omissions in the records for small-size hydropower stations. As of the end of 2019, the total installed capacity of small-size hydropower stations covered by CHD is 35.8 gigawatts, which is only 44% of the national total installed capacity of 81.44 gigawatts. (2) Multiple coding for one hydropower station. Hydropower stations located at the boundaries of multiple jurisdictions, and those undergoing expansion or phased commission, are coded multiple times in CHD (Wan et al., 2022). Therefore, when calculating cross-sectional data, it is necessary to correct and consolidate this information according to other historical materials. Taking the Three Gorges Hydropower Station as an example (**Figure A. 1**), according to the author's coding, it should be recorded under Yichang County, with a count of 1 hydropower stations and an installed capacity of 22.5 gigawatts.

| 1 | GHD_ | Provi | Near_ | Hydro_Dam | Zh_Name | Lon_P_X | Lat_P_Y | Install_Nom | Install_Act | Year_Open |
|---|---|---|---|---|---|---|---|---|---|---|
| 1760 | 1759 | Hubei | Yichang | Three Gorges Dam Stage 1 | 三峡水电站一期 | 110.92245 | 30.84259 | 22500 | 4200.0 | 2003 |
| 1761 | 1760 | Hubei | Yichang | Three Gorges Dam Stage 2 | 三峡水电站二期 | 110.92245 | 30.84259 | 22500 | 5600.0 | 2004 |
| 1762 | 1761 | Hubei | Yichang | Three Gorges Dam Stage 3 | 三峡水电站三期 | 110.92245 | 30.84259 | 22500 | 12000.0 | 2009 |
| 1763 | 1762 | Hubei | Yichang | Three Gorges Dam Stage 4 | 三峡水电站四期 | 110.92245 | 30.84259 | 22500 | 700.0 | 2013 |

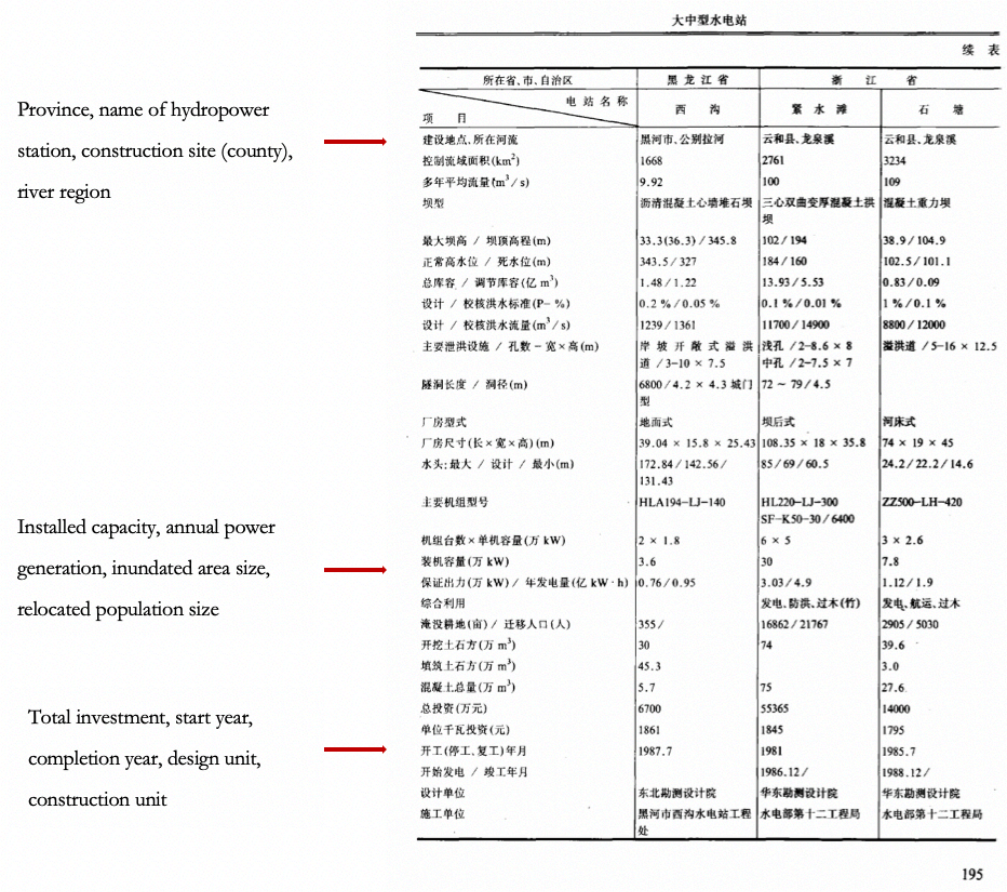
**Figure A. 1.** Example of multiple coding for one hydropower station. Note: This table is cited from the original Chinese Hydropower Database, Hydro_Dam refers to the name in English, Lon_P_X refers to the longitude of the station, Lat_P_Y refers to the latitude of the station, Install_Nom refers to the nominal installed capacity, Install_Act refers to the actual installed capacity, and Year_Open refers to the commission year.

Second, the Global Reservoir and Dam Database is a supplement to the aforementioned CHD. It is a global dataset on reservoirs and dams, providing information on the location (country, county, and longitude and latitude), name (in English), year (of construction, of completion, of commissioning, of refurbishment), and river region of theses hydraulic infrastructures. However, this dataset has the following limitations: (1) As a global dataset, GRanD contains only 770 records for China, leaving significant data omissions. (2) GRanD focuses more on the flood control capacity of hydraulic infrastructures (e.g., height / length of dam, storage capacity / depth of reservoir), with no information on the power generation capacity (i.e., installed capacity) of the associated hydropower stations (typically, hydropower stations are located on dams, with corresponding reservoirs upstream). Thus, GRanD can only serve as a supplementary data source.

For the *Almanac of China's Water Power*, it not only provides basic data on large-size and medium-size hydropower stations, but also includes brief introduction on the construction of these stations. Therefore, the Almanac can supplement the quantitative analysis of this study while serving as a reference for case selection. However, from the perspective of supplementing data, most of large-size and medium-size hydropower stations included in the Almanac have already been covered by the first two data sources. Moreover, the Almanac has certain temporal limitations: prior to 2000, the chapter "Large-size and Medium-size Hydropower Stations" typically includes a table listing newly commenced and newly commissioned hydropower stations of that year (e.g., **Figure A. 2**); between 2001 and 2005, the chapter "Statistical Materials" includes a table listing newly commenced hydropower stations of that year and their projected commissioning year (e.g.,

**Figure A. 3**); From 2006 onwards, the chapter "Statistical Materials" only includes a table on the operational status of commissioned hydropower stations (e.g., **Figure A. 4**), offering limited supplementary value for this study's focus on the hydropower construction.

For other historical sources such as provincial electric power industry chronicles, in the chapter "Power Generation", there is an introduction to small-size hydropower stations within the province (e.g., **Figure A. 5**). However, the limitation of these provincial chronicles is that most of them end their coverage at 1991 or 2002 or 2005, lacking more recent data.



大中型水电站

续 表

| 所在省、市、自治区 | 黑龙江省 | 浙江省 | |
|---|---|---|---|
| 项目 \ 电站名称 | 西沟 | 紫水滩 | 石墙 |
| 建设地点、所在河流 | 黑河市、公别拉河 | 云和县、龙泉溪 | 云和县、龙泉溪 |
| 控制流域面积($km^2$) | 1668 | 2761 | 3234 |
| 多年平均流量($m^3$/s) | 9.92 | 100 | 109 |
| 坝型 | 沥青混凝土心墙堆石坝 | 三心双曲变厚混凝土拱坝 | 混凝土重力坝 |
| 最大坝高 / 坝顶高程(m) | 33.3(36.3)/345.8 | 102/194 | 38.9/104.9 |
| 正常高水位 / 死水位(m) | 343.5/327 | 184/160 | 102.5/101.1 |
| 总库容 / 调节库容(亿 $m^3$) | 1.48/1.22 | 13.93/5.53 | 0.83/0.09 |
| 设计 / 校核洪水标准(P-%) | 0.2%/0.05% | 0.1%/0.01% | 1%/0.1% |
| 设计 / 校核洪水流量($m^3$/s) | 1239/1361 | 11700/14900 | 8800/12000 |
| 主要泄洪设施 / 孔数-宽×高(m) | 岸坡开敞式溢洪道/3-10×7.5 | 浅孔/2-8.6×8 中孔/2-7.5×7 | 溢洪道/5-16×12.5 |
| 隧洞长度 / 洞径(m) | 6800/4.2×4.3 城门型 | 72~79/4.5 | |
| 厂房型式 | 地面式 | 坝后式 | 河床式 |
| 厂房尺寸(长×宽×高)(m) | 39.04×15.8×25.43 | 108.35×18×35.8 | 74×19×45 |
| 水头:最大 / 设计 / 最小(m) | 172.84/142.56/131.43 | 85/69/60.5 | 24.2/22.2/14.6 |
| 主要机组型号 | HLA194-LJ-140 | HL220-LJ-300 SF-K50-30/6400 | ZZ500-LH-420 |
| 机组台数×单机容量(万 kW) | 2×1.8 | 6×5 | 3×2.6 |
| 装机容量(万 kW) | 3.6 | 30 | 7.8 |
| 保证出力(万 kW)/ 年发电量(亿 kW·h) | 0.76/0.95 | 3.03/4.9 | 1.12/1.9 |
| 综合利用 | | 发电、防洪、过木(竹) | 发电、航运、过木 |
| 淹没耕地(亩)/ 迁移人口(人) | 355/ | 16862/21767 | 2905/5030 |
| 开挖土石方(万 $m^3$) | 30 | 74 | 39.6 |
| 填筑土石方(万 $m^3$) | 45.3 | | 3.0 |
| 混凝土总量(万 $m^3$) | 5.7 | 75 | 27.6 |
| 总投资(万元) | 6700 | 55365 | 14000 |
| 单位千瓦投资(元) | 1861 | 1845 | 1795 |
| 开工(停工、复工)年月 | 1987.7 | 1981 | 1985.7 |
| 开始发电 / 竣工年月 | | 1986.12/ | 1988.12/ |
| 设计单位 | 东北勘测设计院 | 华东勘测设计院 | 华东勘测设计院 |
| 施工单位 | 黑河市西沟水电站工程处 | 水电部第十二工程局 | 水电部第十二工程局 |

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**Figure A. 2.** Example of the table "Indicators of Newly Commenced and Commissioned Hydropower Stations with Installed Capacity of over 12,000 kW Nationwide" (part). Note: This table is cited from Editorial Committee: *Almanac of China's Water Power (1984–1988)* (Beijing: China Electric Power Press, 1988). Similar tables can be found in the chapter "Large-size and Medium-size Hydropower Stations" of *Almanac of China's Water Power* for years prior to 2000.

"Indicators of Newly Commenced Large-size and Medium-size Hydropower Stations Nationwide in 2005"

Name of hydropower station, construction site (province, city, and county), river region

Installed capacity, annual power generation, inundated area size, relocated population size

Total investment, start year, completion year, design unit, construction unit



2005 年全国新开工大中型水电站的主要指标表

| 水电站名称 | 溪洛渡水电站 | 锦屏一级水电站 |
|---|---|---|
| 建设地点、所在河流 | 四川雷波县和云南永善县交界的金沙江干流上 | 四川省凉山州木里县和盐源县交界处、雅砻江干流上 |
| 控制流域面积(km²) | 454400 | 102600 |
| 多年平均流量(m³/s) | 4570 | 1220 |
| 工程及建筑物等级 | 一等大(1)型 | 一等大(1)型 |
| 坝型 | 混凝土双曲拱坝 | 混凝土双曲拱坝 |
| 最大坝高/坝顶高程(m) | 278.00/610.0 | 305/1885 |
| 正常蓄水位/死水位(m) | 600.00/540 | 1880/1800 |
| 总库容/调节库容(亿 m³) | 126.7/64.6 | 77.6/49.1 |
| 水库调节性能 | 不完全年调节 | 年调节 |
| 设计/校核洪水标准 P(%) | 0.1/0.01 | 0.2/0.02 |
| 设计/校核洪水流量(m³/s) | 43700/52300 | 12800/15400 |
| 主要泄洪设施/孔数一宽×高(m×m) | 溢流表孔/7—12.5×13.5、泄洪洞/4—6×6.7、竖井泄洪洞/1—14×12 | 表孔/4—11×12、深孔/5—5×6、泄洪洞/1—待定 |
| 隧洞长度/洞径(m) | 左岸:313.65～424.19/10、右岸:306.64～377.04/10 | |
| 厂房型式 | 地下厂房 | 地下厂房 |
| 厂房尺寸(长×宽×高)(m×m×m) | 381.03×28.40×75.10 | 284.8×25.5×66.7 |
| 水头:最大/设计/最小(m) | 226/186/155 | 240.00/200.00/153.00 |
| 主机型号 | HL(1535.5)—LJ—750 | HU(148.5)—LJ—655 |
| 机组台数×单机容量(万 kW) | 18×70 | 6×60 |
| 装机容量(万 kW) | 1260 | 360 |
| 保证出力(万 kW) | 339.5 | 108.6 |
| 年发电量(亿 kW·h) | 571.2 | 166.2 |
| 综合利用 | 发电、拦沙、防洪 | 主要任务是发电 |
| 淹没耕地(亩)/迁移人口(人) | 41843.21/39467 | 14095/4841 |
| 开挖土石方(万 m³) | 3543.45 | 1853.89 |
| 填筑土石方(万 m³) | 268.56 | 111.81 |
| 混凝土总量(万 m³) | 1305.36 | 742.47 |
| 静态投资(亿元) | 461.25 | 183.7166 |
| 动态投资(亿元) | 607.6389 | 232.3229 |
| 单位千瓦投资(元)(静态) | 3660 | |
| 投资方及投资比例 | | |
| 开工时间(年.月) | 2005.12 | 2005.11 |
| 计划首台/末台机组投产时间(年.月) | 2014.10/2018.12 | 2012/2014 |
| 业主单位 | 中国长江三峡工程开发总公司 | 二滩水电开发有限责任公司 |
| 设计单位 | 中国水电顾问集团成都勘测设计研究院 | 中国水电顾问集团成都勘测设计研究院 |
| 监理单位 | 二滩国际工程咨询有限公司、中国水利水电工程建设咨询中南公司、长江三峡技术经济发展有限公司 | 长江水利委员会监理中心、中国水利水电建设工程咨询西北公司 |
| 主要施工单位 | 水电八局、水电四局、葛洲坝集团公司、水电十四局等 | 葛洲坝集团公司、水电七局、水电十四局、水电十一局、水电四局等 |

**Figure A. 3.** Example of the table "Indicators of Newly Commenced Large-size and Medium-size Hydropower Stations Nationwide" (part). Note: This table is cited from Editorial Committee: *Almanac of China's Water Power (2005)* (Beijing: China Electric Power Press, 2005). Similar tables can be found in the chapter "Statistical Materials" of *Almanac of China's Water Power* for years from 2001 to 2005.

"Operational Status of Large-size and Medium-size Hydropower Stations Nationwide in 2019"

Name of hydropower station, installed capacity, annual power generation

716 统 计 资 料

**2019 年大中型水电厂生产运行情况表**

一、抽水蓄能电厂

| | 电厂名称 | 总装机容量（万 kW） | 机组台数（台） | 年发电量（亿 kW·h） | 年抽水电量（亿 kW·h） | 等效可用系数（%） | 各类工况运行总时间（h） | 各工况启动次数（次） | 启动成功率（%） |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 十三陵蓄能电厂 | 80.00 | 4 | 9.88 | 13.04 | 87.69 | 12625.33 | 3210 | 99.88 |
| 2 | 潘家口蓄能电厂 | 27.00 | 3 | 3.10 | 4.12 | 80.82 | 8526.93 | 1994 | 99.60 |
| 3 | 张河湾蓄能电厂 | 100.00 | 4 | 5.05 | 6.33 | 85.85 | 4709.15 | 1723 | 100.00 |
| 4 | 西龙池蓄能电厂 | 120.00 | 4 | 4.35 | 6.02 | 93.86 | 3772.31 | 1327 | 100.00 |
| 5 | 蒲石河抽水蓄能电厂 | 120.00 | 4 | 17.49 | 21.39 | 92.74 | 13937.91 | 3836 | 99.95 |
| 6 | 白山抽水蓄能电站 | 30.00 | 2 | 0.48 | 4.38 | 88.83 | 3069.55 | 777 | 100.00 |
| 7 | 宜兴抽水蓄能电厂 | 100.00 | 4 | 12.00 | 14.85 | 87.13 | 10865.61 | 3297 | 100.00 |
| 8 | 天荒坪抽水蓄能电厂 | 180.00 | 6 | 17.05 | 21.23 | 68.91 | 13133.37 | 3289 | 99.97 |
| 9 | 桐柏抽水蓄能电厂 | 120.00 | 4 | 16.25 | 19.61 | 88.13 | 12370.89 | 3308 | 100.00 |
| 10 | 仙居抽水蓄能电厂 | 150.00 | 4 | 19.11 | 23.60 | 86.28 | 11932.79 | 3325 | 99.94 |
| 11 | 仙游抽水蓄能电厂 | 120.00 | 4 | 20.38 | 25.37 | 90.62 | 17672.79 | 3579 | 99.94 |
| 12 | 洪屏抽水蓄能电厂 | 120.00 | 4 | 13.94 | 16.60 | 86.59 | 10372.23 | 2099 | 100.00 |
| 13 | 琼锁山抽水蓄能电厂 | 60.00 | 4 | 7.77 | 9.62 | 91.13 | 11119.96 | 2771 | 100.00 |
| 14 | 响水涧抽水蓄能电厂 | 100.00 | 4 | 14.55 | 17.98 | 90.99 | 13273.47 | 3037 | 99.93 |
| 15 | 响洪甸蓄能电厂 | 8.00 | 2 | 0.86 | 1.41 | 88.46 | 4938.88 | 1308 | 99.93 |
| 16 | 泰山抽水蓄能电厂 | 100.00 | 4 | 4.67 | 5.80 | 94.55 | 4711.32 | 2419 | 100.00 |
| 17 | 宝泉蓄能电厂 | 120.00 | 4 | 16.13 | 19.94 | 84.53 | 11972.53 | 2832 | 100.00 |
| 18 | 回龙抽水蓄能电厂 | 12.00 | 2 | 1.76 | 2.39 | 85.47 | 7282.60 | 2243 | 99.86 |
| 19 | 白莲河蓄能电厂 | 120.00 | 4 | 9.02 | 11.22 | 87.24 | 6808.02 | 1546 | 100.00 |
| 20 | 黑麋峰抽水蓄能电厂 | 120.00 | 4 | 14.27 | 17.24 | 84.44 | 10844.91 | 2505 | 99.95 |
| 21 | 广州蓄能水电厂 | 240.00 | 8 | 25.24 | 32.84 | 87.01 | 3057.5 | 6577 | 99.92 |
| 22 | 惠州蓄能水电厂 | 240.00 | 8 | 25.17 | 32.25 | 95.16 | 3522.59 | 8215 | 99.99 |
| 23 | 清远抽水蓄能电站 | 128.00 | 4 | 15.80 | 20.23 | 93.52 | 3458.64 | 4657 | 99.94 |
| 24 | 深圳蓄能水电厂 | 120.00 | 4 | 13.21 | 16.62 | 86.64 | 2545.12 | 3123 | 99.84 |
| 25 | 海南蓄能水电厂 | 60.00 | 3 | 1.35 | 1.77 | 84.63 | 771.64 | 666 | 98.65 |

**Figure A. 4.** Example of the table "Operational Status of Large-size and Medium-size Hydropower Stations Nationwide" (part). Note: This table is cited from Editorial Committee: *Almanac of China's Water Power (2019)* (Beijing: China Electric Power Press, 2019). Similar tables can be found in the chapter "Statistical Materials" of *Almanac of China's Water Power* for years from 2006 to 2019.

"Overview of Small-size Hydropower Stations with Installed Capacity of over 2,000 kW in Zhejiang Province in 1990"

City, county, name of hydropower stations, installed capacity, storage capacity, year of completion

表 2-3-1　　1990 年全省 2000 千瓦及以上小型水电站一览表

| 地区（市） | 县 | 电站名称 | 装机容量（千瓦） | 装机数（台×千瓦） | 正常库容（万米³） | 联网年月 |
|---|---|---|---|---|---|---|
| 杭州 | 临安 | 青山 | 2000 | 4×500 | 3850 | 1973.6 |
| | 临安 | 鱼跳 | 2400 | 3×800 | 径流 | 1982 |
| | 富阳 | 岩石岭二级 | 2400 | 3×800 | 1536 | 1983.6 |
| 湖州 | 安吉 | 老石坎 | 2800 | 2000+800 | 5400 | 1969 |
| | 安吉 | 赋石 | 3750 | 3×1250 | 10250 | 1978 |
| 宁波 | 奉化 | 横山 | 2850 | 1250+2×800 | 7640 | 1970 |
| | 鄞县 | 皎口 | 3750 | 3×1250 | 7808 | 1978.5 |
| | 奉化 | 亭下 | 4000 | 2×2000 | 10000 | 1984 |
| 绍兴 | 嵊县 | 南山 | 3750 | 3×1250 | 6987 | 1967.4 |
| | 嵊县 | 平天荡 | 2000 | 2×1000 | 870 | 1978.5 |
| | 新昌 | 长诏 | 6000 | 3×2000 | 13640 | 1980.7 |
| | 新昌 | 棣山 | 4000 | 2×2000 | 梯级 | 1981.12 |
| | 诸暨 | 陈蔡 | 3200 | 2×1600 | 6190 | 1986 |
| | 新昌 | 门溪 | 3200 | 2×1600 | 1856 | 1989.10 |

**Figure A. 5.** Example of the table "Small-size Hydropower Stations Across the Province" (part). Note: This table is cited from Editorial Committee: *Electric Power Industry Chronicles of Zhejiang Province* (Beijing: China Water Resource and Electric Power Press, 1995). Similar tables can be found in other provincial electric power industry chronicles.

## A.2 Data Descriptions and Sources

**Table A. 1.** Data Descriptions and Sources

| Variable | Description | Source |
|---|---|---|
| N_Jurisdiction | The total number of grassroots township-level administrative authorities, including townships (乡), towns (镇), subdistricts (街道), and ethnic townships, towns, and sums (民族乡). | National Zone Code and Classification Code (全国统计用区划代码和城乡分类代码), 2020[a] |
| Tax_Gdp | The proportion of budget revenue to GDP in the county, calculated as follow: %Tax_GDP=Budget_revenue/GDP×100%. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| HydroPower_dummy | Whether or not there are hydropower stations in the county, 1=Yes, and 0=No. | Chinese Hydropower Database (CHD, 2021)[b], Global Reservoir and Dam (GRanD, 2011, version 2019)[c], Almanac of China's Water Power (《中国水力发电年鉴》), and provincial electric power industry chronicles (各省电力工业志) |
| HydroPower_n | The number of hydropower stations in the county. | Chinese Hydropower Database (CHD, 2021), Global Reservoir and Dam (GRanD, 2011, version 2019), Almanac of China's Water Power (《中国水力发电年鉴》), and provincial electric power industry chronicles (各省电力工业志) |
| HydroPower_capacity | The total installed capacity of hydropower stations in the county. | Chinese Hydropower Database (CHD, 2021), Global Reservoir and Dam (GRanD, 2011, version 2019), Almanac of China's Water Power (《中国水力发电年鉴》), and provincial electric power industry chronicles (各省电力工业志) |
| Slope | Average slope of the county, which is measured in degree from 0 (flat) to 90° (vertical). | ASTER Global Digital Elevation Model V003[d] |
| Area | Absolute value of the acreage of county-level administrative region. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| Population | Absolute value of the registered population (户籍人口) in the county in 2020. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| %Primary_GDP | Value-added of primary industry as a share of GDP in the county, the primary industry refers to agriculture, forestry, animal husbandry and fishery. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| %Secondary_GDP | Value-added of secondary industry as a share of GDP in the county, the secondary industry refers to mining, manufacturing, production and supply of electricity, gas and water, and construction. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| Budget_revenue | Absolute value of local general public budget revenue in the county, including tax revenues, special revenues, and other non-tax revenues. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| Budget_expenditure | Absolute value of local general public budget expenditure in the county, including expenditures on general public services, public security, and social undertakings. | China Statistical Yearbook (County-level) (《中国县域统计年鉴鉴》), 2021 |
| Deposit | Total savings deposit of household. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| Loan | Loans of all forms provided by financial institutions to non-financial sectors. | China Statistical Yearbook (County-level) (《中国县域统计年鉴》), 2021 |
| Population_history | Absolute value of the registered population (户籍人口) in the county in 1953. | The 1st National Population Census (第一次全国人口普查), 1953 |
| Year_history | The number of years from 2020 when the hydropower station was first constructed in the county, calculated as follow: Year_construction=2020－year of hydropower inception. | Calculated by author according to Chinese Hydropower Database (Wan et al., 2021), and Global Reservoir and Dam (Lehner et al., 2011) |

a. See National Bureau of Statistics, https://www.stats.gov.cn/sj/tjbz/tjyqhdmhcxhfdm/2020/index.html, last accessed in September 24th, 2024.

b. See Chinese Hydropower Database (Wan et al., 2022), https://figshare.com/articles/dataset/Chinese_hydropower_database_HP_model_and_outputs/18586136/3, last accessed in September 24th, 2024.

c. See Global Reservoir and Dam (Lehner et al., 2011), https://sedac.ciesin.columbia.edu/data/collection/grand-v1, last accessed in September 24th, 2024.

d. See NASA EOSDIS Land Processes Distributed Active Archive Center (2019), https://cmr.earthdata.nasa.gov/search/concepts/C1711961296-LPCLOUD.html; National Earth System Science Data Center, National Science & Technology Infrastructure of China (Xu, 2019), http://www.geodata.cn/data/datadetails.html?dataguid=5865392&docId=4, last accessed in September 24th, 2024.

## Appendix B: Comparing Counties with and without Hydropower Stations

Here, **Figure B. 1** compares control variables between counties with at least one hydropower station (Hydropower County) and of those without (Non-hydropower County). The hydropower counties differ from the non-hydropower counties in a few socioeconomic indicators (administrative area, budget revenue, and deposits balance of residents), and two groups are equivalent in terms of historical and current conditions.

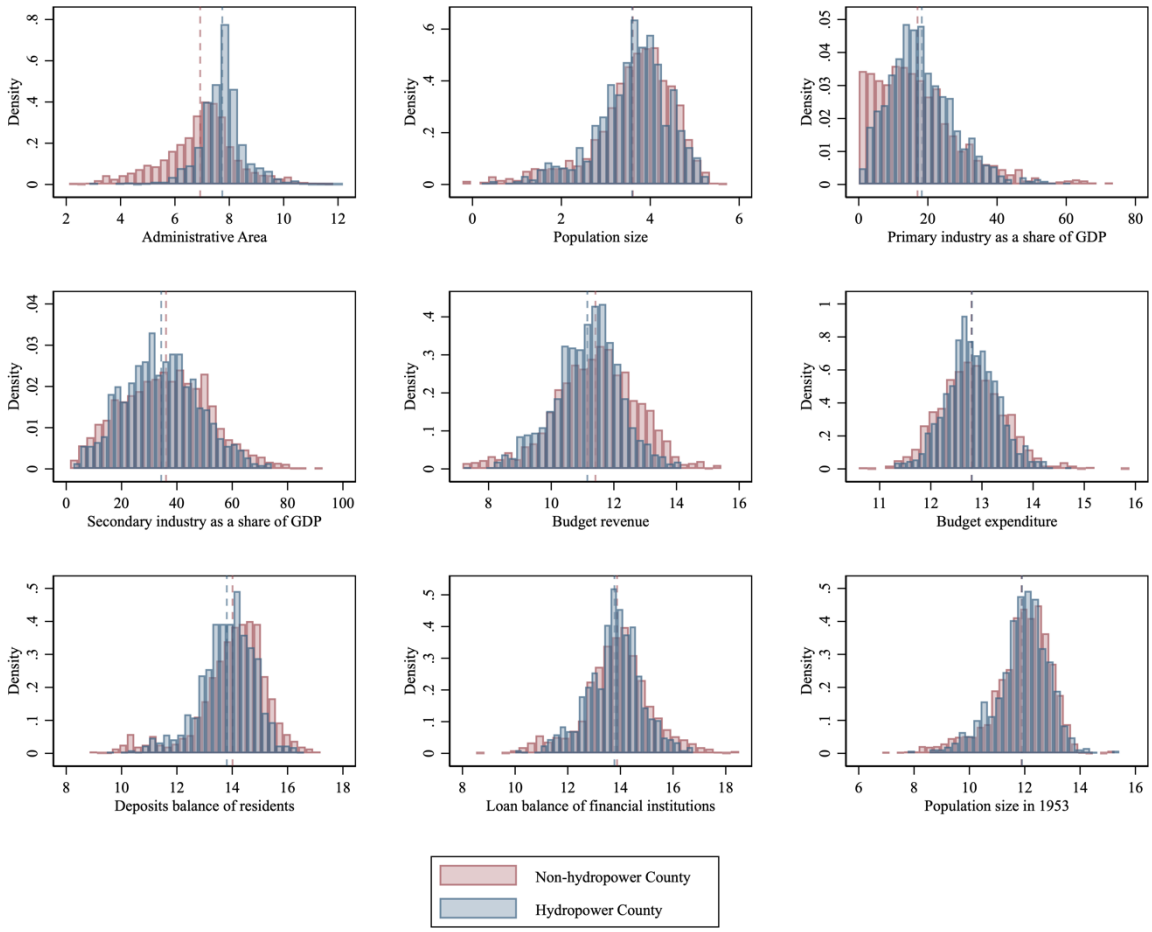


**Figure B. 1.** Comparison between counties with hydropower stations and those without hydropower stations by the end of 2020.

## Appendix C: Summary of Explanatory Variables in Different Periods

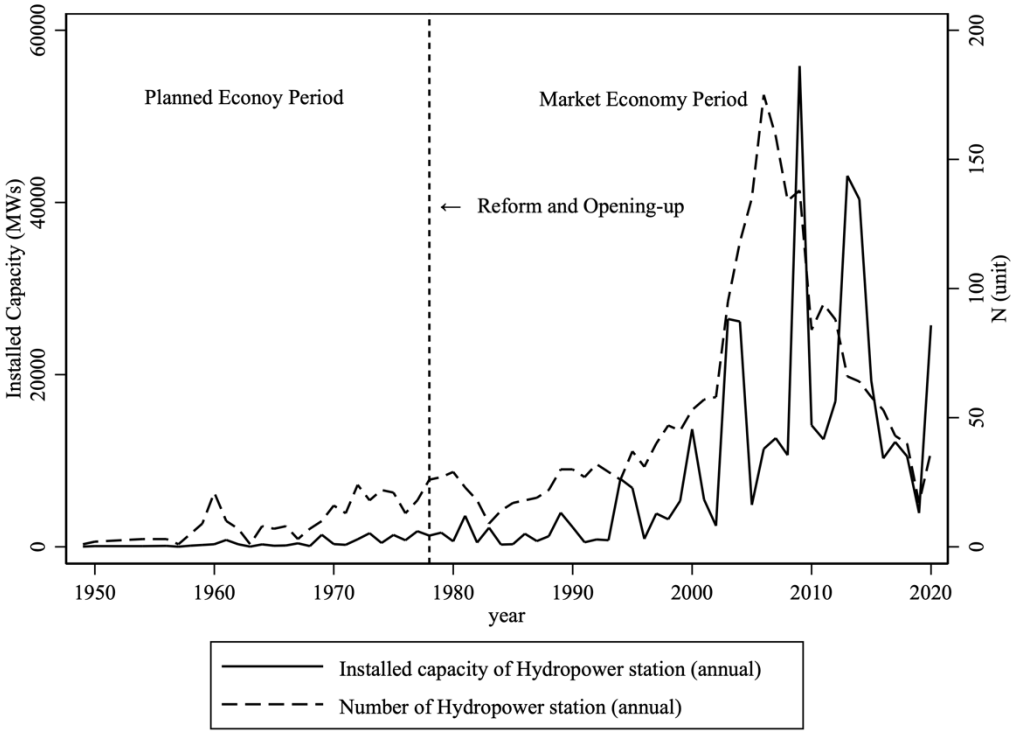


**Figure C. 1.** Number and installed capacity of newly constructed hydropower stations each year (1949–2020).

## Appendix D: Robustness Checks

### D.1 Alternative definitions and measurements

#### D.1.1 Robustness Check 1: Five-year average of explanatory variables

In the baseline model, cross-sectional data from 2020 is used (e.g., number of towns, and proportion of budget revenue to GDP). In **Table D. 1**, five-year average of explanatory variables is used, in case anomalies of cross-sectional data from a single year caused by unobserved events.

**Table D. 1.** Five-year average of explanatory variables

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| variable (logarithm) | N_Jurisdiction | Tax / Gdp | N_Jurisdiction | Tax / Gdp |
| HydroPower_n | 0.007** | 0.003 | | |
| | (0.00) | (0.00) | | |
| HydroPower_capacity | | | 0.012 | 0.041* |
| | | | (0.02) | (0.02) |
| Constant | -1.231*** | 0.627 | -1.292** | 0.587 |
| | (0.39) | (0.50) | (0.40) | (0.49) |
| Control variable | Yes | Yes | Yes | Yes |
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.866 | 0.777 | 0.866 | 0.778 |
| Observations | 2,033 | 2,033 | 2,033 | 2,033 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: Logarithms of Area, Population, Budget_revenue, Budget_expenditure, Deposit, and Loan, Primary%GDP, Secondary%GDP, History_population, Year_construction, and Rainfall are used as control variables in the regressions.

### D.1.2 Robustness Check 2: Alternative definition of penetration and extraction

Another concern is that the indicator for state capacity might not be effective. To address this concern, the author replaces the number of towns with the number of villages (including villages and communities) under each country as an indicator of penetrative capacity. The data is also calculated from China's National Zone Code and Classification Code.

Also, budget revenue might be a noisy indicator of extraction, since the administrative complexity varies significantly among different types of revenues. For instance, income, property, and domestic consumption taxes require higher levels of record keeping and more sophisticated bureaucratic apparatus than revenues from customs and mineral resources (Hanson and Sigman, 2021; Lieberman, 2002; Rogers and Weller, 2014). Besides general budget, however, there is no access to detailed county-level data in different tax categories after 2010. Thus, the latest and most comprehensive county-level fiscal data available from *National Statistics of Fiscal Data for Prefectures and Counties in 2006* (2006 年全国地市县财政统计资料) is used as an alternative indicator of extractive capacity. The author calculates the proportion of the sum of turnover tax (including value-added tax and business tax) and income tax (including enterprise income tax and individual income tax) to GDP at the county level. As **Table D. 2** shows, the result is consistent with baseline.

**Table D. 2.** Alternative definition of penetration and extraction

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| variable (logarithm) | village | turnover+income | village | turnover+income |
| HydroPower_n | 0.010** | 0.024* | | |
| | (0.00) | (0.01) | | |
| HydroPower_capacity | | | 0.068*** | 0.023 |
| | | | (0.02) | (0.01) |
| Constant | 1.441** | -2.820* | 1.336** | -2.994* |
| | (0.46) | (1.26) | (0.46) | (1.26) |
| Control variable | Yes | Yes | Yes | Yes |
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.917 | 0.472 | 0.917 | 0.472 |
| Observations | 2,033 | 1,856 | 2,033 | 1,868 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: Logarithms of Area, Population, Budget_revenue, Budget_expenditure, Deposit, and Loan, Primary%GDP, Secondary%GDP, History_population, Year_construction, and Rainfall are used as control variables in the regressions.

### D.1.3 Robustness Check 3: Different control variables

What also need to be concerned is that the number of jurisdictions and the proportion of budget revenue to GDP might be affected by different factors. Thus, the author controls different variables while estimating the effects of hydropower construction on these two different aspects of stats capacity, respectively. For the number of jurisdictions, county's scale and historical factors are controlled, including the administrative area ($Area$), the population size ($Population$), and the population size in 1953 ($Population_history$). For the proportion of budget revenue to GDP, industrial structure and the anticipations of local government, firms, and households on the local development are controlled, including value-added of primary industry as a share of GDP ($Primary\%GDP$), value-added of the secondary industry as a share of GDP ($Secondary\%GDP$), budget revenue ($Budget_revenue$), budget expenditure ($Budget_expenditure$), deposit balance of residents ($Deposit$), and loan balance of financial institutions ($Loan$). Historical and natural factors such as the number of years from the inception of hydropower in the county to 2020 ($Year_history$) and the average annual precipitation ($Rainfall$), which related to the construction of hydropower stations, are controlled in all the models (see **Table D. 3**).

**Table D. 3.** Different control variables

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| variable (logarithm) | N_Jurisdiction | Tax / Gdp | N_Jurisdiction | Tax / Gdp |
| HydroPower_n | 0.010*** | 0.009** | | |
| | (0.00) | (0.00) | | |
| HydroPower_capacity | | | 0.032+ | 0.031* |
| | | | (0.02) | (0.02) |
| Area | 0.151*** | | 0.154*** | |
| | (0.01) | | (0.01) | |
| Population | 0.465*** | | 0.462*** | |
| | (0.02) | | (0.02) | |
| Population_history | -0.013 | | -0.012 | |
| | (0.01) | | (0.01) | |
| Primary%GDP | | -0.004*** | | -0.004*** |
| | | (0.00) | | (0.00) |
| Secondary%GDP | | -0.011*** | | -0.011*** |
| | | (0.00) | | (0.00) |
| Budget_revenue | | 0.742*** | | 0.743*** |
| | | (0.02) | | (0.02) |
| Budget_expenditure | | -0.297*** | | -0.295*** |
| | | (0.03) | | (0.03) |
| Deposit | | -0.347*** | | -0.351*** |
| | | (0.03) | | (0.03) |
| Loan | | -0.116*** | | -0.113*** |
| | | (0.02) | | (0.02) |
| Year_history | 0.000 | -0.000 | 0.001* | -0.000 |
| | (0.00) | (0.00) | (0.00) | (0.00) |
| Rainfall | 32.957** | 61.322*** | 38.541*** | 67.725*** |
| | (10.26) | (10.71) | (10.07) | (10.81) |
| Constant | 0.238+ | 4.255*** | 0.205 | 4.239*** |
| | (0.14) | (0.24) | (0.14) | (0.24) |

| | | | | |
|---|---|---|---|---|
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.833 | 0.858 | 0.832 | 0.858 |
| Observations | 2,321 | 2,024 | 2,321 | 2,024 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: Logarithms of Area, Population, History_population, Year_construction, and Rainfall are put into the regressions as control variables in model (1) and (3). Logarithms of Budget_revenue, Budget_expenditure, Deposit, and Loan, Primary%GDP, Secondary%GDP, Year_construction, and Rainfall are used as control variables in model (2) and (4).

## D.2 Subsamples

### D.2.1 Robustness Check 4: Exclude counties without any hydropower stations

In the baseline analysis, nearly 70% of the sample counties do not have any hydropower stations, which indicate a skewed distribution of the explanatory variables. **Table D. 4** reports sample counties with at least one hydropower station, and the result is consistent with the baseline result.

**Table D. 4.** Exclude counties without any hydropower stations

| | Sub-sample (numerical) | | | |
|---|---|---|---|---|
| | (1) | (2) | (3) | (4) |
| variable (logarithm) | N_Jurisdiction | Tax / Gdp | N_Jurisdiction | Tax / Gdp |
| HydroPower_n | 0.006* | 0.010** | | |
| | (0.00) | (0.00) | | |
| HydroPower_capacity | | | -0.000 | 0.062*** |
| | | | (0.02) | (0.02) |
| Constant | -0.868 | 0.372 | -0.945 | 0.024 |
| | (0.66) | (0.77) | (0.66) | (0.79) |
| Control variable | Yes | Yes | Yes | Yes |
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.887 | 0.896 | 0.883 | 0.902 |
| Observations | 817 | 815 | 799 | 797 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: Logarithms of Area, Population, Budget_revenue, Budget_expenditure, Deposit, and Loan, Primary%GDP, Secondary%GDP, History_population, Year_construction, and Rainfall are used as control variables in the regressions.

### D.2.2 Robustness Check 5: Counties with > or = 300 megawatts hydropower stations

In **Table D. 5**, the analysis is limited to counties with large-size hydropower stations (with an installed capacity greater than or equal to 300 megawatts), which reduces the number of samples to 646. By limiting the analysis to these counties, the author compares counties that possess large-scale hydropower stations, which rules out the unrecorded and omitted small-scale hydropower stations' impact on the estimates.

**Table D. 5.** Counties with hydropower stations > or = 300 MW

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| variable (logarithm) | N_Jurisdiction | Tax / Gdp | N_Jurisdiction | Tax / Gdp |
| HydroPower_n | 0.008* | 0.011** | | |
| | (0.00) | (0.00) | | |
| HydroPower_capacity | | | 0.005 | 0.010** |
| | | | (0.01) | (0.00) |
| Constant | -0.104 | 0.165 | -0.267 | -0.107 |
| | (0.90) | (0.88) | (0.90) | (0.91) |
| Control variable | Yes | Yes | Yes | Yes |
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.897 | 0.904 | 0.896 | 0.852 |
| Observations | 574 | 572 | 574 | 572 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: Logarithms of Area, Population, Budget_revenue, Budget_expenditure, Deposit, and Loan, Primary%GDP, Secondary%GDP, History_population, Year_construction, and Rainfall are used as control variables in the regressions.

### D.2.3 Robustness Check 6: Counties with hydropower stations constructed during different periods

The central government's approach to "tightening" (centralizing) and "loosening" (decentralizing) control over local governments has varied across different periods (Cao and Wang, 2019, 2020). Based on the inception year of hydropower, sample counties are categorized into those from the planned economy period (1953–1978) and those from the reform period (1979–2020). For hydropower stations that do not record the year of construction, the author supposes they were constructed before 1979. **Table D. 6** and **Table D. 7** report the positive impact of hydropower construction on extractive capacity is statistically significant in both planned economy period and reform period, suggesting there is no significant difference between different periods. The impact on penetrative capacity is no longer significant, which might be due to a small sample size and numerous factors related to county-level administrative adjustments.

**Table D. 6.** Counties with hydropower stations constructed during planned economy period (1953–1978)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| variable (logarithm) | N_Jurisdiction | Tax / Gdp | N_Jurisdiction | Tax / Gdp |
| HydroPower_n | 0.004 | 0.010** | | |
| | (0.00) | (0.00) | | |
| HydroPower_capacity | | | 0.006 | 0.054* |
| | | | (0.03) | (0.02) |
| Constant | 0.113 | 1.827+ | 0.203 | 1.449 |
| | (0.94) | (1.05) | (0.91) | (1.09) |
| Control variable | Yes | Yes | Yes | Yes |
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.899 | 0.901 | 0.902 | 0.900 |
| Observations | 478 | 477 | 460 | 459 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: Logarithms of Area, Population, Budget_revenue, Budget_expenditure, Deposit, and Loan, Primary%GDP, Secondary%GDP, History_population, Year_construction, and Rainfall are used as control variables in the regressions.

**Table D. 7.** Counties with hydropower stations constructed during reform period (1979–2020)

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| variable (logarithm) | N_Jurisdiction | Tax / Gdp | N_Jurisdiction | Tax / Gdp |
| HydroPower_n | 0.019+ | 0.019+ | | |
| | (0.01) | (0.01) | | |
| HydroPower_capacity | | | 0.016 | 0.079* |
| | | | (0.05) | (0.03) |
| Constant | -1.626 | 0.031 | -1.835 | -0.829 |
| | (1.27) | (1.35) | (1.34) | (1.46) |
| Control variable | Yes | Yes | Yes | Yes |
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.921 | 0.938 | 0.916 | 0.950 |
| Observations | 339 | 338 | 329 | 328 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: Logarithms of Area, Population, Budget_revenue, Budget_expenditure, Deposit, and Loan, Primary%GDP, Secondary%GDP, History_population, Year_construction, and Rainfall are used as control variables in the regressions.

## Appendix E: Instrumental Variable Estimates

**Figure E. 1** and **Figure E. 2** show the topography and the construction scale of hydropower stations in prefectural-level on the map. As shown in the maps, both the number and the total installed capacity of hydropower stations might have positive associations with the average slope, indicating that a higher level of average slope is associated with a larger construction scale of hydropower stations (see **Figure E. 3**).

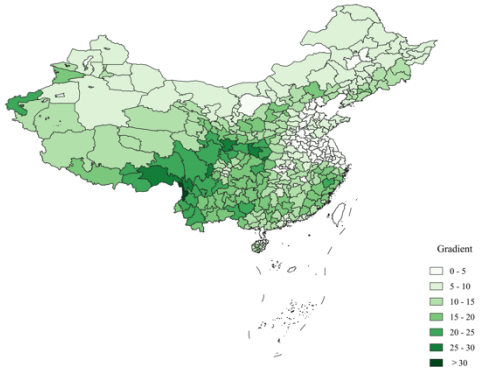


**Figure E. 1.** Average slope. Note: Data is shown at the provincial level.

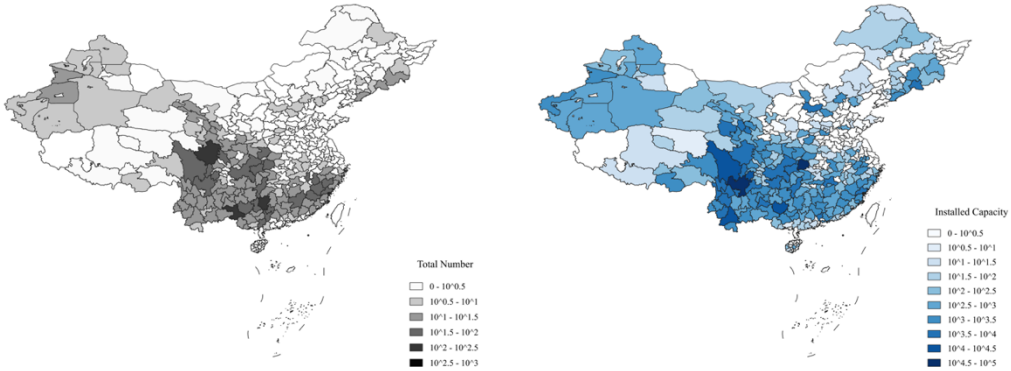


**Figure E. 2.** Construction scale of hydropower stations (1953–2020). Note: The left is measured by the number of hydropower stations, and the right is measured by the total installed capacity of hydropower stations. Data is shown at the provincial level.

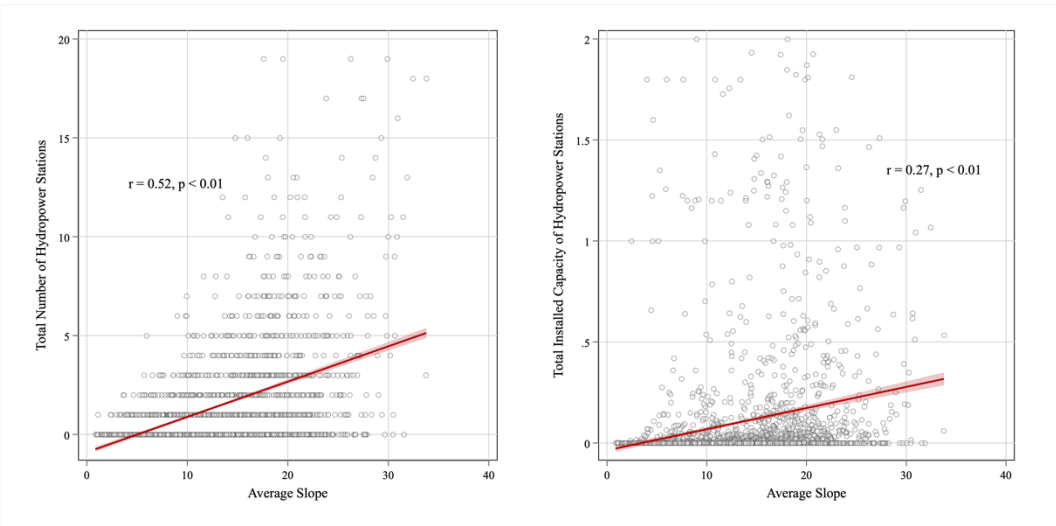


**Figure E. 3.** Scatter Plot of Average Slope and Construction Scale of Hydropower Stations (with fit and 95% CI).

One possible violation of the exclusion restriction is that the average slope may influence population size, and therefore may affects the scale of grassroots jurisdictions and budget revenue. To test this assumption, the author uses the population size in 1958 and 2020 and test whether counties with steeper slopes have larger population size. This is unlikely, as **Column 1 – 2** show, the effect of average slope on population size is negative and statistically significant.

Another possible violation of the exclusion restriction is that the state is subject to transportation cost when penetrating into local societies, and therefore it is the construction of roads, rather than hydropower stations, that has increased the number of grassroots jurisdictions and the proportion of budget revenue to GDP (Herbst, 2014). To test this assumption, the author collects data on the length of roads from *China Urban-Rural Construction Statistical Yearbook* (《中国城乡建设统计年鉴》), and calculates the density of roads in each county. As **Column 3** shows, counties with steeper slopes have significantly lower road density.

The third potential violation of the exclusion restriction is that the average slope may affect the expansion of postal services, and therefore influences the transactional cost for the state penetrating into and extracting from local societies (Acemoglu et al., 2016; Rogowski et al., 2022). To test this possibility, the author uses Gaode Map API to collect Point of Interest (POI) data on post offices within each county to proxy for the accessibility of postal services, and test whether counties with steeper slopes have more post offices. **Column 4** shows that, conversely, the effect of average slope on the number of post offices is also negative and statistically significant.

**Table E. 1.** OLS Estimates of the Effects of Average Slope on Alternatives Explanatory Variables

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| variable | Population_history | Population | Road_density | Post Office |
| Slope | -0.008$^{+}$ | -0.027*** | -0.004*** | -0.026*** |
| | (0.00) | (0.00) | (0.00) | (0.00) |
| Constant | 2.495 | 4.054*** | 0.226*** | 4.196*** |
| | (6.07) | (0.12) | (0.05) | (0.17) |
| City fixed effect | Yes | Yes | Yes | Yes |
| R–squared | 0.613 | 0.731 | 0.765 | 0.643 |
| Observations | 2,846 | 2,360 | 1,495 | 2,823 |

Note 1: Standard errors in parentheses. *** Significant at 0.1%. ** Significant at 1%. * Significant at 5%. + Significant at 10%.

Note 2: This table presents the OLS estimate of the effects of Average Slope on some alternative explanatory variables. Population_history is the logarithmic population size in 1958 at the county level, from *The 1st National Population Census, 1958*. Population is the logarithmic population size in 2020 at the county level, from *China Statistical Yearbook (County-level), 2021*. Road_density is the road density in 2020 at the county level, calculated as follow: Road_density=Length of Roads / Acreage of Administrative Region, from *China Urban-Rural Construction Statistical Yearbook , 2021* (《中国城乡建设统计年鉴》). Post Office is the logarithmic number of post office in 2020 at the county level, from Gaode Map Point of Interest (POI), https://lbs.amap.com/demo/webservice/guide/api-advanced/search.

## Appendix F: Case Evidence: Supplementary Material

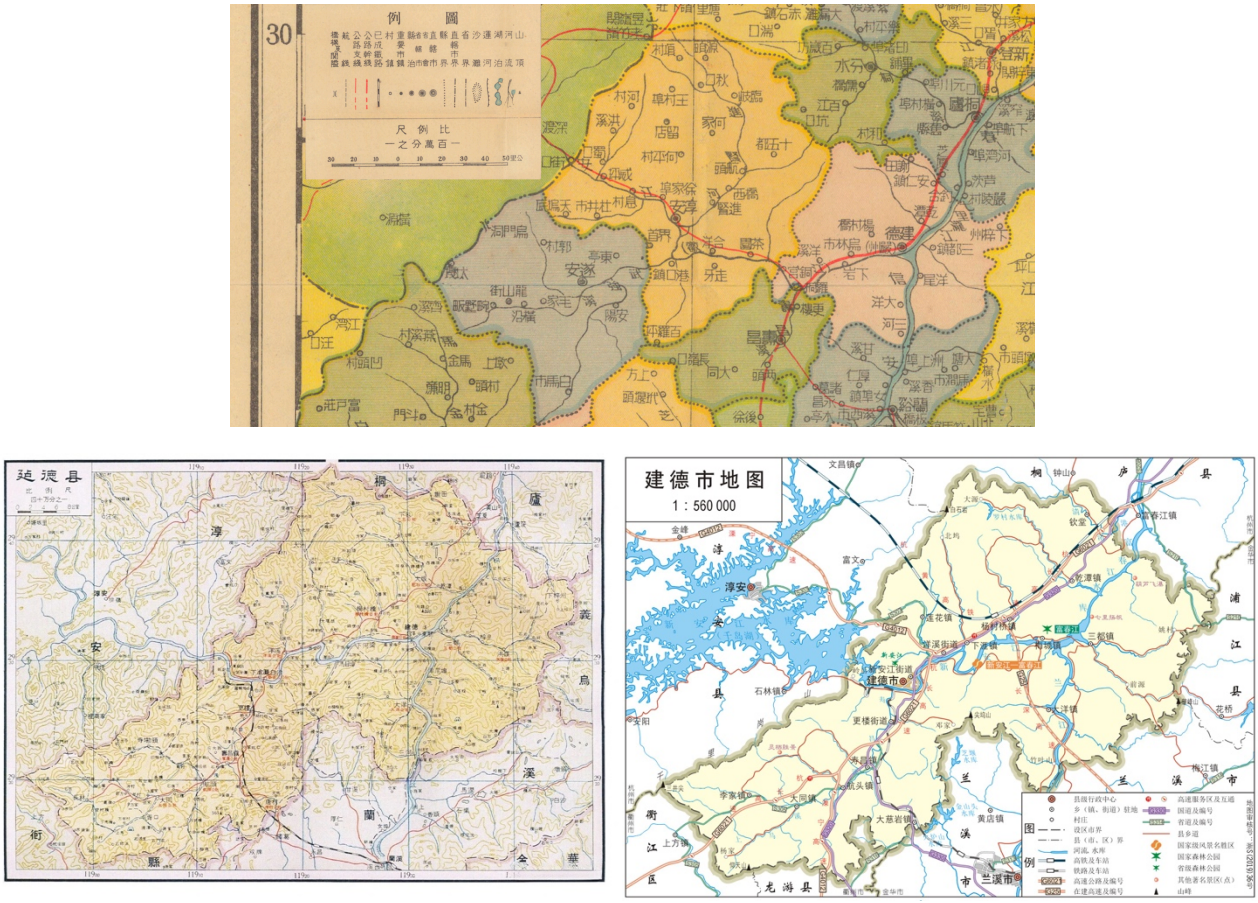


**Figure F. 1.** Changes of grassroots jurisdictions in Jiande County (1947–2019). Note: Top is the Map of Jiande County and Shouchang County in 1947, from *Detailed Map of Zhejiang Counties* (part) (Taiwan: Library of Ministry of the Interior, Number: map_moi2_2moi00095, 1986). Bottom Left is the Map of Jiande County in 1962, from Editorial Committee: *Atlas of Zhejiang Province* (Hangzhou: Zhejiang Provincial Geological Survey Team, 1962). Bottom Right is the Map of Jiande City in 2019, from Zhejiang Provincial Geographic Information Public Service Platform (https://ditu.zjzwfw.gov.cn/, 2019).

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