

Appendices for Online Publication

Appendix A. Results for Tax Rates

We discuss how local governments adjust tax rate in response to the potential decline in government income due to the implementation of the Action Plan. Before proceeding, we would like to clarify two terminologies used by the tax system: “payable tax” means the amount of tax that a firm should pay according to the formula given by the tax law, and “effective tax” means the amount of tax that the tax bureau has actually received.

The tax rate that directly affects the economy and governments’ tax income is the “effective tax rate” underlying “tax paid”. Specifically (we omit the prefecture subscript “i” for brevity),

$$ETR_I = \frac{ET_I}{GDP_I}, \quad ETR_T = \frac{ET - ET_I}{GDP_T},$$

where ETR_I (GDP_I) and ETR_T (GDP_T) are the effective tax rates (GDP) of the industrial and tertiary sectors, respectively; ET_I and ET represent the effective tax paid by the industrial sector and the whole local economy. Since China has abolished agricultural tax since 2005, $ET - ET_I$ represents tax paid by the tertiary sector.

However, we do not directly observe ET_I in the dataset. Instead, we only have access to PT_I , the payable tax of the industrial sector. Hence, if we replace ET_I by PT_I in the formula above, we are essentially getting:

$$PTR_I = \frac{PT_I}{GDP_I} \quad \text{and} \quad TR_T = \frac{ET - PT_I}{GDP_T},$$

where PTR_I is the payable tax rate of the industrial sector, and TR_T is a measure of tax rate for the tertiary sector that is neither the payable tax rate nor the effective tax rate. In particular,

$$ETR_T = TR_T + \left(\frac{PT_I}{GDP_T} - \frac{ET_I}{GDP_T} \right).$$

Hence, the effects of the Action Plan on the effective tax rates of the industrial and the tertiary sectors are given by:

$$\begin{aligned} \Delta ETR_I &= \Delta PTR_I + \left(\Delta \frac{ET_I}{GDP_I} - \Delta \frac{PT_I}{GDP_I} \right) \\ \Delta ETR_T &= \Delta TR_T + \left(\Delta \frac{PT_I}{GDP_T} - \Delta \frac{ET_I}{GDP_T} \right) = \Delta TR_T + \frac{1}{GDP_T} \times (\Delta PT_I - \Delta ET_I), \end{aligned}$$

where the second equality in the ΔETR_T equation follows from the finding that the

Action Plan has little effects on tertiary GDP (see Appendix Table A1).

When the industrial sector is negatively affected by the environmental policy, it is highly likely that the industrial sector's effective tax rate drops by a larger amount than the drop in its payable tax rate because local governments have incentive to reduce the overall burden of industrial firms' real (effective) tax burden. That is, it is reasonable to assume that $\Delta \frac{ET_I}{GDP_I} - \Delta \frac{PT_I}{GDP_I} < 0$. According to the left panel of Table A2, $\Delta \frac{PT_I}{GDP_I}$ is around 0. Hence, the Action Plan will at least not push local governments to increase the effective tax rate of the industrial sector.

Besides, $\Delta \frac{ET_I}{GDP_I} - \Delta \frac{PT_I}{GDP_I} < 0$ also indicates that $\Delta PT_I - \Delta ET_I > 0$, which implies that the estimate of the Action Plan's effect on TR_T (i.e. 0.457) is a lower bound for its impact on the effective tax rate of the tertiary sector. Hence, the effective tax rate facing the tertiary section increases by an even larger amount.¹

The significant increase in the effective tax rate of the tertiary sector while holding that of the industrial sector at least non-increasing creates a wedge between sectoral tax rates, creating possible cross-sectoral misallocation. Indeed, if the government had not changed the tax rate, the tertiary sector would have expanded. This represents another cost of environmental regulation brought by local governments' responses.

¹ Judging by Appendix Figure A1, the parallel trend assumption also holds for this regression. Figure A1 also indicates that the impact on the effective tertiary sector tax rate increases overtime. Indeed, the increase in effective tertiary tax rate drives up the amount of effective tax collected from the tertiary sectors (because GDP_T stays unchanged), which makes the total amount of local tax decline at a slower rate in 2016 and 2017 (see the dynamic effect on local tax income in Figure 2).

Table A1. Effects of the Action Plan on Tertiary Sector GDP

	Local Tertiary Sector GDP (log)	
	(1)	(2)
Tight×Post2013	0.004 (0.003)	0.004 (0.003)
Control Variables	N	Y
Prefecture Fixed Effects	Y	Y
Province-Year Fixed Effects	Y	Y
# Observations	1,645	1,574
Adjusted R^2	0.997	0.997

Notes: This table reports the estimated effects of the Action Plan on local tertiary sector's GDP. Control variables include lagged total population in log and lagged miles of paved road in log. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Table A2. Effects of the Action Plan on the Tax Rates of the Industrial and Tertiary Sectors

	Payable Tax Rate of the Industrial Sector (PTR_I)		Tax Rate of the Tertiary Sector (TR_T)	
	(1)	(2)	(3)	(4)
Tight×Post2013	-0.070 (0.081)	0.006 (0.081)	0.589*** (0.157)	0.457*** (0.158)
Control Variables	N	Y	N	Y
Prefecture FE	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y
# Observations	1,569	1,482	1,490	1,411
Adjusted R^2	0.739	0.736	0.829	0.836

Notes: This table reports the estimated effects of the Action Plan on the tax rate facing local industrial and Tertiary Sectors. Control variables include lagged total population in log and lagged miles of paved road in log. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

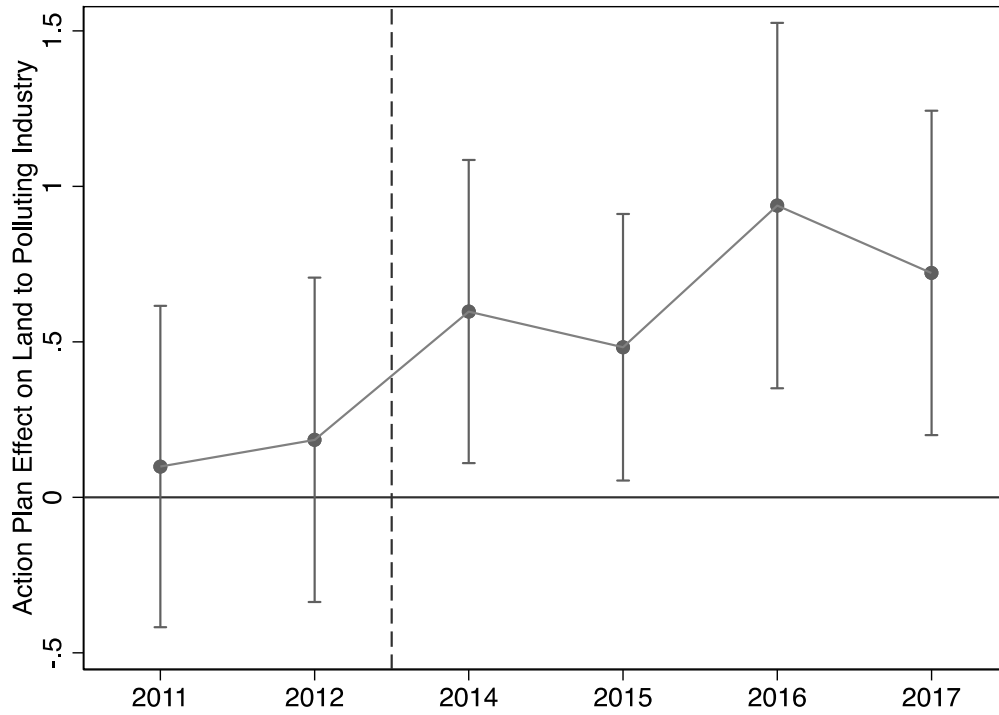


Figure A1. Parallel Trends Test for the Tax Rate of the Tertiary Sector

Note: This figure plots the results of the parallel trends test for the effective tax rate of the tertiary sector. The base year of the test is 2013. The test is conditional on prefecture fixed effects, province-by-year fixed effects, lagged prefecture-level population in log and lagged miles of paved road in log.

Appendix B. Land Financing

B1. Land Financing Introduction

According to the Land Management Law revised in 1999, the ownership of rural land belongs to the village collective, while that of urban land belongs to the state. Thus, Local governments, as the agents of the state, are *de facto* landowners and keep 100% of land sale revenue to supplement local governments' revenue loss after the 1994 tax-sharing reform. The use of this revenue is subject to inadequate supervision from the central government or the fiscal system, making it an important source of off—balance-sheet revenue. Together with the rapid industrialization and urbanization beginning in the late 1990s, land sale revenue has become the second largest revenue source on local government balance sheets. As shown in Panel A of Figure B1, from 2007 to 2019, the ratio of land sale to public fiscal revenue ranged between 18–38%.²

Moreover, local governments categorize urban land to its usage purpose: residential, commercial or industrial. Industrial land is typically sold directly at discounted price to enterprises or investors for the development of manufacturing plants, warehouses, and other industrial facilities. Residential and commercial land are sold through auctions. Hence, industrial, commercial, and residential land markets are segmented (Lu et al. 2024). In particular, industrial land is employed as the inputs of industrialization, structure upgrade (adjustment), and infrastructure investments to promote local economy. It took more than 50% of land supply in terms of supplied area but accounted for less than 30% of land sale revenue from 2007 to 2019, as shown in Panel B of Figure B1. On the contrary, commercial and residential land are used to collect revenue. Thus, commercial and residential land sales dominated, which accounted for at least 70% of the total land sale revenue from 2007 to 2019.

² Although urban land transactions began in the late 1980s, there were no actual markets for residential and commercial land prior to 2004 or for industrial land prior to 2007.

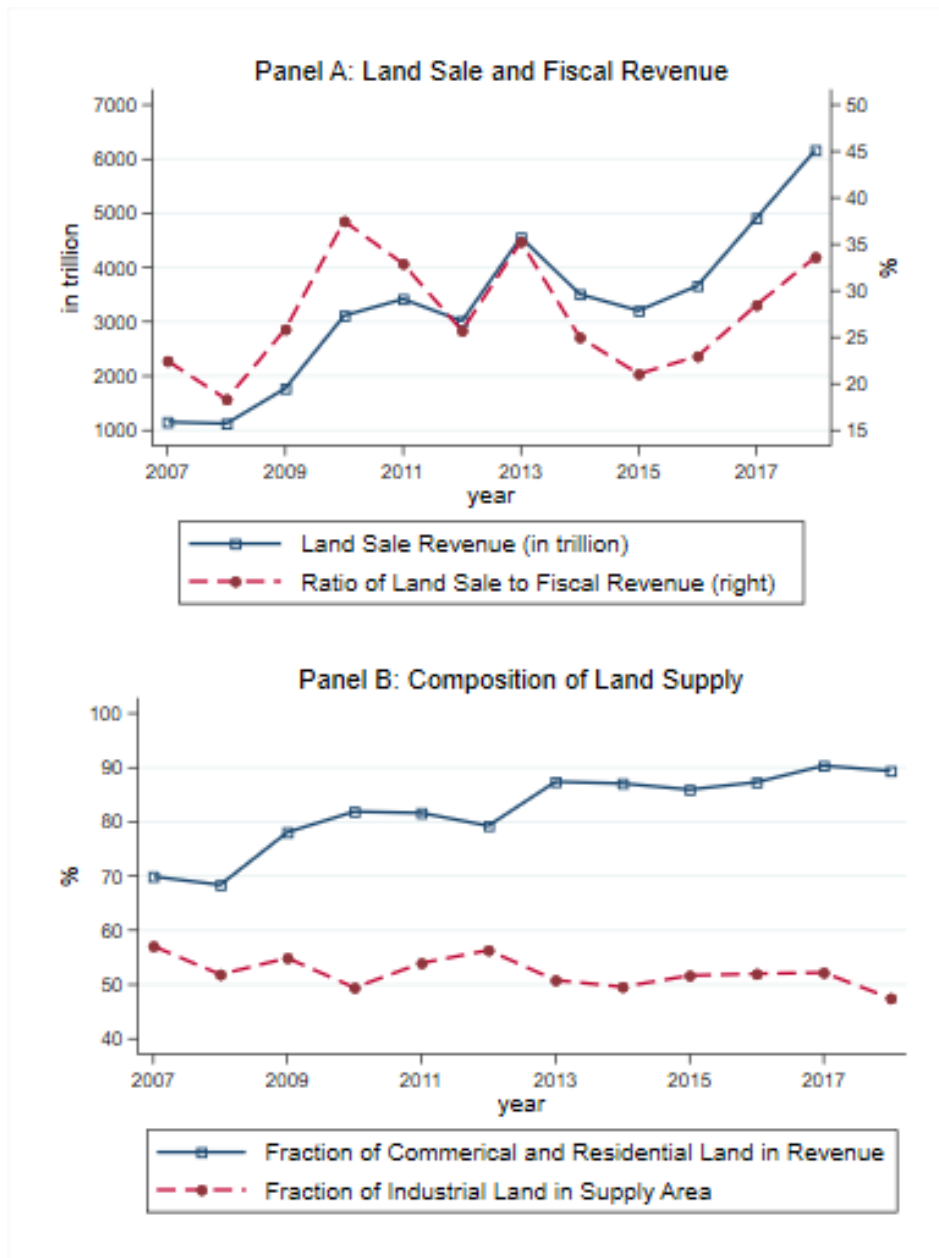


Figure B1. Characteristics of Land Supply

Notes: Panel A shows total land sale revenue and the ratio of land sale to fiscal revenue from 2007 to 2018, respectively. Panel B plots the fraction of commercial and residential land in revenue and the fraction of industrial land supply in area from 2007 to 2018, respectively. Fiscal Revenue series is from the Ministry of Finance. The series of land sale revenue and sold area are aggregated from the parcel-level land transaction data within each year. Parcel-level land transaction data collected from the website of China's Ministry of National Land and Resources: www.landchina.com.

B2. Potential Risk Mitigation – Industrial Land Allocation

Admittedly, local governments can use other policy tools to mitigate the risk of debt increase. One such policy tool is industrial land allocation. Prior to 2007, industrial land was granted for free to new firms via negotiations. However, this led to significant waste in land resource utilization (Tian and Ma, 2009), spurring the central government to introduce an auction mechanism in the industrial land market and set minimum land prices to ensure efficiency and management costs.³ Nevertheless, the price of industrial land remains far below that of residential and commercial land.⁴ Indeed, local governments mainly use industrial land allocation as inputs of industrialization and infrastructure investments to promote the local economy and foster future income sources with the construction of new plants. The estimation results in Appendix Table B1, however, indicate that the Action Plan did not significantly affect the land area allocated to either non-polluting- or polluting-manufacturing industries.⁵ On average, local governments did not utilize the industrial land allocation tool to mitigate increased debt risk.

One possible reason is that the land allocation scheme for manufacturing industries is relatively rigid. Local governments must submit their allocation schemes to the central government annually, who then ultimately determines the amount of land that can be allocated. With less flexibility available, local governments may not use this policy tool as much as they can use LGFV tools.

However, the effects do vary by local officials' terms of office and prefecture's historical LGFV debt risk. Columns (1) and (3) in Appendix Table B2 shows that local party secretaries with higher promotion urgency reduced the amount of industrial land allocated to polluting-industries by a larger extent in response to the Action Plan. However, no similar difference was observed for land allocated to non-polluting-industries. As discussed above, land allocation to manufacturing industries must be approved by higher-

³ For details regarding the industrial land auction mechanism and minimum land prices, please refer to Tian et al., (2020).

⁴ According to the authors' calculations, the average residential and industrial land prices in 2019 were 4,346 and 288 yuan per square meter, respectively.

⁵ Polluting industries (two-digit industry codes) include: petroleum processing, coking products, and gas production and supply (25); raw chemical materials and chemical products (26); medical and pharmaceutical products (27); chemical fibers (28); rubber products (29); plastic products (30); nonmetal mineral products (31); and smelting and pressing of ferrous metals (32). For brevity, we have only listed the two-digit industry codes of non-polluting industries in the manufacturing sector: 13-24 and 33-43.

order authorities and is relatively inflexible. To ensure they are able to meet the environmental targets necessary for them to receive a promotion, the secretaries facing a higher level of urgency are incentivized to spare no effort to reduce the amount of land allocated to polluting industries. However, land allocation to non-polluting industries neither generates immediate fiscal income nor directly relates to pollution control. Therefore, neither secretaries with more urgency nor those with less urgency are willing to undertake a lengthy approval procedure to increase the amount of land allocated to non-polluting industries. The overall decline in land allocation to manufacturing industries created by local officials' promotion incentives further weakens the economy's ability to mitigate the increased risk of future debt.

In contrast, we find that local prefecture-level governments with higher pre-policy debt risk tend to resolve the risk of increased debt in the future. Specifically, as shown by Columns (2) and (4) in Appendix Table B2, local governments with higher pre-policy debt risk increased the allocation of industrial land to non-polluting industries, but reduced that to pollution industries following the implementation of the Action Plan. Although the coefficients are insignificant, their p-values are not far below 10%.

Table B1. Effects of the Action Plan on Local Governments' Land Allocation to Manufacturing Sectors

	Areas Allocated to Non-polluting Sectors (log)		Areas Allocated to Polluting Sectors (log)	
	(1)	(2)	(3)	(4)
Tight×Post2013	0.039 (0.032)	0.051 (0.032)	0.012 (0.044)	0.000 (0.044)
Control Variables	N	Y	N	Y
Prefecture FE	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y
# Observations	1,639	1,558	1,618	1,527
Adjusted R^2	0.808	0.811	0.726	0.726

Notes: This table reports the estimated effects of the Action Plan on local Governments' land allocation to manufacturing sectors. We divide these sectors into polluting sectors (left panel) and non-polluting sectors (right panel). Control variables include lagged total population in log and lagged miles of paved road in log. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Table B2. Effects of the Action Plan on Local Governments' Land Allocation to Manufacturing Sectors – By Term of Office and Historical LGFV Debt Risk

	Areas Allocated to Non-polluting Sectors (log)		Areas Allocated to Polluting Sectors (log)	
	(1)	(2)	(3)	(4)
Tight×Post2013	0.038 (0.043)	0.065* (0.038)	0.084 (0.057)	0.001 (0.044)
Tight×Post2013×HighIn	-0.009 (0.072)		-0.266*** (0.096)	
Tight×Post2013× pdebt ₁₁₁₃		0.070 (0.055)		-0.071 (0.044)
Control Variables	Y	Y	Y	Y
Prefecture FE	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y
Number of Observations	1,395	1,438	1,376	1,411
Adjusted R^2	0.820	0.811	0.731	0.729

Notes: This table reports the heterogeneous effects of the Action Plan on local Governments' land allocation to manufacturing sectors by local officials' terms of office and prefecture's historical LGFV debt risk, respectively. We divide these sectors into polluting sectors and non-polluting sectors. Control variables include lagged total population in log and lagged miles of paved road in log. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Appendix C. Additional Tables and Figures

Table C1. Robustness Checks

	Local LGFV Debts: Total (log)	Other Payables/Total Debt
	(1)	(2)
<i>Panel A: Results in the Main Text</i>		
Tight×Post2013	0.054*** (0.016)	-0.002 (0.004)
<i>Panel B: With $\mathbf{z}_{ipre} \times \mathbf{f}(t)$ as Control Variables</i>		
Tight×Post2013	0.047*** (0.016)	-0.001 (0.004)
<i>Panel C: Dropping 2016 and 2017 Observations</i>		
Tight×Post2013	0.034** (0.016)	-0.001 (0.005)
<i>Panel D: Dropping Metropolitan Prefectures</i>		
Tight×Post2013	0.055*** (0.018)	-0.001 (0.005)
<i>Panel E: Dropping Prefectures with Pilot Carbon Markets</i>		
Tight×Post2013	0.047*** (0.018)	0.002 (0.005)
Control Variables	Y	Y
Prefecture FE	Y	Y
Province-Year FE	Y	Y

Notes: Panel B of this table reports the results of the robustness check when flexibly controlling for possible differentiated pre-policy trends in log (outcome variables) for prefectures with different treatment intensities. We do so by including $\mathbf{z}_{ipre} \times \mathbf{f}(t)$ as additional controls, where \mathbf{z}_{ipre} includes *pre-policy* (i.e., 2013) outcome variables, the fraction of employment by the secondary industry, terrain roughness, elevation, wind speed, temperature and precipitation. $\mathbf{f}(t)$ is a third-order polynomial of time. To facilitate comparison, Panel A of this table replicates the estimation results of the main regressions. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Table C2. Alternative Treatment Intensity Definition

	Local LGFV Debts: Total (log)	Other Payables/Total Debt
	(1)	(2)
<i>Panel A: Results in the Main Text</i>		
Tight×Post2013	0.052*** (0.017)	0.000 (0.004)
<i>Panel B: Alternative Treatment Definition: Tight = 2013 SO2 removal/ GDP * (1+target)</i>		
Tight×(1+target)×Post2013	0.050*** (0.017)	0.000 (0.004)
Control Variables	Y	Y
Prefecture FE	Y	Y
Province-Year FE	Y	Y

Notes: Panel B of this table reports the results of the robustness check for the main regression results where an alternative definition of treatment intensity is adopted. To facilitate comparison, Panel A of this table replicates the estimation results of the main regressions reported. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Table C3. Effects of the Action Plan on the Costs of LGFVs' Bond Financing

	Interest Rate Spread		
	(1)	(2)	(3)
Tight×Post2013	0.116** (0.048)	0.126** (0.063)	0.121** (0.049)
Tight×Post2013×HighIn		0.037 (0.120)	
Tight×Post2013× pdebt ₁₁₁₃			-0.089** (0.038)
Control Variables	Y	Y	Y
Prefecture FE	Y	Y	Y
Province-Year FE	Y	Y	Y
Number of Observations	926	809	898
Adjusted R^2	0.738	0.755	0.736

Notes: This table reports the effects of the Action Plan on the costs of LGFV's bond financing and its heterogeneous effects by local officials' terms of office and prefecture's historical LGFV debt risk, respectively. The interest rate spread is the average coupon rate (weighted by issuance volume) for each city in a certain year minus the benchmark loan rate announced by the PBoC in corresponding year. Control variables include lagged total population in log and lagged miles of paved road in log. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Table C4. Effects of the Action Plan on Local LGFV Debts: regulation tightness is measured by COD abatement intensity of each prefecture in 2012

	Local LGFV Debts: Total (log)	Local Debt: Non- other Payables (log)	Local Debt: Other Payables (log)	Local Industrial Revenue (log)	Local GDP (log)
	(1)	(2)	(3)	(4)	(5)
Tight×Post2013	-0.016 (0.026)	-0.026 (0.029)	0.039 (0.029)	0.007 (0.008)	-0.005 (0.003)
Control Variables	N	N	N	N	N
Prefecture FE	Y	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y	Y
# Observations	1,389	1,389	1,388	1,500	1,555
Adjusted R^2	0.971	0.968	0.941	0.986	0.997

Notes: This table reports the estimated effects of the Action Plan on local LGFV debts, local industrial sector revenue and local GDP when the regulation tightness is measured by Chemical Oxygen Demand abatement intensity of each prefecture in 2012, i.e., $\text{COD adatement}_{i,2012}/\text{GDP}_{i,2012}$. We divide LGFV debts into two categories: i. non-other payable debts that includes municipal construction bonds, bank loans and other debts that are under strict supervision (Column (2)), and ii. other payables including firm-to-firm debts and other debts that are subject to looser supervision and are riskier (Column (3)). The results for local industrial sector revenue and local GDP are reported in the Column (4) and (5). Control variables include lagged total population in log and lagged miles of paved road in log. All variables are winsorized at 1% and 99% levels. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

Table C5. Effects of the Action Plan on Local LGFV Debt: winsorizing all variables at the 1% and 99% levels

	Local LGFV Debts: Total (log)		Other Payables/Total Debt		Local Debt: Non-other Payables (log)		Local Debt: Other Payables (log)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Tight×Post2013	0.048*** (0.016)	0.045*** (0.016)	0.008** (0.004)	0.008** (0.004)	0.036** (0.017)	0.033* (0.017)	0.082*** (0.029)	0.078*** (0.029)
Control Variables	N	Y	N	Y	N	Y	N	Y
Prefecture FE	Y	Y	Y	Y	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y	Y	Y	Y	Y
# Observations	1,519	1,491	1,499	1,475	1,519	1,491	1,516	1,491
Adjusted R^2	0.970	0.970	0.692	0.690	0.967	0.967	0.939	0.939

Notes: This table reports the estimated effects of the Action Plan on local LGFV debts and by debt source. We divide LGFV debts into two categories: i. non-other payable debts that includes municipal construction bonds, bank loans and other debts that are under strict supervision (Column (5) and (6)), and ii. other payables including firm-to-firm debts and other debts that are subject to looser supervision and are riskier (Column (7) and (8)). The results for the share of other payables in total LGFV debts is also reported in the Column (3) and (4). Control variables include lagged total population in log and lagged miles of paved road in log. All variables are winsorized at 1% and 99% levels. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

**Table C6. Effects of the Action Plan on Local Industrial Revenue and GDP:
winsorizing all variables at the 1% and 99% levels**

	Local Industrial Revenue		Local GDP	
	(log)		(log)	
	(1)	(2)	(3)	(4)
Tight×Post2013	-0.030*** (0.011)	-0.029** (0.011)	-0.016*** (0.004)	-0.016*** (0.004)
Control Variables	N	Y	N	Y
Prefecture FE	Y	Y	Y	Y
Province-Year FE	Y	Y	Y	Y
# Observations	1,651	1,612	1,714	1,669
Adjusted R^2	0.987	0.987	0.996	0.997

Notes: This table reports the estimated effects of the Action Plan on local industrial sector's revenue (left panel) and local GDP (right panel). Control variables include lagged total population in log and lagged miles of paved road in log. All variables are winsorized at 1% and 99% levels. Standard errors clustered at prefecture-by-year level are reported in parentheses. *** Significant at 1% level, ** significant at 5% level, and * significant at 10% level.

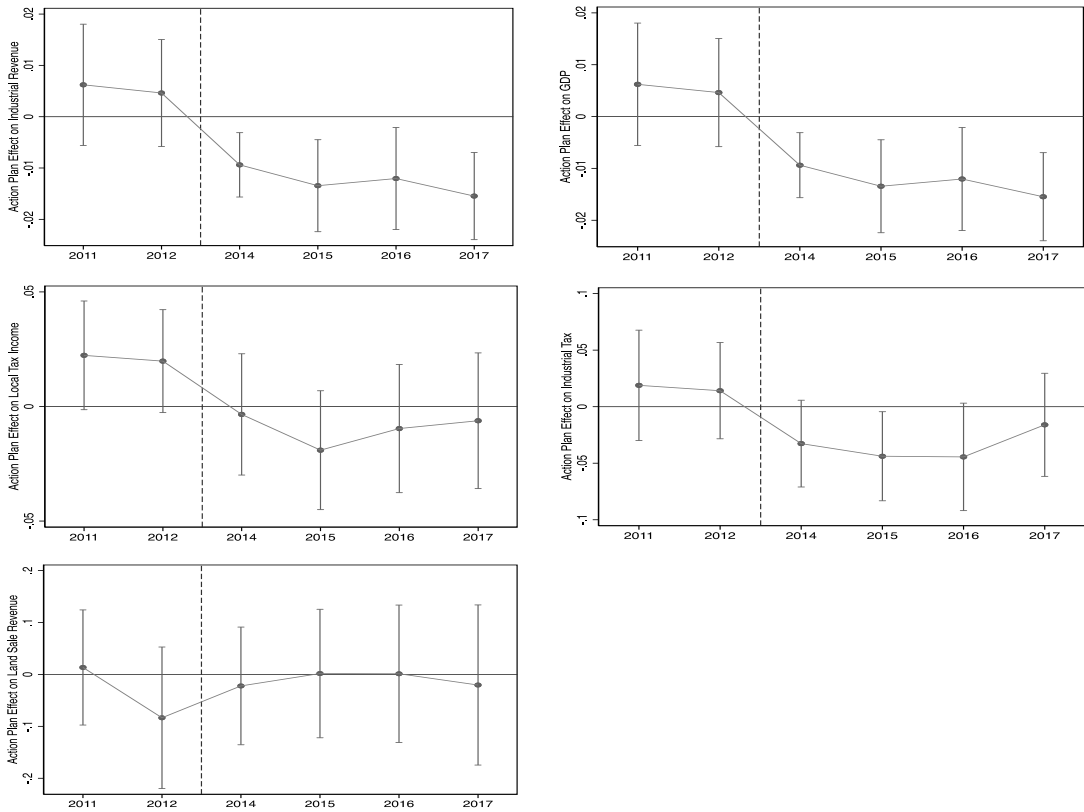


Figure C1. Results of the Parallel Trends Test for Variables in the Mechanism Analysis