Environmental Conservation

cambridge.org/enc

Research Paper

Cite this article: Ren L and Wang R (2024) The Five-Year Plan and target allocation cycle of environmental pollution in China. *Environmental Conservation* **51**: 211–218. doi: 10.1017/S0376892924000158

Received: 17 October 2023
Revised: 12 May 2024
Accepted: 13 May 2024
First published online: 19 September 2024

Keywords:
Environmental pollution; Five-Year Plan (FYP); political business cycle; target allocation cycle

Corresponding author:
Renhe Wang;
Email: wrh18@tsinghua.org.cn

The Five-Year Plan and target allocation cycle of environmental pollution in China

Liuqing Ren[1,2] and Renhe Wang[1,3]

[1]School of Politics and Public Administration, South China Normal University, Guangzhou, Guangdong 510006, PR China; [2]Schar School of Policy and Government, George Mason University, Arlington, VA 22201, USA and [3]School of Public Policy and Management, Tsinghua University, Beijing 100084, PR China

Summary

This paper establishes a theoretical connection between China's Five-Year Plan (FYP) and environmental pollution. We propose a target allocation cycle theory to explain the periodic feature of environmental pollution, which advances political business theory in different institutional contexts. By analysing industrial SO_2 and $PM_{2.5}$ data as well as the political career data of officials in 277 Chinese cities from 2003 to 2019, we reveal a significant influence of China's political business cycles, as dictated by the FYP, on the periodicity of environmental pollution. Specifically, the emissions of industrial SO_2 and $PM_{2.5}$ exhibit a U-shaped periodic trend, peaking during the initial 2 years of each FYP, followed by a gradual decline in subsequent years, only to peak again in the first year of the succeeding FYP. These findings suggest that local political leaders strategically allocate their efforts in managing environmental pollution. Initially, there is a relaxation of environmental regulation during the early stages of a FYP, which is then followed by a shift towards more stringent environmental governance after the midpoint of the FYP.

Introduction

Why does environmental pollution in China exhibit cyclical patterns? What factors contribute to the periodic emissions of pollutants? This article explores and evaluates the link between China's Five-Year Plan (FYP) and environmental pollution, proposing that the cycles of the FYP significantly influence pollution trends. This research explores the intersection of political business cycles and environmental policy within the unique institutional context of China's centralized governance system. We propose a theory of target allocation cycles to explain why local governments initially relax environmental regulations at the beginning of the FYP and progressively strengthen them as the plan progresses. Understanding these cyclical patterns is vital for policymakers and environmental planners aiming to design more consistent and effective strategies for balancing economic growth with environmental sustainability. By identifying the underlying incentives and pressures that drive these cycles, more robust frameworks for environmental governance can be developed to ensure lasting improvements in pollution control and environmental quality.

A large and growing body of work has demonstrated that political business cycles exist not only in established democracies but also in countries going through democratic transitions and even in countries considered to be established autocracies (Nordhaus 1975, Alesina et al. 1997, Baleiras & Santos 2000, Drazen 2000, Gonzalez 2002, Shi & Svensson 2006, Guo 2009, Blaydes 2011). Political business cycles are driven by elections and party alternation in democracies as governments pursue expansionary monetary or fiscal policies during election periods in order to win elections. Democratic elections and party rotation both indicate that speculation or opportunism is exhibited by local leaders to signal competence to irrational voters. Another stream of political business cycle scholarship shows that any regular political event could form a political business cycle, not being solely contingent on democratic elections or party rotation. This expands the scope of political business cycle theory to encompass different institutional settings (Tao 2006, Nie et al. 2013, Xi et al. 2018, Fan et al. 2022). However, the fundamental logic underlying both streams of scholarship remains consistent: political business cycles stem from the speculation of political officials. In democracies, political officials engage in opportunistic behaviour to secure voter support, while in autocracies, speculation is aimed at signalling competence to higher authorities for potential promotion.

In other words, local officials exhibit similar speculation and selective policy implementation regardless of them being members of distinct political institutions (O'Brien & Li 1999, Ran 2013). It thus becomes imperative to consider other institutional variables to enhance understanding of political business cycle theory. In the context of China, the central government wields considerable authority to formulate a comprehensive national development plan and relies on mechanisms such as promotion incentives and control over officials to achieve planning objectives. It is crucial not to overlook this pivotal institutional arrangement, particularly the FYP in China, which involves long-term target allocation. Developing such insight is crucial as it suggests that cycles are driven by target allocation arrangements rather than the opportunism of officials' political behaviour.

Schulze (2021) found that the production of climate policies in democracies tends to increase as elections approach, driven by an uptick in 'soft' climate policies such as subsidies and information campaigns. This behaviour contrasts with the more consistent production rates of 'hard' policies such as taxes and regulations, indicating a nuanced response to electoral pressures that might parallel China's handling of environmental policies during the FYP. This dynamic, in which soft policies are favoured before elections to avoid voter backlash while still signalling action, aligns with China's periodic intensification of environmental regulation towards the end of the FYP cycle as officials respond to the dual pressures of achieving both economic and environmental targets.

The FYP is crucial for understanding China's target governance approach, as it serves as a central tool for nationwide political and economic development (Heilmann & Melton 2013, Mao et al. 2014, Shi & Xu 2018). The central government formulates overarching policy guidelines and delegates policy objectives and standards to provincial governments (Zhou 2016). These policies are then further distributed to municipal governments, and ultimately local governments are responsible for their implementation. While environmental targets are set in the FYP every 5 years, the specific timing of their implementation within that period is at the discretion of local governments, granting them significant flexibility. For example, in the 11th FYP period (2006–2010), some local governments distributed environmental targets on an annual basis, while others set higher targets for the first or last year of the FYP (Kostka 2013).

Local officials therefore wield discretionary power, typically prioritizing short-term objectives over long-term objectives (Olson 1993) and strategically addressing multiple goals with limited attention and search capabilities (Lindblom 1959). This often results in the sidelining of other priorities initially, with officials only shifting their focus to unresolved matters when pressure mounts in the medium term. This leads to officials focusing their attention on specific areas in the early stages of the FYP, pushing other priorities aside and only beginning to focus on unfinished issues when pressure increases in the medium term. This raises the question relating to when environmental regulation becomes intense or relaxed, prompting the development of target allocation cycle theory to examine cycles in environmental pollution.

Under China's bureaucratic system characterized by centralization, local leaders are required to balance competing goals and pressures to strategically allocate resources and attention over a 5-year period, resulting in target allocation strategies at different points in time. This involves finding a balance between short-term speculation and stable actions (Zhou et al. 2013), giving rise to the target allocation cycle. Hence, we hypothesize that during the FYP environmental pollution exhibits a specific periodic pattern. Local governments tend to initially relax environmental regulation and subsequently strengthen it year by year.

Limited existing research explicitly examines the link between the political business cycle of official tenure and environmental implications. Cao et al. (2019) suggested that career incentives tied to an official's tenure can create an environmental political business cycle, revealing a U-shaped relationship between a party secretary's years in office and $PM_{2.5}$ levels. Shen (2018) distinguished between tenure cycles and lengths, proposing that the tenure cycle drives periodic $PM_{2.5}$ emissions. These studies imply that incentives may reduce environmental regulation enforcement in the first and last years of an official's tenure, leading to periodic environmental pollution fluctuations. Nonetheless, the unpredictability and high rotation rate of local leaders' tenure in China, largely determined by upper-level governments (Eaton & Kostka 2014), render tenure as an ineffective indicator of political or policy cycles. Given the substantial flexibility in local leader tenure limits and durations, this paper argues that the FYP is a more convincing variable for explaining China's target allocation cycle and its environmental impact.

The primary objective of this article is to examine whether environmental pollution exhibits a regular cycle during the FYP period. Therefore, it is important to select reliable measurements for environmental pollution. Building on the methodology employed in He (2006), Shen (2018) and Cao et al. (2019), this study incorporates both $PM_{2.5}$ and industrial SO_2 emissions indicators for assessing environmental pollution. Public awareness of $PM_{2.5}$ surged following the clear skies initiative for the 2008 Beijing Olympics, which spurred subsequent air pollution control policies. $PM_{2.5}$ has been a focal point since the 13th FYP. In addition, industrial SO_2 emissions, which represent total emissions from industrial activities, are closely associated with economic activity (Li & Ma 2014). These emissions are vital for economic growth, particularly in industrial cities, and they have been a significant indicator since the 11th FYP, reflecting the ongoing challenge facing local governments to reconcile economic development with environmental pollution (Cao et al. 2009).

Methods

We use the data of 277 prefecture-level cities in China over 17 years (2003–2019) as observation samples to explore the target allocation cycle of environmental pollution in China.

Atmospheric $PM_{2.5}$ and industrial SO_2 were selected as dependent variables to represent environmental pollution. The annual industrial SO_2 emissions of 277 cities from 2003 to 2019 were obtained from the China City Statistical Yearbook (National Bureau of Statistics of China 2020). The most recent $PM_{2.5}$ data for 277 cities from 2003 to 2018 came from Dalhousie University's Atmospheric Composition Analysis Group, based on global $PM_{2.5}$ raster data measured by NASA satellites.

We use the time points of the FYP to depict the target allocation cycle. According to the official gazette of the Chinese government, we have collected the release dates of the 10th, 11th, 12th and 13th FYPs. Taking the fourth year of the FYP as the baseline, YP1, YP2, YP3 and YP5, respectively, represent the dummy variables of the first, second, third and fifth years of the FYP. If this year was the first, second, third or fifth year of the FYP, then YP1, YP2, YP3 and YP5 were equal to 1, otherwise they were equal to 0. The selected time period (2003–2019) covers the last 3 years (2003–2005) of the 10th FYP, the two complete FYP cycles of the 11th FYP (2006–2010) and the 12th FYP (2011–2015) and the first 4 years of the 13th FYP (2016–2019).

For control variables, our focus primarily centred on a range of economic indicators, including the urban economic growth rate (gdpr) and GDP per capita (gdppc). To account for the influence of economic structure, population density and employment conditions on environmental pollution, we incorporated additional variables such as the ratio of tertiary industry to GDP (ser), the proportion of secondary industry in GDP (ind), population density (rkmd) and unemployment data (unem).

Furthermore, we introduced the ratio of foreign direct investment in GDP (fdig) to control for the impact of foreign enterprises on environmental protection following Zeng and Eastin (2007). Previous research has demonstrated that local governments with more flexible fiscal resources tend to be more proactive in environmental regulation (Liang & Langbein 2015). Therefore, we included the percentage of general budget expenditure to GDP as an indicator of fiscal stress (fisg) to account for potential effects in this area. Data for these variables were sourced from the China City Statistical Yearbook (National Bureau of Statistics of China 2020).

Based on Porter and Linde (1995), who posited that environmental regulations can incentivize firms to enhance their production technology and that technological innovation can reduce environmental pollution and improve environmental governance, we introduced a variable to measure the level of green technological innovation (ino). This variable was obtained from data on the number of invention patents and utility model patent applications filed with the State Intellectual Property Office. We accessed these data directly through the China Research Data Service Platform (CNRDS) 'green patent GPRD' database, with green patents defined according to the criteria outlined in the 2010 'Green Patent List' issued by the World Intellectual Property Organization (WIPO).

To further confirm the influence of the FYP on environmental SO_2 emissions, we conducted a series of robustness checks. We substituted the FYP dummy variables with an alternative metric. Recognizing the consistent 5-year cycle of the FYP, we introduced a variable named 'planyear', which denotes the years remaining in the current FYP cycle. We assigned this variable a value of 5 in the first year of the FYP, decreasing to 1 in the final, fifth year. This coding scheme is designed to reflect the diminishing time local leaders have to meet their objectives before the FYP evaluation period, thus capturing the pressure on local leaders to achieve their priorities during the FYP.

Additionally, in our robustness testing section, we further introduced control variables related to the characteristics of officials, as proposed in the existing literature on the environmental pollution cycle. These variables encompass the relative ages of municipal party committee secretaries and mayors (Liu & Wan 2019), the calculation of a 5-year term for municipal party committee secretaries and mayors and the consideration of whether it was a second term (Cao et al. 2019) and variables related to the terms of municipal party committee secretaries and mayors (Shen 2018).

To compile data on the political careers of key officials in China's prefecture-level cities, we gathered information on the age and term of office for mayors and municipal party committee secretaries from official media sources such as the People's Daily Online (http://renshi.people.com.cn), the Local Party and Government Leaders Database of China Economic Website (http://district.ce.cn/zt/rwk/) and relevant government websites. We code the data according to the month in which they took office. If the term of office in that year was less than 6 months, it was calculated as the following year. When the term of office was longer than 6 months, it was calculated as the current year. The value of the first year of the term of office was 1, increasing year by year as the term of office continued. After calculation and re-coding, we took the term of office as a variable to construct two more variables, namely the term of office of the municipal party committee secretary (sjrq) and the term of office of the mayor (szrq). If the term of office of a local leader exceeded 5 years, the code started again with 1. Then we recorded according to whether it was a second term, and finally we constructed the four variables of the term cycle of the municipal party committee secretary (sjrq_again) and the term cycle of the municipal party committee secretary (szrq_again), and whether it was the second cycle (sjrq_second, szrq_second). For the relative age variable of the local leaders, according to the promotion rule of Chinese cadres, the local leaders of prefecture-level cities essentially lose any chance of promotion when they are more than 55 years old. Therefore, according to the algorithm shown in the literature, we used the difference between the age of officials and 55 years of age at the time of the next transition as the standard to obtain two variables: the relative age of the municipal party committee secretary (sjage_relative) and the relative age of the mayor (szage_relative).

To address outliers and missing values, we utilized a moving average method for interpolation. Descriptive statistics for all variables are presented in Table 1.

To comprehensively analyse the trends in China's industrial SO_2 emissions and $PM_{2.5}$ levels throughout the FYP cycle, we employed a panel regression model. Recognizing that the diverse economic and geographical conditions in different cities can impact air quality, we utilized a fixed-effects model, a choice validated through the Hausman test. To address the potential issue of multicollinearity between the introduced fixed time effect and established dummy variables, we took a two-pronged approach. Firstly, we included a comprehensive set of control variables to capture various factors that could influence the outcomes. Additionally, we introduced time trend variables to account for the broader macro-level time effects. The mathematical representation of this approach is as follows:

$$SO_{2it}/PM_{2.5it} = \beta_0 + \beta_1 YP1_{it} + \beta_2 YP2_{it} + \beta_3 YP3_{it} + \beta_4 YP5_{it} + \beta X_{it} + Trend_t + \sigma_i + \theta_i + \varepsilon_{it}$$

Among these, i represents 277 cities in China, t represents time (2003–2019) and SO_2 and $PM_{2.5}$ are the dependent variables as the annual average industrial emissions of SO_2 per city entity from 2003 to 2019 and the annual average $PM_{2.5}$ of each city entity during 2003–2018. YP1–5 is a dummy variable of the FYP time, Trend is a time trend variable, σ_i and θ_i are the dummy variables of the city and province, respectively, reflecting the fixed effect of the city and province that will not change in a short time period, and X_{it} is a series of the control variables mentioned above to ensure the robustness of hypothesis verification. ε is the error term and β is a parameter to be fitted. We use the clustered standard errors at the level of the prefecture-level city to ensure the robustness of the model.

To validate the genuine significance of the FYP cycle and eliminate potential alternative explanations, we introduced the aforementioned categories of variables related to local leadership characteristics for examination. More specifically, we took into account the variables concerning the tenures of local leaders. These variables were subjected to robustness tests in the final stage of our empirical analysis.

Results

Environmental pollution cycle of the Five-Year Plan

The average emissions of SO_2 and $PM_{2.5}$ varied by year and FYP (Fig. 1). The years 2006, 2011, and 2016 were, respectively, the first

Table 1. Descriptive statistics for all variables (see main text for variable descriptions)

Variable	Observations	Mean	Standard deviation	Minimum	Maximum
SO_2	4709	48 892.01	46 931.91	2	496 000
$PM_{2.5}$	4416	43.036	18.946	4.883	110.118
gdpr	4709	11.169	4.818	−19.38	109
gdppc	4709	37 095.25	31 437.62	1892	468 000
ser	4709	48.127	32.449	9	2139
ind	4709	38.595	9.638	8.58	85.34
rkmd	4709	420.927	314.945	4.7	2759.139
fdig	4709	27.184	30.504	0	454.017
fisg	4709	16.689	10.128	0.012	193.638
ino	4709	311.937	996.508	1	20 305
unem	4709	27 157.99	275 000	142.67	18 800 000
sjrq	4709	3.298	1.965	1	13
szrq	4709	3.087	1.817	0	11
sjrq_again	4709	2.598	1.334	1	5
szrq_again	4709	2.535	1.313	0	5
sjrq_second	4709	0.073	0.261	0	1
szrq_second	4709	0.035	0.183	0	1
sjage_relative	4709	0.235	3.734	−13	18
szage_relative	4709	2.293	4.055	−8	18

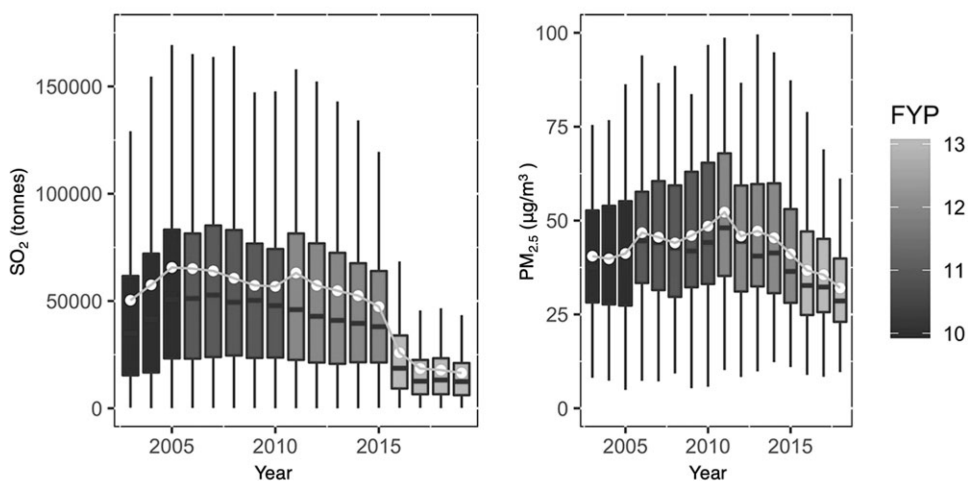

Figure 1. Historical trends in SO_2 and $PM_{2.5}$ for each Five-Year Plan (FYP).

years of the FYPs. Both SO_2 and $PM_{2.5}$ were at high levels and then decreased, which indicates the cyclical characteristics of China's environmental pollution.

Furthermore, we calculated and plotted the average trends of SO_2 and $PM_{2.5}$ at five time points of the different FYPs from 2003 to 2019. There was a discernible pattern in China's FYPs concerning environmental pollution (Fig. 2). Specifically, during the initial year following the commencement of a new FYP, there has tended to be a notable increase in pollution emissions. However, as the FYP has progressed and reached its midpoint, a noticeable reduction in pollution emissions occurs, aligning with the objectives of environmental assessment targets. It typically takes c. 3 years after the launch of a new FYP for prefecture-level cities to formulate comprehensive plans within the FYP framework, in alignment with the central government's objectives extending from the provincial to the local level. Local governments often do not prioritize environmental considerations and face less immediate pressure to meet environmental goals before receiving assessment tasks from higher-level authorities. It is noteworthy that, in the fifth year of the FYP, local governments have tended to exhibit a more relaxed approach to environmental regulation.

Further evidence of an environmental pollution cycle

To ensure that the stationarity of variables does not impact the regression outcomes, we conducted both unit root and co-integration tests, following the methodology outlined by Baltagi (2008). The test results indicated that our panel data are both stationary and co-integrated. Table 2 provides an overview of the regression analysis results for SO_2 and $PM_{2.5}$ across different FYP cycles.

There has been a significant U-shaped periodic trend in environmental pollution control throughout the FYP period (Table 2, columns (1) and (2)). Specifically, using the fourth year of the FYP as a baseline, both SO_2 emissions and $PM_{2.5}$ concentrations have exhibited cycles. In the initial 2 years of the FYP, SO_2 emissions increased by 3151 and 3224 tonnes, respectively. SO_2 emissions then decreased, reaching their lowest point in the third year, showing a reduction of 1772 tonnes, before rising again to 5738 tonnes in the final year. $PM_{2.5}$ concentrations follow a similar pattern, with the highest levels in the first 2 years – increasing by 2.295 and 0.706 μg/m^3, respectively. The lowest $PM_{2.5}$ concentrations occur in the third year, with a decrease of 1.724 μg/m^3, and then there is a slight rise to 0.315 μg/m^3 in the fifth year of the FYP. This trend suggests that environmental protection has not been

https://doi.org/10.1017/S0376892924000158 Published online by Cambridge University Press

Table 2. Basic model analysis results

	(1) SO_2 2003–2019	(2) $PM_{2.5}$ 2003–2018	(3) SO_2 2006–2015	(4) $PM_{2.5}$ 2006–2015
YP1	3151.673***	2.295***	5785.216***	3.590***
	(866.875)	(0.292)	(1459.939)	(0.439)
YP2	3224.688***	0.706***	3321.226***	−0.370
	(637.724)	(0.252)	(888.398)	(0.302)
YP3	−1772.110***	−1.724***	1738.262***	−0.416
	(476.319)	(0.165)	(656.325)	(0.264)
YP5	5738.766***	0.315*	−1805.809*	−0.975***
	(766.900)	(0.191)	(951.460)	(0.205)
Control	Y	Y	Y	Y
Trend	Y	Y	Y	Y
City FE	Y	Y	Y	Y
Province FE	Y	Y	Y	Y
Constant	142 412.273***	41.854***	103 017.752***	56.352***
	(7080.173)	(5.093)	(30 416.060)	(6.584)
Observations	4709	4416	2770	2760
R^2	0.7546	0.8858	0.8535	0.9315

*p < 0.1, **p < 0.05, ***p < 0.01.
Robust standard errors clustered by city in parentheses. The dependent variable of columns (1) and (3) is SO_2 (tonnes), and the sample periods are 2003–2019 and 2006–2015, respectively. The dependent variable of columns (2) and (4) is $PM_{2.5}$ (μg/m^3), and the sample periods are 2003–2018 and 2006–2015, respectively. The control variables include gdpr, gdppc, ser, ind, rkmd, fdig, fisg, ino and unem (see main text for variable descriptions). The models in these columns all control the time trend term (Trend), the city fixed effect (City FE) and the province fixed effect (Province FE).

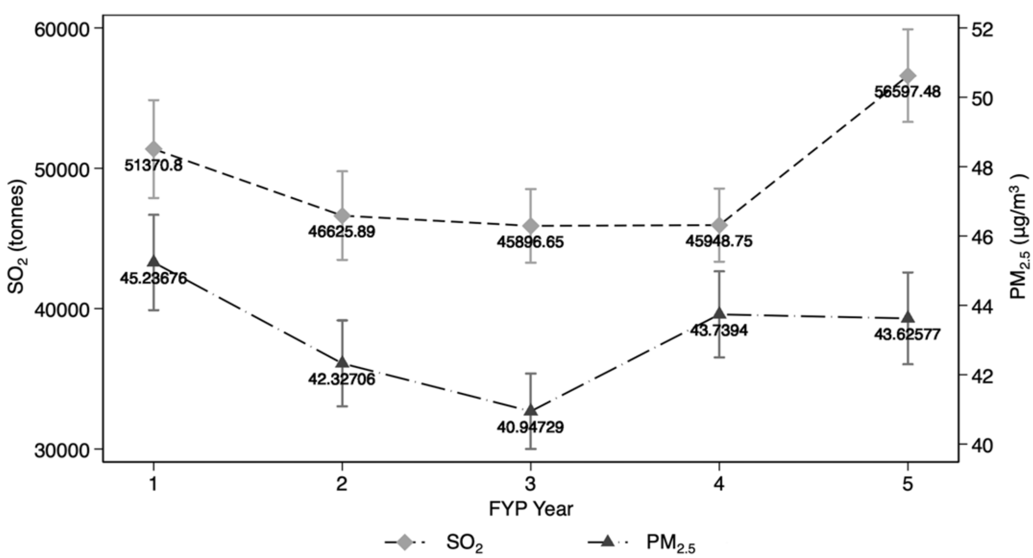

Figure 2. Average SO_2 and $PM_{2.5}$ over different Five-Year Plan (FYP) years.

prioritized in the early stages of the FYPs. However, as plans progress and the pressure to meet environmental targets increases, local governments increase their focus on environmental protection.

To further validate the existence of the target allocation cycle within two complete FYP cycles (the 11th and 12th FYPs), we narrowed our sample to the period from 2006 to 2015 (Table 2, columns (3) and (4)). A comparison with columns (1) and (2) in Table 2 highlights variations in the regression coefficients of the third and fifth years of the FYPs. The coefficients for SO_2 and $PM_{2.5}$ steadily declined from their peaks in the first years of the FYPs to negative values in the fifth years (YP5). Specifically, SO_2 emissions decreased from the peak of 5785 tonnes in the first years of the FYPs to −1805 tonnes in the fifth years, whereas $PM_{2.5}$ levels decreased from 3.59 μg/m^3 in the first years to −0.975 μg/m^3 in the fifth years.

These findings further confirm the consistent pattern of decreasing pollution levels year by year after peaking in the first and second years of the FYPs. In the early FYP years, local environmental pollution remains a significant concern, but as the deadline for the FYP environmental target assessments approaches, local governments intensify their efforts regarding environmental protection, resulting in a reduction in environmental pollution. These results underscore the presence of a target allocation cycle in China's environmental pollution management, which is closely linked to the FYP framework.

Robustness test

The robustness test confirms that environmental SO_2 pollution has exhibited a cyclical pattern during the FYP periods (Table 3, panel A, column (5)). Notably, SO_2 emissions reached their peak in the first years of the FYPs and then decreased by 1854 tonnes each subsequent year based on the remaining years of the FYP. $PM_{2.5}$ levels decreased by 0.904 μg/m^3 each year during the remaining years of the FYPs (Table 3, panel B, column (10)).

Regression outcomes with introduced variables related to local leaders' tenure and personal characteristics as controls align closely with the previous conclusion (Table 3, panel A, columns (6)–(9)

https://doi.org/10.1017/S0376892924000158 Published online by Cambridge University Press

Table 3. Robustness tests results of the basic model

Panel A: SO_2 as dependent variable	(5)	(6)	(7)	(8)	(9)
YP1		2670.543***	3421.542***	3124.342***	3174.758***
		(866.029)	(881.057)	(868.899)	(965.251)
YP2		2337.589***	3228.076***	3257.183***	3293.667***
		(645.668)	(636.480)	(639.429)	(852.881)
YP3		−2474.164***	−2209.629***	−1785.503***	−1781.719***
		(487.002)	(483.202)	(471.495)	(478.941)
YP5		5026.088***	5871.606***	5734.050***	5740.095***
		(754.941)	(785.049)	(753.227)	(779.534)
planyear	1854.344***				
	(431.404)				
Official	N	Y	Y	Y	Y
Control	Y	Y	Y	Y	Y
Trend	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y
Constant	98 846.545***	139 468.997***	143 857.005***	142 447.285***	142 660.032***
	(30 404.011)	(7197.753)	(7061.957)	(7068.125)	(7193.435)
Observations	2770	4709	4709	4709	4709
R^2	0.8535	0.7577	0.7553	0.7549	0.7546

Panel B: $PM_{2.5}$ as dependent variable	(10)	(11)	(12)	(13)	(14)
YP1		2.499***	2.412***	2.228***	2.395***
		(0.304)	(0.299)	(0.296)	(0.304)
YP2		0.775***	0.724***	0.691***	0.884***
		(0.261)	(0.256)	(0.251)	(0.304)
YP3		−1.598***	−1.827***	−1.735***	−1.729***
		(0.168)	(0.163)	(0.165)	(0.166)
YP5		0.421**	0.387*	0.288	0.357*
		(0.203)	(0.198)	(0.192)	(0.192)
planyear	0.904***				
	(0.049)				
Official	N	Y	Y	Y	Y
Control	Y	Y	Y	Y	Y
Trend	Y	Y	Y	Y	Y
City FE	Y	Y	Y	Y	Y
Province FE	Y	Y	Y	Y	Y
Constant	50.981***	40.676***	41.906***	42.054***	42.198***
	(6.476)	(4.899)	(4.997)	(5.061)	(5.130)
Observations	2760	4416	4416	4416	4416
R^2	0.9286	0.8875	0.8862	0.8861	0.8859

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Robust standard errors clustered by city in parentheses. Panel A considers SO_2 (tonnes) as the dependent variable; panel B considers $PM_{2.5}$ (μg/m^3) as the dependent variable. Columns (5) and (10) cover the sample period from 2006 to 2015, whereas the other columns encompass the broader period from 2003 to 2019. Various official-related variables are incorporated in these columns, serving as controls: columns (6) and (11) consider sjrq and szrq; columns (7) and (12) involve sjrq_again and szrq_again; columns (8) and (13) involve sjrq_second and szrq_second; columns (9) and (14) take into account sjage_relative and szage_relative. The control variables include gdpr, gdppc, ser, ind, rkmd, fdig, fisg, ino and unem (see main text for variable descriptions). The models in these columns all control the time trend term (Trend), the city fixed effect (City FE) and the province fixed effect (Province FE).

and panel B, columns (11)–(14)); thus, China's FYPs play a substantial role in driving cyclical patterns of environmental pollution, and officials' decisions regarding the prioritization of other goals versus environmental governance in a given year are contingent on the FYP year.

Discussion

Our empirical findings suggest that local governments exhibit strategic behaviour on environmental pollution topics when managing multiple objectives. Specifically, the emissions of industrial SO_2 and $PM_{2.5}$ display U-shaped periodicity, with peaks in the first and second years of the FYP, followed by a gradual decrease and then a resurgence in the first year of the next FYP. This trend highlights a deliberate target allocation strategy by local leaders, who initially relax environmental regulations at the start of each FYP and subsequently intensify enforcement as the plan progresses.

Our findings resonate with Lindblom's (1959) theory that bureaucrats navigate the complexity of managing multiple objectives within the constraint of limited attention. Similarly, Eaton and Kostka (2014) emphasized the presence of a 'short time horizon' amongst local leaders in China, which leads to strategic behaviour. Specifically, failing to achieve environmental policy objectives in the early stages of implementation may generate increasing pressure as deadlines approach, prompting a shift in focus and priorities. This increasing pressure to meet binding environmental targets may exacerbate the cyclical behaviour of local leaders (Kostka & Hobbs 2012), resulting in last-minute, short-sighted actions (Harrison & Kostka 2014).

These short-sighted actions reflect the challenges inherent in authoritarian environmentalism and the strategic manoeuvres of officials. While authoritarian environmentalism can effectively respond to immediate threats, its success is often temporary. Once environmental targets are achieved, pollution levels frequently return to their previous states, underscoring the limitations of binding environmental targets (Kostka 2013, Ran 2013). Environmental targets set within the FYP do not provide as strong a set of incentives as those aimed at economic development. Officials often prioritize economic growth over environmental objectives, exhibiting a strategic pattern of initially loosening and then tightening environmental regulations.

A significant reason for this strategic behaviour is the intrinsic link between China's economic development and environmental pollution. (Based on a reviewer's suggestion, we conducted additional empirical tests on economic development during various FYP periods. We found a positive correlation between economic growth rates and environmental pollution; interested readers may contact us via email to request the empirical results.) Economic development and environmental pollution typically peak in the first 2 years and the final year of each FYP, indicating that economic growth often comes at the cost of the environment and is a strategic focus in the early years of the plan, leading to increased pollution. In contrast, the third year sees a noticeable shift as the momentum for economic growth wanes, aligning with efforts to mitigate environmental pollution. This dynamic underscores the prevalent extensive economic development model in China, which relies heavily on environmental exploitation. This indicates that the strategic alignment of environmental objectives with economic activities during the FYP is direct and consequential.

Our observations are contrasted with other perspectives, suggesting that local governments may not always delay intensifying environmental regulations until the last minute but may instead exert considerable efforts from the beginning. For example, actions such as upgrading factory scrubbers and adopting advanced pollution prevention technologies are common early initiatives (Zhou et al. 2013, Eaton & Kostka 2014). Some jurisdictions strategically choose not to implement all energy conservation and emission reduction measures simultaneously. In a similar vein, to meet environmental targets officials may invest significant efforts in the early stages of policy implementation, with pressure gradually diminishing after the assessment targets are met (Zhou et al. 2013). These contradictory approaches help us to understand why and how local environmental policy implementation may vary. However, the crucial question of when such variations occur is often overlooked: is it possible that environmental regulation can be intense at times and relaxed at others? This is a key aspect that our target allocation cycle theory seeks to address. Local leaders employ strategic resource allocation and attention management to achieve their goals, offering valuable insights into our proposed target allocation cycle of environmental pollution.

Further research demonstrates that local authorities have the ability to tactically adjust the strictness of pollution regulations. Cai et al. (2016) showed that local governments can influence the rigour of law enforcement through the collection of pollution fees and the inspection of illegal activities. As a binding indicator for the FYP, two main policies are implemented to reduce SO_2 emissions. Firstly, there has been a nationwide shutdown of 50 GW of inefficient and highly polluting small power plant capacity. Secondly, flue gas desulphurization equipment has been installed in both new and existing coal-fired power plants (Cao et al. 2009). While routine updates such as reinstalling scrubbers are standard pollution control measures, they may not be sufficient to tackle significant environmental pollution from such production. Kostka (2016) observed that, regarding SO_2 targets, monitors are installed primarily by larger companies. However, these monitoring devices are often technologically outdated, unreliable and insufficient in quantity. Consequently, local governments often resort to drastic measures in the middle of the FYP, such as ordering immediate business suspensions and work stoppages, to achieve environmental goals. While the FYP sets broad objectives, these need to be broken down into annual milestones in order to be achievable. Notable examples include the 'elimination of backward production capacity' and the 'closure of small factories' campaigns in 2010, as well as the air pollution prevention action plan in 2013. Many of these initiatives employed drastic and unconventional measures, including the immediate closure of polluting factories and cutting off of water and electricity supplies.

Conclusion

This paper explicitly challenges the speculative model of political business cycle theory: long-term and stable development planning can also give rise to cyclical patterns. Consequently, we examine the impact of the FYP on environmental pollution: both of the SO_2 and $PM_{2.5}$ variables exhibit U-shaped periodicity. Across different sample periods, local governments ease environmental regulations during the initial stages of each FYP and intensify them after the midpoint of the FYP. Hence, we posit the theory of the target allocation cycle to elucidate how China manages the balance between environmental objectives and economic goals within an authoritarian regime.

This study contributes to the scientific understanding of how political cycles influence environmental governance, particularly in a non-democratic context. By examining $PM_{2.5}$ and industrial SO_2 emissions during the FYP, this paper addresses a significant gap in the literature on environmental policy implementation under China's unique political and administrative system. The findings are poised to offer insights into the effectiveness of China's environmental regulations, the strategic behaviour of its local officials and the broader implications of such cycles for sustainable development. Our research has significant implications for assessing the comparative effectiveness of environmental governance strategies and understanding the long-term impacts of these cyclical policies on environmental governance. Insights into local governance dynamics and central mandates further our understanding of the complexities faced by officials in balancing policy implementation with political objectives, particularly under authoritarian regimes.

This study opens several avenues for future research. Comparative analysis of environmental governance in various regimes could verify the presence of cyclical patterns similar to those observed in this study. For instance, examining the intersection of electoral and policy cycles with climate policies, as discussed by Schulze (2021) in the USA, could illuminate the political impacts on environmental strategies globally. Longitudinal studies could further elucidate the long-term effects of these cycles on sustainable development, exploring the socio-economic factors emphasized by Liu and Lin (2019). Additionally, examining how public perception and data collection impact policy enforcement and compliance, as shown in studies by Abulude et al. (2022) and on advancements in GIS technology (Filonchyk et al. 2018, Kumar et al. 2022), could enhance our understanding of environmental policy effectiveness. These approaches highlight the necessity of integrating macro-political and micro-public dynamics to more effectively navigate the complex interplay of policy, technology and public engagement in environmental governance.

Data availability. The datasets used and/or analysed during the current study are available from the corresponding author on request.

Code availability. Available on request.

Acknowledgements. We extend our sincere gratitude to the reviewers, whose insightful comments and suggestions significantly enhanced the quality of this manuscript. We would also like to express our gratitude to the editors for their diligent work. This meticulous attention to detail and commitment to editorial excellence significantly contributed to the clarity and quality of our work.

Author contributions. The authors contributed equally to this work.

Financial support. None.

Competing interests. The authors declare none.

Ethical standards. None.

References

Abulude FO, Abulude IA, Oluwagbayide SD, Afolayan SD, Ishaku D (2022) Air Quality Index: a case of 1-day monitoring in 253 Nigerian urban and suburban towns. *Journal of Geovisualization and Spatial Analysis* 6: 1–13.

Alesina A, Roubini N, Cohen GD (1997) *Political Cycles and the Macroeconomy*. Cambridge, MA, USA: MIT Press.

Baleiras N, Santos V (2000) Behavioral and institutional determinants of political business cycles. *Public Choice* 104: 121–147.

Baltagi BH (2008) *Econometric Analysis of Panel Data*, 4th edition. New York, NY, USA: Wiley.

Blaydes L (2011) *Elections and Distributive Politics in Mubarak's Egypt*. Cambridge, UK: Cambridge University Press.

Cai H, Chen Y, Gong Q (2016) Polluting thy neighbor: unintended consequences of China's pollution reduction mandates. *Journal of Environmental Economics & Management* 76: 86–104.

Cao J, Garbaccio R, Ho MS (2009) China's 11th Five-Year Plan and the environment: reducing SO2 emissions. *Review of Environmental Economics and Policy* 3: 231–250.

Cao X, Kostka G, Xu X (2019) Environmental political business cycles: the case of $PM_{2.5}$ air pollution in Chinese prefectures. *Environmental Science & Policy* 93: 92–100.

Drazen A (2000) The political business cycle after 25 years. *NBER Macroeconomics Annual* 15: 75–117.

Eaton S, Kostka G (2014) Authoritarian environmentalism undermined? Local leaders' time horizons and environmental policy implementation in China. *The China Quarterly* 218: 359–380.

Fan F, Zhang X, Wang X (2022) Are there political cycles hidden inside collaborative innovation efficiency? An empirical study based on Chinese cities. *Science and Public Policy* 3: 532–551.

Filonchyk M, Yan H, Li X (2018) Temporal and spatial variation of particulate matter and its correlation with other criteria of air pollutants in Lanzhou, China, in spring–summer periods. *Atmospheric Pollution Research* 9: 1100–1110.

Gonzalez M (2002) Do changes in democracy affect the political budget cycle? Evidence from Mexico. *Review of Development Economics* 6: 204–224.

Guo G (2009) China's local political budget cycles. *American Journal of Political Science* 53: 621–632.

Harrison T, Kostka G (2014) Balancing priorities aligning interests: developing mitigation capacity in China and India. *Comparative Political Studies* 47: 450–480.

He J (2006) Pollution haven hypothesis and environmental impacts of foreign direct investment: the case of industrial emission of sulfur dioxide (SO_2) in Chinese provinces. *Ecological Economics* 60: 228–245.

Heilmann S, Melton O (2013) The reinvention of development planning in China 1993–2012. *Modern China* 39: 580–628.

Kostka G (2013) *China's Evolving Green Planning System: Are Targets the Answer?* Working Paper Series. Frankfurt, Germany: Frankfurt School of Finance & Management.

Kostka G (2016) Command without control: the case of China's environmental target system. *Regulation & Governance* 10: 58–74.

Kostka G, Hobbs W (2012) Local energy efficiency policy implementation in China: bridging the gap between national priorities and local interests. *The China Quarterly* 211: 765–785.

Kumar A, Dhakhwa S, Dikshit AK (2022) Comparative evaluation of fitness of interpolation techniques of ArcGIS using leave-one-out scheme for air quality mapping. *Journal of Geovisualization and Spatial Analysis* 6: 1–11.

Li S, Ma Y (2014) Urbanization economic development and environmental change. *Sustainability* 6: 5143–5161.

Liang J, Langbein L (2015) Performance management high-powered incentives and environmental policies in China. *International Public Management Journal* 18: 346–385.

Lindblom CE (1959) The science of 'muddling through'. *Public Administration Review* 19: 79–88.

Liu K, Lin B (2019) Research on influencing factors of environmental pollution in China: a spatial econometric analysis. *Journal of Cleaner Production* 206: 356–364.

Liu L, Wan Z (2019) The impact of central environmental performance assessment on local SO_2 emissions: an examination based on the 11th and 12th Five-Year Plan period. *Environmental Conformity Assessment* 11: 113–118.

Mao X, Zhou J, Corsetti G (2014) How well have China's recent Five-Year Plans been implemented for energy conservation and air pollution control? *Environmental Science & Technology* 48: 10036–10044.

National Bureau of Statistics of China (2020) *China City Statistical Yearbook 2004–2020*. Beijing, China: China Statistics Press.

Nie H, Jiang M, Wang X (2013) The impact of political cycle: evidence from coalmine accidents in China. *Journal of Comparative Economics* 41: 995–1011.

Nordhaus WD (1975) The political business cycle. *Review of Economic Studies* 42: 169–190.

O'Brien KJ, Li L (1999) Campaign nostalgia in the Chinese countryside. *Asian Survey* 39: 375–393.

Olson M (1993) Dictatorship democracy and development. *American Political Science Review* 87: 567–576.

Porter ME, Linde C (1995) Towards a new conception of the environment–competitiveness relationship. *Journal of Economic Perspectives* 4: 97–118.

Ran R (2013) Perverse incentive structure and policy implementation gap in China's local environmental politics. *Journal of Environmental Policy & Planning* 15: 17–39.

Schulze K (2021) Policy characteristics, electoral cycles, and the partisan politics of climate change. *Global Environmental Politics* 21: 44–72.

Shen SV (2018) *The Political Pollution Cycle: An Inconvenient Truth and How to Break It*. PhD dissertation. Stanford University [www document]. URL https://purl.stanford.edu/nz069yb9602.

Shi M, Svensson J (2006) Political budget cycles: do they differ across countries and why? *Journal of Public Economics* 90: 1367–1389.

Shi X, Xu Z (2018) Environmental regulation and firm exports: evidence from the eleventh Five-Year Plan in China. *Journal of Environmental Economics and Management* 89: 187–200.

Tao YF (2006) The evolution of 'political business cycle' in post-Mao China. *Issues and Studies* 42: 163–194.

Xi T, Yao Y, Zhang M (2018) Capability and opportunism: evidence from city officials in China. *Journal of Comparative Economics* 46: 1046–1061.

Zeng K, Eastin J (2007) International economic integration and environmental protection: the case of China. *International Studies Quarterly* 51: 971–995.

Zhou LA (2016) The administrative subcontract: significance, relevance and implications for intergovernmental relations in China. *Chinese Journal of Sociology* 2: 34–74.

Zhou X, Lian H, Ortolano L, Ye Y (2013) A behavioral model of 'muddling through' in the Chinese bureaucracy: the case of environmental protection. *The China Journal* 70: 120–147.