Pricing the Priceless: The Financial Cost of Biodiversity Conservation *

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Abstract

Biodiversity loss as a global concern requires drastic shifts in conservation efforts that carry substantial costs. We investigate how the financial market prices such conservation costs, exploiting the "Green Shield Action" (GSA) — a regulatory change aimed at preserving biodiversity in national nature reserves in China — as an exogenous shock to local public financing. We document that GSA, while improving biodiversity, augments the yields of municipal corporate bonds by around 24 basis points. The effects are more pronounced for bonds with shorter maturities and for local governments in weak fiscal positions. The increased cost of public capital can be largely attributed to transition pressure resulting from pre-existing economic activities within reserves and the growth in local public spending on biodiversity following the reform. Investors show little consideration beyond financial payoffs towards endeavors counteracting biodiversity loss. Our findings also point to the role of investor education and policy interventions in closing the financing gap for biodiversity conservation.

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1 Introduction

The ongoing biodiversity crisis casts an imminent shadow over the intricate nexus between nature and the global economy (Flammer *et al.*, 2023). Without drastic transition from current practices, up to 50% of all species may face extinction in the next 2-3 decades (Deutz *et al.*, 2020). This reality calls for a unified effort in biodiversity conservation. Although prior studies have evaluated direct economic costs of this transition (IPBES, 2019; Deutz *et al.*, 2020) and the equity pricing implications of biodiversity risks (Garel *et al.*, 2023; Giglio *et al.*, 2023), the financing of biodiversity transition and its implications for financial markets remain largely unexplored (Karolyi & Tobin-de la Puente, 2023; Starks, 2023).

We contribute to bridging this gap in the literature by analyzing a major policy shift for biodiversity conservation in China, the Green Shield Action (GSA)—a large regulatory shock aimed at reinforcing the safeguarding of national nature reserves (NNRs). GSA, while improving biodiversity, augments the public cost of capital by 24 basis points, an effect more pronounced for bonds with shorter maturities and for local governments in weak fiscal positions. The increase can be largely attributed to transition pressure resulting from pre-existing economic activities within reserves and the growth in local public spending on biodiversity following the reform, even though local governments did not raise additional capital. We show that, when it comes to counteracting biodiversity loss, investors primarily consider their financial payoffs rather than other potential benefits. We further quantify the aggregate cost on public financing of biodiversity transitions and discuss the heterogeneity in the tradeoffs between economic sustainability and biodiversity sustainability, with implications for future policy interventions and funding allocations.

China is blessed with a wealth of biodiversity. The country's nature reserves, especially those at the national level, are legally designated to play a pivotal role in biodiversity preservation. Nevertheless, some reserves failed to fulfill their protective responsibilities for a prolonged period.[1] In response, the Chinese central government launched GSA in July 2017, targeting violations within NNRs such as mining, tourism, and hydropower. In practice, the central government has conducted rigorous investigations and exerted substantial rectification pressure on local authorities. Consequently, GSA has led to notable increases in local governments' efforts on biodiversity conservation and NNR management, marking a milestone in China's commitment to biodiversity conservation.[2]

We focus on the impact of GSA on the pricing of municipal corporate bonds (MCBs), a setting offering several advantages. First, GSA is a unified, top-down initiative explicitly

[1] A prime example is the Qilian Mountain National Nature Reserve in Gansu Province, where rampant illegal exploration and mining activities have caused significant damage to the reserve for an extended period (see details in Section 2.1).

[2] For example, after GSA, the Management Committee of the Chongqing Jinyun Mountain National Nature Reserve executed environmental remediation and ecological restoration projects, and developed a management plan for the NNR via government procurements (see details in Appendix B.1).

targeting NNRs, leaving little discretion for local governments in terms of implementation (Wang *et al.*, 2023). The conservation and funding efforts for preserving biodiversity in NNRs largely fall on the shoulders of local governments. This has led to substantial increases in financial pressure for municipalities containing NNRs after the introduction of the GSA. Second, unlike corporations, municipalities cannot change their locations to avoid transition and conservation costs. Thus, MCB investors must account for such local risk when valuing municipal bonds.

Our empirical analysis utilizes multiple datasets. First, we use data on issuance and trade information on all MCBs in China from January 2013 to June 2022. Second, we manually construct a new dataset containing the geographical location of all NNRs in China. This enables us to identify municipalities whose territory encompasses these natural reserves. To evaluate the impact of GSA on local conservation efforts, we also use satellite remote sensing data, and information sourced from government procurement documents, newspaper articles, and bird observation records. These additional datasets provide a multifaceted perspective for ascertaining the mechanisms through which GSA influences public financing costs.

We follow a standard difference-in-differences (DID) strategy, comparing changes in the yield spreads of MCBs for cities with at least one NNR (NNR municipalities) relative to those without NNRs (non-NNR municipalities) before versus after the launch of GSA. We select the third quarter of 2017—when GSA was launched—as the beginning of the treatment period. We document that, compared to non-NNR municipalities, NNR municipalities experience a 24 basis points larger increase in their yield spreads following the introduction of GSA. This corresponds to 17-18% of the in-sample standard deviation (136 basis points). We also extend the specification to more flexible measures of treatment intensity (i.e., the number and area of NNRs), finding consistent pricing effects. The results are robust to alternative bond spread measures and data frequencies.

A central challenge with our identification strategy is whether the documented differences in bond yields between treatment and control municipalities around the introduction of GSA are driven by expected local public financing costs or other confounding factors. A comparison of municipality characteristics shows that municipalities with and without NNRs are similar across a large set of observables in the pre-GSA period. We augment the estimating equation with controls for bond- and city-level characteristics, and show that the main coefficients are stable when including such controls. Finally, we show that municipalities with and without NNRs display similar trends in yield spreads in the period before the introduction of GSA, lending support to our identification assumptions.

To explain how GSA prompted an increase in the risk premium demanded by MCB investors, we underscore the market's apprehensions regarding biodiversity transition costs and provide multiple pieces of supporting evidence. First, we investigate whether the transition pressure can explain the increased MCB spreads. We focus on the (ex-

ante) extent of undesirable human economic activities within the NNRs, as it reflects the expected effort level that local governments have to undertake to comply with the criteria of GSA (i.e., eliminating illegal activities inside NNRs and recovering the corresponding damaged local biodiversity). Utilizing remote sensing data on developed land and nighttime luminosity, we show that a higher presence of human economic activities within NNRs before GSA is associated with a more pronounced pricing effect.

Second, we explore biodiversity-related public spending through changes in government procurement contracts, a critical and observable component of government expenditure. We classify the contracts pertaining to NNRs using a standard textual analysis. Empirical results reveal that, after the implementation of GSA, NNR municipalities experienced a larger increase in the value of NNR-related procurement contracts. These results directly shed light on the potential connection between biodiversity transition and the observable escalation in MCB spreads from the perspective of the real costs incurred.

Third, we study the overall changes in the local public creditworthiness following GSA. We find a decline in the fiscal surplus of NNR municipalities compared with non-NNR municipalities. Moreover, the impact of GSA on MCB spreads is larger for municipalities with a heavier initial debt burden and for MCBs with shorter maturity. We consider whether the observed pricing effects could be attributed to an escalated public financing demand. To fund the growing spending on biodiversity, local governments may not only reorganize internal resources, but also seek more external financing. This surge in the demand side of local public financing could theoretically exert upward pressure on interest rates as the government competes for capital. An additional concern is that the documented change in MCB yields could be driven by an increase in political risk for the local public officials that are now accountable for the implementation of the reform. However, we find no supportive empirical evidence for these two alternative channels. Borrowing activities of local governments and the turnover of local officials remain stable around GSA. Collectively, these findings offer compelling evidence in support of the pricing impact of the deteriorating local public credit conditions.

In addition to examining investor decisions related to transition costs in GSA, we also study investors' potential non-pecuniary preference for biodiversity (i.e., the so-called "Values" in Starks, 2023). Specifically, if there is a considerable number of "impact investors" who indeed care about biodiversity but are uninformed of the actual biological conditions within NNRs, then the GSA may remind them of the poor management there in the early stages. This information effect may trigger investors to impose an overdue punishment on the financing securities on responsible authorities. If this mechanism holds, we expect that cities with higher information asymmetry on NNRs experienced a larger increase in MCB spreads. We compare NNR municipalities to different levels of newspaper coverage of related NNRs but find insignificant heterogeneity effects.

Investors' non-pecuniary preference could also favor biodiversity enrichment from the

GSA. By analyzing data on bird species recorded by both birdwatching enthusiasts and research observation stations, we consistently find that GSA has indeed led to an increase in the diversity of local bird species, which serves as a proxy for biodiversity. However, NNR municipalities with greater improvement in biodiversity did not exhibit smaller increases in MCB spreads. These findings highlight the positive impact that GSA can have on promoting and sustaining biodiversity, and further contrast the adverse influence of escalating financing costs on the biodiversity transition. A lack of alignment between biodiversity benefits and investors' valuation may hinder biodiversity conservation effort.

To quantify the aggregate effect of the pricing of biodiversity transition, we make a back-of-envelope calculation of the additional financing costs resulting from GSA by comparing counterfactual payments inferred from DID estimates. Our conservative calculation is based on the outstanding debts of Local Government Financing Vehicles (LGFVs) with MCBs from 2013 to 2021.[3] Given the estimated global annual financial gap of 711 billion dollars since 2019 by Deutz *et al.* (2020), China needs to spend 45.5 billion dollars per year on protecting biodiversity according to its proportion of species. The extra financing costs brought by GSA accounted for 11.33%, 17.95%, and 29.57% of the total direct costs ($45.5 billion) in 2019, 2020, and 2021, respectively. Our findings also inform about the heterogeneity in policy efficacy and how to allocate resources from the central government to best alleviate local financial debacles. Importantly, policy-makers need to recognize and balance the tradeoff between fiscal sustainability and biodiversity sustainability.

Our paper contributes to studies assessing the benefits and costs of natural capital and biodiversity protection. The seminal contributions by Weitzman (1992, 1993, 1998) measure the "value of diversity." Heal (2001) provides an overview of biodiversity's services, and Brock & Xepapadeas (2003) integrate ecological and economic systems through a framework for valuing biodiversity. Recent studies indicate that, as an example of natural capital, wetlands can reduce flood risk (Rizzi, 2022; Taylor & Druckenmiller, 2022). However, the private cost of protecting biodiversity could be substantial (Watson *et al.*, 2014; Adams *et al.*, 2019), and the benefits might be minimal (Simpson *et al.*, 1996), making it difficult for the private sector to act in biodiversity conservation (Flammer *et al.*, 2023). Meanwhile, existing papers have evaluated the economic costs of preserving biodiversity from many angles; we advance the literature by exploring the neglected public financing costs in biodiversity transitions. Our work thus complements the recent studies on the correlation between biodiversity loss risk and the financial market (Garel *et al.*, 2023; Giglio *et al.*, 2023), and responds to the calls for research on "biodiversity finance" (Karolyi & Tobin-de la Puente, 2023) and "biodiversity risk" (Starks, 2023).

Our paper also contributes to the financial implications of environmental regulation by extending the existing literature to include biodiversity protection within this broader context. In recent years, climate regulation has emerged as a prominent environmental

[3] In practice, LGFVs are direct issuers of MCBs (see details in Section 2.3).

theme and its financial implications, especially its negative impact on borrowing activities, have attracted considerable attention (e.g., Seltzer *et al.*, 2022; Jha *et al.*, 2020; Dang *et al.*, 2022). In addition, Ilhan *et al.* (2021) emphasize the potential risks associated with stranded assets due to changes in environmental policy, which also manifests in banking activities (Delis *et al.*, 2018). Hong *et al.* (2023) study the risk of stranded assets in the bond market, highlighting the transition costs that firms encounter in response to Renewable Portfolio Standards. While numerous private entities have dedicated efforts towards climate change, there remains a notable gap in action regarding biodiversity (Karolyi & Tobin-de la Puente, 2023). Our paper contributes by establishing a causal link between biodiversity regulation and the public cost of capital, while existing studies predominantly focus on transition risks within corporations. Moreover, our work provides insights into the land use policy and resource allocation concerning biodiversity, whose risks differ from climate risk that emphasizes more on carbon emission and pollution (Garel *et al.*, 2023).

Third, our paper adds to studies on the determinants of local public financing costs. Prior works focus on the U.S. municipal bond market. Factors discussed include state fiscal policy (Poterba & Rueben, 2001; Gao *et al.*, 2021; Babina *et al.*, 2021), municipal governance quality (Butler *et al.*, 2009; Gao *et al.*, 2020), climate risk (Painter, 2020; Goldsmith-Pinkham *et al.*, 2022; Jerch *et al.*, 2023), demographic features (Dougal *et al.*, 2019; Butler & Yi, 2022), public health issues (Cornaggia *et al.*, 2022b; Gao *et al.*, 2022; Tran & Uzmanoglu, 2022; Cheng *et al.*, 2023), pension underfunding (Novy-Marx & Rauh, 2012), the credit rating (Cornaggia *et al.*, 2018), and other market frictions (Butler, 2008; Schultz, 2012; Chalmers *et al.*, 2021; Cornaggia *et al.*, 2022a). Turning to China, MCB is deemed to be the only asset with market prices that can capture the funding costs of Chinese city and county government, inextricably tied to regional development (Liu *et al.*, 2017; Ang *et al.*, 2023). Nevertheless, the impact of policies promoting economic transition (e.g., industry restructuring, going green) on the government's own borrowing has received limited attention overall. Jha *et al.* (2020) present an increase in municipal bond yields after the Clean Air Act. In a causal context, our work implies that while government intervention may address the problems of externality inherent in the sustainability transition, there exists other frictions that cause social deadweight loss. In the absence of mechanisms within financial markets to support long-run social benefits, policies aimed at sustainability counterintuitively elevate the cost of public capital.

The rest of the paper is organized as follows. Section 2 presents background information about the nature reserves in China, GSA, and the MCB. Section 3 describes the data. Section Section 4 reports the identification strategy and empirical findings. Section 5 explores underlying economic channels for the increased cost of public capital. Section 6 considers the biodiversity benefits associated with the reform and investors' non-pecuniary values. Section 7 quantifies the aggregate cost and discusses policy implications. Section 8

concludes.

2 Institutional Background

2.1 Nature Reserves in China

With vast expanses of diverse terrain and climate zones and a recorded number of known species reaching 138,293 — a remarkable 6.4% of the total worldwide tally of 2,161,755 (as of 2022, including 687 mammal species, 10.4% of the recorded global mammal total of 6,596 and 46,725 plant species, 11% of the recorded global plant total of 424,335), China is among the most biologically diverse countries in the world.[4] For example, China ranks third in the world in terms of its number of vascular plant species, surpassed only by Brazil and Colombia. This wealth of biodiversity is a testament to China's natural heritage and underscores its vital importance to the global ecosystem.

To protect its natural capital, China has designated an extensive network of nature reserves — land, inland waters, or seas containing representative natural ecosystems, hotspots for rare and endangered wild species, or natural relics with distinctive significance.[5] Among these reserves, National Nature Reserves (NNRs) hold the highest rank with the most extensive regulatory oversight and strictest legal provisions compared with other provincial, municipal, and county nature reserves. Correspondingly, regulations stipulate that only reserves "holding typical significance domestically and internationally, exerting remarkable international scientific influence, or possessing extraordinary research value" can be designated NNRs.

The designation of NNRs is solely based on the endowment of natural resources, without considering the local economic and fiscal conditions.[6] According to regulations, the local government should first submit a formal application to the administrative authority of NNRs under the State Council. Then the central review committee for NNRs is responsible for the evaluation process. After receiving a report on the candidate reserve's biological situation, committee members vote. For an NNR to be eligible for State Council approval, it must receive a two-thirds majority vote from the committee. The representativeness, fragility, diversity, rarity, endangered status, importance, and scientific value of the reserve's natural resources carry significant weights in the evaluation. The members of the review committee are predominantly experts in the field of natural sciences,

[4] See in http://www.sp2000.org.cn/CoLChina and https://www.iucnredlist.org/resources/summary-statistics.

[5] Specifically, our definitions of the nature reserve are all based on the Regulation of the People's Republic of China on Nature Reserves. Legally, the establishment and management of nature reserves within the territory of the People's Republic of China and other sea areas under the jurisdiction of the People's Republic of China shall be governed by this regulation. Consequently, in a practical view, nature reserves are specifically for biodiversity preservation in China.

[6] See more details in: https://www.mee.gov.cn/stbh/zrbhq/gjjzrbhqps/201605/t20160522_342427.shtml.

with no representation from the economic or financial domains. Figure 1 illustrates the development process of nature reserves in China.[7] It is evident that the number and size of nature reserves have slowed down after 2010.

Following the establishment of an NNR, the local governments are responsible for managing, supervising, and conserving NNRs within their jurisdictions. Each NNR is typically governed by a dedicated management committee that handles its routine operations. This committee functions as an administrative entity under the local government's authority, and it is financed by local government funds.[8] In addition to local financial support, NNRs also receive funding from the central government. Nevertheless, this central funding is not adequate. For example, Jianbo Sun, a delegate of the 13th National People's Congress, presented a proposal highlighting that the central government's annual funding for all NNRs totals only 600 million yuan. This breaks down to an average of just 1.26 million yuan for each reserve. Given this limited central funding, local governments bear the brunt of the financial responsibility for maintaining NNRs.[9]

Although a large number of nature reserves were established, their actual effectiveness in protecting biodiversity fell short of expectations in the initial phase. Local officials mostly prioritized economic development over environmental issues over the several decades before our sample period (Guan *et al.*, 2010; Liu, 2010), resulting in the deterioration of numerous reserves. A prime example is the Qilian Mountain National Nature Reserve in Gansu Province, where rampant improper exploration and mining activities caused substantial damage to local vegetation, soil erosion, and surface subsidence for an extended period. For instance, 14 mining and exploration rights granted within this area were found unauthorized, with 3 instances within the core zones. In addition, over 30 mining projects were concealed, and over 40 hydropower facilities were constructed illegally. This "Qilian Mountain Incident" precipitated the special supervision and inspection actions led by several national departments, namely the Green Shield Action (GSA).[10]

[7] As illustrated in Figure 1, the history of reserves dates back to the 1950s, with the establishment of the first nature reserve, the Dinghushan Nature Reserve. Following the economic reform and liberalization of 1978, the number of nature reserves underwent substantial growth. Then towards the end of the 20th century, China experienced several environmental crises, including the drying out of the Yellow River in 1997, the flooding of the Yangtze River in 1998, and the sandstorm that swept Beijing in 2000. These disasters necessitated a reconsideration of the connection between economic growth and ecology, culminating in a further significant expansion of nature reserves during 1997-2010. Subsequently, the rate of growth slowed considerably. By 2017, the number of nature reserves had reached around 2,700, covering over 140 million hectares.

[8] See Appendix B.2 for more details regarding the institutional structure arrangement of NNRs.

[9] See Appendix B.3 for more details regarding funds sources for nature reserves.

[10] The central government conducted a special investigation into the Qilian Mountain National Nature Reserve, verified the ecological damage, held responsible leaders of local governments and state-owned enterprises accountable, and made a public announcement (see http://www.gov.cn/xinwen/2017-07/20/content_5212107.htm).

2.2 Green Shield Action

Launched in July 2017, GSA covers all NNRs in China for the first time and marks a full-scale effort for biodiversity conservation. Its initial round identified over 20,800 potential issues and concerns related to nature reserves, resulting in the closure and ban of over 2,460 enterprises and the demolition of over 5.9 million square meters of constructed facilities. Meanwhile, more than 1,100 local government officials were held accountable, and several local regulations inconsistent with higher-level law were modified. Overall, GSA marks a monumental change in China's effort to regulate and supervise NNRs, and reflects policymakers' commitment to improving biodiversity conservation.

Specifically, GSA utilized various technologies to monitor and inspect, including high-resolution remote sensing, geographic information systems, global positioning systems and big data to identify illegal activities. The central government also called for lists of remote sensing problems so that various departments can promptly provide relevant information to the central inspection team or the local supervision authority. Every local government unit possessing NNRs must create and execute a detailed work plan that aligns with the guidelines set by GSA. This plan should include regular inspections of nature reserves and the establishment of tracking systems for any unauthorized actions. By utilizing these approaches, the central government placed significant political incentives on local officials to ensure that illicit activities are seriously addressed.[11]

GSA implementation encountered local resistance. For one, the reserves had long suffered from a lack of resources. Without the central funding, some NNRs were severely understaffed. Moreover, prior to the designation of an area as an NNR, there were already a large number of residents living within these regions. Relocating these residents and demolishing their structures had proven to be extremely challenging. Finally, local governments also need to undertake ecological restoration projects within the reserves and allocate substantial funds to enhance the supervision of these areas and improve their operations. All these factors entail significant costs.[12]

Based on the annals of GSA, a representative case is the relocation of Jinyun Mountain Nature Reserve in Chongqing. The reserve was strictly off-limits to all individuals and entities, with only personnel engaged in scientific research and observation activities being legally allowed to enter a buffer zone. However, with nearly 9,000 residents living within the reserves, local authorities faced an immense burden in meeting GSA's requirement to safely evacuate the area. Specifically, the Beibei District Government, which oversees the Jinyun Mountain Reserve mainly, invested over 440 million yuan in the relocation effort in 2019, despite its fiscal revenue being a mere 3 billion yuan for that same year. Additionally, GSA stipulates that Chongqing Government should demolish all illegal buildings within the reserve, including housing, agricultural tourism facilities, hotels, and

[11] See Appendix B.4 for further details regarding the political incentives faced by local officials.
[12] See Appendix B.5 for further details regarding the challenges encountered during GSA.

horse farms. Such requirements cannot be immediately solved and further compound the already substantial economic costs.[13]

Following the GSA introduction in late 2017, the central government continued the effort in subsequent years. The objectives of the following years entail reinforcing the biodiversity transition, verifying the implementation of rectification requirements, scrutinizing new violations of laws in nature reserves, and supervising the fulfillment of management responsibilities of relevant departments. These efforts indeed promoted the restoration of the local ecology (e.g., see the changes in the land cover of the Qilian Mountain National Nature Reserve shown in Figure A1). Meanwhile, by perpetuating these actions annually, the central government solidifies overall expectations of their unwavering resolve to protect biodiversity and nature reserves, thus shaping the financial market's perception of the substantial transition costs associated with biodiversity conservation.

2.3 Municipal Corporate Bonds

In the 1990s, the tax-sharing reform in China substantially reduced the proportion of tax revenue allocated to local governments. Meanwhile, the 1994 Budget Law prohibited local governments from directly engaging in any form of debt financing. For municipalities, one way to balance the growing demand for public investments and insufficient fiscal resources is to establish local government financing vehicles (LGFVs), special-purpose state-owned enterprises. LGFVs primarily undertake the supply of local common goods (e.g., public infrastructure) and are not contained in the local government's balance sheet. To finance public projects with long cycles and low direct earnings, LGFVs can borrow from financial institutions and issue bonds, backed by local-authority-appropriated land, subsidies, and other implicit guarantees.

Due to regulatory restrictions, LGFVs grew slowly in the early stage until the Chinese central government launched a large stimulus package in November 2008 in response to the global financial crisis. The fiscal part of this package is commonly known as the 4-trillion-RMB plan, which mainly consists of public infrastructure and social welfare projects. Financing-wise, more than two-thirds of planned investments (2.82 trillion RMB) were expected to be funded by local governments. To facilitate these programs, the central government introduced a series of credit expansion (Cong *et al.*, 2019) and financial deregulation policies (Bai *et al.*, 2016), encouraging local governments to raise

[13] These economic costs at least include: (1) The direct costs of demolition: hiring contractors, machinery, and workforce to carry out the destruction of the buildings. (2) Relocation costs: providing compensation or support for those who are displaced by the demolition. (3) Potential legal and administrative costs: arising from disputes or negotiations with property owners. See Appendix B.6 for further details regarding the initiatives undertaken by the Chongqing government.

funds through LGFVs.[14] Subsequently, both the number and total liability of LGFVs experienced a significant surge[15], which raised concerns about the default risks of municipalities.[16] Then Beijing reverted its aggressive credit policy back to normal in 2010, making LGFVs resort more to bond financing when facing rollover pressure from bank debt coming due around 2012 (Chen *et al.*, 2020).

The bonds issued by LGFVs are generally referred to as municipal corporate bonds (MCBs, see, e.g., Chen *et al.* (2020); Gao *et al.* (2021)), where "corporate" reflects the fact that LGFVs have the same legal status as other regular corporations nominally, and "municipal" indicates the exclusive implicit guarantee from the local government.[17] In 2015, the new Budget Law became effective, allowing provincial governments to issue municipal bonds directly. However, MCBs are still the dominant form of local public financing in our setting. First, the overwhelming majority of city governments are not authorized to issue municipal bonds on their own, and the intra-provincial distribution of proceeds is also not publicly disclosed.[18] In contrast, the vast majority of MCB issuers are LGFVs owned by local governments below the province level.[19] As displayed in Figure 2, every province in China's mainland has multiple NNRs, but a city may not necessarily own one. Therefore, MCBs are better than municipal bonds in matching the cross-sectional variations of GSA.

Second, the market still holds the faith in municipalities' implicit guarantee for LGFVs and thereby price credit risk of local governments when investing MCBs after 2015 (Liu *et al.*, 2017). In general, MCBs' credit rating reports typically consider local governments' fiscal conditions at first, which is rarely seen among other issuers. For example, in Moody's Local Government Financing Vehicles in China Methodology, "government

[14] Financial deregulation policies include: (1) Guidelines on Further Strengthening the Adjustment of Credit Structure to Promote Steady and Rapid Development of Economy, released by the China Banking Regulatory Commission (CBRC) in March 2009, (see `http://www.gov.cn/gongbao/content/2009/content_1336375.htm`). (2) the Notice on Accelerating the Implementation of Local Supporting Funds for Central Government Investment Projects to expand Domestic Demand, released by the Ministry of Finance of the People's Republic of China (PRC) in October 2009 (see `http://www.gov.cn/zwgk/2009-10/13/content_1437713.htm`).

[15] Fan *et al.* (2022) show that in 2009, the total value of LGFV bonds increased by 217%, and bank loans to LGFVs surged by 93%. Besides, the debt raised by LGFVs represented more than 70% of the total debt of local governments, and it surged from 1.7 trillion yuan in 2007 to 6.6 trillion yuan in 2010 and doubled again in 2014.

[16] Gao *et al.* (2021) show that some LGFVs fell to an actual default on loans, suggesting that municipalities indeed have considerable credit risk that could be priced in MCB yields, consistent with Ang *et al.* (2023).

[17] MCB is "cheng-tou-zhai" in Chinese, which means "city investment bonds." It is synonymous with some other translations, such as "local government bonds" (Huang *et al.*, 2020), "Chengtou bonds" (Ang *et al.*, 2023), and "urban construction and investment bonds" (Liu *et al.*, 2017), and "LGFV bonds" (Fan *et al.*, 2022).

[18] According to regulatory requirements, only Dalian, Qingdao, Ningbo, Xiamen, and Shenzhen have the right to issue municipal bonds independently among the hundreds of prefecture-level cities.

[19] In our sample, bonds issued by LGFVs owned by provincial governments only account for approximately 10% of the total MCBs from 2013 to 2022.

support" is set as the primary evaluation factor of MCB rating.[20] The rationale behind this is that since cities do not have discretion on issuing municipal bonds directly, their LGFVs are still mainly engaged in non-self-supporting public utilities and rely on recurring financial support from owner governments. In practice, governments at different levels have repeatedly defused the debt repayment crisis of LGFVs. There have been no real default on MCBs so far.[21] All the facts suggest that the price of MCB can incorporate market views on local public financing cost during our sample period.

3 Data Description

3.1 National Nature Reserves

We collect the list of nature reserves, along with zoning images of NNRs, from the Ministry of Ecology and Environment of the People's Republic of China (PRC). By aligning these zoning images of NNRs with the standard administrative map of China, we construct a dataset that includes information on the locations, borders, inception dates, and tier classifications of NNRs. This dataset enables us to calculate some fundamental attributes of NNRs (e.g., land area) at both reserve and administration levels. Furthermore, we can construct novel metrics (e.g., human economic activities within NNRs) after merging the data with other geographical datasets.

3.2 Data on Municipal Corporate Bonds

We obtain municipal corporate bond data from Wind Information Co. (WIND), the leading financial data vendor in China.[22] WIND provides data on: (1) Issuing yield and attributes of each MCB, including issuing price, issuing yield, issuance date, maturity date, issuing amount, bond type, interest type, credit rating at issuance, state of guarantee, and option clause. (2) Daily transaction information of each MCB, including trading price, trading yield, trading date, trading volume, trading site, residual maturity, and credit rating on the trading day. (3) Information of each MCB issuer, including location, affiliation and bond issuance. (4) Daily yield curve of national bonds and bonds issued by the Chinese Development Bank (CDB).

We study MCB yields around GSA at the quarterly frequency using the last daily

[20] See https://ratings.moodys.com/api/rmc-documents/386644 (This methodology was first published on July 29, 2020, and updated on April 12, 2022).

[21] In contrast, some private-owned and non-LGFV state-owned bond issuers have defaulted (Geng & Pan, 2023).

[22] We select WIND as our primary data source, as it is the most widely used MCB database in China during our sample period. Our sample completely follows WIND's own classification.

transaction price of the quarter for each MCB.[23] To proxy for the risk premiums that investors demand for investing in bonds, we use the CDB bond as the reference and calculate MCB spreads as the difference between the MCB yield and CDB yield on the same day and of the same maturity (Geng & Pan, 2023).[24] Moreover, we collect the yields of national bonds for robustness checks.

3.3 Sample and Summary Statistics

Our sample covers the time period from January 1, 2013, to June 30, 2022.[25] Table 1 reports the descriptive statistics for the main variables used in our analysis. Besides MCB spread and relevant indicators of GSA described above, there are other bond- and city-level variables. Bond characteristics include the logarithm of the issuing amount, residual maturity, bond rating, issuer rating, and whether the bond is option embedded, secured, and traded on the exchange market at trade. City features include several pre-determined variables that characterize the economic and social conditions of a city (collected from the local Bureaus of Statistics in China in 2013). Details of all these variable definitions are presented in the Table A1. To prevent potential estimation error caused by outliers, we winsorize the MCB spreads, as well as city-level continuous variables, at lower 0.5% and upper 99.5% of the baseline sample.

Table 1 shows that about 51% of MCB observations are from NNR municipalities, with about 63% of the observations occurring after GSA, which is consistent with the fact that NNR municipalities account for more than half the cities and the MCB bond market has grown over time. For bond characteristics, unlike the U.S. market, entities in China issue credit bonds with shorter maturity, and has both exchange and interbank (over-the-counter) markets, with the latter dominant. Our sample accords with these facts, for they have an average bond residual maturity of 3.83 years in our sample and were less traded on the exchange market. For credit ratings, we convert letter grades into numerical numbers by assigning 1 to AAA, 2 to AA+, 3 to AA, and so on. The average

[23] WIND reports historical transaction information in the daily frequency, with price-related metrics weighted by the volume of each trade to the day level. In addition, "trading day" used in this paper refers to the day on which a real transaction took place on the corresponding bond, rather than the day on which investors can trade but not.

[24] The CDB is China's largest development-oriented financial institution with a safe degree of creditworthiness (Gao *et al.*, 2021), directly supervised by the central government. Besides, the same as credit bonds including MCB, CDB bonds are not tax-exempt and more comparable to MCBs, making CDB yield a good proxy for the risk-free rate in the context of our study.

[25] As explained by Chen *et al.* (2020), the MCB market was relatively underdeveloped before 2012. Another vital fact is that since the 18th National Congress of the communist party of China (CPC) at the end of 2012, China overall has experienced a new stable political cycle in our sample period without the turnover of the general secretary of the CPC. In addition, we restrict the bond-quarter sample to MCBs issued by city- and county-level LGFVs with fixed interest rates and residual maturity above one year. We also exclude MCBs in the form of private placement notes, convertible bonds, exchangeable bonds, and asset-backed securities, due to their non-standard structure, limited market size, or opaque information disclosure.

bond rating and issuer rating are all below 3, which is higher than non-MCB corporate bonds analyzed by Ding *et al.* (2022) and Geng & Pan (2023), reflecting the attribute of "municipal" for MCBs.

Figure 3 illustrates the unconditional dynamic of the average MCB spreads over time. The gap between financing costs of NNR and non-NNR municipalities exhibits no substantial disparities in the pre-GSA period, while the former group surged much more in MCB spreads following GSA.

4 Empirical Strategy and Findings

4.1 Empirical Strategy and Main Results

Our baseline empirical strategy is a standard difference-in-differences approach which compares the relative changes in the MCB spreads in NNR municipalities and non-NNR municipalities. The model specification takes the following form:

$$Spread_{bict} = \beta NNR_c \times Post_t + \delta_{ci} + \lambda_t + \theta \mathbf{X}_{bict} + \varepsilon_{bict} \tag{1}$$

where b indexes bonds, i indexes issuers, c indexes cities, and t indexes year-quarters. The dependent variable, denoted $Spread_{bict}$, is the spread of bond b issued by issuer i, located in city c, and traded in year-quarter t. NNR_c is a dummy variable that equals one if a city geographically intersects with an NNR and zero otherwise.[26] $Post_t$ is a dummy variable that equals one for the period after the introduction of GSA (i.e., from the third quarter of 2017 to the second quarter of 2022). The model also contains bond issuer and year-quarter fixed effects, δ_{ci} and λ_t. $\mathbf{X}_{bict}$ denotes city-level control variables and bond-level characteristics (described in Section 3.3). Specifically, we interact the predetermined city-level variables in 2013 with $Post_t$ to allow the effect of these characteristics to vary before and after GSA. The coefficient of interest is β, the estimated impact of GSA on MCB spreads. Standard errors are clustered at the city level in all specifications.

One obvious concern with using Equation (1) to identify the effect of GSA on spreads is that there might be considerable differences between NNR and non-NNR municipalities that might affect the evolution of bond spreads during the period under study. To investigate this concern, we collect data on city-level baseline characteristics from the local Bureaus of Statistics in China. In Table A2, we compare NNR and non-NNR municipalities across baseline characteristics (the average value of corresponding economic variables of each city from 2013 to 2016). As shown, NNR and non-NNR municipalities

[26] In 2017 and 2018, China introduced 29 new NNRs, which were upgraded from provincial nature reserves (No additional NNRs have been added since 2019). These new NNRs account for only 6% (29/475) of the total number of existing NNRs and encompass 22 cities. Although new NNRs have also been under the supervision of GSA since their establishment, we are still concerned about the potential selection bias associated with the presence of these NNRs. To ensure the validity of our empirical identification, we exclude all 22 cities where the number of NNRs changed after GSA from our sample.

are not systematically different in most dimensions in the period before the introduction of GSA.

We present the baseline estimates of Equation (1) in Table 2. Column (1) only includes issuer and time fixed effects to rule out all time-invariant issuer features and time shocks (year-quarter level) that affect all bonds. In Columns (2)-(4), we augment the specification with bond- and city-level controls. The results across all specifications are significantly positive and remain stable in magnitude when including controls. Specifically, the estimates in Column (4) imply that NNR municipalities experienced a larger increase in MCB spreads of around 23.7 basis points following GSA compared with non-NNR municipalities. This effect corresponds to a 12% increase from the sample mean (197 basis points) and a 17.4% increase from the sample standard deviation (136 basis points). These findings are consistent with the notion that the costs brought about by GSA are priced in the MCB market.

To investigate the potential role of dynamic confounders, we also estimate a period-by-period specification of the following form:

$$Spread_{bict} = \sum_{t} \beta_t NNR_c \times Time_t + \delta_{ci} + \lambda_t + \theta \mathbf{X}_{bict} + \varepsilon_{bict} \tag{2}$$

where all variables are defined as in Equation (1). The estimated vectors of β_t captures the differences between the treatment and control groups in each time period.

Figure 4 plots the estimates of Equation (2) and their 95% confidence intervals. The conditional difference between NNR and non-NNR municipalities is small in magnitude and non statistically significant before the introduction of GSA, consistent with the parallel trend assumption.

After the introduction of GSA, NNRs became the burden of the local governments, increasing local financing costs. As shown in Figure 4, we find a relative increase in MCB spreads in the post GSA period, which however takes materialize with a delay of about one year. Two plausible factors may explain the delay in the effect on bond spreads. First, after the central government completed inspections of NNRs from the end of 2017 to the beginning of 2018, it took some time for local governments to implement and promote the central government's orders. Investors might also experience delays in receiving up-to-date information about the actions and inputs of local authorities under the GSA. This was partly because the primary sources of such information, like the annual work reports of local governments, are not published immediately. As a result, there was a time lag before investors could fully understand and react to the real impact of local government initiatives within the GSA framework.

Second, local officials and investors might be uncertain regarding the determination of the central government to implement complete reforms (Wang *et al.*, 2023). Local officials were annually confronted with a plethora of campaign-style political tasks from the

central government, wherein GSA seemed not necessarily taking precedence but endowed with considerable execution costs. It was only after observing repeated inspections by the central government in the subsequent year (signaling a significant shift from purely campaign-style enforcement to a regular regime) , that real actions were taken by local authorities and biodiversity transition costs were then factored into the pricing of MCB. We provide a more detailed summary of the factual logic related to the lagged effects in the Appendix B.4, Appendix B.5 and Appendix B.6.

The gap in MCB spreads between NNR municipalities and non-NNR municipalities persisted and exhibited an upward trend following the implementation of GSA. This dynamic pattern aligns with the features of the enforcement in GSA. First, the central inspection on NNRs was not only conducted in 2017, but were repeated annually in subsequent years. Under such a regular supervisory arrangement, it was difficult for local officials to undertake temporary accommodative actions. Thus, NNR municipalities were forced to allocate sustained inputs towards biodiversity conservation. Second, the process of local governments implementing the required rectification under GSA was not immediate and intensive but rather gradual and progressive. For example, in the survey of Wang *et al.* (2023), in June 2019, a local county government announced its wetland recovery work that would be completed by June 2022. Appendix B.6 presents a more specific case in which a local government adopted a phased investment plan in the reform. In a nutshell, the trend observed in the event study test is consistent with facts about how transition costs are incurred.

4.2 Robustness Tests

We demonstrate the robustness of our baseline estimates to a range of alternative treatment intensities, spread measures, and sample frequencies. First, we examine two alternative measures of treatment intensities. At baseline, we specify a binary treatment variable and draw natural comparisons between NNR and non-NNR municipalities. We then move forward to more flexible measures of treatment intensities: the number of NNRs and the proportion of NNRs in the area of urban administrative areas. Both measures capture continuous variations in pressure on municipalities to manage NNRs. Table A3 and Panel A-B of Figure A2 report the results of replacing the binary variable with alternative measures. Incorporating more flexible variables into the estimation did not alter the significance of the coefficients.

Second, in Table A4 and Panel C-I of Figure A2, we report the results of alternative spread measures. Specifically, we utilize the quarterly median of spread, the quarterly mean of spreads, quarterly trading-volume-weighted spreads, and measures of replacing the benchmark with yields of the national bonds. All results accord with the baseline estimates.

Third, we examine the robustness using alternative data frequency of MCBs and the

primary bond issuance market data. The corresponding sampling processes are the same for the quarterly secondary market datasets at baseline. Results are reported in Table A5 and Figure A3 in the order of monthly frequency, semi-annual frequency, annual frequency, and issuance sample. We see that the t-statistics are consistent and significant regardless of how we adjust the sample.

4.3 Contemporaneous Events

The current evidence suggests that GSA indeed led to an increase in the MCB spreads in NNR municipalities. One may wonder whether other events related to environmental issues occurring during the same period could also impact the MCB market. To address this concern, we examine the two important events that occurred around GSA: (1) "Central Inspection on Environmental Protection" and (2) "Nationwide Campaign to Prevent and Control Pollution" initiated by the Chinese central government.

Central Inspection on Environmental Protection (CIEP): In 2016, the Chinese central government launched a vital initiative to inspect and improve environmental conditions in each province.[27] This groundbreaking endeavor, approved by Beijing in July 2015, is commonly known as the Central Inspection on Environmental Protection. An essential aspect of this initiative was the establishment of a new mechanism for environmental inspection: specific central inspection groups were dispatched to check local environmental protection and policy implementation on a provincial basis. Two rounds of these inspections have been conducted so far: the first round lasted from January 2016 to September 2017, while the second one took place from July 2019 to June 2022. Both rounds primarily focused on the environmental disruption across the region and related dereliction of duty in environmental work by local governments.

Nationwide Battle to Prevent and Control Pollution (NBPCP): In June, 2018, Beijing announced a comprehensive plan for pollution reduction, named Nationwide Battle to Prevent and Control Pollution.[28] The ambitious plan aimed to improve the country's environmental quality and mitigate relevant risks by drastically reducing the emissions of major pollutants. In addition to continuing to highlight the importance of GSA, three border parts of this plan were striking at that time, namely, the battles of protecting Blue Sky, Clear Water, and Clean Land, with explicit goals set on corresponding pollution reduction for 2020. For example, the proportion of excellent air quality days in cities should reach over 80%; sulfur dioxide emissions should be reduced by at least 15% compared with the level in 2015; the proportion of surface water bodies classified as Grade I-III should

[27] The Ministry of Ecology and Environment of the CPC has released detailed information on the Central Inspection on Environmental Protection (see: https://www.mee.gov.cn/ywgz/zysthjbhdc/).

[28] The corresponding policy document is the Guidelines on Comprehensively Strengthening Ecological and Environmental Protection and Resolutely Fighting the Battle to Prevent and Control Pollution, June 2018, (see: https://www.gov.cn/zhengce/2018-06/24/content_5300953.htm?eqid=804df71900054d4500000056461879e).

exceed 70%; the proportion of nearshore seawater classified as excellent (Grade I, II) should surpass 70%; The safe utilization rate of polluted plots should be over 90%.

The possible correlation between these two events and GSA lies in two aspects: Firstly, their implementations began around the same time. CIEP was launched in 2016, while NBPCP kicked off in 2018. GSA was initiated in the second half of 2017. Secondly, all of them target the regulation of environmental issues. CIEP and NBPCP mainly focus on overall environmental risk and pollution activities, whereas GSA concentrates on biodiversity issues, particularly those within NNRs. Thus, the former two events pose a potential threat to our identification.

To address this concern, we examine the impact of these events based on our baseline model. In Panel A of Table A6, we study CIEP by using four indicators: (1) *After the 1st round*, a dummy variable that equals one if it is after the first round of CIEP and zero otherwise; (2) *After the 2nd round* is a dummy variable that equals one if it is after the second round of CIEP and zero otherwise; (3) *In the 1st round*, a dummy variable that equals one if it is in the quarter of the first round of CIEP and zero otherwise; (4) *In the 2nd round*, a dummy variable that equals one if it is in the quarter of the second round of CIEP and zero otherwise. We find that after the first round of CIEP, MCB spreads rise slightly. However, CIEP cannot influence our conclusions on the impact of GSA since its coefficient remains significant.

Moving to NBPCP, Panel B of Table A6 presents its effects on the MCBs. Considering that NBPCP has quantifiable targets for pollution reduction and primarily focuses on enterprise pollution behaviors, we select four city-year-level pollution metrics in 2017: Air Quality Index, industrial sulfur dioxide emissions, industrial wastewater emissions, and industrial dust emissions. Air Quality Index, as disclosed by the Ministry of Ecology and Environment of the PRC, is a composite index weighted by concentrations of six major air pollutants, with higher scores indicating more severe local air pollution. The other three metrics, collected from the local Bureaus of Statistics, are scaled by the GDP of the secondary sector. We assume that the higher the pollution level, the greater the price that a city needs to pay to comply with NBPCP. We interact these metrics with $PostNBPCP$, a dummy variable that equals one if the first quarter of 2018 and zero otherwise, and then add interaction terms into our baseline specification. Results in Columns (1)-(6) show that the impact of GSA is not driven by NBPCP or pressure on pollution reduction.

4.4 Placebo Test

Another concern is that our results might reflect the effects of other features of nature reserves rather than transition costs incurred due to the GSA inspection. For example, the presence of nature reserves might constrain local economic development through approaches such as occupying urban land use (e.g., having complex topography and

restricting human economic activities). This might have profound implications for the region's fiscal revenue streams for servicing public debts, increasing the risk profile and financing costs associated with MCBs. Meanwhile, there might be changes in attention to the biodiversity following GSA, which might also affect the pricing of MCBs in a way different from transition costs.[29] While having controlled fixed effects and a large set of covariates, we attempt to implement an additional placebo design.

We utilize nature reserves at lower levels, including the provincial, municipal, and county levels. Similar to NNRs, lower-level reserves may also restrict business by hindering land use for urban exploitation and drawing social attention to biodiversity. Despite this, GSA did not prioritize the inspection of non-NNR reserves. Due to the lack of political incentives, as well as the much larger number of non-NNR reserves than NNRs, it is also less likely that local officials took proactive effects to rearrange lower-level reserves. Therefore, non-NNR reserves can be an ideal placebo group, which helps to separate potential omitted effects related to the presence of NNRs. If GSA matters in our identification, we expect a minimal and insignificant effect with non-NNR reserves.

Based on the comprehensive list of nature reserves, we introduce *Provincial NR*, *Municipal NR*, and *County NR*, where each equals one if the city intersects with the corresponding type of reserves and zero otherwise, and then interact them with *Post*. Table 3 presents the results. As expected, variations in non-NNR reserves do not exhibit similar effects once NNRs are considered. Overall, the findings support GSA's role over alternative explanations related to other attributes of the presence of nature reserves.[30]

5 From Transition Cost to Public Cost of Capital

Having established that GSA increased the MCB spreads, we next explore the underlying mechanism of this effect. As explicated in Section 2.2, GSA compelled local administrations to reinforce safeguarding NNRs, resulting in considerable short-term economic costs. On the one hand, GSA compelled unauthorized industries originally established within the NNRs to relocate, including mining, power generation, and tourism, leading to a possible decline in economic outputs and public revenue sources. On the other hand, the relocation and compensation for unregistered residents, the removal of illegal constructions, and the remediation of ecology on illegally occupied land within the NNRs, necessitated significant public spending.[31] Local governments were major investors and

[29] The attention channel will be further discussed in Section 6.

[30] In practice, GSA occasionally extended beyond NNRs in certain years, yet inspections for these non-NNR reserves were not consistently repeated in subsequent years, indicating much weaker enforcement efforts. Moreover, according to official statements from the central government, routine supervisions and achievements attained of GSA primarily focus on NNRs, suggesting that only these reserves have undergone significant biodiversity transition and serve as the actual treatment. The placebo results in this section further confirm this observation.

[31] These expenses may include mending fragmented watersheds destroyed by hydroelectric power stations or rehabilitating barren mines into forests, as described in Section 2.2.

cost-bearers in this reform. The opportunity cost incurred, namely biodiversity transition cost, therefore, is expected to be the dominant pricing factor of MCB in the market regarding GSA.

We now examine the role of biodiversity transition cost by studying variations in (ex-ante) transition pressure across regions, changes in public spending on biodiversity and overall public creditworthiness, as well as heterogeneity in bond term structure. We also discuss alternative explanations for GSA influencing the financing activities of local governments.

5.1 Economic Activities within Reserves and the Transition Pressure

For the implementation and assessment of GSA, the primary regulatory focus is the human activities driven by non-scientific purposes within the NNRs. The central government employs the intensity of human activity to demonstrate the performance of GSA.[32] More pre-existing economic activities within NNRs would be associated with more decreases in government revenue and increases in expenditures on conserving natural capital (e.g., changes shown in Figure A1) to comply with GSA. Consequently, cities with more human economic activities within NNRs before the introduction of GSA would be expected to face heightened pressures for transition, which could lead to an amplified surge in MCB spreads. Fortunately, our geographic datasets described in Section 3.1 allow for a detailed characterization of human activities within NNRs, thereby facilitating our tests on the hypothesis of pricing biodiversity transition cost.

Developed Land within NNRs: We first utilize the area of developed land within NNRs to capture economic activities within the NNRs. In remote sensing, the land cover types comprise forest, grassland, farmland, wetland, urban built-up land, water bodies, glaciers, and so on. Among these types, urban built-up land and farmland have the highest intensity of economic activities, and face the most serious artificial reconstruction, far from the status of the primitive ecosystem. Therefore, transition pressure in NNRs with more farmland and urban built-up land is expected to be much higher. We sum these two types of land cover as the developed land. The raster data is from the land cover dataset constructed by MODIS-IGBP program.

We classify cities into three categories: NNR municipalities in the top quartile of the distribution of developed land area within NNRs in 2016, NNR municipalities not in the top quartile of the distribution of developed land area within NNRs in 2016, and non-NNR municipalities. Panel A of Figure 5 illustrates unconditional dynamics in MCB spreads over time for these categories of cities. In the early stage, the trends of MCB spreads across all three groups were almost parallel. However, following GSA, MCB spreads began to diverge. NNR municipalities with large area of developed land within NNRs

[32] For instance, see: https://www.mee.gov.cn/ywdt/xwfb/202304/t20230427_1028560.shtml.

experienced the greatest surge in MCB spreads, followed by NNR municipalities with small area of developed land within NNRs, while non-NNR municipalities underwent the smallest increase. This pattern preliminarily supports the logic that GSA imposed a more significant impact on cities with vigorous-intensity economic activities within NNRs.

We then conduct a formal test on whether cities with large area of developed land within NNRs experienced a more significant increase in MCB spreads following GSA. Table 4 reports the results. In Column (1), we compare NNR municipalities with large area of developed land within NNRs to all other cities, and find that the former group were indeed more significantly affected by GSA on average. In addition, Column (2) shows that, NNR municipalities with different levels of developed land area within NRRs, relative to their non-NNR counterparts, experienced greater increases in MCB spreads after GSA. Meanwhile, those with more pre-existing developed areas within NNRs underwent a larger magnitude of influence, and the Wald test reveals that the difference is statistically significant. These findings confirm that cities with more economic activities within NNRs were more likely to face more increases in public financing costs, reflecting the market's concern about the expected burden of local governments on biodiversity conservation.

Nighttime Luminosity within NNRs: We also utilize nighttime luminosity as an alternative measure for economic activities. Specifically, we employ the raster data constructed by Zhang *et al.* (2021) and calculate the total nighttime light intensity within the boundary of NNRs as of 2016. We again classify cities into three categories: NNR municipalities in the top quartile of the distribution of nighttime light intensity within NNRs in 2016, NNR municipalities not in the top quartile of the distribution of nighttime light intensity within NNRs in 2016, and non-NNR municipalities.[33] Panel B of Figure 5 plots the dynamics of MCB spreads in three groups. Columns (3)-(4) of Table 4 report the results of formal regression tests. We find that estimates based on nighttime light intensity consistently confirm that cities with more ex-ante economic activities within NNRs face greater transition pressure from GSA. The higher transition costs borne by local governments are then priced by investors in the MCB market as a larger rise in MCB spreads.

5.2 Public Spending on Biodiversity

While cross-sectional heterogeneity in ex-ante transition pressure provides insights into the financial market's expectations, a key issue still lies in whether and how much local governments have made concrete efforts in biodiversity conservation. Although we have introduced examples of how local governments governed NNRs following GSA in the

[33] It is worth mentioning that there are potential measurement errors of nighttime luminosity to proxy economic activities. Light sources outside NNRs may have spillover effects, while several types of human activity are also rarely done on a large scale at night (e.g., crop planting). These issues are merely faced by the measurement of land cover. Thus, we suggest exercising caution in interpreting the result of light grouping. It is more suitable as a robustness test for studying the pre-existing economic activities within NNRs and transition pressures from GSA.

preceding background section, one might still want quantitative evidence on public inputs under GSA.

Insufficient disclosure exists concerning the allocation of fiscal resources across different affairs. Thus, it is challenging to disaggregate specific portions dedicated to biodiversity conservation from local fiscal budget data, especially regarding general items such as salaries of civil servants responsible for nature reserves, compensation for resettlement of indigenous communities and businesses, and other associated taxes. Despite the difficulty in completely identifying how much is paid by municipalities in implementing GSA, we can explore some implications from a core spending pattern — public procurement contract, which is the primary comprehensive and detailed fiscal spending subject disclosed publicly in China, widely used in prior studies (Beraja *et al.*, 2023). These contracts provide insights into the direct public investments in protecting biodiversity, which co-move with the aforementioned indirect fiscal parts.

Identifying NNR Contracts: We identify and analyze public procurement contracts related to NNRs, which are made by the responsible city governments and referred to as "NNR contracts" in this paper. The data for these contracts are sourced from the China Government Procurement website, maintained by the Ministry of Finance of the PRC.

We define NNR contracts as follows: NNR contracts must explicitly mention the name of an NNR and the term "reserve" (translated as "baohuqu" in Chinese) within the contract text. This is achieved by referencing the NNR name list and utilizing textual analysis. For instance, a contract for "Remote Monitoring Facility Project of Heixiazi Island National Nature Reserve" would be considered an NNR contract as it includes both the NNR name "Heixiazi Island" and the term "reserve" in its content. Consequently, in cities that do not encompass any NNRs, there would logically be no NNR contracts. After removing duplicates, we identify 2,682 NNR contracts from 2015 to 2021. Next, we manually obtained the amounts for each contract. Out of these, 2,635 contracts had recorded amounts.

Analyzing NNR Contracts: According to the methodology of textual analysis explained above, the purchasers in NNR contract are all from NNR municipalities, as each NNR contract is explicitly associated with a specific NNR. Non-NNR municipalities have no obligation to cover NNR expense, and they indeed have a government procurement amount of zero for all years. Therefore, we cannot conduct a standard DID estimation, but instead directly aggregate all contract amounts by year to observe the unconditional trend.

Figure 6 illustrates the changes in the proportion of the total amount of NNR contracts relative to the total amount of all public procurement contracts. It is evident that in the two years prior to the implementation of GSA (i.e., 2015 and 2016), the share of NNR contracts remained relatively stable. However, following GSA, the proportion of NNR contracts gradually increased year by year, reaching around 0.03% in 2021, an

increase of about 2.3 times compared to the pre-GSA period. This gradual increase trend is also consistent with the bond spread trend we observed in the dynamics pattern of Figure 4. Specifically, when GSA began in 2017, local officials might fail to promptly undertake actions in response to the first-round inspection due to time constraints or adopt a wait-and-see attitude. Correspondingly, the increase in NNR contracts in 2017 was insignificant, only rising from 0.013% to 0.0144%. As GSA gradually became a regular regime rather than a campaign-style regulatory measure after 2018, and as local governments gradually carried out reification work on NNRs, NNR contracts increased. Therefore, by analyzing government procurement contracts, we observe a significant real rise in specific parts of fiscal spending on biodiversity preservation, which is clearly driven by the implementation time of GSA and provides additional evidence supporting the mechanism of pricing biodiversity transition costs through which GSA affects local public financing costs.

5.3 Local Public Creditworthiness

To make our argument on mechanism more complete, we further examine whether transition costs driven by GSA exacerbated local public creditworthiness. In practice, Chinese local governments have seldom issued special financing instruments with clearly defined sources of repayment funds for nature reserves (e.g. revenue bond). Instead, general fiscal budgets account for the most investments in biodiversity. In our sample, there is also no MCB issued for biodiversity conservation. Thus, MCB investors may exclusively pay great attention to the overall credit condition of the city government behind the MCB.

Local Fiscal Conditions: We first empirically examine whether GSA worsened local fiscal conditions. We calculate local fiscal deficit as the ratio of the difference between fiscal expenditure and revenue, to fiscal revenue. Greater government deficits typically indicate a poorer capacity for public debt repayment. We construct a city-year-level panel and test the effects of GSA on local fiscal deficit using the standard DID estimation. We include the year and city fixed effects, as well as the baseline city-level controls. Panel A of Table 5 reports the results. The difference between NNR municipalities and non-NNR municipalities in terms of fiscal deficits significantly increased, suggesting that local fiscal conditions deteriorated following GSA. This might be a key indicator that drove investors' concern about the public debt prepayment.

Local Public Debt Burden: In addition to the fiscal consequence, we also utilize cross-sectional variations in the pressure for local public debt repayment to explore the market's expectations of the default probability for MCBs. Theoretically, given the enormous costs caused by GSA, cities with high (ex-ante) public debt burden are more likely to face financial distress and find it challenging to service their bonds. Conversely, cities with low public debt burdens may still possess sufficient funds to safeguard the bondholders'

interests. Therefore, in terms of bond pricing, MCB spreads of the former regions would increase more than those of the latter.

To test this conjecture, we construct two measures of the local public debt burden. In China, all entities requesting authorization to issue a corporate bond in a given year are required to disclose their liabilities for the current year and (at least) the three previous years. Besides, during the MCBs' outstanding period, the issuer should also publicly reveal its liabilities on a regular basis. Following Huang *et al.* (2020), we conduct a conservative calculation of the debt of LGFVs with bond outstanding, and aggregate LGFVs' total debts and interest-bearing debts to the city-year level as proxies of local public debt burden, respectively. We then define the dummy variable, $High\ debt\ burden$, which equals one if a city's level of public debt burden is in the top quartile of the distribution for the year before the bond trade and zero otherwise.

Panel B of Table 5 reports the differential effects of GSA on levels of local debt burden. We introduce a triple differences (DDD) specification based on Equation (1), with the triple interaction term $NNR \times Post \times High\ debt\ burden$. In this specification, the triple interaction term estimates the difference in treatment effects between the cities with high- and low-level public debt burdens. As is standard in the DDD approach, we also include the dual interaction terms, $NNR \times Post$, $NNR \times High\ debt\ burden$, $Post \times High\ debt\ burden$, and $High\ debt\ burden$. Columns (1) and (2) show that the coefficients of the triple interaction term are both significantly positive, suggesting that the effect of GSA on MCB spreads for cities with high-level debt burden is greater than that for cities with low-level debt burden. This result further corroborates the notion that there is a concern about the expected probability of MCB default from MCB investors following GSA.

Effects on the MCB Term Structure: The complete recovery of biodiversity within NNRs and the generation of its sustained social benefits necessitate a long time horizon. However, the transition costs associated with GSA have already emerged in the short run. Thus, if the additional increase in public financing costs in NNR municipalities was driven by investors' concerns over transition costs, the pricing effects should be more pronounced on short-term MCBs. We employ a residual maturity of 3 years (or 4 years) as the criterion to classify between long-term and short-term bonds. As described in Section 3.2, the maturity of credit bonds issued in the Chinese market is shorter than that in the U.S. market. In our sample, both the mean and median of residual maturity of MCB observations fall within the range of 3 and 4 years. Table 6 presents that both long-term and short-term MCBs experienced the increase effect of GSA, while the impact on short-term bonds is significantly more substantial than that on long-term ones. The former finding may be attributed to the overall short maturity of MCBs (with a maximum maturity of less than 15 years), while the latter finding aligns with the logic of pricing transition costs incurred in GSA.

5.4 Alternative Explanations for Public Financing Activities

Financing Demands of Local Governments: Based on the findings presented in the previous sub-sections, GSA has led to an increase in local governments' inputs on biodiversity-related matters. Consequently, an alternative channel through which GSA potentially contributes to the widening of MCB spreads is by exerting greater upward pressure on the demand curve of NNR municipalities in the financial market, instead of damaging local fiscal sustainability. We examine the impact of GSA on the quantity of local public financing based on the specification in Panel A of Table 5. We replace the dependent variable with the indicator that represents the amount of local public financing. Table A7 reports the effects on (1) the probability of new MCB issuance, (2) the amount of new MCB issuance, (3) the growth rate of total local public debts, (4) the growth rate of local public interest-bearing debts successively, at the city-year level. The latter two metrics are measured in a way consistent with methodology in Section 5.3. We find that GSA insignificantly hindered local public borrowing. This result suggests that even though local governments' demand for funds was growing after GSA, there was a constrained willingness of MCB investors to provide proceeds due to worrying about the creditworthiness of NNR municipalities. The latter effect played a dominant role in determining the amount of financing and drove up the MCB risk premium.

Local Political Risk: As outlined in Section 2.2, GSA holds officials accountable for negligence, which might affect the political turnover (ex-post) and change the promotion incentive for officials (ex-ante). For instance, in the "Qilian Mountain Incident", the area under the jurisdiction of Zhangye City recorded the most violations. Following the inspection by the central government, Shengwu Mao, the former municipal secretary of the CPC in Zhangye, and Zeyuan Huang, the incumbent mayor of Zhangye, both received the severe warning within the party, which primarily means they would not be allowed to be promoted to higher positions for a minimum period of one and a half years. It is also worth noting that the punishment one level higher than a severe warning leads to dismissal.

From the view of some MCB investors, GSA adds evaluation requirements for local officials, which possibly creates additional political risk. Thus, the perceived rise in risk premium could be attributed to the market's concern about the stability of the local political environment. To explore this conjecture, we first study changes in the positions of the municipal secretary of the CPC and the mayor, two primary leaders in Chinese city governments. Again, using the similar city-year-level specification in Panel A of Table 5, we find that GSA had an insignificant impact on local political turnover (Panel A of Table A8). We also employ the DDD specification (similar to that in Panel B of Table 5) to study whether the impact of GSA is different during the first two years of the leading official's term. Prior studies reveal that officials in the early stages of their terms (i.e.,

the first two years) tend to have weaker political incentives, compared with their more established counterparts (Buntaine *et al.*, 2022). Intuitively, during the late stage of their term, officials have limited leeway to incur penalties such as severe warnings that influence their promotion prospects for several years. As presented in Panel B of Table A8, we do not observe significant heterogeneity across different stages of officials' tenures. Overall, these results suggest that the potential increase in local political risk could not dominate the pricing effect of GSA.

6 Biodiversity Improvement and Value Versus Values

6.1 Proxy for Biodiversity Improvement

The preceding discussion has focused on the negative financial impact of GSA. How about its biodiversity impact? Has GSA genuinely improved local biodiversity as intended by Beijing, or is it a futile campaign?

Because biological systems are more complicated than physical systems, there have not been reliable and widely accepted metrics to measure the performance of biodiversity finance (Karolyi & Tobin-de la Puente, 2023), such as temperature and carbon emission used in climate finance. Neither are there currently complete panel statistics on various species at the prefecture level in China. Therefore, we center our attention on examining the changes occurring in a particular animal group — birds. Our proxy for biodiversity is partially driven by data availability — we can access two specific datasets that capture the dynamics of bird species in China. More importantly, birds are an important indicator group of biodiversity due to their wide range and sensitivity to the environment.

The primary dataset is from the China Bird Report Center (CBRC), the leading Internet bird data recording and sharing platform. The data structure of the CBRC resembles that of the eBird Reference Dataset, a citizen science dataset comprising reports from users with detailed descriptions of their birdwatching trips, as well as the species of birds observed. We construct panel data of birdwatching activities at the city-quarter level from 2015 to 2021, using reports uploaded on the CBRC. We exclude the city-quarter observation with no birdwatching report, and then empirically explore the effects of GSA on the number of bird species observed through employing the DID specification. As shown in Column (1) of Table A9, following GSA, more bird species are reported in NNR municipalities compared to non-NNR municipalities. Although the records from voluntary observation activities cannot convincingly represent the actual status of local wildlife, it seems reasonable to assume that the more abundant the bird population, the more likely it is to be observed. Therefore, the results are consistent with the notion that local biodiversity really benefited from more endeavors made by the government on biological conservation due to the enforcement of GSA. Furthermore, Column (2)

and Column (3) of Table A9 present that the intensity of birdwatching activities had no significant change around GSA, evidenced by the number of reports and reporters, indicating that the increase in bird species observed is not driven by more attention from birdwatchers.

Another complementary dataset is the monitoring information of birds from the Chinese National Ecosystem Research Network (CNERN), an information-sharing platform constructed by the Ministry of Science and Technology of the PRC, integrating resources of multiple existing field observation and research stations. Specifically, the data on birds is summarized from eight forest ecological stations [34] , which conduct a systematic survey of birds every five years in corresponding areas. Since these stations are all located in NNR municipalities, we cannot employ a DID estimation and only perform descriptive statistics at the time series level. Figure A4 shows that the number of bird species surveyed declined by about a quarter in the first fifteen years of this century, and recovered a few following GSA, demonstrating a clear U-shape dynamic. This pattern provides further insights into the real positive effect of GSA on biodiversity.

The contrast between the biological implication and public financial costs of GSA prompts we to explore the role that the market's valuation of biodiversity plays in determining the price of MCB.

6.2 Information Asymmetry

Our previous discussions focus on explanations from the pecuniary preference of the market (i.e., the concern about the transition costs). However, it is possible that some investors' decisions are motivated by non-pecuniary values (Starks, 2023). Suppose that there are a considerable number of investors who really care about biodiversity value for the sake of their non-pecuniary preference in the MCB market. However, they know little about the actual situation of NNRs, probably due to high information acquisition costs (e.g., conducting field visits and measuring biodiversity). In that case, the announcement of GSA plays a role in delivering delayed information on the poor management of biodiversity within NNRs. The major reactions of these impact investors to GSA may not be appreciating governments' forthcoming efforts, but blaming local authorities for past negligence and worrying about incurred biodiversity loss. If this assumption holds, the existence of these impact investors further increases local public financing costs.

We notice that the role of information asymmetry is critical for this channel to work. If impact investors can keep up to date with the situation of NNRs, GSA offers little new information and could not trigger significant incentives to concern biodiversity loss and punish NNR municipalities. Therefore, we collect newspaper coverage of NNRs

[34] The list of these eight stations: Ailao Mountain Station, Beijing Forest Station, Banna Station, Changbai Mountain Station, Dinghu Mountain Station, Gongga Mountain Station, Heshan Station, Huitong Station, Maoxian Station, Qingyuan Station, Shennongjia Station.

from *WiseNews*, a leading Chinese newspaper aggregator. We measure the degree of information ambiguity by whether the NNRs managed by an NNR municipality was covered by the top 10 comprehensive newspapers by average circulation in 2016. As shown in Table A10, NNR municipalities with different levels of newspaper coverage of their own NNRs see similar increases in MCB spreads around GSA, compared to non-NNR municipalities. Wald tests present insignificant heterogeneity. In addition, the information effect of GSA ought to gradually weaken over time theoretically, which is inconsistent with the pattern presented in Figure 4. In a nutshell, the heightened premium observed around GSA is not driven by information updating of biodiversity impact investors.

6.3 Investors' Valuation of Biodiversity Improvements

We now consider an alternative channel through which preferences for biological well-being may influence the MCB markets. Investors may significantly reward NNR municipalities that demonstrate effective ecological improvements. This mechanism is crucial for rethinking how sustainable finance works. Although the net effect of the GSA reveals a prevailing market apprehension about the costs incurred by ecological transition, favorable investment strategies associated with biodiversity improvements can substantially mitigate the increase in the public cost of capital, thereby benefiting social welfare.

We categorize the birdwatching reports data introduced in Section 6.1 into two phases: from January 2015 to June 2017, and from July 2017 to December 2021. For each NNR municipality, we aggregate the number of bird species reported, subsequently calculating the corresponding changes in the post-GSA period compared to the pre-GSA period. We compare the top quartile of NNR municipalities, which exhibit a substantial increase in bird species observed around GSA, with other NNR municipalities. The results presented in Table A11 reveal that these NNR municipalities with greater improvements in local biodiversity did not experience a significantly lower rise in MCB spreads. The role of pricing conservation costs behind biodiversity enrichment seems to be pervasive across groups.

In addition, the cross-sectional tests on ex-ante information asymmetry associated with NNRs discussed in Section 6.2 also indicate an insignificant impact of incentives to reward efforts on protecting biodiversity. Specifically, if NNRs with larger biological value are more likely to be covered by newspapers, then NNR municipalities with more NNR news have access to more favorable financing. This assumption implies the same sign of heterogeneity across municipalities with different levels of NNR news coverage as that under the hypotheses of punishment for dereliction and concern for biodiversity loss. However, as we have discussed in Section 6.2, Table A10 suggests a tiny disparity associated with ex-ante attention on NNRs. Consistent conclusions are also implied by the insignificant effects among non-NNR nature reserves shown in Table 3, if there is awareness spillover for biodiversity. Moreover, the social benefits of biodiversity restoration ought

to become more evident in the long run, while the positive effects of GSA on spreads of long-term MCBs presented in Table 6 further indicate that valuing biodiversity do not play a dominate role in the financial market.

These findings underscore the absence of impact investments that favors ecological enhancement in the MCB market. In early 2024, Nobel Laureate Michael Spence emphasizes the empowerment of consumers, urging them to discern and support companies that prioritize climate change as a fundamental aspect of their business strategy.[35] Our work suggests that in the context of biodiversity conservation — a similar issue of significance to social and environmental well-being — there may still remain a significant gap in alignment and action.

7 Aggregate Financing Costs and Policy Implications

Our final section assesses the aggregate financing costs resulting from GSA. It is worth noting that a complete public borrowing cost analysis is beyond the scope of our analysis. We are only able to make a simple back-of-the-envelope calculation of the additional financing costs for LGFVs with outstanding MCBs. Specifically, we compute the interest-bearing debts of LGFVs and, subsequently, the rises in interest payments caused by GSA. We examine how these additional financing costs changed from 2013 to 2021 and how much GSA contributed to this change.

Overall Additional Financing Cost: As depicted in Figure 7, the debt cost escalated following the implementation of GSA: the actual public financing costs (the solid red line) remained below 50 billion dollars until 2018, after which these costs began to rise and reached approximately 120 billion dollars in 2021. To conduct a counterfactual analysis, we assume that the channel of NNRs is shut down by setting NNR to zero in Equation (1). In this scenario, the counterfactual public financing cost (the dashed blue line) was similar to the actual financing cost before 2018. However, it started to diverge after 2018, reaching around 107 billion dollars in 2021. The green bar describes the disparity between actual and counterfactual financing costs. Since GSA began to advance, the gap between actual and counterfactual financing costs has been increasing gradually year by year.

In Table 7, we present the estimates of the global biodiversity financial gap based on Deutz *et al.* (2020) and calculate the corresponding financial gaps that China needs to bear under three scenarios. In scenarios A, B, and C, China needs to bear the biodiversity financial gaps based on its share of global species, land area, and GDP, respectively. Given the estimated global annual financial gap of 711 billion dollars since 2019 by Deutz *et al.* (2020), for instance, China needs to spend 45.5 billion dollars per year on protecting biodiversity under scenario A. Meanwhile, the extra financing costs brought by GSA

[35] The concepts related to societal and environmental well-being implied by the lecture also applies to biodiversity conservation (see more details in: https://etinsights.et-edge.com/ai-looms-india-thrives-nobel-laureate-michael-spence-on-navigating-a-fractured-world/).

accounted for 11.33%, 17.95%, and 29.57% of the total costs (45.5 billion dollars) in 2019, 2020, and 2021, respectively. This suggests that, in practice, the cost of protecting biodiversity should involve not only direct investment but also indirect costs, such as the loss in financial markets due to changes in asset price (i.e., the cost of capital). Given the significant magnitude of these indirect costs (probably around three out of ten of the direct investments in 2021), scholars and policymakers should not overlook them in designing global biodiversity conservation frameworks.

Disaggregate Cost Burden Versus Biodiversity Improvement: Beyond assessing the economic significance of additional financing costs during biodiversity transition, we preliminarily consider how government-led conservation can become more efficient given the presence of financial frictions identified in this study. Figure A5 illustrates a raw map of the biodiversity improvement status and financial burden relative to additional financing costs of each NNR municipality around GSA. The vertical axis represents the proportion of cumulative additional financing costs to cumulative GDP for each NNR municipality from 2018 to 2021. The horizontal axis represents the increase in bird species observed following GSA relative to the level prior to the implementation, which has been discussed in Section 6.1 and Section 6.3.

As indicated in this unconditional scatter plot, there is substantial variation in the financial sustainability (i.e., the cost) and ecological sustainability (i.e., the benefit) during the transition among NNR municipalities. Meanwhile, the cost and benefit parts are not highly correlated (indicated by the red fitted line). Thus, the central government faces the problem of optimal biological targeting in practice. A blanket reform approach like GSA can lower policy implementation costs (e.g., the complexity of regulatory standard). However, given the heterogeneity across regions, a more targeted plan is necessary for broader biodiversity conservation actions beyond NNRs to further improve social efficiency. This becomes particularly crucial in the context where private capital has yet to engage in biodiversity transition (called for by Karolyi & Tobin-de la Puente (2023), necessitating public capital to move first proactively).

To shed some light on the optimal targeting in biodiversity transition, we partition Figure A5 into four quadrants, based on the sample median values of indicators in two dimensions. Specifically, (1) The lower right quadrant represents NNR municipalities with high biodiversity benefits and low financial burdens during transition, encouraging a broader conservation approach; (2) The upper left quadrant represents those with low biodiversity benefits and high financial burdens, suggesting a lower priority in practice; (3) The lower left quadrant represents those with low biodiversity benefits and low financial burdens, requiring more attention on biological enhancement; (4) The upper right quadrant represents NNR municipalities with high biodiversity benefits but high financial burdens, necessitating more intricate allocations designs (e.g, central fundings) to mitigate financial risks. Considering measurement errors associated with the metrics

of birds aggregated at the city level and the restricted sample only encompassing NNR municipalities, the analysis above mainly serves as an initial benchmark.

8 Conclusion

We study the relationship between the transition to biodiversity conservation and the cost it imposes on local governments in terms of public financing. In particular, we exploit the Green Shield Action (GSA) in China as an exogenous shock from such a transition to local financial and fiscal burdens to study the responses from the municipal corporate bond (MCB) markets. Using a variety of data, including unstructured texts and zoning images, we present plausibly causal evidence that cities with National Natural Reserves (NNRs) experienced greater increases in public borrowing costs after the implementation of GSA. The effects come from the transition pressure from pre-existing economic activities within NNRs and increased public spending on biodiversity following the policy. These constraints and costs worsen local fiscal conditions, amplifying investors' concern about the probability of local government default. Our findings cannot be explained by financing demand of local governments, heightened political risk, or information disclosure. We also find that though GSA improved biodiversity, investors are not considering these values when making investment decisions, neither are they financially punishing cities with appalling environmental degradation. Finally, we provide a conservative estimate of how much additional public financing costs GSA has incurred and how to best allocate central funding or prioritize biodiversity transitions. Given China's abundance of natural capital, economic scale, and the representative biodiversity challenge, our findings provide valuable initial benchmarks for future research and practice.

Our work likely has several policy implications. First, estimating the financing gap for biodiversity conservation requires considerations beyond direct investments for biodiversity transition. It also needs to account for any additional costs in the financial market. Thus, our study is informative given the current global acceleration of biodiversity loss and the urgent need for collective efforts to save natural capital. Second, we provide insights into how investors' lack of internalization of the (long-run) environmental benefits of government policies may hinder sustainable development goals. Policymakers must consider the reactions of financial markets when formulating relevant sustainable development policies. More detailed disclosure, dedicated financing vehicles, and promotions for the social recognition of biodiversity value constitute key steps in reversing the trend of nature capital loss.

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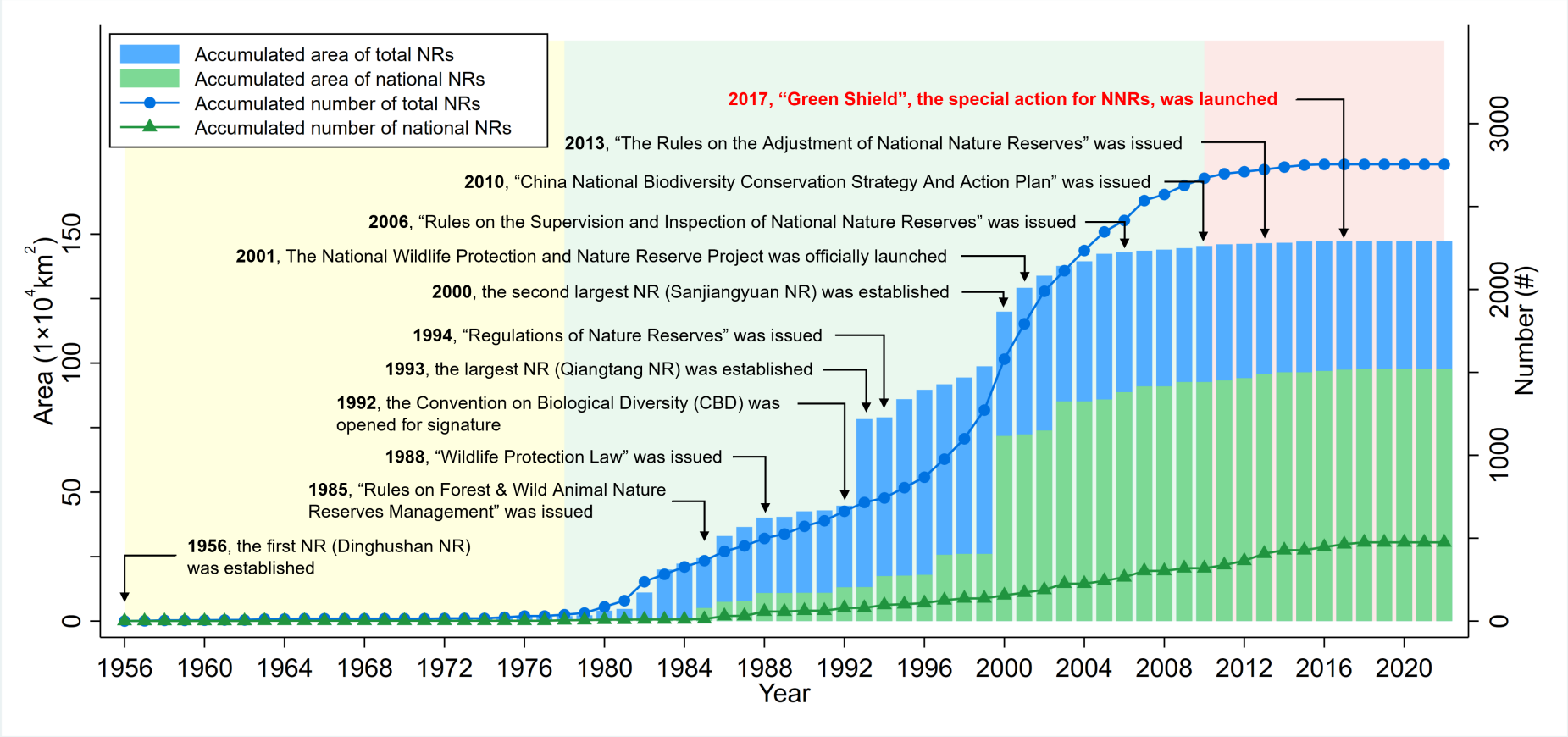
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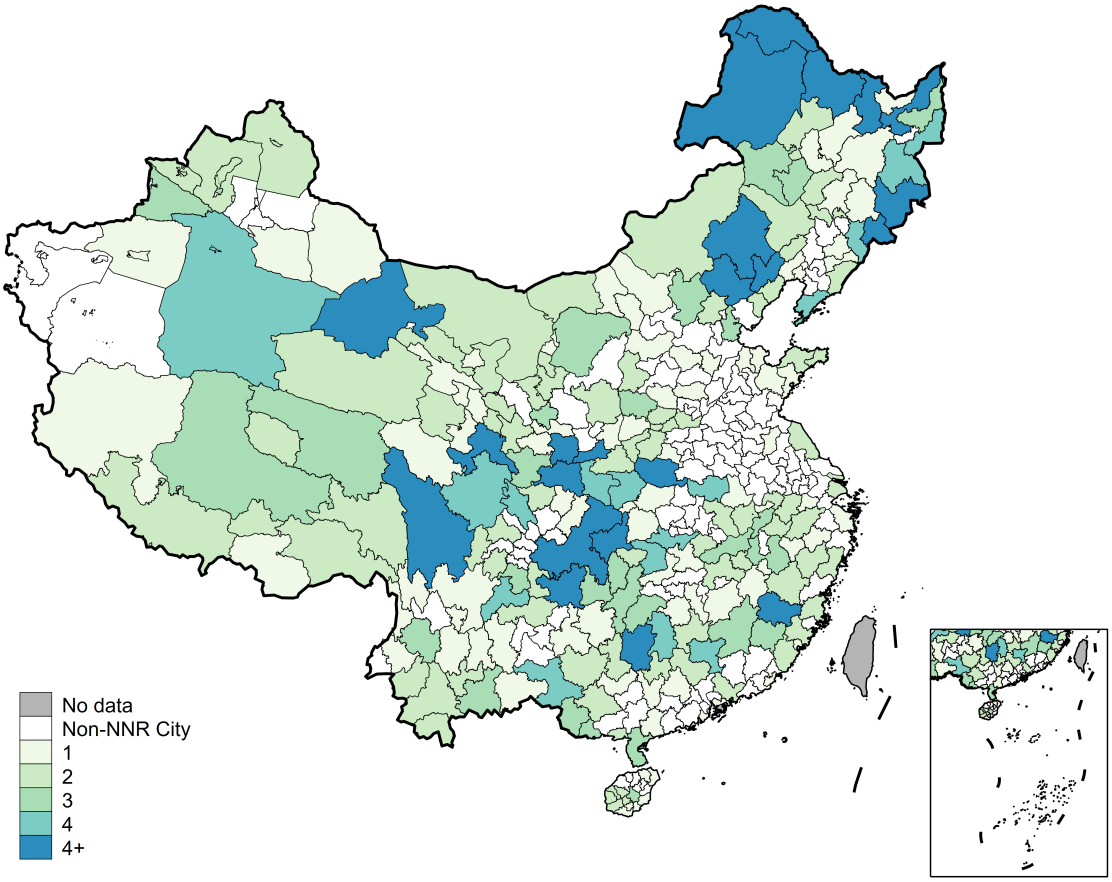
Figures and Tables

Figure 1: Development Process of Nature Reserves and Important Relevant Events in China



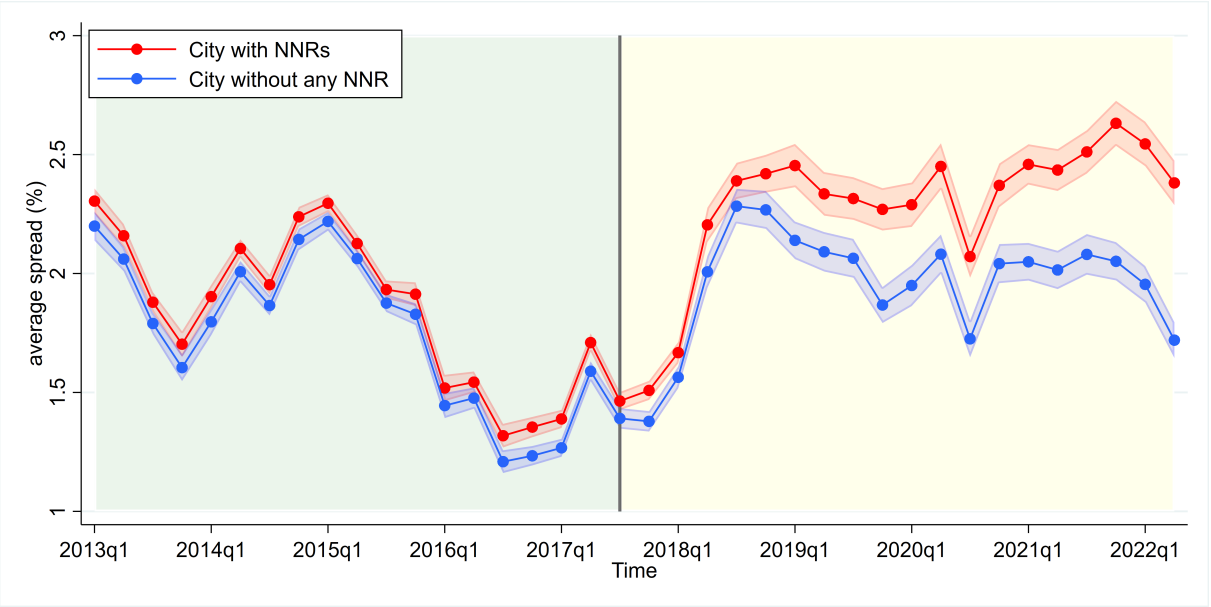
Notes: This figure illustrates the number (right axis) and area (left axis) of national nature reserves (NNRs) in China from 1956 to 2022. Important policies are also marked with arrows on the corresponding year.

Figure 2: The Geographical Distribution of NNRs at the City Level



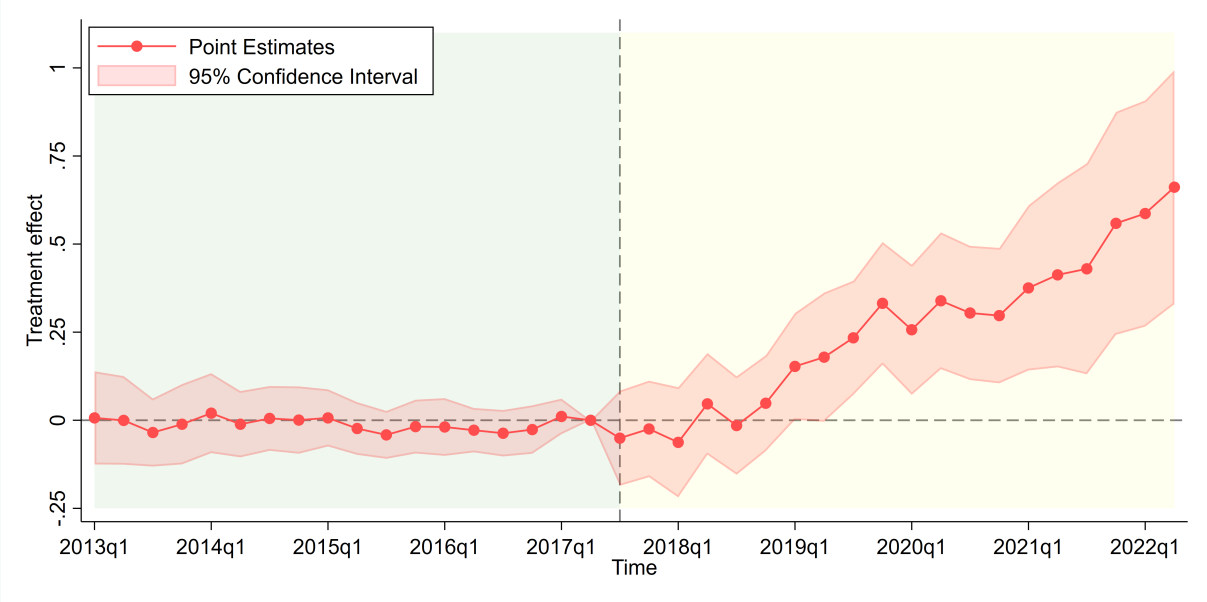
Notes: This figure illustrates the number of national nature reserves (NNRs) in each city in China as of 2016. The regional boundaries are delineated down to the city level. The legend depicts the range of the number of NNRs corresponding to each color depth.

Figure 3: The Dynamics of MCB Spreads over Time



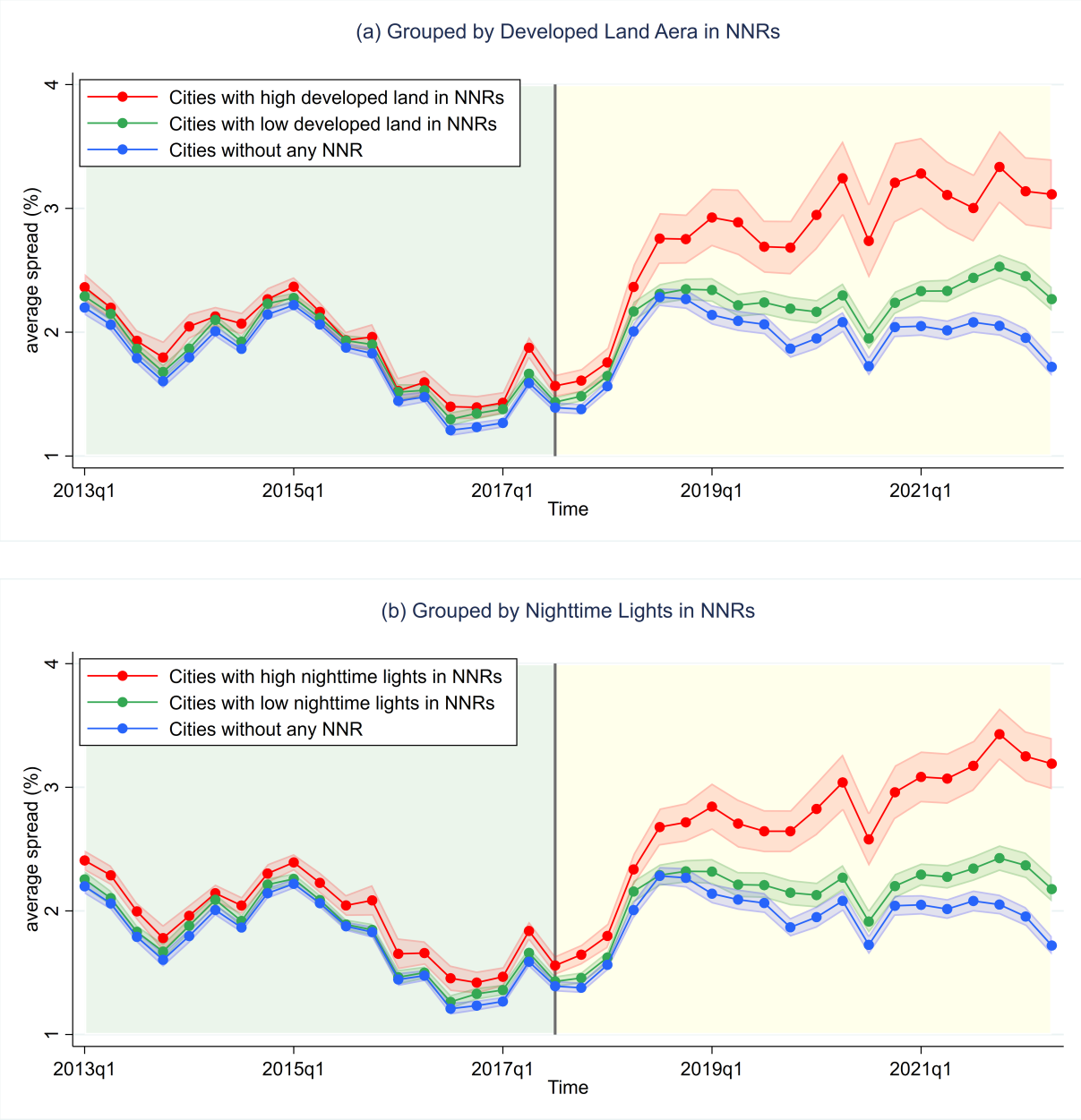
Notes: This figure depicts the raw pattern of average MCB spreads and 95% confidence interval for NNR municipalities and non-NNR municipalities. MCB spread is calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. The solid vertical line represents the time when the Green Shield Action (GSA) was launched.

FIGURE 4: CHANGES IN MCB SPREADS BEFORE AND AFTER THE GSA



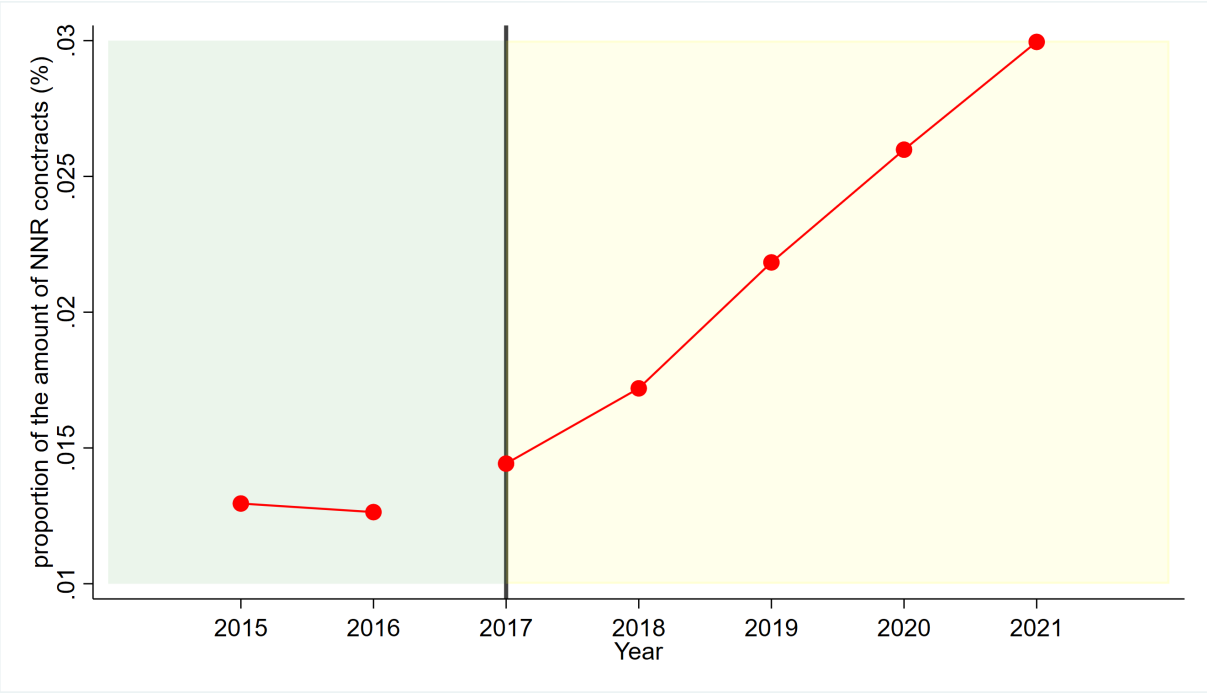
Notes: This figure depicts the estimated differences in MCB spreads between NNR municipalities and non-NNR municipalities before and after GSA. The markers and capped spikes represent the OLS estimators and 95% confidence intervals. The dependent variable is the MCB spread, calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. The dashed vertical line represents the time when GSA was launched. The reference is the second quarter of 2017. The regression follows Equation (2). The standard errors are clustered at the city level.

FIGURE 5: THE DYNAMICS OF MCB SPREADS OVER TIME PRE-EXISTING ECONOMIC ACTIVITIES WITHIN NNRS



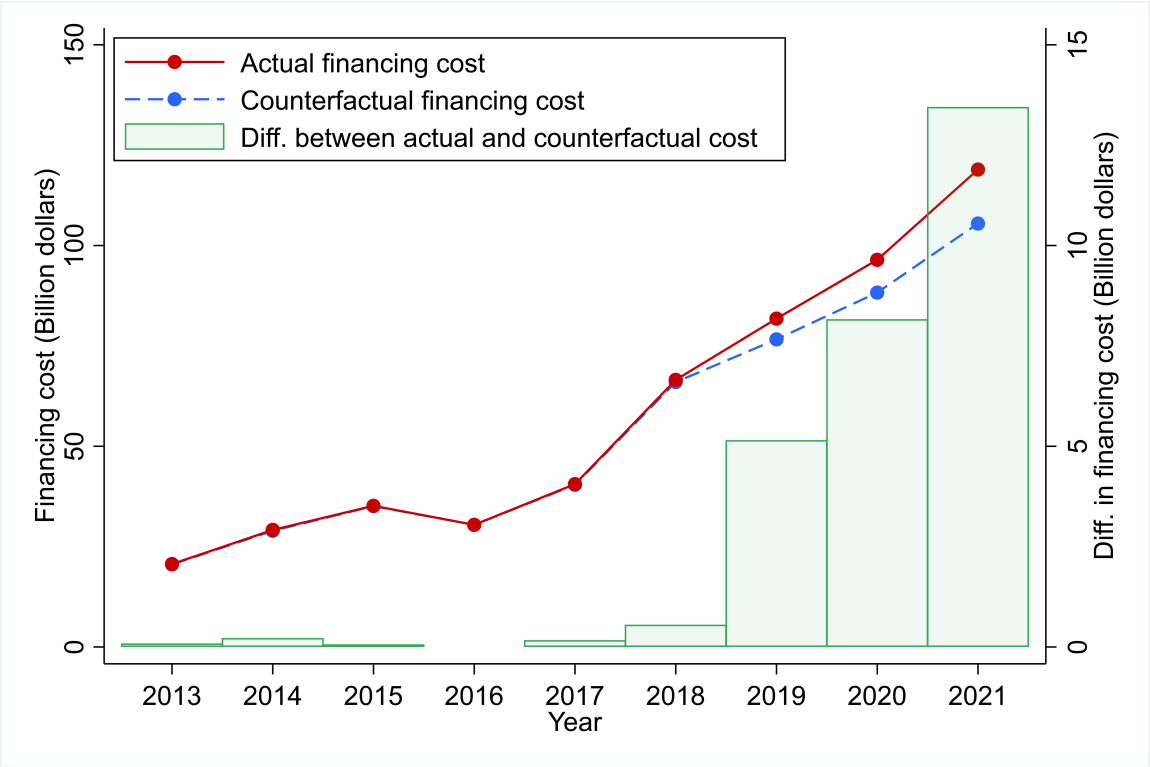
Notes: Panel A of this figure depicts the average MCB spreads and 95% confidence interval for cities in three groups: NNR municipalities in the top quartile of the distribution of developed land area within NNRs in 2016, NNR municipalities not in the top quartile of the distribution of developed land area within NNRs in 2016, and non-NNR municipalities. Panel B of this figure depicts the average MCB spreads and 95% confidence interval for cities in three groups: NNR municipalities in the top quartile of the distribution of nighttime light intensity within NNRs in 2016, NNR municipalities not in the top quartile of the distribution of nighttime light intensity within NNRs in 2016, and non-NNR municipalities. For both panels, MCB spread is calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. The solid vertical line represents the time when GSA was launched.

Figure 6: The Dynamics of Public Procurement on National Nature Reserves over Time



Notes: This figure illustrates the trend of the proportion of amounts of public procurement on national nature reserve to total public procurement from 2015 to 2021. The blue dots represent the proportion, the solid blue line represents the trend, and the red dashed line represents the year of GSA initiation.

Figure 7: Local Public Debt Cost Comparison of True Value and Counterfactual Estimates



Notes: This figure plots the aggregate costs of LGFVs' debt service over time with and without GSA. The solid red line represents the actual aggregate costs of LGFVs' debt service (the left axis). The blue dashed line represents the counterfactual aggregate costs of LGFVs' debt service (the left axis). The green bar represents the difference between actual and counterfactual costs (the right axis) over time, that is, the additional cost of LGFVs' debt service brought about by GSA. The exchange rate between the US dollar and the Chinese RMB yuan is set as 1: 7.

Table 1: Summary Statistics

	Obs	Mean	ST.D	P25	P50	P75
Outcome:						
Spread	87885	1.973	1.360	1.014	1.664	2.509
Treatments:						
NNR	87885	0.511	0.500	0.000	1.000	1.000
Post	87885	0.626	0.484	0.000	1.000	1.000
Bond characteristics:						
ln(Bond size)	87885	2.225	0.530	1.946	2.303	2.565
Time to maturity	87885	3.834	1.757	2.364	3.680	5.148
Option	87885	0.692	0.462	0.000	1.000	1.000
Guarantee	87885	0.230	0.421	0.000	0.000	0.000
Exchange	87885	0.323	0.468	0.000	0.000	1.000
Bond rating	87885	2.290	0.822	2.000	2.000	3.000
Issuer rating	87885	2.654	0.732	2.000	3.000	3.000
City pre-shock features:						
ln(GDP)	87885	3.433	0.952	2.669	3.476	4.234
ln(GDP per capita)	87885	3.981	0.512	3.707	4.051	4.412
GDP growth rate	87885	110.481	1.670	109.400	110.600	111.771
Tertiary sector in GDP	87885	42.915	9.117	36.489	41.979	47.800
ln(Population)	87885	1.741	0.685	1.354	1.718	2.163
Population growth rate	87885	100.710	1.134	100.114	100.416	101.029
ln(Nighttime lights)	87885	16.303	0.755	15.744	16.438	16.853
ln(Fixed investments)	87885	12.271	0.819	11.708	12.219	12.963
ln(Housing price)	87885	8.692	0.447	8.348	8.625	8.951

Notes: This table reports summary statistics in the baseline sample. The main dependent variable is MCB spread, calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city where the issuer is located and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Bond controls include (ln)bond issuing amount, bond maturity, bond rating, issuer rating, whether the bond is option-embedded, guaranteed and traded-on-exchange. City pre-shock variables include (ln)GDP, (ln)GDP per capita, GDP growth rate, the proportion of tertiary sector in GDP, (ln)population, population growth rate, (ln)nighttime light intensity, (ln)fixed investment, and (ln)housing price at city level in 2013. City-level continuous variables are winsorized at the 0.5th and 99.5th percentiles. Detailed variable definitions are presented in Table A1.

Table 2: GSA and MCB Spreads: Baseline Estimates

	Spread			
	(1)	(2)	(3)	(4)
NNR × Post	0.270***	0.250***	0.256***	0.237***
	(0.101)	(0.094)	(0.075)	(0.072)
Year-quarter FE	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Bond controls	No	Yes	No	Yes
City pre-shock var. × Post	No	No	Yes	Yes
Adjusted R^2	0.493	0.552	0.503	0.561
Obs	87885	87885	87885	87885

Notes: This table reports the regression results of the impact of GSA on MCB spreads. The dependent variable is calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city where the issuer is located and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Year-quarter and issuer fixed effects are included. Bond controls include (ln)bond issuing amount, bond maturity, bond rating, issuer rating, whether the bond is option-embedded, guaranteed and traded-on-exchange. City pre-shock variables include (ln)GDP, (ln)GDP per capita, GDP growth rate, the proportion of tertiary sector in GDP, (ln)population, population growth rate, (ln)nighttime light intensity, (ln)fixed investment, and (ln)housing price at city level in 2013. Detailed variable definitions are presented in Table A1. Standard errors in parentheses are clustered at city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table 3: GSA and MCB Spreads: Placebo Test

	Spread			
	(1)	(2)	(3)	(4)
NNR × Post	0.237***	0.234***	0.232***	0.227***
	(0.072)	(0.073)	(0.074)	(0.076)
ProvNR × Post	-0.048			-0.049
	(0.093)			(0.093)
CityNR × Post		-0.018		-0.022
		(0.076)		(0.080)
CountyNR × Post			0.033	0.040
			(0.077)	(0.081)
Controls	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.561	0.561	0.561	0.561
Obs	87885	87885	87885	87885

Notes: This table reports the impact of owning different types of nature reserves on MCB spreads around GSA. *Provincial NR* is a dummy variable that equals one if there is at least one provincial nature reserve in the city where the issuer is located, and zero otherwise. *Municipal NR* is a dummy variable that equals one if there is at least one municipal nature reserve in the city where the issuer is located, and zero otherwise. *County NR* is a dummy variable that equals one if there is at least one county nature reserve in the city where the issuer is located, and zero otherwise. The other designs are identical to Equation (1). The dependent variable is MCB spread, calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city where the issuer is located and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table 4: GSA and MCB Spreads: Pre-existing Economic Activities within NNRs

Grouping indicator	Spread			
	Developed land area		Nighttime light intensity	
	(1)	(2)	(3)	(4)
High ex-ante economic activity in NNRs × Post	0.404***	0.483***	0.320***	0.402***
	(0.122)	(0.131)	(0.115)	(0.119)
Low ex-ante economic activity in NNRs × Post		0.176**		0.181**
		(0.075)		(0.077)
F statistics for testing $\beta^{high} = \beta^{low}$		5.346**		3.269*
Controls	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.561	0.562	0.561	0.562
Obs	87885	87885	87885	87885

Notes: This table reports the heterogeneous effects of GSA on MCB spreads in pre-existing human economic activities within NNRs. *High ex-ante economic activity in NNRs* is a dummy variable that equals one if a city is in the top quartile of the intensity distribution of human economic activities within NNRs in 2016 among NNR municipalities. *Low ex-ante economic activity in NNRs* is a dummy variable that equals one if a city is not in the top quartile of the intensity distribution of human economic activities within NNRs in 2016 among the NNR municipalities. The control groups are all non-NNR municipalities. The intensity of human economic activities is measured by the developed land areas and nighttime light intensity within NNRs, respectively. The other designs are identical to Equation (1). The dependent variable is MCB spread, calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Other designs are identical to Equation (1). The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are clustered at the city level. F statistics is from the Wald test for the difference of regression coefficients. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table 5: GSA and Local Public Creditworthiness

Panel A: GSA and local fiscal condition

	Fiscal deficit	
	(1)	(2)
NNR × Post	25.275***	20.282**
	(9.652)	(7.927)
Controls	No	Yes
Year FE	Yes	Yes
City FE	Yes	Yes
Adjusted R^2	0.924	0.932
Obs	2725	2725

Panel B: GSA and MCB spreads: local debt pressure

	Spread	
Grouping indicator	Total debt	Interest-bearing debt
	(1)	(2)
NNR × Post	0.120	0.097
	(0.093)	(0.098)
NNR × Post × High debt burden	0.245*	0.286**
	(0.127)	(0.136)
Other terms of triple diff	Yes	Yes
Controls	Yes	Yes
Year-quarter FE	Yes	Yes
Issuer FE	Yes	Yes
Adjusted R^2	0.562	0.563
Obs	87837	87837

Notes: This table reports the role of local creditworthiness in the relationship between GSA and MCB spreads. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city and zero otherwise. Panel A reports the effects of GSA on local fiscal conditions at the city-year level. *Fiscal deficit* is the ratio of the difference between annual fiscal expenditures and revenues, to fiscal revenues (in percentage). *Post* is a dummy variable that equals one in and after 2017 and zero otherwise. Year and city fixed effects, as well as the city-level control variables (i.e., *city pre-shock var.*×*Post*), are included. Panel B reports the heterogeneous effects of GSA on MCB spreads in local public debt burden. *High debt burden* is a dummy variable that equals one if a city's level of public debt burden is in the top quartile of the city distribution for the year before the bond trade and zero otherwise, where the debt burden is measured by city-year-level total debt and interest-bearing debt of LGFVs, divided by city GDP, respectively. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are all clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table 6: GSA and MCB Spreads: Bond Term Structure

	Spread					
Grouping indicator	Long Term >3 years			Long Term >4 years		
Sample	Short Term	Long Term	Full Sample	Short Term	Long Term	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)
NNR × Post	0.342***	0.178***	0.311***	0.307***	0.151**	0.278***
	(0.097)	(0.066)	(0.091)	(0.076)	(0.077)	(0.078)
NNR × Post × Long Term			-0.164**			-0.153**
			(0.075)			(0.072)
Other terms of triple diff			Yes			Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.587	0.655	0.563	0.580	0.673	0.562
Obs	35260	52625	87885	48414	39471	87885

Notes: This table reports the heterogeneous effects of GSA on MCB spreads in bond term structure. The criterion to classify between long-term and short-term bond is whether is residual maturity is above 3 years in Columns (1)-(3) and 4 years in Columns (4)-(6), respectively. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. *Long Term* is a dummy variable that equals one if an MCB if classified as a long-term bond. Other designs are identical to Equation (1). The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are clustered at the city level. F statistics is from the Wald test for the difference of regression coefficients. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table 7: Additional Local Public Debt Costs and Corresponding Economic Significance

Scenario A: China bears the gap in biodiversity financing according to its share of global species (6.4%)						
Scenario B: China bears the gap in biodiversity financing according to its share of global land area (7%)						
Scenario C: China bears the gap in biodiversity financing according to its share of global GDP (18.5%)						
Year	2016	2017	2018	2019	2020	2021
Additional financing costs for MBC markets (Billion dollars)	0.00	0.17	0.56	5.15	8.17	13.45
Global biodiversity financing gap estimated by Deutz *et al.* (2020) (Billion dollars)				711	711	711
China's biodiversity financing gap in Scenario A (Billion dollars)				45.5	45.5	45.5
China's biodiversity financing gap in Scenario B (Billion dollars)				49.77	49.77	49.77
China's biodiversity financing gap in Scenario C (Billion dollars)				131.54	131.54	131.54
Proportion of financing costs in China's biodiversity financial gap in Scenario A (%)				11.33	17.95	29.57
Proportion of financing costs in China's biodiversity financial gap in Scenario B (%)				10.35	16.41	27.03
Proportion of financing costs in China's biodiversity financial gap in Scenario C (%)				3.92	6.21	10.23

Notes: This table presents results of a simple back-of-the-envelope calculation on the aggregate costs of GSA on the LGFVs' debt service and the corresponding economic significance. The exchange rate between the US dollar and the Chinese RMB yuan is set as 1: 7.

Appendix

A Additional Tables and Figures

Figure A1: Changes in the Biological Condition of the Qilian Mountain National Nature Reserve around GSA



Pre-GSA period Post-GSA period

Notes: This figure illustrates the contrast in the biological condition within the Qilian Mountain National Nature Reserve before and after GSA, from the perspectives of the disposal of illegal hydropower facilities (the upper part) and colliery (the bottom part). See more details in: https://www.mee.gov.cn/ywgz/zysthjbhdc/dczg/202102/t20210206_820575.shtml.

FIGURE A2: CHANGES IN MCB SPREADS BEFORE AND AFTER THE GSA: ALTERNATIVE MEASURES



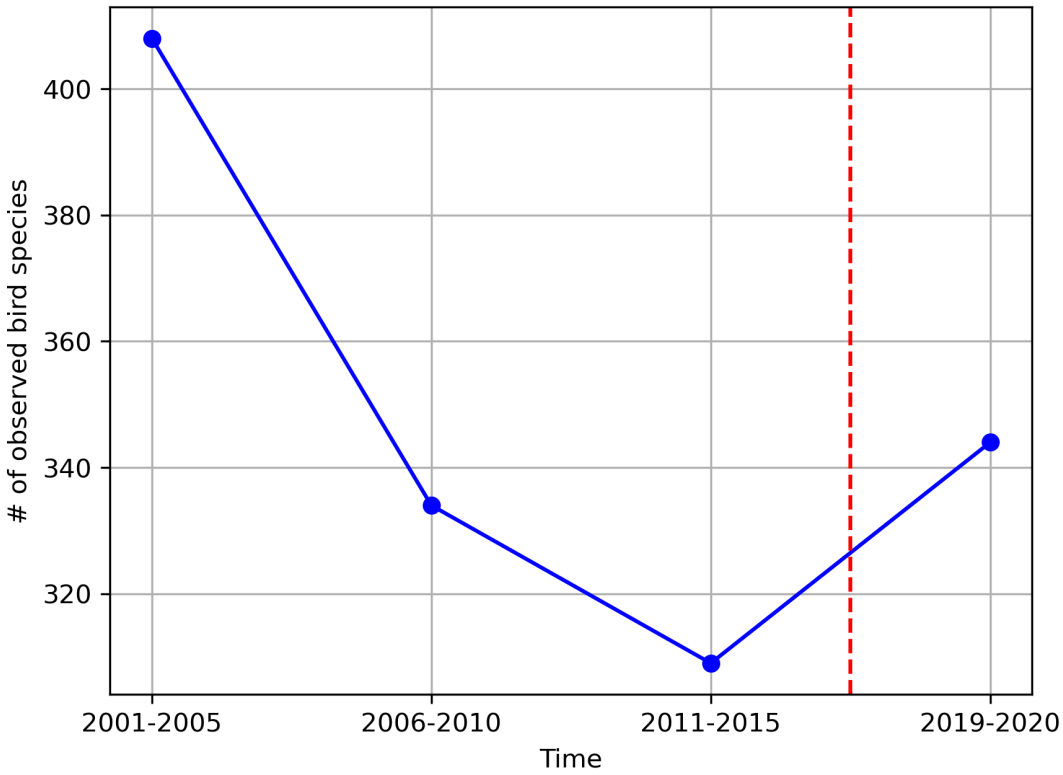
Notes: This figure depicts results of robustness tests on estimated differences in MCB spreads between NNR municipalities and non-NNR municipalities, by replacing the main explanatory variable or the dependent variable of the specification in Figure 4. The alternative measures of treatment intensity used are the number of NNRs and the proportion of NNRs in the area of urban administrative areas within a city in Panel A-B, respectively. The alternative measures used are the quarterly median, the quarterly mean, and the quarterly trading-volume-weighted average of MCB spreads in Panel C-E, respectively, using the benchmark of CDB yield. Panel F-I replace the benchmark with the national bond yield.

FIGURE A3: GSA AND MCB SPREADS: ALTERNATIVE FREQUENCIES OF BOND SAMPLE



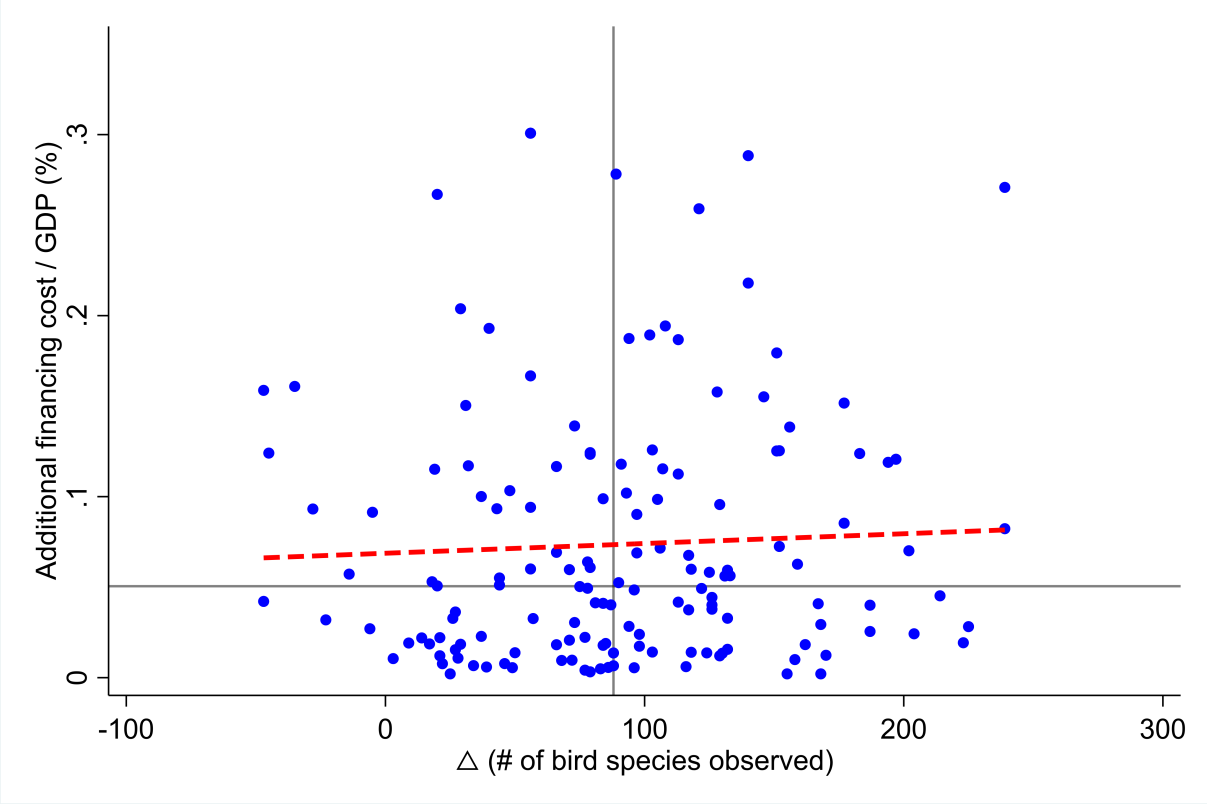
Notes: This figure depicts the results of robustness tests on estimated differences in MCB spreads between NNR municipalities and non-NNR municipalities before and after GSA, by replacing the data frequency of the specification in Figure 4. The alternative frequencies of the bond sample are constructed by choosing the last observation of monthly frequency, semi-yearly frequency, and yearly frequency for each bond in Panel A-C, respectively. The estimation result with the bond offering sample is also shown in the Panel D.

Figure A4: The Dynamics of Bird Species Observed over Time



Notes: This figure depicts the total number of bird species surveyed every five years since the beginning of this century by the forest ecological stations connected with the Chinese National Ecosystem Research Network (CNERN). The dash vertical line represents the time when GSA was launched.

FIGURE A5: ADDITIONAL FINANCING COSTS AND BIODIVERSITY IMPROVEMENT



Notes: This figure illustrates the distribution of NNR municipalities with available data according to additional financing costs and biodiversity improvement. Each blue dot represents a city. The vertical axis represents variations in the proportion of cumulative additional financing costs to cumulative GDP for each city from 2018 to 2021 (in percentage); The horizontal solid line represents the median level of the burden of additional financing costs. The level of biodiversity improvement is measured by the increase in bird species observed following GSA relative to their numbers prior to the implementation; The vertical solid line represents the median level of biodiversity improvement. The red dashed line is the fitted line representing the correlation between the burden of additional financing costs and biodiversity improvement across municipalities.

Table A1: Additional Definitions of Variables

Variable	Definition
ln(Bond size)	The logarithm of a bond issuing amount, in hundred million yuan RMB.
Time to maturity	The residual maturity of a bond traded, in year.
Option	A dummy variable that equals one if a bond is option-embedded and zero otherwise.
Guarantee	A dummy variable that equals one if a bond is guaranteed and zero otherwise.
Exchange	A dummy variable that equals one if a bond is traded on the exchange market and zero otherwise.
Bond rating	A numerical number converted from the real letter grades of a bond, by assigning 1 to AAA, 2 to AA+, 3 to AA, 4 to AA-, 5 to A+, 6 to A, 7 to A-, 8 to grades below A.
Issuer rating	A numerical number converted from the real letter grades of an issuer, by assigning 1 to AAA, 2 to AA+, 3 to AA, 4 to AA-, 5 to A+, 6 to A, 7 to A-, 8 to grades below A.
ln(GDP)	The logarithm of gross domestic product of corresponding city in 2013, in ten billion yuan RMB.
ln(GDP per capita)	The logarithm of GDP per capita of corresponding city in 2013, in thousand yuan RMB.
GDP growth rate	The ratio of GDP in 2013 to that in 2012 of corresponding city, in percentage.
Tertiary sector GDP	The ratio of the tertiary sector in GDP of corresponding city in 2013, in percentage.
In(Population)	The logarithm of permanent residents population of corresponding city in 2013, in thousand people.
Population growth rate	The ratio of permanent residents population in 2013 to that in 2012 of corresponding city, in percentage.
In(Nighttime lights)	The logarithm of nighttime light intensity of corresponding city in 2013.
In(Fixed investments)	The logarithm of fixed investments of corresponding city in 2013, in billion RMB yuan.
In(Housing price)	The logarithm of averaged selling price of commercial housing of corresponding city in 2013, in RMB yuan per square meter.

Notes: This table reports the definitions of variables that may be not explained in detail in notes of corresponding tables and figures.

Table A2: Predetermined Differences between NNR Municipalities and Non-NNR Municipalities

	NNR=1	NNR=0	Difference
	(1)	(2)	(1)-(2)
GDP (ten billion RMB)	20.211	24.248	-4.038
	(2.291)	(2.559)	(3.590)
GDP per capita (thousand RMB)	45.410	49.278	-3.868
	(1.965)	(2.488)	(3.205)
GDP growth rate (%)	108.369	108.692	-0.323
	(0.169)	(0.203)	(0.271)
Tertiary sector GDP (%)	40.992	41.389	-0.397
	(0.678)	(0.738)	(1.055)
Nighttime light intensity	9.037	10.204	-1.167
	(0.543)	(0.672)	(0.879)
Housing price (thousand RMB/ m^2)	5.031	5.112	-0.081
	(0.222)	(0.199)	(0.328)
Fixed investment (billion RMB)	150.397	170.983	-20.585
	(12.223)	(13.532)	(19.106)
Population (million)	3.973	4.436	-0.463
	(0.261)	(0.260)	(0.396)
Population growth rate (%)	100.303	100.614	-0.310
	(0.121)	(0.155)	(0.198)
Local fiscal revenue (million RMB)	21.281	20.966	0.315
	(3.750)	(2.485)	(5.310)
Local fiscal expenditure (million RMB)	38.376	33.470	4.906
	(4.515)	(2.521)	(6.276)

Notes: This table represents the pre-GSA economic variable averages for NNR municipalities and non-NNR municipalities, and the corresponding differences. The sample period covers 2013 to 2016. Standard errors are in parenthese. The exchange rate between the US dollar and the Chinese RMB yuan were typically between 1:6 and 1:7.

Table A3: GSA and MCB Spreads: Alternative Measures of Treatment Intensity

Panel A: Number of NNR in corresponding city

	Spread			
	(1)	(2)	(3)	(4)
NNR number × Post	0.054**	0.058**	0.040*	0.036
	(0.026)	(0.022)	(0.022)	(0.022)
Year-quarter FE	Yes	Yes	Yes	Yes
City-issuer FE	Yes	Yes	Yes	Yes
Bond controls	No	Yes	No	Yes
City pre-shock var. × Post	No	No	Yes	Yes
Adjusted R^2	0.492	0.551	0.502	0.560
Obs	87885	87885	87885	87885

Panel B: Area of NNR in corresponding city

	Spread			
	(1)	(2)	(3)	(4)
NNR area × Post	0.038***	0.035***	0.022**	0.020**
	(0.008)	(0.008)	(0.009)	(0.008)
Year-quarter FE	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Bond controls	No	Yes	No	Yes
City pre-shock var. × Post	No	No	Yes	Yes
Adjusted R^2	0.493	0.552	0.502	0.561
Obs	87885	87885	87885	87885

Notes: This table reports the regression results of the impact of GSA on MCB spreads using alternative measures of treatment intensity. The dependent variable is MCB spread, calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. Panel A employs *NNR number*, a count variable that represents the number of NNRs within the city where the issuer is located. Panel B employs *NNR area*, a continuous variable that represents the proportion of the area of NNR within the city where the issuer is located. Other designs are identical to Equation (1). *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Year-quarter and issuer fixed effects are included. Bond controls include (ln)bond issuing amount, bond maturity, bond rating, issuer rating, whether the bond is option-embedded, guaranteed and traded-on-exchange. City pre-shock variables include (ln)GDP, (ln)GDP per capita, GDP growth rate, the proportion of tertiary sector in GDP, (ln)population, population growth rate, (ln)nighttime light intensity, (ln)fixed investment, and (ln)housing price at city level in 2013. Detailed variable definitions are presented in Table A1. Standard errors in parentheses are clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A4: GSA and MCB Spreads: Alternative Measures of Spreads

	Benchmark: CDB yiled			Benchmark: National bond yiled			
	Quarterly median	Quarterly mean	Trading volume weighted average	Quarterly last obs	Quarterly median	Quarterly mean	Trading volume weighted average
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
NNR × Post	0.235***	0.237***	0.234***	0.241***	0.238***	0.241***	0.238***
	(0.071)	(0.072)	(0.070)	(0.071)	(0.071)	(0.071)	(0.070)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.583	0.586	0.585	0.559	0.580	0.583	0.581
Obs	87885	87885	87259	87885	87885	87885	87259

Notes: This table reports the regression results of the impact of GSA on MCB spreads using alternative measures of spread. The alternative measures used are successively the quarterly median of spread, the quarterly mean of spreads, the quarterly trading-volume-weighted weighted spreads in Columns (1)-(3), using the benchmark of CDB yield. Columns (4)-(7) replace the benchmark with the national bond yield. Other designs are identical to Equation (1). *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city where the issuer is located and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A5: GSA and MCB Spreads: Alternative Frequencies of Bond Sample

Freq.	Spread			
	Monthly	Semi-yearly	Yearly	Offering
	(1)	(2)	(3)	(4)
NNR×Post	0.243***	0.250***	0.235***	0.187**
	(0.077)	(0.074)	(0.075)	(0.080)
Controls	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes
Observations	166265	52767	32119	8961
Adjusted R^2	0.580	0.545	0.550	0.829

Notes: This table reports the regression results of the impact of GSA on MCB spreads using alternative frequencies of the bond sample. The alternative frequencies of sample are constructed by choosing the last observation of monthly frequency, semi-yearly frequency, and yearly frequency for each bond in Columns (1)-(3), respectively. The estimation results with the bond offering sample are also reported in Column (4). Other designs are identical to Equation (1). The dependent variable is MCB spread, calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city where the issuer is located and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Time (corresponding frequency, with quarter fixed effects for the offering sample) and issuer fixed effects, bond-level control variables, and pre-GSA city-level control variables that are interacted with *Post*, are included. Standard errors in parentheses are clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A6: GSA and MCB Spreads: Major Confounding Events

Panel A: Central Inspection on Environmental Protection

	Spread					
	(1)	(2)	(3)	(4)	(5)	(6)
NNR × Post	0.237***	0.237***	0.236***	0.233***	0.229***	0.226***
	(0.072)	(0.072)	(0.072)	(0.072)	(0.072)	(0.073)
In the 1st round	0.055**		0.055**			
	(0.025)		(0.025)			
In the 2nd round		-0.017	-0.017			
		(0.049)	(0.049)			
After the 1st round				0.086**		0.082**
				(0.038)		(0.037)
After the 2nd round					0.084	0.082
					(0.066)	(0.066)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.561	0.561	0.561	0.561	0.561	0.561
Obs	87885	87885	87885	87885	87885	87885

Panel B: Nationwide Battle to Prevent and Control Pollution

	Spread					
	(1)	(2)	(3)	(4)	(5)	(6)
NNR × Post	0.200***	0.229***	0.220***	0.218***	0.213***	0.186**
	(0.076)	(0.073)	(0.074)	(0.075)	(0.076)	(0.080)
AQI × Post2018Q1	-0.004					-0.004
	(0.003)					(0.003)

Industrial SO2 / GDP2 × Post2018Q1		0.718***			0.698***	0.681***
		(0.115)			(0.158)	(0.154)
industrial sewage / GDP2 × Post2018Q1			-0.049		-0.315*	-0.333**
			(0.171)		(0.167)	(0.166)
Industrial dust / GDP2 × Post2018Q1				0.697***	0.281	0.302
				(0.240)	(0.280)	(0.274)
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.553	0.549	0.546	0.546	0.548	0.548
Obs	85741	84739	84628	83482	83482	83482

Notes: This table reports the effects of contemporary major events on MCB spreads. Panel A focuses on the Central Inspection on Environmental Protection (CIEP). *In the 1st (2nd) round* is a dummy variable that equals one if the province is under the first-round (second-round) investigation of CIEP and zero otherwise. *After the 1st (2nd)* round is a dummy variable that equals one if the province has gone through the first (second) round of CIEP and zero otherwise. Panel B focuses on the Nationwide Battle to Prevent and Control Pollution (NBPCP). *AQI* is the Annual Air Quality Index at city level in 2017. *Industrial SO2* represents annual industrial sulfur dioxide emissions at city level in 2017. *Industrial sewage* represents annual industrial wastewater emissions at city level in 2017. *Industrial dust* represents annual industrial dust emissions at city level in 2017. *GDP2* represents gross domestic product of the secondary sector at city level in 2017. *PostNBPCP* is a dummy variable that equals one after the first quarter of 2018 and zero otherwise. The other designs are identical to Equation (1). The dependent variable is MCB spread, calculated as the difference between the MCB yield and CDB yield on the same day and of the same maturity. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city where the issuer is located and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are clustered at city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A7: GSA and Public Financing Demand

Dep. Var	MCB issuance dummy	MCB issuance amount	Growth rate of LGFV debt	Growth rate of LGFV interest-bearing debt
	(1)	(2)	(3)	(4)
NNR × Post	-0.040	-16.151	-1.291	-8.404
	(0.030)	(12.914)	(3.710)	(6.338)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
City FE	Yes	Yes	Yes	Yes
Adjusted R^2	0.372	0.775	0.180	0.154
Obs	2437	2437	2437	2437

Notes: This table reports the city-year-level regression results of the effects of GSA on the quantity of local public financing. *MCB issuance dummy* is a dummy variable that equals one if a city has a new MCB issuance in that year and zero otherwise. *MCB issuance amount* is a continuous variable that represents the the total amount of new MCB issued by a city in that year. *Growth rate of LGFV debt* is a continuous variable that represents the growth rate of city-year-level aggregated total debts of LGFVs with outstanding MCBs. *Growth rate of LGFV interest-bearing debt* is a continuous variable that represents the growth rate of city-year-level aggregated interest-bearing debts of LGFVs with outstanding MCBs. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city and zero otherwise. *Post* is a dummy variable that equals one for years in and after 2016 and zero otherwise. Year and city fixed effects, as well as the city-level control variables (i.e., *city pre-shock var.*×*Post*), are included. Standard errors in parentheses are clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A8: GSA and Local Political Risk

Panel A: GSA and local political turnover

	Turnover dummy	
	Municipal CPC secretary	Mayor
	(1)	(2)
NNR × Post	-0.025	0.042
	(0.032)	(0.028)
Controls	Yes	Yes
Year FE	Yes	Yes
City FE	Yes	Yes
Adjusted R^2	0.093	0.115
Obs	2725	2725

Panel B: GSA and MCB spreads: local political risk

	Spread	
	Municipal CPC secretary	Mayor
	(1)	(2)
NNR × Post	0.237***	0.236***
	(0.081)	(0.079)
NNR × Post × In the first 2 years of tenure	0.004	0.009
	(0.060)	(0.064)
Other terms of triple diff	Yes	Yes
Controls	Yes	Yes
Year-quarter FE	Yes	Yes
Issuer FE	Yes	Yes
Adjusted R^2	0.562	0.561
Obs	87885	87885

Notes: This table reports the relationship between GSA and the local political environment. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city and zero otherwise. Panel A reports the effects of GSA on local political turnover at the city-year level. The dependent variable is a dummy variable that equals one if the corresponding city's leading official changes in that year. *Post* is a dummy variable that equals one in and after 2017 and zero otherwise. Year and city fixed effects, as well as the city-level control variables (i.e., *city pre-shock var.*×*Post*), are included. Panel B reports the differential impacts of GSA during specific stages of official's tenure. *In the first 2 years of tenure* is a dummy variable that equals one if it is in the first two complete years of the corresponding official's term and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are all clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A9: GSA and Birdwatching Activities

Dep. Var	# of bird species observed	# of birdwatching reporters	# of birdwatching reports
	(1)	(2)	(3)
NNR × Post	9.240**	0.646	1.370
	(4.625)	(1.040)	(6.240)
Year-quarter FE	Yes	Yes	Yes
City FE	Yes	Yes	Yes
Adjusted R^2	0.606	0.538	0.456
Obs	4582	4582	4582

Notes: This table reports the city-quarter-level regression results of the effects of GSA on the birding activities reported on the China Bird Report Center. The dependent variables in Columns (1)-(3) are the number of bird species observed, the number of birding reporters and the number of birding reports, respectively. *NNR* is a dummy variable that equals one if there is at least one national nature reserve in the city and zero otherwise. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Year-quarter and city fixed effects are included. Standard errors in parentheses are clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A10: GSA and MCB Spreads - Information Asymmetry

Sample	Spread					
	Low Cover = 0	High Cover = 0	Full Sample	Low Cover = 0	High Cover = 0	Full Sample
	(1)	(2)	(3)	(4)	(5)	(6)
High Cover × Post	0.204***		0.233***	0.230***		0.251***
	(0.076)		(0.077)	(0.075)		(0.075)
Low Cover × Post		0.248**	0.247**		0.248**	0.245**
		(0.107)	(0.108)		(0.107)	(0.105)
F statistics for testing $\beta^{high} = \beta^{low}$			0.018			0.003
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Year-quarter FE	Yes	Yes	Yes	Yes	Yes	Yes
Issuer FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	0.566	0.553	0.561	0.568	0.553	0.561
Obs	74572	56253	87885	61871	56253	75184

Notes: This table reports the heterogeneous effects of GSA on MCB spreads in information asymmetry. For column(1)-(3), *High Cover* is a dummy variable that equals one if NNRs managed by an NNR municipality were covered by the top 10 comprehensive newspapers by average circulation in 2016. *Low Cover* is a dummy variable that equals one if NNRs managed by an NNR municipality were not covered by the top 10 comprehensive newspapers by average circulation in 2016. The control groups are all non-NNR municipalities. For robustness, column(4)-(6) exclude cities that owned NNR and only covered by one source of the top 10 comprehensive newspapers by average circulation in 2016. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Other designs are identical to Equation (1). The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are clustered at the city level. F statistics is from the Wald test for the difference of regression coefficients. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

Table A11: GSA and MCB Spreads: Biodiversity Improvement

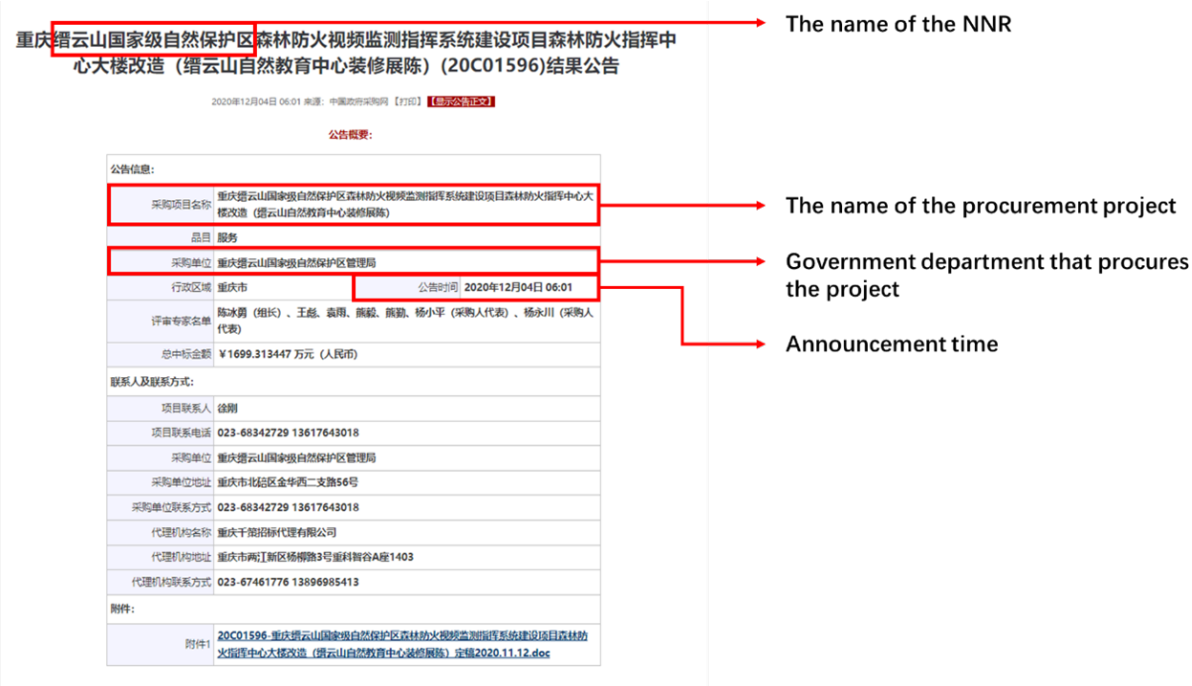
	Spread	
	(1)	(2)
High bio improvement × Post	0.300***	0.385**
	(0.101)	(0.180)
Low bio improvement × Post	0.186**	0.193**
	(0.085)	(0.075)
Controls	Yes	Yes
Year-quarter FE	Yes	Yes
Issuer FE	Yes	Yes
Adjusted R^2	0.560	0.561
Obs	86039	86039

Notes: This table reports the heterogeneous effects of GSA on MCB spreads in biodiversity improvement. *High bio improvement* is a dummy variable that equals one if a city is in the top quartile of the biodiversity improvement among NNR municipalities. *Low bio improvement* is a dummy variable that equals one if a city is not in the top quartile of the biodiversity improvement among NNR municipalities. The level of biodiversity improvement is measured by the absolute increase in number of bird species observed, the relative increase in number of bird species observed following GSA relative to their numbers prior to the implementation, respectively. *Post* is a dummy variable that equals one after the second quarter of 2017 and zero otherwise. Other designs are identical to Equation (1). The specification controls for year-quarter and issuer fixed effects. Additionally, bond-level control variables are included, along with pre-GSA city-level control variables that are interacted with *Post*. Standard errors in parentheses are clustered at the city level. ***, **, and * indicates significance at the 1%, 5%, and 10% level, respectively.

B Additional Materials on Institutional Background

B.1 Several examples of government procurement on NNRs

Figure B1: Government Procurement Contract Related to NNR (1)



Notes: This government procurement contract is about the construction project of the forest fire video monitoring and command system in the Jinyun Mountain National Nature Reserve in Chongqing, especially the renovation of the command center building, as well as the decoration and exhibition work of the Jinyun Mountain Nature Education Center. The purpose of this contract is to establish an effective forest fire video monitoring system to enhance the capacity for fire prevention and response, thereby protecting the forest within the nature reserve. Additionally, through the renovation of the Nature Education Center's exhibition, it aims to enhance public education and awareness of nature conservation and forest fire prevention. The announcement was made on December 4, 2020. The government department that procured the project is Chongqing Jinyun Mountain NNR Administration.

FIGURE B2: GOVERNMENT PROCUREMENT CONTRACT RELATED TO NNR (2)



Notes: This government procurement contract is related to the installation of hardware equipment for the "Intelligent Protection Area Information Construction" project of the Guangxi Daming Mountain National Nature Reserve Administration. The objective of the contract is to install the necessary intelligent hardware equipment, which will contribute to improving the management level and efficiency of the nature reserve through information system construction, thereby enhancing the monitoring and protection capabilities of the ecological environment. The announcement was made on November 28, 2017. The government department that procured the project is Guangxi Daming Mountain NNR Administration.

FIGURE B3: GOVERNMENT PROCUREMENT CONTRACT RELATED TO NNR (3)



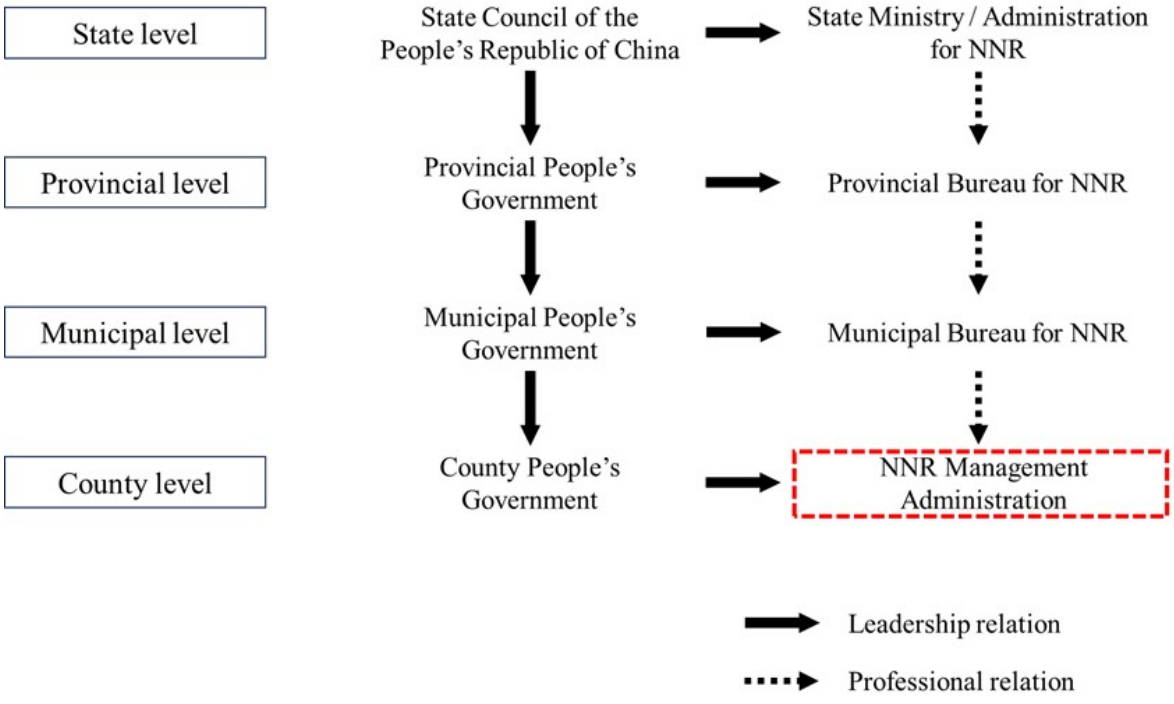
Notes: This government procurement contract is related to the vegetation restoration project in the Xiadu area of the Yangtze Alligator National Nature Reserve in Anhui. The procurement aims to restore the vegetation within the reserve, providing better living conditions for the Yangtze alligator and other wildlife and plants. The announcement was made on February 7, 2018. The government department that procured the project is Yangtze Alligator National Nature Reserve Administration.

B.2 Institutional Arrangements for NNRs

In China, local governments are primarily responsible for managing, supervising, and conserving NNRs within their jurisdictions. Each NNR is typically governed by a dedicated administration committee that handles its routine operations. The governing structure of these committees is termed "dual leadership". Two types of leadership thereof are distinguished: one is called "leadership relation" in which territorial local government controls the personnel, financial budget and material resources of the functional agencies related to NNRs, and the other is called "professional relations" in which superior agencies supervise the daily affairs of agencies at lower levels in carrying out their defined functions.

For the administration committee of nature reserve, the local government has the decision-making power over important matters such as financial allocation and personnel appointment and removal, while the higher-level authority (e.g., the forestry bureau) only maintains a professional leadership relationship with the committees. In the context of decentralized governance, nature reserve management responds more to local government than to the higher-level authority (Wang *et al.*, 2023). Generally, the institutional structure of nature reserve organization can be illustrated as the Figure B4 below.

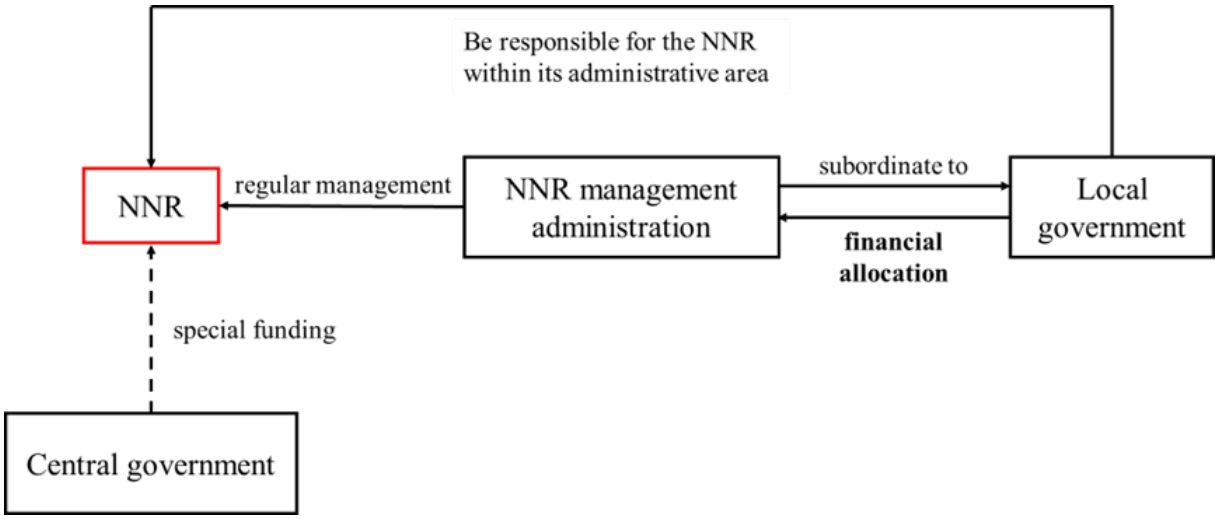
FIGURE B4: INSTITUTIONAL STRUCTURE ARRANGEMENTS FOR NNRS



B.3 Sources of NNR Funds

Consistent with the materials in Section 2 and Figure B4, the operational oversight and fiscal sustenance of NNRs predominantly fall under the purview of local governments in China. In contrast, the allocation of resources from the central government is relatively modest. Figure B5 presents the institutional arrangement features pertaining to the funding of NNRs:

FIGURE B5: THE GENERAL STRUCTURE OF NNR FUND SOURCES



Here are additional materials that can support that local governments provide the majority of funds to NNRs:

1. Statistical data from National Forestry and Grassland Administration of PRC.

According to China Forestry and Grassland Statistical Yearbook, the total investment in the "Natural Reserve Monitoring and Management" project in 2019 was 1.839 billion yuan RMB, of which the funding from the central government was 0.704 billion yuan RMB, accounting for 38.28% of the total investment. In the subsequent years of 2020, 2021, and 2022, the proportions of central government funding were 46.22%, 38.59%, and 41.88% respectively.

2. Some fragments of a report from "YICAI" magazine in 2019.

Based on the interview of the 13th National People's Congress delegate Jianbo Sun by "YICAI" magazine in 2019, the central government's funding allocation for NNRs in China is very limited.

"Nature reserves are public resources of the country, and their cause is a public welfare undertaking. Ensuring funding is an inevitable requirement for the central government to fulfill its responsibility for the management of nature reserves," said Jianbo Sun. However, in reality, the central government only provides a small amount of funding for NNRs that

were originally managed by the forestry system. The central government allocates only 300 million yuan for basic construction and 300 million yuan for capacity-building annually, which can only meet one-third of the needs of the reserves, resulting in a severe lack of conservation funds.

Jianbo Sun summarized the management dilemma of nature reserves in China from five aspects:

(1) The grassroots management force is "weak and incapable." Due to the lack of national investment, some institutions in nature reserves are nominal, with weak functions. In many cases, some nature reserves either have no institutions or have staffing but lack personnel . As a result, the national conservation management policies at the grassroots level suffer significantly by the lack of necessary personnel.

(2) Enforcement and supervision are "well-intentioned but powerless." Due to insufficient funding, conservation management methods are outdated, and there is a severe lack of technical support. Currently, various types of nature reserves in China are still at a primitive stage of "relying on verbal promotion, patrolling on foot, and law enforcement through confrontation." For instance, after marine reserves and marine parks were transferred to the management of the forestry and grassland bureau, Law enforcement officers are no longer allowed to use coast guard or fishery administration vessels. As a result, there is a sense of powerlessness in dealing with illegal fishing and tourism activities within the reserves.

(3) The conservation direction is "contrary to the original intention." In the situation of severe shortage of central and local finances, many regions directly contract out nature reserves to tourism companies, leading to these reserves becoming purely tourist development sites, fundamentally deviating from the original purpose of establishing these reserves.

(4) Infrastructure construction funds are "a drop in the bucket." The central government only allocates 600 million yuan annually for existing 474 national nature reserves, averaging only 1.26 million yuan per reserve. The central government's annual management funds for 244 national scenic spots are only 2 million yuan, averaging less than 10,000 yuan per national scenic spot per year. Moreover, geological parks and marine parks receive no central government funding. Some scenic spots, geological parks, and marine protected areas do not have the funds to build facilities such as boundary markers, management stations, and patrol stations.

(5) International exchange and compliance capabilities are "constrained." China has the most World Natural Heritage Sites and Dual Heritage Sites as well as the most geological parks in the world. However, due to the lack of support for talent development and international exchange funding, out of over 2,100 international personnel working with the United Nations Educational, Scientific and Cultural Organization, only 10 are Chinese. This is incongruent with China's status as a major country with world heritage

sites.

"Increasing central financial support is the fundamental condition for solving the management issues of reserves," Jianbo Sun told the reporter. He expressed that establishing a system of nature reserves is one of the important measures to realize the national will of ecological civilization construction. It should be a public welfare undertaking primarily under the authority of the central government. It is necessary to quickly increase the intensity of central financial investment to address the long-standing historical issues of insufficient management capacity in nature reserves and other accumulated problems.

Then, how much money is needed to effectively protect these nature reserves and safeguard China's ecological security bottom line each year?

The research team led by Yan Xie, deputy researcher at the Institute of Zoology of the Chinese Academy of Sciences and the general coordinator of the research group for nature conservation legislation, previously conducted calculations and provided an answer of 26 billion yuan RMB. "Such a trivial investment can effectively protect 17.48% of China's land and 10% of its marine areas, thus safeguarding the ecological security bottom line of our country," Yan Xie told the reporter.

3. Financial Statements of Authorities of National Nature Reserve: An Example.

Some NNR management committees disclosed the subsidies received from higher authorities in their annual financial statements. We found that management committees received either zero or very little in subsidies from higher authorities. For example, the Jinhuacha National Nature Reserve Management Committee, and the Jiuwan Mountain National Nature Reserve Management Committee received zero subsidies in 2022. The Daming Mountain National Nature Reserve Management Committee in Guangxi received only 127,700 RMB yuan in subsidies in 2022 (See in Figure B6).

Figure B6: Financial Statements of Some Management Committees of National Nature Reserve in 2022

Panel A Jinhuacha National Nature Reserve	
项目 Item	金额 Amount (10 thousand)
一、一般公共预算财政拨款收入 General Public Budgetary Financial Appropriation Income	2,154.35
二、政府性基金预算财政拨款收入 Government Fund Budgetary Financial Appropriation Income	0.00
三、国有资本经营预算财政拨款收入 State-Owned Capital Operation Budgetary Financial Appropriation Income	0.00
四、上级补助收入 Subsidy Income from Higher Authorities	**0.00**
五、事业收入 Operating Income	0.00
六、经营收入 Business Income	0.00
七、附属单位上缴收入 Income Turned Over by Affiliated Departments	0.00
八、其他收入 Other Income	182.89
Panel B Jiuwan Mountain National Nature Reserve	
项目 Item	金额 Amount (10 thousand)
一、一般公共预算财政拨款收入 General Public Budgetary Financial Appropriation Income	2,840.51
二、政府性基金预算财政拨款收入 Government Fund Budgetary Financial Appropriation Income	0.00
三、国有资本经营预算财政拨款收入 State-Owned Capital Operation Budgetary Financial Appropriation Income	0.00
四、上级补助收入 Subsidy Income from Higher Authorities	**0.00**
五、事业收入 Operating Income	0.00
六、经营收入 Business Income	0.00
七、附属单位上缴收入 Income Turned Over by Affiliated Departments	0.00
八、其他收入 Other Income	10.15
Panel C Daming Mountain National Nature Reserve	
项目 Item	金额 Amount (10 thousand)
一、一般公共预算财政拨款收入 General Public Budgetary Financial Appropriation Income	9605.15
二、政府性基金预算财政拨款收入 Government Fund Budgetary Financial Appropriation Income)	0.00
三、国有资本经营预算财政拨款收入 State-Owned Capital Operation Budgetary Financial Appropriation Income	0.00
四、上级补助收入 Subsidy Income from Higher Authorities	**12.77**
五、事业收入 Operating Income	0.00
六、经营收入 Business Income	0.00
七、附属单位上缴收入 Income Turned Over by Affiliated Departments	0.00
八、其他收入 Other Income	363.00

B.4 Political incentives exerted on local officials by GSA

In 2018, the main leaders of the governments and forestry departments of 8 cities (prefectures, districts) in Anhui, Chongqing, and Yunnan provinces were summoned by the Ministry of Ecology and Environment (MEE). This was due to serious illegal development and construction issues within 7 nature reserves in their respective jurisdictions. At the end of the meeting, Changgen Liu, one of the officials from the central environmental department, stated, "It is true that there are many historical legacy issues in our country's nature reserves, and these issues are not the fault of those present here. However, at this stage, addressing these problems is indeed the responsibility and obligation of all of you." The summoning of 11 officials at the department level in a single instance was not common in the past and was seen as a strong move by the MEE to address the management of nature reserves. This kind of summoning placed significant political pressure on local officials, urging them to rectify the issues within the nature reserves.

In addition, according to the interview in Wang *et al.* (2023), the requirements from the central government during GSA had also placed notable political incentives on local officials. For example, one Fujian Forest and Grassland Administration (FGA) official described the requirements as follows:

> *[The GSA team] compared the satellite images to detect which piece of land had changed, sending all these changes as 'issue spots' to us [provincial FGA]. Then we need to figure out why the land is changed and recover it. The GSA team will later sample-check our remedies. If some nature reserves do not resolve these issue spots within a timeline, the managers of the nature reserves may be punished by criticism or even demotion or dismissal.*

In addition, GSA had played a significant role in raising awareness of ecological protection among local cadres. As one Fujian FGA official stated:

> *Handling illegal cases under the GSA has sounded the alarm for many local cadres. Now they all clearly know that the nature reserve authority is very strict, and the land use purpose should not be changed, must not be changed.*

B.5 Challenges Encountered During the Implementation of GSA

Local officials commonly encountered significant resistance while implementing the rectification work. Wang *et al.* (2023) highlight the substantial challenges faced by local officials during the enforcement of rectification measures in nature reserves. A significant number of residents had inhabited the area now designated as a nature reserve in Fujian Province, with many living there well before reserve establishment. Given that no unpopulated nature reserves existed in Fujian Province, the strict application of the rule that forbids human activity within the core areas of the reserves seemed impractical. For example, one local official complained:

> *When the GSA team compared satellite images with the original nature reserve plan, many issue spots emerged. As when the nature reserve was established decades ago, mapping technology was backward, and the boundaries were unclear. Villages, roads, farmland, and commercial forests owned by local farmers were not demarcated from reserve boundaries. Now the GSA team said that 'no human activities are allowed within the reserve. How is it possible to remedy that?*

In addition, the long-term lack of adequate management resources compounded the issue. For instance, in Fujian Province, there were two national nature reserves where the management team consists of fewer than ten people responsible for over 10,000 hectares, underscoring the deficiency in both funding and personnel for proper reserve management.

Besides the complaints of local officials, the local residents were resisting the implementation of GSA. Most local people's attitude was clear. One village leader said, "We understand ecological protection, but we need to live." When GSA officials arrived, and the rectification work started, they encountered strong resistance from local villagers. The incentive for local people to go against GSA was the preservation of their livelihoods, and their objective was for things to continue as they were. Conflicts arose when GSA officials visited the "issue spot". One GSA official mentioned that they were blocked by residents on their way to the village and were questioned by local farmers:

> *You guys came here by car, and you know it is convenient to drive, don't we know that? We [local villagers] raised money and built a road, and the government did not pay one penny. But now you told me that the road is illegal? And ask to demolish it? Is that reasonable?*

B.6 A Case for the Jinyun Mountain NNR in Chongqing: Timeline of GSA Implementation

The implementation of the GSA requirements by the Chongqing Municipal Government is marked by two distinct features: initially, there was a delayed commencement, with actions being taken at least a half year after the GSA's initiation. Subsequently, the government undertook significant measures, particularly in managing the Jinyun Mountain NNR, indicating a robust commitment to the GSA's mandates.

In July 2017, the Ministry of Environmental Protection of PRC, later renamed the Ministry of Ecology and Environment (MEE) announced the launch of GSA. GSA is the first nationwide joint initiative by the supervisory authorities, aimed at conducting comprehensive monitoring and inspection of all national nature reserves.

During July 2017 to December 2017, seven ministries jointly organized and executed GSA for NNRs. The MEE utilized various technological tools to support GSA. They issued remote sensing problem lists, collected and compiled public feedback, and organized self-inspections and provincial spot checks, establishing a comprehensive system to address violations and promote timely rectification.

In April 2018, remote sensing monitoring by the MEE revealed that there were over 500 human activity areas, including tourist facilities and industrial land, within the Jinyun Mountain National Nature Reserve in Chongqing City. This encroachment had significantly exacerbated ecological damage issues.

In June 2018, the central government issued an important instruction regarding the Jinyun Mountain NNR, urging local authorities to earnestly carry out rectification measures. Under the political pressure from the central government, the leadership of Chongqing Municipality had attached great importance to the issues within the Jinyun Mountain NNR. Min'er Chen, the secretary of the Chongqing Municipal Committee of CPC, and Liangzhi Tang, the deputy secretary of the Municipal Committee and the Mayor, had visited Jinyun Mountain nine times to direct, research, and supervise the rectification work. The Chongqing government convened 33 meetings to study and deploy comprehensive rectification work and issued the "Comprehensive Plan for Ecological and Environmental Remediation in Jinyun Mountain Nature Reserve."

In August 2018, the Chongqing government demolished an illegally constructed horse racing track located within the Jinyun Mountain NNR.

In September 2018, the MEE summoned the responsible officials of relevant government departments regarding the encroachment and destruction of natural reserves. Officials from Shapingba District, Beibei District, and the Chongqing Forestry Bureau were among those summoned for meeting. The meeting exerted further pressure on officials from these relevant departments, urging them to properly rectify the nature reserve.

On February 11, 2019, the Chongqing government issued the "Guiding Opinions on Im-

plementing Ecological Relocation Pilot Projects in the Jinyun Mountain Nature Reserve," successively implementing relocation pilot projects for the indigenous people within the core and buffer zones of the Jinyun Mountain Nature Reserve.

In June 2019, the Chongqing government launched a comprehensive improvement project. The project aims to leverage the outstanding natural ecology and landscape of Jinyun Mountain, by restoring wetland hydrology, increasing vegetation coverage, and constructing an ecological system to create a demonstration area for the ecological barrier in the upper reaches of the Yangtze River.

As of April 2020, the Chongqing government had successfully relocated the indigenous people within the NNR, including 442 households totaling 1144 individuals, representing 98.0% and 98.5% of the total households and population slated for relocation, respectively.

In September 2020, the Chongqing government started the Mazhongju Ecological Restoration Project, specifically the "Peng Feng Kan Yun" Scenic Viewing Platform project.

As of May 2021, over the course of three years of comprehensive management, the Beibei District Government (a county-level government under Chongqing Municipality) had cumulatively invested 2.75 billion RMB. This effort had resulted in the resolution of 269 prominent environmental issues in Jinyun Mountain, with the planting of 774,000 trees and shrubs, and the restoration of 450,000 square meters of land for greenery.

During 2021-2022, the Chongqing government remained committed to advancing the implementation of ecological restoration projects within the NNR. The government were dedicated to completing the Overall Plan for the Jinyun Mountain NNR in Chongqing (2021-2030), ensuring a comprehensive and sustainable approach to conservation and restoration. Furthermore, the government were actively working to establish a regular inspection institution specifically tailored to oversee and maintain the integrity of the NNR.

Figure B7 summarizes the timeline of actions taken by the Chongqing government.

FIGURE B7: TIMELINE OF JINYUN MOUNTAIN IN CHONGQING

Wait-and-see stage

- July 2017
  The declaration of the GSA by Ministry of Ecology and Environment (MEE).
- July 2017 ~ Dec 2017
  Seven ministries jointly organized and executed the GSA campaign for NNRs.
- Apr 2018
  Illegal activities were found. The MEE's remote sensing had identified over 500 human activity areas, including tourist facilities and industrial sites, in the Jinyun Mountain NNR.

Accountability and rectification stage

- June 2018
  Central government intervention. The central government issued important instructions, urging local authorities to take serious rectification actions. Then, the Chongqing government issued the "Comprehensive Plan for Ecological and Environmental Remediation in Jinyun Mountain Nature Reserve."
- Aug 2018
  Demolished illegal structures. The Chongqing government demolished illegal structures in a horse farm inside the NNR.
- Sept 2018
  Local government officials are summoned for meeting. The MEE summoned the responsible government departments regarding the encroachment and damage to natural reserves.
- Feb 2019
  Initiation of the relocation of residents. The Chongqing Government initiating the relocation of indigenous residents inside Jinyun Mountain Nature Reserve.
- June 2019
  Start comprehensive improvement project. The comprehensive improvement project of the Jinyun Mountain Nature Reserve in Beibei District was initiated.
- Apr 2020
  The majority of relocation work has been completed. Over 98% of the residents who originally lived within the nature reserve had been relocated. 440 million yuan RMB were used by the local government.
- Sept 2020
  Start Mazhongju Project. Start Mazhongju ecological restoration project inside the NNR.
- May 2021
  2.75 billion yuan in 3 years. As of May 2021, the government of Beibei District (a county-level government under Chongqing Municipality) had invested a total of 2.75 billion yuan in NNR.
- 2021 ~ 2022
- Continue to promote the implementation of ecological restoration projects inside the NNR.
- Complete of the Overall Plan for the Jinyun Mountain NNR in Chongqing (2021-2030).
- Establish the regular inspection institution for nature reserves.