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Subnational Science and Technology Diplomacy: Navigating Geopolitical Challenges Through the Lens of California-China Climate Cooperation

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Abstract: Amid escalating geopolitical tensions, traditional state-centric science and technology (S&T) diplomacy faces significant limitations, while the urgency of the climate crisis necessitates innovative frameworks for collaboration. This article examines the critical role of subnational actors in advancing climate diplomacy, using the case of California-China climate cooperation as an illustrative example. Through an in-depth analysis of the mechanisms and dynamics of collaboration among California's subnational entities, Chinese governmental bodies, private sectors, and academia, the study uncovers the rationale and strategies underpinning these cooperative efforts. The findings reveal that the California-China partnership exemplifies a hybrid governance model that integrates top-down initiatives with bottom-up engagement, guided by the interplay of ideas, interests, and institutionalization (I-I-I). This model is sustained by shared climate priorities, pragmatic economic incentives, and multi-level institutional networks, enabling resilience despite federal constraints and geopolitical uncertainties. By framing California-China climate cooperation as a microcosm of broader U.S.- China relations, this study highlights the transformative potential of subnational actors to navigate geopolitical fragmentation and foster global climate solutions. It contributes to the theoretical understanding of subnational S&T diplomacy by demonstrating how decentralized governance and cross-sector collaboration can transcend competition and advance shared objectives. Ultimately, this research provides a novel lens for reimagining S&T diplomacy in an era of geopolitical complexities and climate urgency intertwined, offering actionable insights for policymakers and scholars alike.

Keywords: Science and Technology Diplomacy; Subnational Cooperation; California- China Climate Cooperation; Geopolitical Challenges

1. Introduction

Subnational climate cooperation between the US and China offers a crucial and concrete avenue for science and technology diplomacy amid rising geopolitical tensions. While national-level engagement remains strained, a network of subnational actors—including U.S. state governments, Chinese central, provincial and municipal bodies, private sectors, and academic communities—continues to demonstrate the capacity and willingness to forge partnerships and advance climate policies and actions.

Theoretically, this challenges the traditional state-centric model of international relations by emphasizing the importance of multi-level landscape of climate cooperation. Subnational actors are uniquely positioned to complement national governments, circumvent obstacles at the federal level, and fill leadership voids when necessary. Their jurisdiction over key climate-relevant sectors such as energy, transportation, and land use enables them to implement innovative policies and pilot projects tailored to regional and local needs. These efforts are often supported by industries and academia, which play a critical role in technological solutions and fostering collaboration.

Under the overarching framework of the U.S.-China Science and Technology Cooperation Agreement (STA) established in 1979, California has emerged as the most pronounced front-runner among U.S. states in accelerating the development and deployment of climate solutions at the subnational level. California's climate diplomacy efforts with its Chinese counterparts have navigated geopolitical complexities by maintaining dialogue, fostering mutual understanding, and achieving tangible progress on climate change. Despite the fact that the newly signed protocol to amend and renew the STA for another 5 years is still under review, the potential for such cooperation remains evident, as demonstrated by historical successes and ongoing programs in both government and private sectors. By bridging local actions and global climate goals, subnational agency not only advances climate outcomes but also serves as a stabilizing force in international relations.

This article seeks to uncover the rationale behind such subnational partnerships in facilitating climate diplomacy under the broader framework of U.S.-China STA. Using California-China climate cooperation as a case study, this article identifies the mechanisms, challenges and opportunities facing diverse subnational actors on both sides. It aims to shed light on the relatively understudied role of subnational agency in science and technology diplomacy, particularly in current context of intensifying geopolitical challenges.

To thoroughly explore the evolving landscape of California's climate policies and actions in navigating geopolitical complexities and strengthening cooperation with China, this article begins by historically contextualizing California-China early-stage engagement from 1979 to the 2000s. This foundational period laid the groundwork for subsequent collaborative expansion and diversification. A brief review of the existing theoretical lenses through which subnational climate cooperation is typically discussed will follow and put forward an analytical framework. The article then delves into representative cross-sector collaborations, including government-led initiatives, private sector

engagement, and academic exchanges. A deeper examination of the structural forces at play, guided by the interplay of ideas, interests, and institutionalization (I-I-I), will uncover the incentives, disincentives and opportunities that have been shaping California-China cooperation. The article concludes by asserting that California-China collaboration is resilient and has the potential to take precedence over competition amid geopolitical uncertainties.

2. Historical and Theoretical Foundations

2.1 Historical Context: The Formative Period of California-China Climate Cooperation (1979-2000s)

The evolution of California-China climate cooperation began in the late 20th century, transitioning from a predominantly California-led initiative to a more reciprocal, two-way collaboration. This gradual transformation underscores the intricate interplay between geopolitical challenges and strategic considerations that have uniquely influenced the trajectory of U.S.-China science and technology ties. Both national and subnational levels of climate collaboration have grown increasingly significant, reflecting the urgent need for solutions to the escalating global climate crisis as both parties strive for green transitions.

The U.S.-China Science and Technology Cooperation Agreement (STA), signed in 1979, marked the beginning of bilateral ties in science and technology diplomacy. This agreement was a key component of U.S. strategy to engage China and counterbalance Soviet influence during the Cold War. As the first major agreement between the two governments, it served as part of US' broader efforts to integrate China into the global system and influence its development. The STA established a foundation for further subnational climate engagement in the decades that followed though, particularly led by California due to its early environmental leadership.

California's leadership in environmental policy began in earnest with the passage of the California Environmental Quality Act (CEQA) in 1970, signed into law by then-Governor Ronald Reagan shortly after the federal National Environmental Policy Act (NEPA). CEQA positioned California as a trailblazer in environmental protection, inspiring fifteen other states to model their environmental statues after it. During the 1980s and early 1990s, California emerged as a national leader in environmental policy through stringent air quality regulations and early adoption of renewable energy initiatives. Influenced by laws such as the Public Utilities Regulatory Policies Act (PURPA), high natural gas prices, and the advancement of new energy technologies, this era cemented California's progressive environmental stance.

This period coincided with rising global awareness of climate change, fostering early-stage dialogue and cooperation between U.S. and Chinese scientists. A notable example emerged in 1988 when the Lawrence Berkeley National Lab in California established the China Energy Program. This initiative aimed to collaboratively investigate solutions to energy, environmental and climate challenges, laying the groundwork for future partnerships.

At the national level, the U.S.-China Environment and Development Forum was established in 1997 during Vice President Al Gore's visit to Beijing. This development aligned with the Clinton administration's broader national security strategy of "engagement and enlargement" toward China. Shortly after, a joint statement was signed between then President Bill Clinton and President Jiang Zemin, expanding the scope of the STA to include cooperative initiatives in climate change, energy and clean technology trade. These efforts demonstrated the early linkages between national science and technology diplomacy and local climate goals.

Building on national momentum, California initiated subnational-level moves at the turn of the century. For instance, after the establishment of the U.S.-China Energy Policy Dialogue in 2004, then-Governor Arnold Schwarzenegger's 2005 trip to China underscored the state's focus on sharing advancements in environmental technology and exploring cooperative opportunities in clean energy and sustainable practices. Domestically, California continued to set itself apart with the enactment of the Global Warming Solutions Act (AB 32) in 2006. This landmark legislation created a cap-and-trade system and ambitious greenhouse gas reduction targets, reinforcing California's position as a leader in climate governance.

Notably, 2006 also marked a turning point in California-China relationship as China surpassed the U.S. as the world's largest annual greenhouse gas emitter. This development signaled a critical shift in their bilateral dynamic, evolving from a California-led cooperation model to a more two-way collaboration driven by both parties' recognition of climate changes. California's advanced legislative framework, innovative clean energy policies and proactive climate leadership created opportunities for international partnerships, particularly with China, whose rapid industrial growth imposed significant environmental pressures. China's growing need for green transition strategies propelled its engagement with California into new dimensions.

While the formative period of California-China interactions did not focus exclusively on climate change, these early exchanges shaped the cooperative trajectory that defines their present-day climate relations. A pivotal example is the 2009 California-Jiangsu agreement, China's first subnational partnership for reducing greenhouse gas emissions. Within the STA's framework for scientific exchange, California's assertive climate actions—combined with China's increasing commitment to sustainable development—foreshadowed the robust partnerships that emerged in subsequent years.

2.2 Theoretical Foundation of Subnational Climate Cooperation Within Recent Realities

The burgeoning body of literature on subnational climate cooperation highlights its growing importance, with California consistently serving as a focal point for academic inquiry. Among the most prominent analytical frameworks are paradiplomacy, multi-level governance (MLG) theory, and polycentric governance, each of which offers valuable insights into the mechanisms of subnational climate diplomacy.

Hocking (1993) conceptualizes paradiplomacy to describe how subnational actors independently engage in international relations, forming networks that support climate goals. In this context, Selin and

VanDeveer (2009) examine the direct engagement of U.S. subnational entities with international counterparts, such as California's partnership with Chinese provinces on emissions trading and clean technology transfers. These collaborations operate within complex legal and policy frameworks, enabling subnational actors to leverage their economic influence and policy innovations to advance climate action. This decentralized approach contributes to a polycentric governance landscape, which, according to Pahl-Wostl (2009), fosters innovative solutions and complements national efforts. Building on this, Kellner, Petrovics and Huitema (2024) have made inspiring strides to enhance the analytical power of polycentric governance by emphasizing the role of the state, diffusion of local actions, and other pertinent factors. Their work provides further evidence that decentralized governance frameworks can be adapted to address complexities across various stakeholder levels.

Expanding on this, Setzer (2015) emphasizes the adaptive nature of decentralized governance, suggesting that distributed policy-making enables subnational actors to develop responsive environmental strategies. Bulkeley (2013) provides further insight through the lens of multi-level governance theory, which asserts that authority is distributed across interconnected levels. Bulkeley notes the capacity of subnational actors, like cities and states, to implement impactful policies that advance global climate agendas—often when national governments hesitate or stall. This aligns with Hocking's argument that subnational entities engage in "paradiplomacy" to form partnerships and independent agreements that proactively drive climate goals (1993).

However, these frameworks often lack the specificity to accurately analyze California-China climate cooperation, particularly in current global contexts characterized by an increasing mix of turbulence and transformation. Climate cooperation has not only been politicized but also securitized at the national level, complicating the engagement. Recent dynamics of great power competition, according to Meckling and Van de Graaf (2020), have bostered power-based explanations of global cooperation, complementing interest-driven analyses in global environmental politics. Scholars such as Bäckstrand et al. (2017) proposes a "hybrid multilateralism" framework, which balances macro- and micro-level perspectives to analyze climate diplomacy. Yet, the distinct contrast between U.S. federal actions, U.S. subnational innovation, and China's proactive approach underscores the need for an innovative analytical framework.

This article argues that existing paradigms lack granularity, to some extent, to explain the complexity of California-China climate cooperation in today's geopolitical climate. The cooperation model emerging from California-China relations exemplifies a hybrid governance model that integrates top-down initiatives with bottom-up engagement, guided by the interplay of ideas, interests, and institutionalization (I-I-I). This study examines how subnational actors from diverse stakeholders in California and China navigate geopolitical constraints and sustain climate cooperation under the broader framework of science and technology diplomacy. By doing so, the article seeks to enrich theoretical understanding and offer actionable insights into the mechanisms motivating subnational climate diplomacy in today's era.

3. A Case Study of California-China Climate Cooperation

This section explores the multifaceted nature of subnational climate cooperation between California and China, focusing on the synergetic effect of government-led initiatives, private sector engagement, and academic exchanges. Through examining representative examples including Memoranda of Understanding (MOUs), flagship private sector localized manufacturing and operations represented by BYD and Tesla, and academic institutions, such as the California-China Climate Institute, this case study highlights that it is the cross-sector cooperative mechanisms that sustain such subnational cooperation amid geopolitical challenges.

3.1 Top-Down Initiatives by Subnational Entities

California's subnational leadership in climate policy has been instrumental in advancing U.S.-China cooperation. Over the past 15 years, the state has demonstrated a polycentric approach (Ostrom, 2010) to climate governance, forging partnerships that complement and, at times, bypass federal-level actions. This resilience has allowed California to maintain its climate diplomacy, even amidst shifting national policies.

One of the most significant tools for California-China collaboration has been Memoranda of Understanding (MOUs). The 2013 MOU between California and China's National Development and Reform Commission (NDRC) set the stage for enduring cooperation on emissions trading, clean energy, and air quality. Since then, California has signed more than 20 MOUs with Chinese national, provincial, and municipal entities, addressing areas such as zero-emission vehicles (ZEVs) and industrial decarbonization. Spanning the leadership of Governors Schwarzenegger, Brown, and Newsom, these efforts highlight California's enduring bipartisan and multi-administrative commitments to achieving mutual benefits.

The gradual formalization and institutionalization of this cooperation mechanism has strengthened California's leadership within its subnational jurisdiction, creating a virtuous cycle of engagement and innovation. Key events, such as the 2017 Subnational Clean Energy Ministerial in Beijing, further solidified California's leadership. Hosted by then-Governor Jerry Brown, the event provided a platform for subnational actors to reaffirm their commitment to the Paris Agreement and expand the Under2 Coalition, a global network of subnational governments committed to reducing emissions. More recently, Governor Newsom's 2023 visit to China reinforced California's role as a climate leader by focusing on emerging areas like offshore wind and climate adaptation.

California's leadership trickles down to private sectors and academic communities facilitated through MOUs. These agreements have been instrumental in forging collaborative pathways on issues such as California's Scoping Plan and China's Five-Year Planning Process, industrial decarbonization with Guangdong, clean energy deployment with Jiangsu, climate mitigation strategy-making with Beijing, and the LA-Shanghai green shipping corridor. By providing clear frameworks for engagement, these agreements enable concrete climate actions and inform broader national discussions, helping to integrate subnational progress into global climate governance.

These initiatives underscore the importance of institutional frameworks like the California Air Resources Board (CARB), which has exchanged expertise with Chinese counterparts on emissions trading and air quality. For example, CARB's collaboration with Beijing contributed to the development of China's air pollution control strategies. Such partnerships highlight the enduring value of California's top-down climate governance in advancing global cooperation.

The state government of California demonstrates competence in alternating between bypassing federal gridlock and leveraging positive federal momentum, which underscores the pivotal role and adaptability of subnational governance in advancing climate diplomacy. Through government-led initiatives, California has laid the groundwork for effective climate collaboration by establishing and enhancing institutional frameworks, fostering high-level policy dialogues, and facilitating staff-level exchanges and training programs. These efforts not only provide the structural and political foundation necessary for long-term cooperation but also highlight the autonomy of subnational actors to act meaningfully, even in the face of fluctuating national-level political conditions. This adaptability ensures continuity and resilience in climate partnerships while sending clear signals to a broad range of stakeholders—governments, businesses, and academia alike—on the priorities and opportunities for engagement.

3.2 Bottom-Up Proactiveness by Private Sector

While top-down initiatives and policies provide the framework, bottom-up proactive engagement led by private sector has been crucial in translating ambitious goals into tangible outcomes. Companies like BYD and Tesla exemplify how businesses can drive innovation, foster international partnerships, and align with subnational climate priorities, particularly when state, provincial, or municipal objectives surpass those set at the national level. In many cases, the private sector pioneers the way in subnational cooperation, often acting ahead of government entities by responding to clear policy signals and taking advantage of institutional frameworks that offer predictability and viable returns on investment. This dynamic underscores how private sector, especially leading enterprises can foster innovation and build momentum for climate goals by leveraging opportunities provided by subnational governance.

3.2.1 BYD Fitting into California's Zero-Emission Transition

BYD, a global leader in electric vehicle (EV) technology based in Shenzhen, China, has not only revolutionized transportation solutions in its home market but also established a significant presence in California as a key player in the state's ambitious transition to clean energy and zero-emission public transportation. BYD's entry into California in 2013, with its North American headquarters located in Downtown Los Angeles, represents a landmark case of proactive engagement by private- sector actors facilitated by subnational entities. This collaboration exemplifies the role of bottom-up governance in fostering international partnerships that align market expansion with local sustainable energy objectives.

A pivotal moment in BYD's California journey came with the establishment of its electric bus manufacturing facility in Lancaster, California, in 2013. This facility—the largest of its kind in North

America—underscored BYD's commitment to localizing production, creating unionized green-sector jobs, and enhancing the economic vitality of the region. By introducing cutting-edge technologies and operating local manufacturing facilities for electric buses and large-scale batteries, BYD has invested significantly in California's green economy. In March 2021, BYD celebrated the delivery of its 400th American battery-electric bus from the Lancaster plant, marking a major milestone in its contribution to California's zero-emission transportation goals. The company was also awarded a $12.1 million contract with Long Beach Transit Authority to produce 10 zero-emissions all-electric buses in April of the same year.

The subnational partnership between BYD and Lancaster was built on over a decade of trust-building efforts and mutual engagement. This relationship originated in 2009, when Los Angeles County Supervisor Michael D. Antonovich and Bill Allen, President of the Los Angeles County Economic Development Corporation (LAEDC), initiated mutual visits to explore opportunities for collaboration. LAEDC, a nonprofit organization focused on equitable economic growth in the Los Angeles region, played a key role in facilitating BYD's entry into the California market. Later, Lancaster Mayor R. Rex Parris and other city representatives participated in a trade mission to China to attract firms to the city. During this mission, they visited BYD's headquarters in Shenzhen, further strengthening the relationship. These efforts culminated in innovative projects such as the "Home of the Future," a partnership between BYD and American home-building giant KB Home, which integrated BYD's solar panels, LED lighting, and energy storage technologies to promote affordable green energy solutions during the 2010s.

Beyond its contributions to California's transit electrification goals, BYD has been instrumental in advancing the state's broader green economy. As the first pure electric vehicle manufacturer in the U.S. to have an all-union workforce and a pioneering Community Benefits Agreement, BYD has worked to ensure that its operations benefit local communities. In partnership with SMART Local 105 and Antelope Valley College, BYD launched the Industrial Manufacturing Technician Apprenticeship Program in 2019. This program enhances production efficiency and product quality while boosting the local economy by providing stable green jobs for residents, including women, veterans, and second-chance employees.

BYD's electric buses have become a cornerstone of California's electrified public transportation system. For example, its collaboration with the Antelope Valley Transit Authority (AVTA) has enabled AVTA to become the first transit agency in North America to operate a 100% electric bus fleet, years ahead of California's statewide mandate for zero-emission buses by 2040. BYD has also been actively involved in transitioning Los Angeles International Airport's (LAX) shuttle bus fleets to electric buses, a project aligned with Mayor Eric Garcetti's "Sustainable City pLAn", known as L.A.'s Green New Deal. BYD's pilot programs with LAX and the University of California Los Angeles (UCLA) have laid the groundwork for the state's mandate for zero-emission airport shuttle fleets by 2035. As a result, in 2020, BYD became a major part of the largest order of electric buses in American history with the Los

Angeles Department of Transportation (LADOT). This proactive engagement has furthered BYD's contribution toward making LADOT's bus fleet entirely emissions-free in time for the opening ceremonies of the 2028 Olympic and Paralympic Games, showcasing the company's alignment with California's long-term sustainability ambitions.

BYD's success in California highlights the power of subnational partnerships in driving international climate action. The company's responsiveness to California's policy landscape—bolstered by frameworks such as zero-emission vehicle (ZEV) mandates and incentives— has allowed it to align its business development with the state's ambitious climate goals. In return, California has benefited from BYD's innovation in green technology, job creation, and economic revitalization. This case not only demonstrates the critical role of private sector actors in advancing subnational climate diplomacy but also serves as a model for how international cooperation can accelerate the transition to a low-carbon future.

3.2.2 Tesla Advancing Sustainability in China

Tesla, a global leader in electric vehicle (EV) innovation based in California, exemplifies how subnational science and technology diplomacy can manifest through private sector engagement. Tesla's entry into China, the world's largest EV market, marks a critical milestone in the internationalization of clean technologies and underscores the reciprocal benefits of U.S.-China collaboration in advancing global sustainability goals. By leveraging China's policy incentives and localizing production through its Shanghai Gigafactory, Tesla has aligned its growth with China's industrial and environmental policy frameworks, creating a dynamic model of transnational cooperation in the EV sector.

Tesla's China operations began in earnest in 2019, with the completion of the Shanghai Gigafactory, the company's first fully foreign-owned manufacturing plant in the country. Located in the Lingang Free Trade Zone, the facility enables Tesla to produce its Model 3 and Model Y vehicles at scale while bypassing tariffs that previously constrained its competitiveness in the Chinese market. This localized manufacturing capacity significantly reduced costs, allowing Tesla to price its vehicles more competitively and expand its customer base in China. As of July 2023, the Gigafactory has the capacity to build over 750,000 vehicles per year and is the primary production site for Tesla vehicles exported to regions without a Gigafactory ("Q2 2023 Update," 2023), contributing to Tesla's leading position in the global EV market.

China's supportive policy environment has been instrumental in Tesla's success. Government initiatives, including subsidies for EV buyers, investments in EV charging infrastructure, and clear targets for reducing internal combustion engine vehicle production, have strengthened Tesla's market prospects. The Chinese central government's promotion of foreign direct investment (FDI) facilitated Tesla's ability to build its factory and operate without a joint venture partner, a significant departure from previous policies governing foreign automakers in China. Additionally, Tesla has partnered with local suppliers for key EV components, such as batteries from Chinese companies like CATL and

lithium sourced from domestic producers, which has further deepened its integration within the Chinese market.

Tesla's presence in China also underscores its role as a global innovation leader. The company has invested heavily in research and development (R&D) to expand the capabilities of its vehicles and adapt them to Chinese consumers' preferences. For instance, Tesla implemented a "made-in-China" strategy, producing affordable localized versions of its vehicles while ensuring the same quality and innovations associated with its U.S. manufacturing. Tesla's research team in Shanghai has been involved in refining its autonomous driving software and battery technologies, contributing to advancements in sustainable mobility in the world's fastest-growing EV market.

Tesla's symbiotic relationship with China has facilitated mutual benefits. For Tesla, access to the Chinese market has propelled the company's growth and global leading position in EV production and sales. Meanwhile, China has benefited from Tesla's ability to accelerate the adoption of high-quality EVs, strengthen domestic supply chains, and drive innovation within its rapidly growing clean technology sector. However, Tesla's operations in China have not been without challenges. Geopolitical tensions between the U.S. and China, the increasing scrutiny of data security issues, and rising competition from local EV manufacturers such as BYD, NIO, and XPeng all pose risks for Tesla's long-term position in the market.

Despite these challenges, Tesla's experience in China demonstrates the critical role private actors play in advancing subnational and international science and technology cooperation. By fostering innovation, transferring expertise, and aligning its operations with local policy priorities, Tesla represents a two-way avenue for collaboration, where global climate goals intersect with national and subnational economic and environmental strategies. As China pushes toward its target of peak carbon emissions by 2030 and carbon neutrality by 2060, Tesla's continued contributions to electrification efforts will be essential in driving global EV adoption and reducing greenhouse gas emissions.

3.2.3 Comparative Analysis: BYD and Tesla in Subnational Climate Cooperation

The cases of BYD and Tesla reflect two dimensions of subnational science and technology diplomacy: bottom-up international collaboration fostered by local entities and private sector-driven global engagement that aligns with national and global climate priorities. While both companies have successfully leveraged subnational policies to advance clean energy transitions, their distinct approaches highlight the reciprocal nature of U.S.-China cooperation in green industry.

First and foremost, in terms of localized production and economic integration, both Tesla and BYD prioritize the localization of production to reduce costs, enhance competitiveness, and align themselves with regional climate policies. BYD's establishment of a manufacturing facility in Lancaster, California, underscores its commitment to creating unionized green jobs and revitalizing the local economy. Similarly, Tesla's Shanghai Gigafactory illustrates how foreign direct investment policies and localized manufacturing enable cost reductions and market access, fueling EV adoption at scale. However, the scale and focus of their local economic contributions diverge. BYD has emphasized its collaborations

with local governments and community organizations, such as its apprenticeship programs in partnership with Antelope Valley College. This highlights a more community-centered approach to workforce development and regional integration. In contrast, Tesla's China operations focus heavily on scaling production and integrating with local supply chains, such as battery partnerships with Chinese manufacturers like CATL. While Tesla has also created significant employment opportunities in China, the company's focus has been more on meeting rapidly growing market demand rather than fostering broader community engagement.

Second, policy alignment and subnational support by local entities have played pivotal roles in the success of both companies. For BYD, partnerships with Los Angeles County and the City of Lancaster exemplify California's role as a climate leader, aligning local economic interests with zero-emission policies. Projects such as "Home of the Future" and AVTA's 100% electric bus fleet highlight how regional initiatives drive innovation and operational success in the green transportation sector. On the other hand, Tesla's expansion into China benefited from the central government's relaxation of regulations on foreign automotive manufacturers and its robust EV subsidies. Tesla has capitalized on China's ambitious national clean energy policies while building relationships with subnational governments in key industrial hubs such as Shanghai. The Shanghai Gigafactory's location in the Lingang Free Trade Zone demonstrates Tesla's ability to navigate and leverage China's evolving FDI framework, setting a new benchmark for foreign automakers in the Chinese market.

Third, technology innovation and knowledge exchange come into play in differentiated ways. Both Tesla and BYD are leaders in EV technology innovation, yet their strategies diverge in terms of fostering cross-border knowledge exchange. BYD's deployment of EV technology in California reflects how Chinese companies can transfer expertise to align with subnational climate mandates. This bottom-up approach underscores the proactive role of American municipalities in attracting international partners to deliver localized, sustainable energy solutions. Tesla's operations in China, on the other hand, illustrate the reverse dynamic: an American company offering global leadership in automotive technology while adapting to local market needs. Tesla's investments in R&D within China, from fine-tuning autonomous driving software to improving battery recycling capabilities, have contributed to advancements in Chinese EV innovation and consumer adoption. In this way, Tesla serves as an example of two-way technology transfer, where foreign expertise is merged with domestic industry capabilities.

Tesla, however, faces challenges partly due to its asymmetrical reliance on China's manufacturing capacity given the "reshoring" strategy deeply embedded in U.S. bipartisan consensus in the last decade or so, leaving it rather sensitive to U.S.-China political dynamics. Also, Tesla must balance its position as a foreign company in an increasingly competitive market dominated by local players. Despite these challenges, the two case studies underscore opportunities and potentialto advance bilateral cooperation at the intersection of science, technology, and climate action. The reciprocal nature of BYD's and

Tesla's efforts demonstrates that both countries' industries can contribute to global solutions, provided that subnational partnerships remain resilient and continue fostering mutual trust.

3.3 Bridging the Divide: Academic Engagement in California-China Collaboration

While the private sector has demonstrated a dynamic ability to drive subnational climate engagement through innovation and strategic partnerships, academic institutions and research organizations have also played an indispensable role in fueling long-term climate collaboration across California and China. By facilitating joint research initiatives, knowledge exchange, and policy dialogues, academia has acted as a neutral and enduring bridge between the two regions, helping to sustain collaboration even during periods of geopolitical strain. These contributions are particularly significant in building the institutional trust and scientific capacity that underpin long-term engagement on climate issues.

One prominent example is the California-China Climate Institute (CCCI), a prominent think tank founded by former California Governor Jerry Brown in partnership with the University of California, Berkeley and key Chinese institutions. The Institute promotes bilateral cooperation through research partnerships, high-level policy dialogues, and joint academic programs focused on developing clean energy solutions and actionable climate policy. For instance, it has hosted forums centering on opportunities for enhanced near-term U.S.-China climate action through subnational climate leadership, such as "Zero-Emission Vehicle (ZEV) Development", "Inside China's National Adaptation Strategy 2035", and "An Inside Look at China and California's Carbon Markets" , providing a platform for policymakers and researchers to exchange insights and strategies. These conversations not only strengthen institutional ties but also ensure that California-China climate cooperation is informed by the latest scientific findings and best practices.

Similarly, academic exchanges between Stanford University and Tsinghua University have further demonstrated the value of collaborative research in advancing climate solutions. Through joint projects on clean energy technology, such as solar power innovations and battery storage systems, these partnerships have yielded breakthroughs that benefit both regions. In addition, Stanford and Tsinghua have co-organized workshops on sustainable urban development, fostering dialogue on how megacities like Beijing and Los Angeles can reduce carbon emissions through smarter planning and technology deployment.

These academic collaborations are supported by an ecosystem of think tanks and research bodies on both sides. For example, the Energy Research Institute of the National Development and Reform Commission (China) and California-based organizations such as the Lawrence Berkeley National Laboratory have demonstrated the power of bilateral knowledge-sharing. Joint research programs between the University of California system and renowned Chinese universities have facilitated collaborative studies on topics such as clean energy technologies, emissions reduction strategies, and climate modeling. Their joint efforts to model energy efficiency policies have provided actionable frameworks for reducing emissions, with implications for other regions worldwide. Such collaborations

highlight academia's unique ability to transcend political divides—focusing instead on scientific innovation, mutual capacity-building, and the shared urgency of climate action.

4. Rationale behind California- China Climate Cooperation Mechanism

As illustrated in the preceding case studies, California-China climate cooperation thrives on a dynamic interplay of cross-sector collaboration, where subnational entities, private industry, and academia work in tandem to advance shared goals. However, understanding the resilience of this partnership requires a deeper examination of the structural forces at play, the interplay of ideas, interests, and institutionalization (I-I-I) in particular. This section delves into the rationale behind California-China cooperation by exploring the incentives that drive engagement, the disincentives that pose barriers, and the opportunities that emerge from their alignment. By linking these dimensions to practical examples, the analysis highlights how mutual priorities and constant trust-building have sustained subnational collaboration in spite of federal constraints.

4.1 Incentives for Engagement

The California-China climate cooperation mechanism has been primarily driven by a convergence of incentives that align the mutual interests of both parties. These incentives spanning economic, technological, environmental, and political dimensions, reinforce the resilience of their collaboration. For both California and China, these incentives act as critical drivers, enabling sustained partnerships challenged by national-level uncertainties.

4.1.1 California's Perspective: A Quest for Economic Growth and Climate Leadership

California's leadership role in global climate diplomacy stems from its dual ambition to foster economic growth and position itself as a leader in climate action. Strategically, engaging with China—one of the largest markets for green technology— offers California an unparalleled opportunity to export innovative solutions, such as electric vehicles (EVs) and renewable energy technologies. Chinese companies, such as BYD, have created green jobs in California, from establishing facilities in Lancaster to reducing emissions through EV production. In 2022 alone, BYD's expansion in California created over 1,000 manufacturing jobs, demonstrating how international collaboration directly supports local economic development. These partnerships highlight how economic incentives, including business investment and job creation, naturally intersect with state-level policies on decarbonization and sustainable development.

In addition, California seeks to showcase its climate leadership globally by pioneering policy frameworks and encouraging international collaboration. Collaborating with China, a key player in the global climate arena, reinforces California's image as a committed and effective advocate for sustainability. Agreements such as the Memoranda of Understanding (MOUs) on zero-carbon technologies signed during Jerry Brown's administration illustrate this marriage of economic ambition

with environmental goals. For California, these initiatives reflect a subnational persistence to advance U.S.-China climate diplomacy even when relations falter at the national level.

4.1.2 China's Perspective: Access to Markets and Innovation

For China, engaging with California offers access to valuable technical expertise, clean technology innovation, and strategic partnerships with one of the largest clean energy markets worldwide. California's advanced policies— such as its ambitious Zero-Emission Vehicle (ZEV) mandates— align closely with China's own clean energy transformation goals, making collaborations mutually beneficial. Companies like Tesla act as role models for sustainable mobility and have contributed to boosting domestic industry capacity in China, with Tesla's Shanghai Gigafactory serving as a case study in integrating international expertise with national priorities.

Moreover, California-China cooperation at the subnational level provides China with an opportunity to bypass policy hurdles imposed by federal tensions in U.S.-China relations. While official relations remain strained, China uses partnerships with California's municipalities, industries, and academic entities to sustain knowledge transfer and strengthen its position as a global leader in clean energy innovation. This engagement not only improves China's access to cutting-edge research but also builds cooperative networks vital for achieving its dual-carbon goals (carbon peak by 2030 and neutrality by 2060).

4.1.3 Shared Incentives: The Economic and Environmental Nexus

Both California and China ultimately share a pressing incentive to address the worsening effects of climate change while simultaneously pursuing economic opportunities through clean energy innovation. By working together in areas such as EV development, renewable energy deployment, and emissions reductions, both sides benefit from advancing their domestic energy transitions while contributing to global progress on climate action. The California-China Clean Tech Partnership, which fosters collaboration in areas like battery storage and grid modernization, exemplifies how both sides leverage their strengths to accelerate clean energy innovation. Additionally, the collaboration has opened pathways for public-private partnerships, fostering creativity and scaling up technological adoption in ways that unilateral action might not achieve.

4.2 Disincentives and Barriers

Barriers to California-China climate cooperation mainly come from within the U.S. Federal government's impediment, partisan thoughts on climate action and trade protectionism at the national level complicate subnational efforts. These challenges underscore the difficulty of sustaining subnational engagements amid volatile U.S.-China relations.

4.2.1 Geopolitical Tensions as Overarching Barriers

It is unrealistic to isolate California-China climate cooperation completely from intensifying geopolitical tensions. The ongoing global polarization creates a pervasive framing challenge, where

every partnership or project is viewed through the lens of "strategic competition" by Washington. Political polarization, coupled with escalating military tensions in the Indo-Pacific, raises questions about the long-term sustainability of California's collaborative efforts, even at the subnational level.

Plus, California's framing of climate action as an crisis-motivated emergency contrasts with China's emphasis more on green economic development, leading to slight divergence. Though those differences are not insurmountable, they prolong timelines to further institutionalize subnational cooperation. Without actionable frameworks that transcend short-term political agendas by federal government, California-China partnerships risk stagnating, leaving critical climate goals unmet amid escalating geopolitical uncertainties.

4.2.2 Federalism and Jurisdictional Overlaps in the U.S.

One of the most pressing barriers arises from the overlapping jurisdictions between the federal government, states, and local governments in the United States. While California has positioned itself as a global climate leader, under U.S. constitutional law, its ability to conduct international diplomacy is constrained by federal oversight. Subnational actors like California lack the legal authority to negotiate treaties, which means its partnerships with its Chinese counterparts at various levels rely primarily on non-binding agreements such as Memoranda of Understanding (MOUs). These agreements, while both symbolically and substantially important, often fall short of guaranteeing enforceable commitments, leading to legal uncertainties for joint projects.

To complicate matters further, the inconsistency of U.S. federal climate policy remains one of the most significant obstacles to long-term California-China climate cooperation. Policy swings between administrations— ranging from Obama's ambitious emissions reduction goals under the Clean Power Plan, Trump's first-term withdrawal from the Paris Agreement, and Biden's Inflation Reduction Act (IRA), to the latest Trump's signing his first-day executive order directing the U.S. a second withdrawal from the Paris Agreement— have created uncertainty for US-China climate engagement. The inconsistency in U.S. federal climate policy complicate subnational efforts by creating a disjointed national climate strategy that hampers California's ability to maintain consistent collaboration with China. California's MOUs with its Chinese counterparts usually face constraint by the federal government's authority over international treaties. Congressional gridlock and partisan divides further weaken the credibility of long-term climate commitments, deterring Chinese partners from fully embracing subnational initiatives. The result is a growing perception of institutional instability in the U.S., which complicates deeper institutionalization under the California-China cooperative framework.

This jurisdictional overlap and discontinuity discourage private-sector and academic stakeholders from committing to long-term projects. Not only do they fear regulatory instability, but federal scrutiny of subnational efforts further complicates California-China relations. These constraints expose the structural limits of subnational diplomacy, underscoring the need for more cohesive federal-state coordination on international climate action.

4.2.3 Chilling Effects on Scientific and Academic Collaboration

One of the most detrimental barriers has been the federal government's "China Initiative," which has created a chilling effect on academic and scientific exchanges between U.S. and Chinese institutions. Established to address concerns about the alleged intellectual property theft and cyber security threats, the program inadvertently disrupted legitimate collaboration by stoking mistrust. Chinese researchers in the U.S., including those collaborating with California's world-renowned academic institutions like Stanford and UC Berkeley, faced heightened scrutiny and fears of racial profiling. Meanwhile, U.S. researchers grew hesitant to engage with Chinese counterparts, fearing accusations of espionage or potential violations of compliance regulations.

This chilling effect is particularly harmful to California-China cooperation because trust between academic and research institutions is essential for advancing technological innovation in areas critical to climate solutions, such as clean energy technologies and urban sustainability frameworks. Without safeguards to ensure academic freedom and distinguish legitimate risks from xenophobia, the "China Initiative" has significantly disrupted cross-border knowledge exchange.

Efforts to reopen academic trust-building remain fragile in the face of lingering and pervading skepticism especially in Trump's second term. Restoring these channels of collaboration is vital to aligning policies, practices, and technologies that California and Chinese provinces could jointly use to respond to the escalating climate crisis.

4.2.4 Economic Protectionism and Regulatory Barriers

Economic tension between the United States and China introduces significant complexity to subnational cooperative efforts. On paper, both California and China share the goal of advancing green technology, but divergent interests between California subnational entities and the U.S. federal government create friction. For example, China's dominance in solar panel production makes its supply chain indispensable to California's renewable energy goals. Yet U.S. federal scrutiny over alleged labor practices under the Uyghur Forced Labor Prevention Act (UFLPA) has led to sanctions and trade restrictions on Chinese solar imports, delaying California-based renewable energy projects and raising ethical dilemmas for state-level policymakers.

Moreover, protectionist measures such as tariffs on Chinese imports introduced during Trump's first presidency, a rather large part of it continued during Biden administration accompanied with even tougher export controls and sanctions, disrupt supply chains essential to California's clean energy transition. Besides, the Biden administration's industrial policies, while focused on domestic green investment through the IRA, send mixed signals internationally by emphasizing subsidy-driven competition rather than true collaboration. While the $369 billion subsidy allocations strengthen the state's clean energy leadership, it has prompted a global "subsidy race to the bottom", creating new barriers to collaboration. Recognizing the financial incentives offered by the IRA, France and Germany, for instance have advocated for aggressive EU-wide green subsidies to stay competitive in the global

clean energy market. As a result, these economic approaches fail to deliver the synergistic effects originally intended by bilateral collaborations, heightening the risks of fragmented global supply chains.

4.2.5 Trust Deficits and Institutional Barriers

Beyond tangible hurdles like jurisdictional constraints and trade barriers, deeper challenges stem from a lack of trust between the U. S. and China. While California has successfully fostered goodwill through cooperative initiatives with Chinese provinces, broader distrust persists at the national level. Political narratives amplify these suspicions.

In the U.S., cooperation with China is often stigmatized as giving an adversary undue leverage, which fuels skepticism toward the institutionalization of trust in climate partnerships. Anti-China rhetorics, coupled with repeated alleged accusations of intellectual property theft and espionage, has stifled collaborative research opportunities in areas pivotal to addressing global climate challenges. Trust-building is further hindered by the politicization and securitization of climate actions amid these tensions, which limits the ability of California and Chinese stakeholders to separate environmental issues from contentious political debates.

Additionally, this skepticism is compounded by institutional inefficiencies. Differentiated decision-making processes between the U.S. and China, together with differences in how decisions are executed, create misalignment. In other words, collaborative projects can face potential delays, bureaucratic hurdles, or unclear expectations, even when there is mutual enthusiasm. These inefficiencies make it difficult to institutionalize partnerships in ways that transcend one-off initiatives or temporary goodwill.

4.3 Resilience and Opportunities

Despite all the disincentives outlined above, resilience and adaptability have been hallmarks of the California-China climate cooperation mechanism. This subnational partnership endures due to its focus on practical benefits, mutual priorities, and institutional flexibility. This section examines the factors that sustain the collaboration, as well as opportunities emerging accordingly when California and China align their shared climate goals within the context of economic, technological, and institutional resilience.

4.3.1 Resilience in the Face of Geopolitical Tensions

California-China climate cooperation has demonstrated remarkable resilience in navigating the challenges of a highly polarized global political environment. This subnational partnership thrives in part because it operates parallel to, and often independently of, federal-level tensions between the U.S. and China. By emphasizing mutual interests pragmatically— such as advancing clean energy technologies and addressing climate change— California and Chinese provinces effectively insulate their collaboration from the broader rhetoric of the so-called “strategic competition”.

Moreover, the flexible nature of these gradually being institutionalized engagement, which largely relies on non-binding MOUs, ensures that they remain less vulnerable to abrupt policy changes or diplomatic conflicts. Unlike federal diplomacy, which can be hindered by partisan gridlock and international rivalry, subnational collaborations are rooted in direct problem-solving and local benefits, allowing for more sustainable and pragmatic exchanges. For example, even during periods of heightened U.S.-China tensions, California's partnerships with Shenzhen on zero-emission vehicle (ZEV) policies and with BYD on green transportation projects have persisted uninterrupted, showcasing the adaptability of this model.

4.3.2 The Role of Key Individuals in Driving Cooperation

Behind every major breakthrough in California-China climate cooperation are key individuals whose leadership and personal diplomacy have bridged divides. At the subnational level, California governors have played a pivotal role in sustaining and advancing partnerships with Chinese regions. For instance, former Governor Arnold Schwarzenegger (2003–2011) pioneered state-level climate action by actively engaging with Chinese officials and regional leaders to promote the exchange of ideas and best practices on sustainability. Schwarzenegger's efforts laid the foundation for California's climate diplomacy, integrating international cooperation into the state's broader climate strategy. Building on this legacy, Governor Schwarzenegger's successors, Governor Brown and current Governor Newsom have both continued to champion California-China partnerships, securing advancement of climate action through collaboration. These personal connections underscore the importance of leadership in maintaining momentum for climate partnerships, even during periods of strained federal relations.

At the federal level, U.S.-China climate cooperation has also been shaped by key figures like John Kerry and Xie Zhenhua, whose long-standing relationship has helped sustain dialogue during challenging geopolitical times. Their ability to maintain communication and broker agreements, such as the Sunnylands Statement and key language in the Paris Agreement, demonstrates how personal diplomacy can sometimes transcend political divides to deliver tangible progress on climate goals.

4.3.3 Opportunities for Economic and Technological Synergies

Despite economic protectionism and regulatory barriers, California-China collaboration remains a critical driver of innovation in the green economy. By pooling resources and expertise, both sides can capitalize on opportunities for joint technological breakthroughs and scale-up production of clean energy solutions. For instance, China's dominance in the manufacturing of solar panels and batteries complements California's expertise in policy innovation and market transformation, creating a fertile ground for cooperation in renewable energy deployment and grid modernization.

Public-private partnerships are equally pivotal in this context, as they serve as a bridge between academic research, industry innovation, and climate policy. Initiatives like the California-China Clean Tech Partnership exemplify how collaboration can overcome bureaucratic inefficiencies to accelerate

adoption of advanced technologies. Additionally, California's ambitious renewable energy targets, coupled with China's industrial capacity, present opportunities to jointly explore emerging fields such as hydrogen energy, carbon capture and storage (CCS), and next-generation battery technologies. These synergies not only strengthen local economies but also contribute meaningfully to global decarbonization efforts.

4.3.4 Advancing Institutional Resilience and Trust-Building

Institutional trust-building is a cornerstone of California-China cooperation. This task is particularly challenging given the backdrop of widening geopolitical distrust, but subnational actors have proven adept at maintaining relationships based on shared interests and mutual accountability. For example, long-standing collaborations between California's universities and Chinese research institutions, such as Tsinghua University, have continued to yield shared climate solutions and technological advancements, demonstrating the value of sustained knowledge exchange.

Furthermore, California's decentralized governance model offers a unique advantage in fostering institutional partnerships, as individual municipalities, academic institutions, and private-sector stakeholders are empowered to contribute to cross-border cooperation. For instance, the University of California system has partnered with Chinese academic institutions to exchange research on urban sustainability and renewable energy technologies, which directly informs localized climate policies. Subnational initiatives also provide a buffer against federal-level uncertainty, ensuring long-term resilience even as geopolitical dynamics shift.

4.3.5 Leveraging Global Consensus for Subnational Cooperation

Amid rising geopolitical tensions, California-China cooperation highlights the critical role that subnational actors can play in advancing global climate goals. The persistence of this partnership demonstrates that climate action can serve as a bridge, even in otherwise adversarial relationships. Leveraging global frameworks—such as the Paris Agreement—California and Chinese provinces align their local strategies with international objectives, ensuring that subnational actions contribute to broader global progress.

Moreover, California's leadership in platforms like the Under2 Coalition and China's active participation in multilateral environmental agreements provide opportunities to set global standards while fostering bilateral learning. These forums amplify the impact of subnational collaborations by creating a space for dialogue where local actors can share best practices and scale successful solutions worldwide.

4.3.6 Seizing Untapped Opportunities in New Frontiers

Looking ahead, California and China have significant opportunities to deepen their collaboration in emerging areas of climate innovation. Joint research initiatives can focus on clean hydrogen technology, leveraging California's early investments in hydrogen refueling infrastructure and China's

expertise in industrial hydrogen production. Similarly, climate adaptation strategies—such as combating wildfires, advancing urban resilience, and improving water management— present areas where localized knowledge can be shared and scaled internationally.

Additionally, as both parties work toward their respective climate goals— California's target of achieving carbon neutrality by 2045 and China's dual-carbon goals— there is a shared urgency to explore mechanisms for scaling up finance for green infrastructure. Collaborations in climate finance, such as joint investments in green bonds or sustainable development projects, could unlock much-needed resources to accelerate the global energy transition. One of the most recent example is that CITIC Group (China International Trust and Investment Corporation) expressed its willingness to explore further cooperation with Tesla in new energy development and comprehensive financial services during its Chairman Qihua Xi's meeting with Tesla's Vice President Mike Snyder on February 14th, 2025 in Beijing.

5. Conclusion

The California-China subnational climate partnership serves as a compelling case study in the evolving landscape of S&T diplomacy, particularly in the context of intensifying geopolitical challenges. This collaboration underscores the critical role of subnational actors in advancing global climate objectives, offering theoretical insights into decentralized governance and actionable lessons for fostering cross-sector cooperation.

From a theoretical perspective, the California-China partnership challenges traditional state-centric models of international relations by emphasizing the effectiveness of multi-level and polycentric governance. Subnational actors, such as California, demonstrate the capacity to complement national governments, bypass federal-level constraints, and address global challenges like climate change. This partnership exemplifies how decentralized governance fosters innovative solutions, particularly when national-level relations are strained. The application of frameworks such as multi-level governance (Bulkeley, 2013) and polycentric governance (Ostrom, 2010) highlights the adaptability and resilience of subnational actors in navigating complex geopolitical landscapes.

Moreover, the California-China collaboration enriches the discourse on hybrid governance models, integrating top-down initiatives with bottom-up engagement, guided by the interplay of ideas, interests, and institutionalization (I-I-I). The subnational cooperation's reliance on MOUs, public-private partnerships, and academic exchanges illustrates how non-binding agreements and informal networks can sustain collaboration even in the absence of formal treaties. This hybrid approach aligns with emerging theories of "hybrid multilateralism" (Bäckstrand et al., 2017), which emphasize the interplay between macro- and micro-level actors in addressing transnational issues. By framing California-China cooperation as a microcosm of broader U.S.-China relations, this study contributes to the theoretical understanding of how subnational actors can navigate geopolitical fragmentation to advance shared objectives.

Practically speaking, the California-China partnership highlights the potential of subnational diplomacy to drive tangible progress in climate action. California's leadership in climate governance, supported by its advanced policy frameworks and institutional networks, has enabled sustained collaboration with Chinese provinces despite broader geopolitical tensions. Initiatives such as the California-China Clean Tech Partnership and the establishment of the California-China Climate Institute demonstrate the effectiveness of cross-sector collaboration in advancing clean energy technologies, emissions reductions, and sustainable development.

On the other hand, the involvement of private sector actors, such as BYD and Tesla, further underscores the importance of bottom-up proactive innovation in achieving climate goals. BYD's localized production in California and Tesla's integration into China's EV market illustrate how businesses can align with subnational climate priorities to foster economic growth and technological advancement. These case studies highlight the reciprocal nature of U.S.-China cooperation in the green economy, where shared incentives— such as market access, job creation, and technological innovation— drive mutual benefits. Furthermore, academic institutions further foster long-term collaboration via joint research and dialogue. The partnership faces federal constraints, trade barriers, and the politicization of climate action, which create trust deficits and complicate deeper institutionalization. However, its resilience and adaptability offer actionable insights in prioritizing clean energy, leveraging global frameworks like the Paris Agreement, and seizing opportunities in hydrogen energy, carbon capture, and climate finance. These emerging areas provide new platforms for innovation and scalable global solutions.

Theoretical insights from this case study contribute to the understanding of decentralized governance and hybrid cooperation models, while its practical achievements showcase the critical role of subnational actors in driving innovation and resilience. The California-China subnational climate partnership exemplifies the transformative potential of S&T diplomacy in addressing global challenges. By bridging local actions with global objectives, this partnership not only advances climate outcomes but also serves as a stabilizing force in international relations.

As the world grapples with the escalating climate crisis, the California-China partnership provides a blueprint for how subnational diplomacy can transcend geopolitical tensions to deliver meaningful progress. Strengthening institutional trust, fostering cross-sectoral collaboration, and exploring untapped opportunities in emerging climate solutions will be essential for sustaining this partnership and achieving shared decarbonization goals. Ultimately, the California-China collaboration underscores the enduring relevance of S&T diplomacy as a tool for navigating global uncertainties and advancing a sustainable future. By focusing on shared priorities and fostering mutual trust, this partnership demonstrates that even amid geopolitical complexities, climate action can serve as a unifying force for global progress.

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Author Contributions

The author Yucan Jin confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

Availability of Data and Materials

The data used in this study are derived from publicly available literature, news reports and web pages, which have been listed in the references.

Conflicts of Interest

The authors declare that they have no conflicts of interest to report regarding the present study.

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