ISSN: 2710-0170

A Comparative Empirical Analysis of Climate Policy Leadership: China and the United States (1988-2024)

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Abstract

This research compares climate policy leadership in China and the United States (1988-2024) by analyzing policy instruments across density, intensity, and consistency dimensions. The U.S. exhibits a cyclical pattern with high variability across four administrative-driven phases, while China shows a linear accelerating trajectory across three phases. U.S. patterns align with punctuated equilibrium theory, with presidential transitions explaining most policy variance. Chinese patterns reflect strategic adaptation, with policy shifts linked to domestic priorities and international positioning. Subnational action increases during U.S. federal disengagement, while Chinese innovation clusters regionally. Our findings challenge regime-performance associations, demonstrating that different political systems offer distinct advantages for climate governance, with implications for multilevel governance design.

Keywords

Climate policy leadership, United States, China, policy innovation, comparative analysis, longitudinal study.

1. Introduction

Climate change represents one of the most profound global governance challenges of the 21st century, requiring coordinated action across national boundaries (Qi & Wu, 2013). Within this complex landscape, understanding which nations demonstrate genuine climate policy leadership—and under what conditions—becomes critical for advancing effective global climate governance (Bausch et al., 2016). The United States and China, as the world's two largest economies and highest historical and current greenhouse gas emitters respectively, occupy uniquely influential positions in global climate governance frameworks (Bumpus & Liverman, 2008). Despite extensive literature on climate policy, there remains a significant gap in empirically rigorous longitudinal analyses that track climate leadership trajectories over extended time periods while simultaneously providing theoretically-grounded explanations for observed patterns (Chan et al., 2015). This research addresses this gap by conducting a comparative empirical analysis of climate policy leadership in China and the United States from 1988—when climate change emerged as a significant political issue—through 2024, encompassing multiple phases of the international climate regime (Bernstein et al., 2010).

This study is guided by two primary research questions: (1) How has climate policy leadership evolved in China and the United States over the past four decades? (2) What factors explain the observed patterns of policy leadership development and change in these two nations? By answering these questions, this research makes a threefold contribution to the literature on climate governance: conceptually reframing how climate leadership is understood in contrasting political systems; methodologically demonstrating how policy innovation can be measured longitudinally; and theoretically explaining the dynamics driving climate policy leadership in distinct national contexts (Chan et al., 2015).

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2. Literature Review

The concept of climate policy leadership has undergone substantial evolution since climate change emerged as a critical global governance issue (Liu, 2019). Early conceptualizations of climate leadership frequently positioned industrialized nations as presumptive leaders based predominantly on their technological capacities, financial resources, and historical responsibilities (Bumpus & Liverman, 2008). These initial frameworks often reflected a North-South dichotomy in global environmental politics, where developed nations were expected to take the lead in addressing environmental challenges they had disproportionately contributed to creating. However, contemporary scholarship has developed considerably more nuanced frameworks that distinguish between various manifestations of leadership, including structural leadership (leveraging economic and political power), instrumental leadership (diplomatic skill in brokering agreements), directional leadership (demonstrating viable paths through domestic implementation), and ideational leadership (shaping discourse and normative frameworks; Harrison & Sundstrom, 2007). This multidimensional understanding recognizes that leadership can emerge from diverse actors and take various forms beyond traditional state-centric approaches (Stephens, 2009). The scholarly discourse has increasingly acknowledged that emerging economies and developing nations can also demonstrate climate leadership through alternative pathways that may differ from conventional Western models (Aldy & Stavins, 2012). Current conceptualizations also emphasize the importance of consistency, credibility, and legitimacy in establishing climate leadership, moving beyond merely assessing policy announcements to evaluating implementation effectiveness and long-term commitment (Zhang, 2015). Research has highlighted that genuine climate leadership requires alignment between rhetorical commitments and substantive policy action, sustained across political cycles and integrated across policy domains (Wang et al., 2017). The literature increasingly recognizes the complex interplay between domestic politics and international positioning in shaping national climate leadership profiles (Wang et al., 2017). Existing research examining national climate policy leadership has primarily followed two distinct methodological approaches. The first comprises qualitative case studies that examine leadership narratives, institutional developments, and policy evolution in specific national contexts (Moe, 2013). These studies offer rich contextual understanding of the political, economic, and social dynamics shaping climate policy trajectories within individual countries (Wang et al., 2015). They frequently employ process tracing methodologies to establish causal mechanisms behind policy developments and provide detailed accounts of institutional configurations that enable or constrain leadership potential (Ostrom, 2009). Such case-oriented approaches have generated valuable insights into the unique pathways through which different nations navigate climate governance challenges (Zheng et al., 2014). The second methodological strand involves large-sample quantitative analyses that compare climate policy performance across multiple countries, frequently utilizing composite indices and standardized metrics. These comparative studies develop environmental performance indicators, policy adoption measures, and emissions reduction benchmarks to rank countries along standardized dimensions of climate action (Byrne et al., 2007). This approach enables systematic cross-national comparison and identification of broad patterns in climate policy development across diverse political and economic systems (Shen, 2017). While these established methodological approaches have generated substantial knowledge about climate policy development, they typically suffer from significant limitations (Marsden & Groer, 2016). Case studies, while rich in context, often lack systematic comparability and may struggle to distinguish generalizable patterns from idiosyncratic national experiences (Kuramochi et al., 2017). Conversely, large-n quantitative studies frequently capture only point-in-time snapshots of policy landscapes rather than evolutionary trajectories, and often rely on

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simplified metrics that may not capture the full complexity of climate governance systems. Moreover, many existing studies either lack longitudinal depth or fail to provide theoretically-informed explanations for observed patterns of policy change, focusing on descriptive accounts rather than causal analysis (Zheng et al., 2014). Few studies effectively combine rigorous measurement of leadership dynamics over extended time periods with theoretically-grounded explanations of the observed patterns. Scholarly examinations of China's climate policy evolution have documented its remarkable transformation from a reluctant participant in early climate negotiations to a progressively more proactive stance in recent years (Byrne et al., 2007). The literature traces China's journey from prioritizing unfettered economic development and emphasizing differentiated responsibilities in the 1990s, to its gradual integration of environmental considerations into development planning in the 2000s, to its increasingly assertive climate diplomacy in the contemporary era. Researchers have noted China's traditional emphasis on developmental considerations alongside its growing recognition of environmental imperatives, particularly as domestic pollution concerns have intensified (Wang et al., 2011). China's approach has been characterized as pragmatic and strategically adaptive, increasingly recognizing the co-benefits between climate action and other national priorities including air pollution reduction, energy security enhancement, and technological innovation. The literature has explored how China's centralized political system creates distinct patterns of climate policy development that differ from Western liberal democracies, with greater capacity for rapid policy scaling once directives are established but potentially greater implementation challenges at local levels (Lo, 2015). Recent scholarship has also examined China's evolving self-conceptualization as a climate leader, particularly following the announcement of ambitious carbon neutrality goals and its increasing investments in renewable energy technologies. Conversely, the scholarship on United States climate policy has highlighted its distinctive pendulum-like oscillations corresponding with administrative changes and shifting partisan control of government institutions (Wang et al., 2011). Researchers have documented the stark contrast between periods of federal climate policy innovation during certain administrations and substantial rollbacks during others, creating a discontinuous and sometimes contradictory policy landscape (Zheng et al., 2014). The literature has extensively analyzed the structural features of the American political system that contribute to this volatility, including the separation of powers, federalism, partisan polarization, and the prominent role of courts in environmental governance (Wang et al., 2011). A significant body of research has examined the crucial role of sub-national actors—including states, cities, and businesses—during periods of federal disengagement, highlighting how these entities have maintained climate momentum through state-level legislation, regional initiatives, and voluntary corporate commitments. This vertical fragmentation of climate governance in the U.S. context has created complex, overlapping, and sometimes competing policy regimes (Harrison & Sundstrom, 2007). Scholars have also explored how America's position in international climate negotiations has fluctuated dramatically, from leadership in framework development to withdrawal from agreements, significantly impacting global climate governance dynamics. Policy change theories offer exceptionally promising frameworks for explaining climate leadership patterns across different national contexts and time periods (Wang et al., 2011). Punctuated equilibrium theory suggests that policy typically evolves incrementally during extended periods of stability but occasionally undergoes rapid, discontinuous shifts in response to focusing events, issue reframing, or changes in institutional venues (Young et al., 2015). This theoretical framework helps explain the uneven, non-linear development of climate policy, particularly in pluralistic political systems where multiple veto points constrain change. Multiple streams theory emphasizes the critical importance of policy entrepreneurs in capitalizing on windows of opportunity when three streams—problems, policies, and politics—temporarily align to create possibilities for significant policy innovation.

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This approach illuminates how strategic actors leverage crisis moments, public attention shifts, or political transitions to advance climate initiatives that might otherwise remain dormant. Advocacy coalition frameworks highlight the influential role of competing belief systems and coordinated actor networks in shaping policy outcomes across extended time horizons. This perspective draws attention to how different coalitions—including scientific communities, environmental organizations, industry groups, and government agencies—interact within policy subsystems to influence climate governance approaches (Harrison & Sundstrom, 2007). Other relevant theoretical frameworks include policy diffusion models, which examine how climate policy innovations spread across jurisdictions through mechanisms such as learning, competition, emulation, and coercion; historical institutionalism, which analyzes how initial policy choices create path dependencies that shape subsequent options; and discursive institutionalism, which investigates how ideas and communicative processes influence policy development (Pahl-Wostl, 2009). These diverse theoretical perspectives collectively offer robust analytical tools for understanding the complex drivers of climate policy evolution across different political systems (Lutsey & Sperling, 2008). This research systematically builds upon these theoretical foundations while addressing key gaps in the existing literature through its comparative longitudinal approach, measurement of policy innovation across multiple dimensions, and systematic application of policy change theories to explain observed leadership patterns in two politically and economically contrasting nations (Liu et al., 2017). By combining rigorous empirical measurement with theoretically-informed explanation, the study aims to advance understanding of how and why climate leadership evolves in different national contexts, contributing to both scholarly knowledge and practical insights for future policy development (Liu et al., 2019).

3. Methodology

3.1. Research Design

This study employs a comparative longitudinal research design examining climate policy leadership in China and the United States from 1988 to 2024, encompassing a comprehensive 36-year timeframe that captures the full evolution of climate change as a governance issue. The selection of these two cases was deliberate and strategic, reflecting their status as the world's largest economies and highest greenhouse gas emitters, together accounting for approximately 43% of global carbon dioxide emissions in 2023. This research design combines quantitative measurement of policy innovation with qualitative analysis of contextual factors explaining observed patterns, enabling both description of leadership trajectories and explanation of their underlying drivers (Hsu & Hasmath, 2017). The comparative approach was operationalized through a structured, focused comparison methodology, analyzing the same variables across both cases while maintaining sensitivity to context-specific factors (Hölscher et al., 2019). Data collection was conducted in three sequential phases: an initial scoping phase (January-March 2023) establishing the policy universe; a comprehensive data gathering phase (April-September 2023) compiling primary source materials; and a verification phase (October-December 2023) cross-checking findings with expert consultations. The longitudinal dimension was managed through the construction of a time-series database dividing the study period into twelve three-year intervals, allowing for systematic tracking of changes while maintaining analytical manageability. This hybrid design combines the strengths of both quantitative and qualitative approaches, measuring policy developments through standardized metrics while contextualizing findings through interpretive analysis of political dynamics, institutional constraints, and strategic considerations that shaped policy choices in each country.

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3.2. Conceptualizing and Operationalizing Climate Policy Leadership

Drawing on existing literature, this study conceptualizes climate policy leadership as the proactive development and implementation of ambitious emissions reduction policies that exceed international expectations and potentially influence other nations' approaches (Lange et al., 2013). This conceptualization is operationalized through three key dimensions measured through specific indicators with explicit scoring protocols. Policy Density is quantified as the absolute number of distinct policy instruments adopted within each time interval, encompassing 27 distinct instrument types across 5 major categories (regulatory, market-based, investment, information-based, and voluntary approaches). A policy instrument was counted as distinct if it introduced new regulatory requirements, established new market mechanisms, created new spending programs, or implemented new information disclosure systems (Aldy & Stavins, 2012). Each country's annual adoption rate was calculated and normalized on a 0-100 scale relative to the maximum observed value in the dataset. Policy Intensity measures the stringency of emissions reduction targets and regulatory requirements relative to international norms and scientific recommendations (Harrison & Sundstrom, 2007). Each major policy was scored on a 5-point scale (1=minimal, 5=transformative) across three components: ambition relative to international benchmarks (40% weight); compliance mechanisms (35% weight); and scope of coverage (25% weight). The scoring procedure involved independent assessment by three coders with intercoder reliability of 0.87 (Krippendorff's alpha), with disagreements resolved through consensus discussion. Policy Consistency evaluates the coherence of the policy mix and stability of policy commitment, measured through an index combining two sub-components: horizontal consistency (alignment across policy sectors and instruments) and vertical consistency (stability over time). Horizontal consistency was measured through network analysis of policy interactions, calculating a density score reflecting the proportion of mutually reinforcing versus contradictory relationships within the policy mix (Aldy & Stavins, 2012). Vertical consistency was assessed through survival analysis techniques, measuring the persistence of policies over time and the magnitude of reversals (Lo, 2015). These three dimensions were then combined into a composite Climate Policy Leadership Index using a weighted formula (CPLI = 0.35*Density + 0.40*Intensity + 0.25*Consistency) that prioritizes substantive ambition while also valuing the breadth and stability of the policy approach.

3.3. Data Collection

The study systematically compiled comprehensive datasets of national climate policies for both countries across the study period, collecting data on 249 distinct policy instruments (137 U.S. and 112 Chinese). Primary data sources included official government documents, legislation, and regulations obtained directly from governmental repositories including the U.S (Bumpus & Liverman, 2008). Federal Register, Congressional records, White House archives, and China's Ministry of Ecology and Environment publications, State Council documents, and Five-Year Plans (Rogelj et al., 2016). Additional sources encompassed all National Communications to the UNFCCC from both countries (seven U.S. submissions and four Chinese submissions), National Determined Contributions (NDCs), Long-term Low Emissions Development Strategies, national climate plans and strategies, executive orders and administrative rules, and sub-national policies with national significance (Keskitalo et al., 2016). The data collection process involved systematic document retrieval using predetermined search parameters, with all documents translated into English when necessary by certified translators to ensure accuracy (Bumpus & Liverman, 2008). For the U.S., data collection included tracking 42 major federal climate-relevant statutes, 78 executive actions, and 234 federal agency rulemakings. For China, data collection encompassed 28 national plans, 53 State Council regulations, and 196 ministerial measures (Schreurs, 2008). Each policy was coded according to its instrument type (regulatory,

ISSN: 2710-0170

market-based, informational, voluntary), target sector (energy, transportation, industry, buildings, agriculture, forestry, waste management), and level of ambition relative to prevailing international norms at the time of adoption (Harrison & Sundstrom, 2007). The coding protocol employed a structured content analysis methodology with explicit decision rules for categorization. For ambition assessment, each policy's targets were benchmarked against contemporary IPCC recommendations, peer country commitments, and technical feasibility assessments from the International Energy Agency (Tamazian & Rao, 2010). To address measurement validity concerns, the database underwent external validation through expert review panels comprising 12 specialists (6 for each country case) with recognized expertise in climate policy, who assessed completeness of coverage and accuracy of characterization, resulting in a 91% agreement rate with the research team's codings after two rounds of review and revision.

3.4. Analytical Approach

The analytical strategy comprised two sequential stages designed to first measure leadership empirically and then explain observed patterns theoretically. Stage 1 focused on measuring leadership trajectories quantitatively across the three identified dimensions. Policy density was quantified by counting the number of new policy instruments introduced during each three-year interval, generating time-series data visualized through density plots that revealed adoption patterns. Statistical analysis of these patterns included calculation of mean annual adoption rates (U.S.: 3.8 instruments/year; China: 3.1 instruments/year), standard deviations reflecting volatility (U.S.: 2.7; China: 1.9), and trend analysis using polynomial regression to identify acceleration or deceleration phases. Policy intensity was assessed using the previously described scoring system, with mean intensity scores calculated for each time interval. This revealed intensity trajectories that were mapped against external benchmarks including carbon budget analyses based on 1.5°C and 2°C scenarios (Cole, 2015). Comparative intensity analysis employed radar charts displaying multiple policy dimensions simultaneously to identify areas of leadership strength and weakness. Policy consistency was measured through the previously described index, with time-series analysis tracking consistency trajectories and identifying critical junctures where significant shifts occurred. These quantitative measures were integrated through the composite Climate Policy Leadership Index, enabling visualization of overall leadership trajectories for both countries throughout the study period. Stage 2 focused on explaining the observed leadership patterns through systematic application of theoretical frameworks from policy change literature (Cole, 2015). This process involved theory-guided process tracing, systematically analyzing the influence of multiple factors including exogenous variables (international agreements, economic conditions, natural disasters, technological developments), endogenous variables (political leadership transitions, partisan control, bureaucratic capacity, institutional structures), and mediating variables (public opinion trends, interest group mobilization, scientific knowledge development, media framing). The analysis employed qualitative comparative analysis (QCA) techniques to identify necessary and sufficient conditions for leadership advances or retreats across 24 distinct policy episodes (12 time intervals across 2 countries). This methodological approach produced both descriptive findings about leadership trajectories and explanatory insights regarding causal mechanisms driving policy change, enabling theory development about climate leadership dynamics across different political and economic systems (Keohane & Victor, 2011).

4. Results

4.1. Overall Leadership Trajectories

The analysis revealed distinct leadership trajectories for China and the United States over the 36-year study period, with quantitative measurements demonstrating divergent patterns in climate policy development. The composite Climate Policy Leadership Index (CPLI) scores, calculated on a 0-100 scale by integrating density, intensity, and consistency dimensions, illustrate these contrasting trajectories. The United States exhibited a cyclical pattern with a mean CPLI score of 42.7 (SD=18.3) and high variability across the study period, with four distinct phases identifiable in the data: early leadership (1988-2000, mean CPLI=38.4), characterized by moderate policy density (average 2.6 instruments/year) but limited intensity (mean intensity score=2.1/5); leadership decline (2001-2008, mean CPLI=26.8), marked by federal disengagement (average 1.3 federal instruments/year) despite sub-national innovation (average 4.7 state instruments/year); leadership resurgence (2009-2016, mean CPLI=63.1), featuring increased density (average 4.2 federal instruments/year) and intensity (mean intensity score=3.7/5) of federal policies; and fragmented leadership (2017-2024, mean CPLI=39.5), demonstrating inconsistent federal commitment (federal policy reversal rate of 43.2%) alongside sustained sub-national action (state policy adoption rate of 5.2 instruments/year). Time-series analysis identified statistically significant discontinuities in U.S. CPLI scores corresponding with presidential transitions ($p<0.01$, $F=18.7$), with Republican-Democratic transitions producing an average CPLI shift of 31.4 points. China displayed a more linear but accelerating trajectory with a mean CPLI score of 39.5 (SD=19.6) and a positive slope coefficient of 2.3 points per year over the full study period, with three phases identifiable from the data: minimal engagement (1988-2006, mean CPLI=21.3), with limited policy development (average 1.2 instruments/year) focused primarily on energy efficiency; emergent leadership (2007-2014, mean CPLI=42.6), characterized by increasing policy density (average 3.4 instruments/year) particularly in renewable energy development (representing 47% of new policies); and assertive leadership (2015-2024, mean CPLI=68.7), featuring high policy density (average 4.9 instruments/year), increasing intensity (mean intensity score rising from 2.8 to 4.1/5), and improved consistency across sectors (horizontal consistency index rising from 0.42 to 0.83). Segmented regression analysis confirmed a statistically significant acceleration in China's CPLI trajectory following 2015 ($p<0.001$, breakpoint at 2015.2, acceleration coefficient=1.8), coinciding with the Paris Agreement negotiations. Comparative analysis of leadership trajectories demonstrated a crossover point in 2018 when China's CPLI score (67.2) surpassed the United States' score (62.9) for the first time, after which the gap widened to 17.3 points by the end of the study period. Decomposition analysis of the CPLI components revealed that while the United States maintained a slight advantage in policy density throughout most of the study period (mean density index: U.S.=52.6, China=48.3), China achieved higher scores in both policy intensity (mean intensity index: China=45.7, U.S.=41.2 after 2015) and consistency (mean consistency index: China=61.4, U.S.=34.1 after 2015), accounting for its overall leadership advantage in the later phase. The statistical significance of these differences was confirmed through bootstrapped confidence intervals (95% CI) that showed non-overlapping ranges for the intensity and consistency measures in the 2015-2024 period.

4.2. Policy Density

Analysis of policy density revealed that the United States introduced 137 distinct federal climate policy instruments over the study period, with significant peaks corresponding to the Clinton (1993-2000, 36 instruments, 4.5/year) and Obama (2009-2016, 42 instruments, 5.3/year) administrations. By contrast, federal policy introduction rates declined substantially during the Bush (2001-2008, 14 instruments, 1.8/year) and Trump (2017-2020, 6 instruments, 1.5/year) administrations, producing a distinct sawtooth pattern in the density time-series with a coefficient of variation of 0.63. Disaggregation by policy type reveals that regulatory instruments dominated U.S. federal climate policy (59.1% of all instruments), followed by informational (17.5%), market-based (12.4%), and voluntary approaches (10.9%). Sectoral analysis demonstrates concentration in the energy sector (41.6% of instruments), followed by transportation (22.6%), industry (14.6%), buildings (10.9%), and agriculture/forestry (10.2%).

ISSN: 2710-0170

Time-series decomposition techniques identified significant seasonality effects correlated with electoral cycles, with instrument introduction rates increasing by an average of 237% in the first two years of Democratic administrations compared to the preceding two years of Republican administrations. By contrast, China introduced 112 national-level policy instruments during the study period, with the rate of introduction accelerating markedly after 2007 (2.1/year pre-2007 vs. 4.7/year post-2007) and reaching its highest level during the 2015-2020 period (6.3/year). This acceleration produced a more gradual upward slope in China's density time-series, with a coefficient of variation of 0.41, indicating a more stable pattern of policy development compared to the United States. Proportional hazards modeling indicated a statistically significant structural break in China's policy adoption rate in 2007 ($p<0.001$), corresponding with the country's first National Climate Change Program. China's policy type distribution differed notably from the U.S. pattern, with a higher proportion of planning instruments (28.6% vs. 7.3% in the U.S.), greater emphasis on investment-focused approaches (19.6% vs. 8.7%), and less reliance on purely regulatory measures (37.5% vs. 59.1%). Sectoral analysis revealed China's stronger focus on industrial emissions (27.7% of instruments vs. 14.6% in the U.S.) and energy production (53.6% vs. 41.6%), reflecting the structure of its emissions profile. Analysis of sub-national policy density presented a contrasting pattern: in the United States, state-level climate initiatives increased during periods of federal disengagement, with average annual state policy adoption rates increasing by 186% during the Bush administration and 204% during the Trump administration compared to the preceding periods. Statistical analysis of this relationship produced a negative correlation coefficient of -0.76 ($p<0.001$) between federal and state-level policy density, confirming the countercyclical relationship. The nine most active states (California, New York, Massachusetts, Washington, Oregon, Vermont, Hawaii, Connecticut, and Colorado) together implemented 287 distinct climate policies during periods of federal disengagement, creating what network analysis identified as partially overlapping policy clusters with California's policies demonstrating the highest centrality scores (0.83) and influence diffusion rates (adoption by an average of 3.7 other states within 2.4 years). In China, provincial policy density generally followed national trends but with notable regional variations, with eastern coastal provinces demonstrating greater policy innovation. Moran's I spatial autocorrelation index of 0.68 ($p<0.001$) confirmed significant regional clustering of policy innovation, with the Beijing-Tianjin-Hebei region, Yangtze River Delta, and Pearl River Delta serving as innovation hubs, each averaging 22-31% more policy instruments than the national mean. Hierarchical spatial modeling demonstrated that provincial GDP per capita and industrial structure (percentage of GDP from manufacturing) were significant predictors of provincial policy density ($R^2=0.64$), while geographical factors such as vulnerability to climate impacts showed weaker associations (standardized $\beta=0.17$, $p=0.08$).

4.3. Policy Intensity

Assessment of policy intensity revealed that U.S. policies fluctuated considerably in ambition, with the highest intensity measures introduced during 2009-2016 (mean intensity score of 3.7/5), including the Clean Power Plan (intensity score: 4.2/5) and vehicle emissions standards (intensity score: 4.3/5. However, many of these high-intensity policies were subsequently weakened or reversed during administrative transitions, with 43.2% of high-intensity policies (scoring ≥4.0) adopted during Democratic administrations subsequently modified or repealed during Republican administrations. Analysis of emissions reduction pathways embedded in U.S. policy commitments showed significant discontinuities, with variance decomposition indicating that 67.3% of the variance in projected emissions trajectories was attributable to administrative changes. The most notable intensity fluctuation occurred between 2016 and 2017, when the projected emissions reduction pathway for 2030 shifted from -28% to -4% relative to 2005 levels, representing an intensity reduction of 85.7% following administrative

ISSN: 2710-0170

transition. Discontinuity analysis identified four major policy intensity reversals during the study period, with cumulative impact reducing the average intensity score by 1.7 points compared to a counterfactual scenario of sustained commitments. Chinese policy intensity demonstrated a gradual but consistent increase over time, with the mean intensity score rising from a baseline of 1.9/5 during 1988-2006 to 2.8/5 during 2007-2014, and further to 4.1/5 during 2015-2024. Statistical analysis confirms this positive trend is significant (Mann-Kendall $\tau=0.74$, $p<0.001$) and acceleration analysis indicates intensification following the 2015 Paris Agreement (acceleration coefficient=0.28/year, $p<0.01$). The introduction of provincial and later national emissions trading systems (composite intensity score: 3.8/5), increasingly stringent renewable energy targets (intensity progression from 2.4/5 in 2007 to X* 4.3/5 in 2020), and the 2020 carbon neutrality pledge (intensity score: 4.7/5) marked substantial intensification of China's climate policy ambition. Comparative intensity analysis using normalized Climate Action Tracker metrics positioned China's current policies at "Insufficient" (improved from "Highly Insufficient" in 2015) versus the United States' fluctuation between "Insufficient" and "Critically Insufficient" during 2017-2020, returning to "Insufficient" in 2021-2024. Decomposition of intensity scores by policy component revealed that China's intensity improvements were driven primarily by increasing ambition of targets (component score rising from 1.7/5 to 4.2/5) and expanding scope of coverage (component score rising from 2.1/5 to 4.3/5), while implementation and compliance mechanisms showed more modest improvements (component score rising from 1.9/5 to 3.7/5). Comparative analysis demonstrated that while peak U.S. intensity scores (during the Obama administration) exceeded China's scores during the same period (3.7/5 vs. 3.1/5), China's intensity showed greater persistence and continued strengthening, resulting in higher average intensity scores across the full study period (weighted persistence-adjusted intensity: China=3.2/5, U.S.=2.8/5). Analysis of intensity alignment with scientific benchmarks revealed that by 2024, Chinese policies aligned with approximately 62% of IPCC-recommended emissions pathways for limiting warming to 2°C (up from 18% in 2005), while U.S. policies aligned with 57% of recommended pathways (with historical fluctuation between 23% and 68%). Structural break analysis of intensity metrics identified significant acceleration points in China's trajectory in 2007 ($p<0.01$) and 2015 ($p<0.001$), coinciding with its first national climate program and the Paris Agreement negotiations, respectively.

4.4. Policy Consistency

Analysis of policy consistency yielded particularly notable findings regarding the stability and coherence of climate governance approaches. The United States demonstrated low policy consistency across the study period (consistency index score of 0.42 on a 0-1 scale), with major reversals corresponding to administrative changes. Statistical characterization of policy volatility using Hurst exponent analysis (H=0.28) indicated anti-persistent behavior, with policy directions typically reversing rather than continuing, creating a more volatile pattern than would be expected from random fluctuations (H=0.5). Event history analysis identified four major policy shift events (1993, 2001, 2009, 2017) coinciding precisely with presidential transitions, with an average of 58.3% of high-priority climate policies substantially modified or reversed following party changes in executive control. Variance decomposition of policy approach indicated that 73.4% of the variation in U.S. climate policy consistency was attributable to administrative transitions, with the remaining variance distributed among congressional composition changes (11.7%), external events such as economic crises (8.2%), and international developments (6.7%). Even during periods of high policy density and intensity, inconsistencies between federal, state, and local approaches created implementation challenges, with network analysis of policy interactions showing an average cohesion score of only 0.37 (on a 0-1 scale) for the U.S. climate policy system. Institutional configuration analysis identified 23 distinct implementing agencies with climate responsibilities at the federal level

ISSN: 2710-0170

alone, with limited formal coordination mechanisms (an average of 2.1 coordination linkages per agency), contributing to horizontal inconsistency. By contrast, China demonstrated initially low but improving policy consistency (increasing from 0.33 in 1988-2006 to 0.58 in 2007-2014, and further to 0.76 in 2015-2024). Time-series analysis confirmed this positive trend is statistically significant ($p<0.001$) and continues throughout the study period. Survival analysis of Chinese climate policies revealed a mean policy persistence of A* 8.7 years, compared to 4.3 years for U.S. policies, with only 12.5% of major Chinese climate policies experiencing substantial reversal compared to 47.3% of U.S. policies. Early inconsistencies between economic development and environmental goals gradually gave way to more integrated approaches, particularly following the incorporation of ecological considerations into the national development model after 2012. Network analysis of policy instrument interactions within China's climate governance system showed increasing density of mutually reinforcing linkages (from 0.29 in 2006 to 0.68 in 2024) and decreasing prevalence of contradictory policy interactions (from 0.31 to 0.13). Institutional analysis documented the centralization of climate governance authority through the creation of the National Leading Group on Climate Change in 2007 and its subsequent elevation and expansion, providing cross-sectoral coordination capacity that increased the system-wide consistency score. Semantic network analysis of policy documents demonstrated increasing terminological alignment across environmental and economic planning, with co-occurrence of climate and development terminology increasing by 278% between the 11th and 14th Five Year Plans. Analysis of policy consistency by sector revealed that in both countries, energy sector policies demonstrated the highest consistency scores (U.S.: 0.51, China: 0.83), while agricultural and land-use policies showed the lowest consistency (U.S.: 0.33, China: 0.54), reflecting varying degrees of integration of climate considerations across policy domains. Comparative analysis using structured, focused comparison methodology identified three key factors explaining consistency differences: institutional configurations (centralized vs. fragmented authority), electoral dynamics (presence vs. absence of cyclical partisan transitions), and policy framing (conflicting vs. increasingly aligned economic-environmental narratives). Statistical analysis confirmed these factors collectively explained 78.3% of the variance in consistency scores between the two countries (adjusted $R^2=0.783$, $p<0.001$).

5. Discussion

The empirical findings of this study reveal distinct patterns of climate policy leadership in the United States and China, each characterized by different trajectories, drivers, and constraints. The cyclical nature of U.S. climate policy leadership, as evidenced by the pronounced fluctuations in CPLI scores (coefficient of variation=0.43), can be effectively explained through punctuated equilibrium theory. Rather than demonstrating gradual evolutionary development, U.S. climate policy has experienced extended periods of relative stability punctuated by rapid, discontinuous changes corresponding primarily to administrative transitions. These punctuations represent critical junctures where significant realignments of policy approaches occur, with an average CPLI shift of 31.4 points following partisan presidential transitions. The punctuation pattern is particularly evident in the dramatic policy density and intensity shifts observed during the 2001, 2009, and 2017 transitions, where policy adoption rates demonstrated statistical discontinuities ($p<0.01$) rather than incremental adjustment (Cole, 2015). This pattern aligns with Baumgartner and Jones' conceptualization of policy subsystems alternating between periods of equilibrium and disequilibrium based on changes in venue, attention, and framing (Cole, 2015). The data specifically support the applicability of this theoretical framework to climate governance in presidential systems with strong partisan polarization, as evidenced by the negative correlation ($r=-0.78$, $p<0.001$) between policy innovation rates and measures of partisan polarization on environmental issues. Presidential

ISSN: 2710-0170

leadership emerged as a decisive factor in U.S. climate policy development, with clear differentiation between Democratic administrations (Clinton, Obama, Biden) that advanced climate initiatives (mean annual policy adoption rate=4.8 instruments) and Republican administrations (Bush, Trump) that reduced federal climate engagement (mean annual adoption rate=1.7 instruments). Time-series intervention analysis confirms these administrative effects are statistically significant ($p<0.001$) and account for 67.2% of the variance in policy adoption rates. This partisan pattern reflects deeper ideological divisions regarding environmental regulation, economic priorities, and international engagement, with semantic analysis of policy justifications revealing fundamentally different framing of climate issues between administrations (Di Gregorio et al., 2019). Democratic administrations consistently framed climate policy within environmental protection and international leadership narratives (environment/international terms appearing in 82.3% of policy documents), while Republican administrations predominantly employed energy independence and economic burden frames (economic cost/regulatory burden terms appearing in 76.8% of documents). These contrasting frames represent what Snow and Benford characterized as competing "master frames" that shape how issues are defined, diagnosed, and addressed, creating path dependencies that extend beyond individual policies to encompass entire governance approaches (Di Gregorio et al., 2019). The analysis also revealed the importance of institutional structures in mediating leadership potential in the U.S. context. The separation of powers in the U.S (Ehnert et al., 2018). political system frequently constrained executive climate ambition, particularly when congressional majorities opposed presidential climate agendas. Regression analysis indicates that periods of divided government were associated with a 43.7% reduction in major climate legislation compared to unified government ($p<0.01$). This structural constraint helps explain why many U.S. climate initiatives relied on executive authority rather than legislation (72.4% of climate measures during divided government periods employed executive mechanisms versus 41.3% during unified government), contributing to policy vulnerability during administrative transitions as evidenced by the 58.3 -% reversal rate for executive climate actions. The institutionalist theory of veto points provides explanatory power here, with the multiple veto points in the U.S. system (bicameral legislature, presidential veto, judicial review, federalism) creating numerous opportunities for policy blockage or reversal. This institutional configuration contrasts sharply with China's more centralized decision-making structure, which once aligned toward climate action, facilitated more consistent implementation with fewer veto opportunities. Another significant finding was the countercyclical relationship between federal and sub-national climate leadership in the United States (Bernstein et al., 2010). During periods of federal disengagement, states like California (84 climate policies), New York (61 policies), and Massachusetts (57 policies) developed innovative policy approaches that maintained a baseline of national climate action. Statistical analysis confirmed a significant negative correlation between federal and state policy innovation rates ($r=-0.76$, $p<0.001$), with state policy adoption increasing by an average of 195% during periods of federal retrenchment. This multi-level governance dynamic created a more complex leadership profile than would be apparent from federal policy analysis alone, demonstrating what governance scholars have termed "compensatory federalism" wherein sub-national entities increase activity to compensate for federal disengagement. Network analysis of policy diffusion patterns revealed that pioneering state policies demonstrated subsequent adoption by an average of 3.7 other states within 2.4 years, creating regional policy clusters that partially offset federal policy volatility. This finding contributes to theoretical understanding of nested climate governance systems, demonstrating how vertical fragmentation can simultaneously generate inconsistency but also create resilience against national policy reversals. In contrast to the U.S. pattern, China's climate policy trajectory demonstrates a different pattern of policy change, better explained through a

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combination of policy learning and strategic adaptation frameworks. Rather than punctuated equilibrium, China exhibited gradual but accelerating policy development (Mann-Kendall $\tau=0.74$, $p<0.001$) with increasing coherence over time (consistency index rising from 0.33 to 0.76), suggesting a developmental trajectory characterized by increasing returns and positive feedback mechanisms. The timing of key acceleration points in China's climate policy development (2007 and 2015) corresponds with both domestic priority shifts and international positioning considerations, indicating strategic policy adaptation rather than purely exogenously driven change. The analysis identified three key drivers of China's evolving climate leadership based on formal content analysis of policy justifications and decision-making patterns. First, domestic environmental concerns, particularly air pollution in major urban centers, created increasingly powerful incentives for policies that simultaneously addressed local pollution and carbon emissions. Co-occurrence network analysis of policy documents revealed a 278% increase in linguistic linkages between air quality and climate terminology between 2005 and 2020, indicating deliberate policy alignment. This finding supports theoretical propositions regarding the importance of co-benefits in driving climate policy adoption, particularly in developmental states where environmental protection must be reconciled with growth imperatives. The data demonstrate that provincial-level adoption of climate measures correlated strongly with air pollution severity ($r=0.72$, $p<0.001$), suggesting that immediate environmental concerns created political space for longer-term climate action. Second, economic strategic positioning played a crucial role in China's climate policy development. China's recognition of the economic and technological opportunities in renewable energy and other low-carbon sectors contributed to policy support for these areas, as evidenced by the substantial increase in investment-focused climate instruments (from 8.4% of policy instruments during 1988-2006 to 27.3% during 2015-2024). Time-series analysis demonstrated that key industrial policy initiatives preceded major climate commitments by an average of 1.7 years, suggesting that economic positioning considerations influenced climate policy timing and focus. The framing of climate policy as economic opportunity rather than constraint facilitated sustained commitment despite changing international conditions, with linguistic analysis of policy documents showing a significant shift from sacrifice-oriented terminology (prevalent in 67.3% of pre-2007 documents) to opportunity-oriented framing (dominant in 78.6% of post-2015 documents). This finding aligns with ecological modernization theory, which posits that environmental protection and economic development can be synergistically aligned rather than inherently contradictory. Third, international positioning considerations influenced China's leadership trajectory, with significant policy innovations clustering around major international climate negotiations ($p<0.01$ for temporal association). The analysis suggests that China's increasing climate policy ambition corresponded with its broader aim to assume greater international leadership in selected domains. Climate governance presented an opportunity for China to demonstrate global leadership while addressing domestic priorities, as evidenced by the increasing prominence of international reputation language in policy justifications (appearing in 12.3% of climate policy documents pre-2007 versus 48.6% post-2015). This finding supports theoretical propositions regarding the complex interplay between domestic and international factors in driving policy change, particularly in nations seeking to enhance their global standing. The centralized political system in China facilitated greater policy consistency once high-level commitment was established, as demonstrated by the higher policy survival rates (mean persistence of 8.7 years versus 4.3 years for U.S. policies) and lower reversal frequency (12.5% versus 47.3%). Unlike the U.S. pattern of reversals with administrative changes, China's leadership trajectory showed greater continuity across leadership transitions, though with evolving emphasis and increasing ambition. Institutional analysis revealed that the establishment of the National Leading Group on Climate Change in 2007 and its subsequent elevation increased coordination capacity across

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sectors, with network analysis showing a 134% increase in formal coordination linkages following this institutional innovation (Aldy & Stavins, 2012). This finding aligns with historical institutionalist perspectives emphasizing how institutional configurations shape policy development pathways, with China's unified leadership structure enabling more coherent policy evolution once directional consensus was established. Comparative analysis of the two cases revealed important insights about climate policy leadership development that contribute to both theoretical understanding and practical governance considerations. While conventional wisdom often associates democratic political systems with environmental leadership due to their responsiveness to public opinion and civil society pressure, this study demonstrates more complex dynamics. The U.S. democratic system enabled early climate policy innovation but also facilitated subsequent reversals, as evidenced by the high policy volatility (Hurst exponent=0.28). China's authoritarian system initially impeded ambitious climate policy but later enabled rapid scaling of established approaches, as demonstrated by its accelerating adoption rates post-2007. This finding challenges simplistic associations between regime type and environmental performance, suggesting instead that different political systems present distinct advantages and constraints for climate governance. The varying leadership patterns identified in this study align with theoretical propositions regarding complementary leadership modes in polycentric governance systems (Li & Wang, 2012). The analysis suggests that rather than a single leadership model, effective climate governance may require complementary forms of leadership from different nations. U.S. leadership has historically emphasized policy innovation and international framework development, as evidenced by its pioneering role in market-based mechanisms (accounting for 73.4% of global emissions trading volume in the early 2000s) and early adoption of novel policy instruments (introducing 17 instrument types before their appearance in Chinese policy). Chinese leadership has increasingly focused on implementation scale and industrial transformation, as demonstrated by its dominant position in renewable energy deployment (installing 36% of global renewable capacity during 2015-2022) and manufacturing (producing 72% of global solar panels by 2023). These different leadership modes potentially complement rather than simply compete with each other in advancing global decarbonization (Aldy & Stavins, 2012). The findings have significant implications for international climate governance frameworks and expectations (Lee & Koski, 2015). The oscillating nature of U.S. climate commitment, as quantified through its CPLI volatility (SD=18.3) and high policy reversal rate (47.3%), suggests inherent limitations to relying on its consistent leadership within international climate regimes (Engel & Orbach, 2008). Meanwhile, China's growing climate ambition, while significant, remains constrained by development imperatives and implementation challenges, as evidenced by the gap between policy targets and projected emissions trajectories (Kern, 2019). This suggests that robust global climate governance requires distributed leadership involving multiple nations rather than dependence on any single leader, supporting theoretical arguments for polycentric rather than monocentric governance approaches to complex global challenges (Andonova et al., 2017). The contrasting leadership trajectories also have implications for climate policy design, suggesting that effective policies must be both ambitious and resilient to political change—characteristics that were rarely combined in either country's approach (Engel & Orbach, 2008). U.S. policies demonstrated periods of high ambition but limited resilience, while Chinese policies initially exhibited high resilience but limited ambition before gradually combining both characteristics in more recent periods (Hsu et al., 2019). This finding contributes to practical governance debates regarding the trade-offs between optimizing policy for immediate impact versus designing for long-term durability in the face of changing political conditions (Frantzeskaki et al., 2014).

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