Journal of Chinese Political Science (2024) 29:461–482
https://doi.org/10.1007/s11366-023-09875-x

RESEARCH ARTICLE

The United States–China Race for Green Transformation: Institutions, Incentives, and Green Industrial Policies

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Accepted: 25 October 2023 / Published online: 7 November 2023
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Abstract

This article provides political analysis of the extent to which new state strategies of involvement in climate technologies have shaped the green markets in both China and the United States. Using rational choice institutionalism and comparative case studies, this article analyzes state involvement in novel governance techniques and green industrial policy competition related to climate technologies in the United States and China. The guiding research question asks to what extent green industrial policy and its related incentives are useful for understanding the transition to green energy in the two countries. This study further explores the ways in which both countries enhance the competitiveness of national industries for science and technology in alternative energy. The rivalry between China and the US has accelerated, to some extent, the process of strengthening regulatory intervention in knowledge creation, public financing for climate technologies, and other domestic economic interests, while the emergence of green industrial policy has become part of the win−win rhetoric and practices to facilitate a green economy. This research contributes to the comparative understanding of the proliferation of mission-oriented innovation initiatives, as well as the challenges in reorganizing them with new green industrial policy concepts.

Keywords Industrial Policy · USA · China · Environment · Development

Introduction

How can we understand the changing relationship between state and market in the climate technology competition between China and the United States? What are the similarities and differences of green industrial policies in both countries? Researchers in the field of innovation studies have highlighted the important role the government plays in co-shaping strategic economic growth and sectoral development [56].

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The government can trigger competition among economic actors leading to innovation in many science and technology fields and even achieve long-term transformations in the system [17]. Over the past two decades, academic debate has focused on how to deliver transformational innovation for sustainable development as effective policy instruments [14]. The formulation of these directions, from military technology, medical innovation, and cybersecurity to the energy industry, seems to reflect the significance of mission-oriented policies as a framework to promote and change the relationship between public financing (not just subsidizing) and public–private market interconnections [18, 46]. Researchers have also pointed out that policies related to climate technologies, as a new mission-oriented program, are different from traditional types of industrial policies. The green industrial policies related to climate technologies should be re-established through collective, targeted government intervention that shapes and corrects contemporary markets and processes. This policy intervention means that, as Mazzucato emphasized, the government is expected to envision those missions that "require picking the willing: those organizations across the economy (in different sectors, including both the public and private sphere) that are 'willing' to engage with a societally relevant mission"[36].[1] I aim to further explore the cases of the United States and China in understanding how incentive structures shape the willingness of transformative actors in purposeful innovation investment. Public−private collaboration, particularly through decentralized control, is considered able to effectively promote innovation and change, whether gradual or rapid [36]. For proponents of the mission-oriented framework, movement toward a more sustainable society relies on multiple actors interacting, structurally evolving, and understanding the complex process of value and profit generation in a decentralized system of institutional formation and innovation. Thus, these actors facilitate paradigm shifts that benefit new industries with social value, which can push forward the transformation of conventional utilities [3]. However, the process of innovation relies largely on decentralized control to varying degrees, and there seems to be no unitary understanding of how decentralized arenas for certain new environmental technologies between policy areas or countries should be regulated. The policy approaches do not appear to be in the same direction as the dimension and depth of government intervention. Therefore, in this article, I comparatively analyze two countries, China and the United States, to explore the impact of strategic green industrial interventionist policies on technology competition and incentives for innovation to transform the energy sector. The setting of mission-oriented programs by the state, changes to them and the reasons for those changes will be discussed below.

The annual increase in protection measures for the clean energy industry constitutes important research that has not yet been comparatively explored. Some researchers have pointed out that China and the United States have formed two different political-economic structural capitalist models in the process of competing for the green economy [16, 42], and such a distinction seems to imply a logic of a clear either-or difference, as well as a seemingly defined boundary between democratic and authoritarian political-economic systems [30, 59]. It might also be convenient

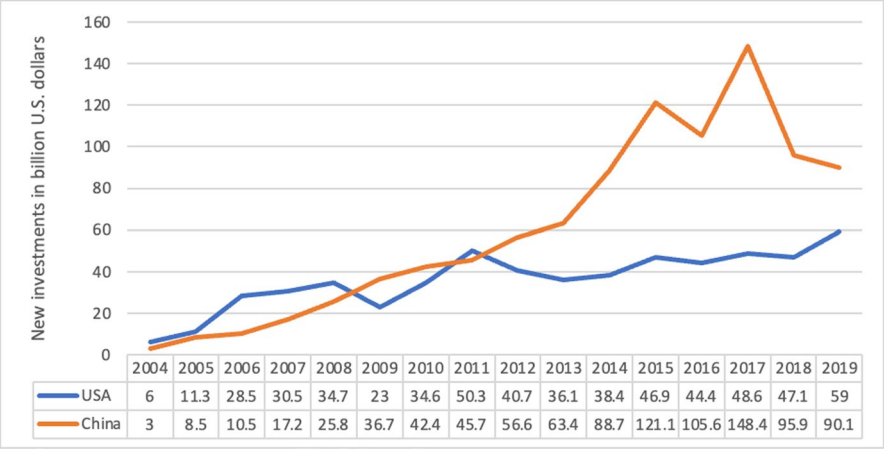
[1] Mazzucato, Mission-Oriented Innovation Policies, 806.

to imagine the United States as a neoliberal state that is ideologically distinct from China. However, Weiss argued that the neoliberal state is a fallacy, a fictional narrative created by orthodox political economists; those who support Weiss say the United States has never been a neoliberal state [58]. In contrast, state intervention has always prevailed in any transitional process of green economic development [34, 57], as occurred in the development of East Asian countries and economies, and it also occurs in China's current green statecraft. When describing the so-called green transformation, Altenburg and Pegels identified it as a process toward a paradigm shift [3], and "the transition to 'green' technology needs pro-active government support if multiple market failures are to be overcome."[2] When viewing the process of China's green transformation, some scholars indicate that the Chinese state has inherited a fragile capacity for intervention in the fragmented political system that has existed since the beginning of the policy of reform and opening up, which to some extent has led to unsuccessful clean development outcomes [54]. Coincidentally, scholars have indicated that the politics of green transition in the United States also suffer from political fragmentations: the fragmentation and stalemate in US climate policy-making are related to the lobbying of conventional utilities and boycotts [40]. Both China and the United States, in fact, need to build coalitions of economic actors in the domestic political system while shaping climate policy, dissimilar to state intervention when understood as conventional market fixing [35]. Rather, the state engages by creating an innovation ecosystem conducive to strategic green industries, which relies in particular on a certain degree of the public sector to provide "patient capital" for long-term investment in climate technology sectors [36].[3] Figure 1 shows that the value of new investments in renewable energy soared in the United States and China from 2004 to 2019. Both countries have been actively contributing relatively long-term inputs to green investments in the past 15 years. Figure 2 illustrates the differences in the sectors that contribute to carbon emissions between the United States and China. From 2004 to 2008, both the United States and China's new investments in renewable energy showed slow growth. However, in 2009, China's new investments surpassed that of the United States for the first time, and it subsequently rose sharply from USD 36.7 billion in 2009 to USD 148.4 billion in 2017 when China's new investments in renewable energy reached their highest point; since then, China has showed a downward trend. At the same time, the United States has shown steady incremental growth in this field. Although there have been slight fluctuations, new investment in 2019 reached USD 59 billion. These data demonstrate the long-term commitment of the two countries to financing this mission-oriented experimental field. However, although the US renewable energy market was larger than China's before 2010, China's markets for wind power, solar energy, and electric vehicles surpassed those in the United States in 2020 [53].

The phenomenon of green transition in China and the United States may provide useful insights from a scholarly perspective on these pending and developing puzzles; most studies examine political processes, domestic institutional structures, and the functional analysis of the development of environmental politics.

[2] Altenburg and Pegels, Sustainability-Oriented Innovation Systems, 12.

[3] Mazzucato, Mission-Oriented Innovation Policies, 808.



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
USA	6	11.3	28.5	30.5	34.7	23	34.6	50.3	40.7	36.1	38.4	46.9	44.4	48.6	47.1	59
China	3	8.5	10.5	17.2	25.8	36.7	42.4	45.7	56.6	63.4	88.7	121.1	105.6	148.4	95.9	90.1

Fig. 1 Value of new investments in renewable energy in the United States and China from 2004 to 2019 (in billion US dollars) (Global Trends in Renewable Energy Investment 2020, pp. 62–63, https://www.fs-unep-centre.org/wp-content/uploads/2020/06/GTR_2020.pdf. Accessed 15 Oct 2023. The total values of the renewable energy investment include all financial transactions and estimates for undisclosed deals.)

In this article, I seek to demonstrate that although the two cases present multiple divergent factors in political systems and institutions, when faced with the new pressure of catastrophic climate change, both countries seem to actively propose nonneoliberal state interventions in cultivating climate technology industries suitable for their economic imperatives. By comparing the potential roles of incentive structures embedded in political contexts, I point out how green industrial policy has been proposed as a means of addressing crises in two countries in seemingly different regimes.

Through comparative analysis, I use rational choice institutionalism as the theoretical approach to explore the extent to which the incentive schemes influence and shape the perceived state interest in supporting climate technologies; these interests are entangled in the institutional framework of the two countries' techno-industrial governance. As an important part of new institutionalism, rational choice institutionalism can provide a more useful explanation for the contingent nature of energy systems in both countries and provide a better comparative discussion of the incentive structures of national energy governance than other approaches [44, 49]. It can support the literature on sociotechnical systems by "open[ing] up new questions and provid[ing] some useful empirical material particularly relevant for the study of the wider political contexts within which transitions are emerging" [31].[4] In addition to the issue of path dependency, rational choice institutionalism can also be used to explore how collective interests are shaped and constrained by institutions when discussing energy transition systems [33]. Existing discussions on rational choice institutionalism and energy transitions are mostly limited to developed economies. This

[4] Matthew Lockwood et al., Historical Institutionalism and the Politics of Sustainable Energy Transitions, 313.

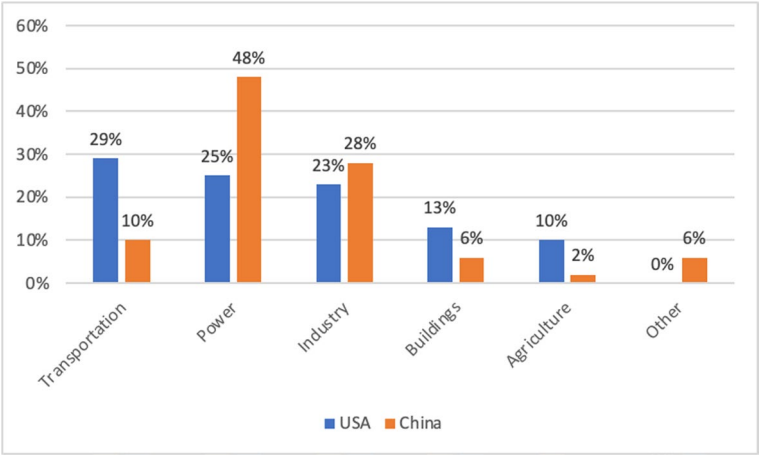


Fig. 2 The United States' and China's Carbon Dioxide Emissions by Sector, 2019 (Shiran Victoria Shen, *Accelerating Decarbonization in China and the United States and Promoting Bilateral Collaboration on Climate Change*, Nov 2021, p. 15, https://energy.stanford.edu/sites/g/files/sbiybj9971/f/us-china_roundtable_report.pdf. Accessed 15 Oct 2023.)

article will further explore to what extent the approach of green industrial policy is useful to understand the convergent trajectory of the transition toward alternative energy technologies in China and the United States; it will also explore the unintended consequences through the comparison of China as a nondeveloped country and the United States as a developed one. The structure of this article begins with an analysis of green industry and strategic competition in the United States and China, in which the green industrial policies of each country are discussed. The article will then focus on comparing internal incentives in both countries, elaborating on the role of the state in incentivizing alternative green technologies, followed by the external statecraft in collaboration and cooperation to construct each country's leading advantages. After the analysis of institutional restructuring and policy configuration, the interpretation of state-led green transformation will further be put forward.

Green Industry as Part of Economic Statecraft

Historically, the United States has put more emphasis on regulatory interventions that are considered market-oriented and conducive to environmental protection in a gradual way. As the main government actor involved in regulations, the US relies on developing an alliance of stakeholders. Governments under a federal system strive to balance the competition and cooperation of parallel forces, new market entrants, independent producers, and incumbent interests. Market efficiency often seems to be perceived as the optimization goal of green transformation by policymakers, and traditional fossil fuel entities resist change in transition proposals in the United States [51]. However, in the context of strategic competition between the United States and China, the two countries have intentionally emphasized security

regulations and barriers in shaping economic statecraft in the past ten years to curb the impact of potential external forces on domestic national security. Such security anxiety is reflected in the changes in the diplomatic relationship between the two countries. As Wang and Sun identified, the US−China relationship has evolved "from symbiotic towards increasingly competitive," particularly after the 2008 global financial crisis [55].[5] Such a change implies that both countries rely more on the nationalist approach that prioritizes innovations in strategic domestic industries, especially by enhancing innovativeness and increasing the national capacity for energy independence [7]. In addition to industrial policies and purposeful mission-oriented programs boosting local industries, the two countries have introduced trade measures and investment regulations to restrain each other's clean energy economic actors from entering their own markets. The Trump administration used Sect. 201 to launch an investigation of China. After the investigation, the US government determined that China's solar sector had a serious impact on the US industry and then proposed raising tariffs on some solar equipment exported from China [1]. As early as the promulgation of the Renewable Energy Law in 2007, China restricted new investments from US renewable energy equipment manufacturers in China. Restricting the scale of foreign capital for large-scale wind power projects is also mandatory through localization measures such as local content requirements [10]. In addition, the impact of strategic competition between China and the United States is also reflected in recent bills to monitor or prevent foreign direct investment for the purpose of technology transfer, which suppresses mergers and acquisitions that compulsively acquire corporate intellectual property rights. The Foreign Investment Risk Review Modernization Act (FIRRMA) promulgated by the United States in 2018 and China's newly revised Foreign Investment Law in 2019 can both be deemed countermeasures and domestic investment regulations in response to strategic competition.

The abovementioned layout of economic statecraft, which involves the protection and support of local green industries, appears to be tit-for-tat in the context of Sino–US strategic competition and seems to be in line with the rationale of economic security. However, the institutional complex that shapes the trajectory of green transformation in the United States has not been consistent. In fact, its position in mission-oriented programs involving new social demands and government intervention has shown some ambiguous changes in recent decades. Conventional wisdom indicates that the United States is a neoliberal state in which free market environmentalism and nonintervention of the state in the market are the norms for the techno-industrial governance system. However, an increasing number of scholars dispel the various fictitious narratives of capitalism scattered across academia and point out that the United States actively provides hidden industrial policy. In the twentieth century, the Advanced Research Projects Agency (ARPA) was important evidence of a pilot agency that closely nurtured economic actors in key industries with the goal of technological modernization, which depended on covert measures protecting a few technology firms in producing commercialized products for the world. The coordination and communication in tight networks, guided closely by

[5] Wang and Sun, From Globalization to Regionalization, 71.

the state aiming for technological transformation, happened precisely at the height of the neoliberal rhetoric introduced by the Reagan administration [5]. The political elites' perception of globalization at the time led to such a policy transition. As Block rightly pointed out, "it was anxieties about the ability of U.S. firms to compete successfully in the global economy that had forced industrial policy ideas onto the political agenda in the first place."[5][6] Beginning in the twenty-first century, rooted in this model, the Advanced Research Projects Agency-Energy (ARPA-E) in the United States targeted clean energy technology with large-scale, state-led innovation support [6]. In 2007, Congress passed "The America COMPETES Act," officially authorizing the creation of ARPA-E. The state directly allocated funds through the ARPA-E program to sponsor potentially cutting-edge technologies related to the energy transition. The US mission aims to promote economic development, national security, and environmental welfare. The projects are numerous, but the most recent endorsement concerns a pledge backed by the Biden–Harris administration calling for a clean energy future for the United States and net-zero emissions across the economy by 2050.[7] ARPA-E adopts the "multigenerational technology thrust" in the DARPA model, creates more possibilities to connect larger innovative elements in its innovation culture, strengthens the strategic connection between technologies, and expands the potential for commercializing new technology [6]. This practice once helped the United States obtain a leading global position in the field of information technology in the twentieth century [34].

The abovementioned national intervention included the federal government's investment scheme in future technology innovation industries, the ability to commercialize cutting-edge technology, a series of government procurements, and the introduction and adjustment of state regulations. The *hidden* developmental state institutions fostered the United States' global hegemonic position in the military, space technology and pharmaceutical industries [32]. In the twenty-first century, the enthusiasm for such a hidden model has manifested with particular clarity in policy interventions into green transformation [32]. A meaningful combination of policy imperatives for both environmental protection and industrial growth emerged during the Clinton administration, during which time the federal government, through the Climate Action Plan, proposed a series of loans and tax credits for the renewable energy technology industry. The populist tendencies of the Bush administration in some ways meant that there were few additions to climate policy until the Obama administration made major environmental promises at home and abroad. During the Trump administration, the United States gave up its efforts to jointly combat climate change with China and turned to a noncooperative attitude [21]. Moreover, "China-bashing" seems to have become one of the main political campaigns in the Trump administration, and US−China relations have turned to policies of competition and containment [47]. The United States also gradually relinquished its global climate

[6] Block, Swimming Against the Current, 179.

[7] For the description of the support, see, the Authenticated U.S. Government Information, "America Competes Act," (9 Aug 2007) Public Law 110–69, https://www.govinfo.gov/content/pkg/PLAW-110publ69/pdf/PLAW-110publ69.pdf; Advanced Research Projects Agency – Energy (2022), https://arpa-e.energy.gov/about/budget-requests. Accessed 15 Oct 2023.

leadership during the Trump administration. At the state government level in the United States, renewable portfolio standards (RPSs) and carbon markets were the main instruments used to provide opportunities for the green transition before the Biden–Harris administration, when the Inflation Reduction Act was introduced in 2022. A 400 billion-dollar commitment to the green transition was raised, which will be further discussed in later sections [37, 39].

Compared with the covert interventions of the United States before 2022, China's green statecraft has seemed to benefit from the central government's unhesitating large-scale public financing investment in green technologies. The state engages in central steering through the deployment of developmental state policy instruments [9]. Starting from the administration of Hu Jintao and Wen Jiabao, the policy discourse and practice of green transformation was put on the high-level political agenda [12]. New energy is regarded as a new type of winning strategy that needs to be provided meticulous support and supervision by the state.[8] Capital injections have increased, and industrial policy around emerging green industries is also an economic stimulus measure to address the country's re-entry into the market after the global financial turmoil [13]. In this context, a "centrally driven policy experimentation" with a series of industrial policies dedicated to green transition was launched [50]. The policy elites of the central government introduced a series of industrial policies cultivating the selected state-owned strategic industries pertinent to the energy transition.[9] This action clearly emphasized the economic goal of catching up with renewable manufacturing technologies and capabilities to promote China's domestic green energy sector; the state also periodically deployed trade protection measures and encouraged the local practice of local content requirements to boost the domestic development of green energy equipment supply chains [9]. To some extent, the hierarchical institutional structure of incentives has helped consolidate the central and local governments in cooperation to temporarily resist challenges from any incumbent interests in traditional development [4].

The green industrial policy for renewable energy started with the 12th Five-Year Plan (2011–2015). Policy elites continue to seek solutions to create a market that includes a semiopen or open institutional environment including both domestic and foreign economic actors and greatly reducing its manufacturing costs for wind power and solar energy. China's nonhydro renewable energy market has been the world's largest [28], although only 15 years ago, most of China's wind turbines and solar energy equipment and components were directly imported from developed economies [25]. However, in this decade alone, local manufacturing brands have risen rapidly and taken over domestic and foreign markets [10, 15, 27]. Technological innovation in this field has formed an important part of the political agenda. The ability

[8] National Energy Administration, 2023 Nengyuan gongzuo zhidao yijian [guiding opinions on energy work in 2023], 6 April 2023.

[9] For more details of the industrial policy experiments, see, for example, National Energy Administration, Guojia nengyuan yanfa chuangxin pingtai guanli banfa [Administrative measures for the national energy R&D innovation platforms], 9 Sep 2020. National Energy Administration, Guojia nengyuan ju zonghe si guanyu "shisiwu" di yi pi guojia nengyuan yanfa chuangxin pingtai mingdan de gongsh [Announcement of the General Affairs Department of National Energy Administration on the list of the first batch of national energy R&D innovation platforms during the "14th Five-Year Plan"], 20 Mar 2023.

of Chinese firms to adopt upgraded science and technology know-how has now directly influenced changes in the global industry supply chain [43]. The drive for technological advancement exists under a political–economic imperative of carbon neutrality, as targeted by the central government. Once upon a time, China's domestic wind turbine market was dominated by a limited number of European frontrunners, such as Vestas or Siemens [25]. Under the guidance of central and local industrial policies and the initiative of enterprises, domestic Chinese manufacturers have quickly begun to grasp opportunities through joint research and development, the purchase of rights to use intellectual property, and the mergers and acquisitions of foreign companies [26, 27, 52]. In the next section, the paper emphasizes the focus on incentive structures behind the institutional configuration in both countries for comparative political analysis.

Structuring Internal Incentives for Green Transformation

The key to understanding the politics behind climate policy may lie in understanding a country's ability to govern, its rational underpinnings, the preference structure in which policy-makers live, and the relationship between perceived interests and policy choices. Meckling and Nahm, at a time when green industrial policy seemed to emerge as a global environmental movement [2], rightly gave such a new emphasis to the foundation of change, stating that green industrial policy is a means of building new strategic state capacity. They claim that "strategic state capacity refers to the ability of the state—defined here as the executive and/or the legislature—to mobilize or demobilize interest groups in pursuit of official policy goals."[40][10] Their study rests on evidence from advanced economies, pointing out numerous forms of negotiations with interest groups in European and American countries, and their research indicates that the variable levels of state capacity create a variety of intervention methods to promote the advancement of climate policy. The green energy transition originated from challenging the existing market structure and order. Large-scale power manufacturing companies occupy most of the wind power and solar power markets. These power companies are different from incumbent utilities in terms of identity. They unite policy entrepreneurs and gradually deploy a "substitution pathway" to replace the existing share of the fossil energy market with green power [22].[11]

In this context, US state governments have chosen to create green transitions through local climate policies via tax credits and renewable energy portfolio standards. Since the 2000s, carbon pricing has been selected by a number of state governments as a policy tool to promote the transition, albeit with limited effectiveness. Indeed, as Meckling points out, the general energy system inevitably generates institutional inertia, which makes any technology disruption difficult, as incumbent utilities resist changes to avoid the new costs they would have to bear [38]. To defend against the risk of this new type of transaction cost, incumbent utilities, especially

[10] Meckling and Nahm, Strategic State Capacity, 495.
[11] Kelsey and Meckling, Who Wins in Renewable Energy, 66.

in the United States, usually conduct active political lobbying to protect existing fossil fuel interests [38]. Building consensus and coalitions to challenge established political–economic structures is often difficult in a pluralist capitalist society, which means that the United States has long struggled to effectively develop a long-term decarbonization plan that can both lead the way in addressing the catastrophic climate crisis and propose economic compensation for losers in the green transformation. In a country that culturally embraces neoliberal rhetoric and ideas, US policy executors and voters are uncomfortable with the existence of state subsidies, even though the country does not form a neat dichotomy between state and market relations in practice as it otherwise claims.

Regarding the policy arena dominated by orthodox economic thinking, the long-standing policy of feed-in tariffs, which has supported emerging market entrants in Germany, Spain, Denmark and other counties, thus far has been rarely used by US policy-makers. Although industrial policy still exists in the United States, the federal government intervenes in selected markets to support certain industries, such as pharmaceuticals and the military complex, on a large scale. Nevertheless, US policy-makers were hesitant to directly subsidize the development of R&D and equipment manufacturing in the green transition and instead subsidized it with less effective measures such as tax credits.[12] The slow involvement of state governments in the country's green transition does not mean that the federal government has not done much. In fact, the US federal government has actively provided research and development support programs for the solar industry: the federal government's Solar Technology Office has provided loans for many low-cost solar power manufacturing projects. During the 1990s, solar power manufacturing gradually evolved into a federally supported program with tax credits, which was launched on a large scale in 2006. Then, from 2009 to 2011, so-called "loan guarantees" and "advanced energy manufacturing tax credits" were launched to support green projects.[13] The latter policy embodies protectionist economic measures, incentivizing local solar manufacturers to keep their projects and bases in the United States. The federal government provides a 30 percent tax credit to renewable energy companies willing to invest in their new equipment in the United States. Overall, however, the tax credit programs described above appear to have failed to boost US solar productivity on a large scale.[14]

According to Hughes and Meckling, to understand the purpose of policy-makers for introducing competitive industrial policies, it is necessary to compare the markets in which these policies are introduced and operated. In the process of green transformation in the United States, because most solar panel manufacturers are located in upstream in the global industrial chain, the government's intervention is mostly aimed at boosting the innovation capacity of local enterprises, not just the production capacity. When developing countries target the scaled growth and expansion of new energy with industrial policy interventions in green transformation,

[12] Mazzucato, *The Entrepreneurial State*, 87.

[13] International Energy Agency, *Special Report on Solar PV Global Supply Chains* (Paris: IEA), 111–112.

[14] International Energy Agency, *Special Report on Solar PV Global Supply Chains* (Paris: IEA), 111–112.

price competition becomes market entrants' main strategic operation rather than technological upgrading [20]. The US federal government's intervention with green industry policy tends to support the R&D stage of start-ups, especially through key support for early cutting-edge projects at universities and research institutions. In the field of renewable energy, before 2022, compared to Chinese enterprises, US economic actors receiving governmental support are small and medium-sized with limited capacity for scaling up, and firms even outsource the manufacturing process to the developing world.[15] After 2022, the Biden–Harris administration seemed to depart from the model of relatively moderate financial support in the past, dramatically allocating more special funds to support innovative technologies related to the energy transition and using competitive strategic support to cultivate domestic industries. Before 2022, the government's green industrial policy support was still cautious, which was different from the approach used with conventional state-led measures, such as biomedical, aerospace, and communication technology support, from the hidden developmental state institutions in the past. In the field of renewable energy, the federal government aimed to boost the economy by giving consumers tax credits via the introduction of the Emergency Economic Stabilization Act of 2008.

The industrial policy of such tax credits was also extended in the American Recovery and Reinvestment Act (ARRA) introduced by President Barack Obama in February 2009. ARRA was a landmark industrial policy plan aimed at market revitalization in response to global financial turmoil. It was a key act to lead the United States at a critical juncture in the race with China's green transformation. This key act specifically focused on energy innovation. The total bet has exceeded "USD 8 billion, a figure that seems to be close to the highest point of US government investment in the field since 1978." [16][16] Despite the disastrous rollback of climate policies during the Trump administration, the Biden administration appears to be back on its feet, expanding the Democratic Party's commitment to fighting climate change initiated during the Obama era and aligning climate policy more positively with the stimulus of the New Green Deal. Economic policies are connected to increase investment programs to protect the country's domestic firms, green infrastructure and social assistance; for these programs, the historic Infrastructure Law has promised an investment of 3.7 billion US dollars.[17] The federal government has played a leading role in the design and implementation of green industrial policies for perceived new competition in the climate technology field. To some extent, the leaders of the Democratic Party have successfully united opinion leaders, businesses and policy entrepreneurs to promote a win−win situation. These efforts have resulted in, as mentioned previously, the proposal of the most iconic domestic policy against global warming in the United States: the Inflation Reduction Act in 2022. The leading mission-oriented program has created a new epoch of decarbonization. This bill decisively provides long-term "patient capital" in financial support for

[15] Nahm, *Collaborative Advantage*, 151–157.

[16] Gallagher and Xuan, *Titans of the Climate*, 114.

[17] See [8]; US Department of Energy. Biden-Harris administration announces $3.7 billion to kick-start America's carbon dioxide removal industry. 13 Dec 2022. https://www.energy.gov/articles/biden-harris-administration-announces-37-billion-kick-start-americas-carbon-dioxide. Accessed 15 Oct 2023.

cross-sector decarbonization technology industries through the federal government, giving many private companies long-term tax credits, loans, and grants. This mission-oriented policy scheme involving nearly USD 400 billion aims to incentivize new market entrants and investors' new investment in innovative industries, especially the electric vehicles, batteries, and solar energy sectors.[18] A year after the law was introduced, as of the time of writing this article, the bill had spurred more than USD 270 billion in new investment in clean energy technology and equipment, well beyond the total national investment in the eight years prior to the introduction of the law.[19] Since then, many investments related to the energy transition have come from conventional utilities, such as petrochemical energy corporations.[20] Although it will take some time to assess the results of the series of policy schemes for energy transition, its positive significance cannot be underestimated, which makes the state's green industrial policy a benchmark for the development of a new economy.

Compared with the recent active green statecraft efforts of the United States, green statecraft in China seems to have started earlier. The stimulus package launched by China after the global financial turmoil in 2008 pioneered its long-term investment in the green transformation. The mechanism and structure of these incentives face a relatively smaller amount of resistance from conventional utilities than the power companies in the United States put up against federal policy at the beginning, and such conditions are supported by China's approach to the green industry as a strategic economic sector. Looking back on the development of nonhydro renewable energy in China, we can recognize that this is a sector shaped and cultivated by the state from the very beginning [28]. In political rhetoric, indigenous innovation has dominated the development of the so-called pilot industries. In a survey of the reserves of renewable energy resources, we find the formulation and adjustment of renewable energy tariffs, the planning of several rounds for the central state to bid on the construction of renewables, the introduction of economic incentives at various levels, including provincial and municipal levels, and the development of international trading strategies [23]. It seems that the advancement of this field reflects the understanding of policy elites of the complex system of China's developmental delays in this field. Advancement is emphasized through powerful government agencies intervening in the developmental state model with closely coordinated economic actors and direct or indirect support for the development of domestic firms to catch up with the West.[21] The year 2006 can be regarded as an important turning point in the brief history of new energy development in China. A law governing the development of renewable energy throughout the country was introduced. This phenomenon released a signal that the central government would emphasize specific industrial development and that the provincial governments had begun to draw up corresponding development plans. Since then, a large number

[18] Maurice Hewins. One year on from the Inflation Reduction Act – Who are the winners and losers?" 7 Aug 2023. https://www.schroders.com/en-us/us/individual/insights/one-year-on-from-the-inflation-reduction-act-who-are-the-winners-and-losers-/. Accessed 15 Oct 2023.

[19] American Clean Power. Clean energy investing in America. Aug 2023. https://cleanpower.org/resources/clean-energy-investing-in-america-report/. Accessed 15 Oct 2023.

[20] Justin Worland. How the Inflation Reduction Act has reshaped the U.S.—and the world. 11 Aug 2023. https://time.com/6304143/inflation-reduction-act-us-global-impact/. Accessed 15 Oct 2023.

[21] See [9, 62].

of private and public enterprises have actively joined the investment opportunities led by the state as new market entrants [10]. Foreign-funded enterprises have not obtained many concessions in this process of market shaping.[22] The threshold of market access for foreign companies has been augmented. Those wind power plants that participated in the aforementioned central government public bidding were encouraged to be joint ventures with a Chinese manufacturer, and the companies participating in the bidding were required to have Chinese shareholders own more than 50 percent of their shares. In addition, there was a local content requirement of 70 percent for bidding for local manufacturers [51]. Although this Listian-style economic patriotism does not prevent foreign companies from entering the Chinese market, the local market of China's emerging renewable energy industry has changed.

With its economic intervention, the government aims to boost the country's economic position in the global chain of the climate technology industry [63]. This strategy no longer relies on the dominance of Sino–foreign joint ventures that have been regarded as failures in the past. Instead, through a refined industrial policy, a gradual reregulation of individual projects has been implemented. These controls include the development sites selected by the government and rules formulated by the government that tend to enable wins for domestic bidders [10]. Ownership management has become the main instrument for facilitating the localization of technological innovation since Xi came to power. The government pays more attention to supporting the ability of domestic enterprises to transform self-generating technological outcomes for the global industrial chain. Enterprises can receive direct or indirect support, including tax incentives for investment in domestic and overseas R&D (including more active R&D cooperation with other countries' business actors, the purchase of licenses, and even integration and mergers and acquisitions). Since Xi came to power, the central state has also induced more research institutes and universities in the national innovation system to cooperate with enterprises to promote localization capabilities with the purpose of supporting the transfer of strategic industry technology, including larger wind turbines to be deployed in the Chinese market. In the past few years, local Chinese companies have brought their relatively strong capital and manufacturing capabilities into cooperation with European design teams in creating mutually complementary projects. The Chinese team also acquired technology in this cooperation and then provided its own successes in independent innovation, allowing firms to target markets in the developing world. In the next section, a further comparative discussion of the US's and China's state involvement in the transnational networks of green transitions will be presented.

Internationalization of Green Statecraft

In addition to supporting mission-oriented green industrial programs located in China, green statecraft led by governments outside China and the United States demonstrate that new capital investment to expand both countries' influence overseas is

[22] General Office of the State Council (2014) Guowuyuan bangongting guanyu yinfa nengyuan fazhan zhanlue xingdong jihua (2014–2020 nian) de tongzhi [Notice of the General Office of the State Council on Issuing the Energy Development Strategic Action Plan (2014–2020)]. No. 31.

provided. With Xi Jinping as the active defender of globalization, under his administration, China has more publicly advocated cooperation in energy infrastructure with the Belt and Road countries since 2013,[23] and this transnational cooperation is conducted with the support of related investment and financing led by the Chinese state.[24] Among these new economic–patriotic strategies, the most important financial institution is the Asian Infrastructure Investment Bank (AIIB). China established this institution between 2013 and 2014. As of 2019, 97 countries had joined. This institution, established in Beijing, can directly provide loans to institutional entities or enterprises in any member state in accordance with the articles. As of 2019, of the projects approved by the AIIB, the largest number are energy projects, accounting for approximately 34 percent.[25] These power generation projects, which involve the construction of power stations, power grids, and renewable energy, are all located in the Asian cooperative countries of the Belt and Road Initiative, including India, Bangladesh, Tajikistan, Myanmar, and Pakistan.

Compared with previous leaders, Xi has been relatively high-profile in advocating the significance of combatting global warming and insisting that China must make a difference in climate leadership [24]. One of his ambitions is to focus on the country's foreign investment by capitalizing on global cooperation. The Chinese national institution that is more relevant to global clean energy is, in fact, the New Development Bank. This bank was established in 2013 by the leaders of the five BRICS countries, with US$100 billion in initial capital and contributions from the five founding members. The bank aims to raise funds for infrastructure and, particularly, for sustainable development projects in the developing world.[26] The projects funded by this Shanghai-headquartered bank focus more on large-scale wind power, solar and hydropower, and more importantly, these projects seem to be typical of the catalyst for economic patriotism. The export of capital and borrowing and on-lending of funds have been supported through direct state intervention, such as the on-lending measures of the renewable energy transmission, the distribution project undertaken by the National Development Bank of Brazil and the infrastructure of the South African National Electricity Company and the South African Development Bank for power grid technology. China itself also obtained major project financing from other countries from the capital injection provided to this bank. The funded projects include the following: the Lingang distributed solar power project

[23] National Energy Administration (2021) Guojia nengyuanju zonghesi guanyu jianli "yi dai yi lu" nengyuan hezuo huoban guanxi hezuo wangluo de tongzhi [Notice from the General Affairs Department of the National Energy Administration on establishing the "Belt and Road Initiative" energy partnership cooperation networks]. 8 June. For the assessment of the debate, see [45].

[24] Liao, Jessica C. (2021) China's Green Mercantilism and Environmental Governance: A New Belt and Road to the Global South? The 2020-2021 China Fellowship Report. Washington, D.C.: The Wilson Center, pp. 10–11.

[25] Xu Hongfeng, and Wang Jing (2019) Zhongguo nengyuan jinrong fazhan baogao: Zhongguo yu "yi dai yi lu" guojia kezaisheng nengyuan hezuo ji tourongzi. Beijing: Qinghua daxue chubanshe [Report on China's energy finance development: Renewable energy cooperation, financing and investment between China and the cooperative countries "the Belt and Road Initiative". Beijing: Tsinghua University Press], 302.

[26] New Development Bank. Data and Documents. 2021. https://www.ndb.int/data-and-documents/ndb-core-documents/. Accessed 15 Oct 2023.

in Shanghai; the Putian Pinghaiwan offshore wind farm project in Fujian Province; and the Guangdong Yudean Yangjiang offshore wind power project in Guangdong Province.[27] China seems to be satisfied not just with the domestic green energy market but with an initial internal-to-outward transnational strategy of green policy that has explicitly been attached to the state-permeated and export-oriented mercantilism embedded in the grand narrative of the Belt and Road Initiative. Such continued endeavors of the "going-out" campaign have relied relatively frequently on multinational organizations to solve China's own internal governance dilemma, including the handling of issues such as state asset supervision and corruption [61]. However, as Liao and Katada indicated, the widespread use of transnational industrial policies marked a new pattern in technological catch-up strategies under Xi's administration [29]. Abdur Rehman Shah further pointed out that the Belt and Road Initiative (BRI) has caused perceived security threat concerns among US foreign policy-makers. However, the real challenge of the BRI does not seem to lie in security concerns but in how to achieve good economic governance outcomes by effectively carrying out institutional supervision [48].

Such a trajectory of development has seemed to lead the United States to reconsider the deployment of green industrial policy from behind the hidden political veil and to further maintain influence in the developing world. Compared with China, the United States did not appear active in green statecraft until the Partnership for Global Infrastructure and Investments of the G7 2022, where the United States was the leading state for the coalition that is deemed a global alliance to compete with China's Belt and Road Initiative. As a result of this agreement, the Biden Administration promised to give a loan of USD 200 billion for the United States to invest, sponsoring purposeful mission-oriented projects, some of which involve financial support for clean energy and nuclear power infrastructure. The US government cooperates with private American companies to assist in constructing solar projects worth USD 2 billion and strives to assist Angola in creating capacity for decarbonization commitments. It also provides construction funds for smart grids worth USD 2 billion in South Asia. In addition, American companies will also provide USD 14 million over five years to assist Romania with the technical capital and service to support new nuclear power reactor projects.[28] In addition, in 2019, the United States, Japan, and Australia organized the Blue Dot Network, seeking to provide standard services for sustainable infrastructure projects for private enterprises in many countries across the world through OECD networks.[29]

[27] Xu Hongfeng, and Wang Jing (2019) Zhongguo nengyuan jinrong fazhan baogao: Zhongguo yu "yi dai yi lu" guojia kezaisheng nengyuan hezuo ji tourongzi. Beijing: Qinghua daxue chubanshe [Report on China's energy finance development: Renewable energy cooperation, financing and investment between China and the cooperative countries "the Belt and Road Initiative". Beijing: Tsinghua University Press], 309.

[28] The White House. Fact sheet: President Biden and G7 leaders formally launch the partnership for global infrastructure and investment. 26 Jun 2022. https://www.whitehouse.gov/briefing-room/statements-releases/2022/06/26/fact-sheet-president-biden-and-g7-leaders-formally-launch-the-partnership-for-global-infrastructure-and-investment/. Accessed 15 Oct 2023.

[29] OECD. OECD and the Blue Dot Network. 2022. https://www.oecd.org/finance/oecd-and-the-blue-dot-network.htm/. Accessed 15 Oct 2023.

The abovementioned outreach projects have cooperated with the US Trade and Development Agency, the US Agency for International Development, and the Millennium Challenge Corporation as several relatively large foreign aid support agencies researching overseas financing programs; these agencies have spent many years in the review, promotion, and implementation of policies to strengthen the competitiveness of American firms, including increasing investment opportunities for infrastructure and business and network funding for renewable energy. Through multinational partners and organizations, these institutions increase US private firms' investment in clean energy infrastructure in other countries.[30] However, the US-led infrastructure funding projects have bluntly claimed to create a coalition that is, in terms of values, different from China's "Belt and Road," which seems to pave the way for strategic discourse that competes against China's global ambitions. These forms of US foreign economic statecraft seem to be part of the US countermeasures to prevent China from being a regional and even global power competitor [19]. Nevertheless, the two countries suggest that there is a common theme in strategic competition in recent foreign green statecraft operations; that is, both countries have not left the market passively but have actively engaged in economic intervention in the process of globalization, promoting market conformity and selecting the local competitors they both consider appropriate to support either the emergence, consolidation, or integration of supply chains. These clearly earmarked public funds lead both countries to unabashedly choose local flagship sectoral enterprises, whether private or public economic actors, to complement the governments' open industrial policies, having sought to create new commercial space at the frontier of green technology innovation. However, this does not mean that the development of industrial policies always corresponds to ideas that policy-makers originally aimed at. Many unintended developmental outcomes have also emerged after implementation. The paradox is that both at home and abroad, there may be policies at the top and countermeasures at the bottom. Neither government may always be able to linearly support their chosen objectives. For example, in China, science, technology, and economic policies often favor domestic state-owned enterprises. In the process of localizing solar energy equipment manufacturing, there are still many fraudulent compensation behaviors. In addition, even though Chinese companies generously support localized green technology and the US government is vigorously discouraging investment from Chinese high-tech businesses,[31] both countries still unintentionally attract new start-ups from China or the United States, such as Tesla's recent plan to establish Megapack energy storage system in a factory in Shanghai or BYD's large investments in US territory.[32] Despite growing security concerns, both China and the United States have discouraged foreign competitors from investing in their homeland. Paradoxically, that does not seem to stop the two countries' leading

[30] U.S. Department of Energy. Agency financial report fiscal year 2021. 15 Nov 2022. https://www.energy.gov/cfo/articles/fy-2022-doe-agency-financial-report, pp. 18–20. Accessed 15 Oct 2023.

[31] For the discussion and debate of the US changing strategy toward China, see [11, 60].

[32] Hudson Lockett and Edward White. Tesla boosts China investment with plans for Shanghai battery factory.*The Financial Times*. 9 Apr 2023. https://www.ft.com/content/37b2d801-4850-4aa5-a341-3da08b609913. Accessed 15 Oct 2023.

electric vehicle companies from expanding their plans to invest and build factories in each other's countries.[33] The confrontation between China and the United States to some extent also encourages hoarding activities by the electric vehicle industry to obtain key raw materials, such as lithium.[34] The above examples show that the internationalization of green statecraft faces its own limitations, and both China and the United States have encountered contradictory and unintended outcomes in the process of introducing strategically competitive green industrial policies. Table 1 briefly summarizes many of the similarities and differences in the adoption of green industrial policies in the United States and China.

Toward Converging Models of State-Led Green Transformation

From the above comparative political analysis, we can understand that both countries seem to use a protectionist approach – whether through external or internal public financing incentives – aiming for environmental protection on the one hand and trying to deploy green industrial policy to revive the so-called green economy on the other hand. At first glance, the two countries seem to have come to a new, isomorphic situation, that is, the rise of green industrial policy as a "new deal" seems to be able to foster the energy transition and to thwart any monopoly of the carbon energy market by interest groups while providing a mission-oriented solution to the effects of catastrophic global warming.

Chinese political elites put decarbonization endeavors in the context of an economy that is still "catching up" [9], rationalizing the internal strategic support of the party-state for green pilot policies in selected industries through developmental strategies [41]. Relatively, the domestic green industry policy of the United States seems to have been seriously introduced a little late, and to some extent, these policies are a passive response to the industry–university alliance responding to the national economic statecraft imperative caused by the perceived impact of strategic competition between China and the United States. The timing of the introduction of mission-oriented programs in the United States seems to be complicated to some extent. Because most US firms possessed innovative knowledge of upstream technology at an early stage, the government's favorable policy is concentrated on the dominant position of high-end local enterprises. The process of energy transformation creates a new game scenario between winners and losers. Compared to China's system, the American political system seems to encounter more organized resistance from conventional utilities during green transformation. The oil industry and the automobile industry have already monopolized the basic market structure, which means that many new entrants struggle to survive even before considering

[33] Norihiko Shirouzu. Focus: China's BYD takes cautious approach to U.S. in global EV push. Reuters, 18 Jan 2023. https://www.reuters.com/technology/chinas-byd-takes-cautious-approach-us-global-ev-push-2023-01-18/. Accessed 15 Oct 2023.

[34] Joe McDonald. Threatened by shortages, electric car makers race for supplies of lithium for batteries. *The Associated Press*. 28 Jun 2023. https://apnews.com/article/china-ev-lithium-united-states-battery-87eb9382a0181bb7ee64e835efe7b170. Accessed 15 Oct 2023.

Table 1 Green Industrial Policy Schemes in the United States and China

Similarities	Trade measures	
	Investment regulations and mission-oriented programs	
	State financing schemes, loans, and grants	
	Commercialization of cutting-edge technologies	
	Government procurements	
	External green statecraft	
Dissimilarities	United States	China
	Tax credits-focused incentive schemes; Renewable energy portfolio standards; Alliance of stakeholders; Private enterprises as innovation builders	Local content requirement; Concession bidding; Feed-in tariffs; Hierarchical institutional structure of incentives; State-owned enterprises as innovation builders

attacks and restrictions from conventional industrial economic actors. The promotion of renewable energy in the United States is focused on a coalition of various participants from the bottom up before petitioning the government to introduce new green industrial policies that are beneficial to society. In contrast, in China, because the market initially had no existing technological advantages, the political cost of renewable energy development is relatively low, and the resistance encountered from internal interest groups is also relatively low. Nevertheless, from the comparison of the external green statecraft process, both China and the United States have further united cross-border capital institutions to impact the existing order under the green narrative. Although the effectiveness of both external green statecraft investments remains to be tested, the United States and China seem to both conduct a seemingly green state mechanical approach, deploying parallel internal and external green industrial policies for the energy transition.

Conclusion

This article explores the divergent implementations and practices of green industrial policies in the United States and China through comparative analysis of institutional incentives and green industrial policies reflected in green transformation. Although the developmental outcomes of the green industrial policies for energy transition proposed by China and the United States may look different, both cases seem to indicate convergent institutional patterns of state-led intervention toward economic protection of climate technology industries. The United States has shown more policy support over the past decade even though its green transition begins with and is constrained by the competitive nature of the interest groups in a pluralist system. As has been expected, the process must involve coalition building among emancipatory and decentralized green energy and environmental protection movement protesters, policy entrepreneurs, and small and medium-sized new market entrants. In China, with its authoritarian system, the governance hierarchy is somewhat locally

embedded through an insistence on the inherent dominance of the one-party institution; the business of wind and solar energy equipment manufacturing and installation benefits in part from this relative lack of incumbent interests in a challenging policy environment. The Chinese central government sets a larger framework for the growth of the green transition at the transnational level and financially incentivizes cross-national cooperation to carry out new projects. To a certain extent, the two countries have successfully boosted the performance of renewable energy investments, although it remains to be seen if these experimental new trials in the real transformation of the energy structure can mitigate the effects of climate change. To fundamentally change the energy mix, perhaps more determination and a more efficient coalition-building process need to be consolidated among the economic and political actors in both countries.

Acknowledgements I wish to thank the editors and two reviewers of the *Journal of Chinese Political Science* for investing considerable time in providing constructive suggestions. I would also like to thank Seungjoo Lee, Heejin Han, Malcolm Campbel-Verduyn, and all participants of both parts of the conference "The U.S.−China Technology Competition and Economy–Security Nexus in Asia" on 24 August and 24 October 2022 by the Institute of National Interest at Chung-Ang University for their very valuable comments on earlier versions of this paper.

Data Availability The author confirms that all data generated or analyzed during this study are included in this published article. Furthermore, primary and secondary sources and data supporting the findings of this study were all publicly available at the time of submission.

Declarations

Conflict of Interests The author declares no conflicts of interest.

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