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# Strategies of Green Industrial Policy: How States Position Firms in Global Supply Chains

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*The resurgence of industrial policymaking—particularly for emerging low-carbon industries—challenges social science theories that expect such interventions from centralized states or suggest that different kinds of states specialize in various forms of innovation policy. Interventionist forms of industrial policy have made a comeback among liberal economies. Coordinated economies now make use of market-driven strategies. This paper argues that the new generation of industrial strategies is shaped by the industrial development challenges that policymakers face at the sectoral level. It proposes a new theoretical framework that distinguishes between the policy orientation (targeted or open-ended) and the central agents driving financial and technological decision-making (governments or firms). We show that the choice of strategy is shaped by the level of uncertainty and the position of the domestic industry in global supply chains, that is, whether global supply chains are emerging or mature and whether the domestic industry is an entrant or incumbent.*

## INTRODUCTION

Over the past three decades, the global political economy has been slowly transformed by a series of successive macroeconomic and geopolitical changes. China's rise has altered production and trade flows while showcasing an alternative economic model. The loosening of trade restrictions and capital flows fed the hyperglobalization of supply chains, many of which were rerouted through China (Gereffi 2018). The neoliberal paradigm, which ushered in these changes, has been weakened by successive crises (Blyth 2013; McNamara and Newman 2020). Finally, climate change has been transformed from an environmental issue to a first-order political and economic problem.

Nowhere is the impact of these changes more evident than in the rise of green industrial policy. Long the domain of late-developing economies, particularly in East Asia, the past decade has brought a resurgence of industrial policy, including in advanced industrial economies. Clean energy industries are rapidly becoming important global sectors with enormous growth potential. Much to the concern of policymakers in the rest of the world, China currently dominates manufacturing for key segments of their supply chains. In response, governments are now deploying green industrial policies to strategically position their economies in global clean energy industries of the future. These policy interventions are reshaping the global economic order as they reconfigure supply chains and generate new sources of trade conflict.

Making sense of this geopolitical landscape requires new tools to explain the role of the state in reshaping the global landscape of technology and energy. The new patterns of state action do not map easily onto theories that posit national economic policymaking traditions or those that build on statist–liberal categories. Green industrial policies challenge existing theories that have long viewed industrial policy as primarily deployed by centralized and hierarchical governments with dirigiste approaches to economic governance (Amsden 1989; Johnson 1982).[1] For example, the United Kingdom, often touted as an archetypal liberal market economy, has put forward ambitious, targeted, and government-led industrial policies to support its aggressive decarbonization goals. Meanwhile, China and other East Asian states, having long served as classic examples of government-led industrial policy, are using industrial policies that leave key financial and technological decisions to the private sector. As governments have converged on the use of a heterogeneous portfolio of industrial policy tools ranging from state-led to firm-driven approaches, the sectoral dimension of industrial policymaking has emerged as a central challenge to existing theories based on national-level characteristics.

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[1] We define green industrial policy as investments, incentives, regulations, and policy supports designed to stimulate and facilitate the development of green technologies (Rodrik 2014). A market reform strategy counts as an industrial policy if it is intended to build a low-carbon industry.

These new patterns of industrial policy do not fall into clear national typologies. States are now using different policy approaches across and even within sectors. The use of heterogeneous industrial policies breaks with recent studies drawing on the Varieties of Capitalism literature, which suggests that coordinated and liberal market economies specialize in different forms of innovation and industrial policy (May and Schedelik 2021; Meelen, Herrmann, and Faber 2017). Such work extends the findings of earlier scholarship that argued that political, economic, and cultural institutions produced distinct national styles of innovation and industrial policy (Dobbin 1994; Katzenstein 1985).

A rich and growing vein of scholarship on the political economy of climate change now seeks to understand the dynamics of the energy transition and the role of industrial policy in building coalitions for deep decarbonization (Breetz, Mildenberger, and Stokes 2018; Colgan, Green, and Hale 2021; Finnegan 2022; Lewis 2014; Meckling et al. 2015; Stokes 2020; Stokes and Breetz 2018). These theories provide compelling accounts of why states engage in green industrial policy. They do so to catalyze technological change, generate domestic political benefits, and respond to coalitional demands. However, explanations for states' choice of strategies are beyond the scope of such research.

In this paper, we develop a new approach to explain the strategies states use to position their firms in global supply chains. In our theory, governments grapple creatively with a rapidly changing landscape at the sectoral level. Policies are not determined solely by structural or political–economic features of the state. Rather, the diversity of policy responses reflects the fact that policymakers simultaneously confront a variety of industrial development challenges in the sectors in which they operate. These strategies do not easily map onto a single statist–liberal spectrum, as they frequently combine elements of state initiative with firm control over key financial and technological decisions. We stress that a variety of states have converged on a portfolio of policy options that differ along two central dimensions. On the first dimension, governments choose among a continuum of targeted versus open-ended industrial policies. Along a second dimension, policies vary between those that are primarily state-driven and those in which firms make key technology and investment decisions. We then explain what forces push policymakers along these continua, shaping where they end up in the policy space.

We argue that policy choice is structured by the level of uncertainty and the global position of the firms governments seek to support. On the first dimension, the level of technological uncertainty in the sector shapes whether they choose targeted or open-ended policies. Only when governments can map desired supply chains or technological outcomes can they incentivize firms to meet industrial development benchmarks in return for public assistance. Uncertainty at the technological frontier can make such targeted interventions impossible, thereby favoring more exploratory policy measures.

On the second dimension, we contend that when governments seek to actively build domestic supply chains, they play an important role in sector-level technological and financial decisions. This is because establishing a whole ecosystem entails coordination across multiple firms and regions. By contrast, when the goal is to foster competition among domestic firms to help the strongest firms integrate into global supply chains, such decisions can be more easily delegated to the private sector. The industrial policy choice along this second dimension hinges on the relative position of the targeted industry in global supply chains. When governments seek to integrate firms into mature and technologically developed green industries, they can use exposure to global markets to foster the innovation and discipline needed to compete. When governments are trying to create or nurture nascent supply chains, they take a more active role in building up firms and infrastructure.

The argument builds on existing literature on comparative capitalisms and climate policy to offer a new account of industrial policymaking. A full understanding of the rise of green industrial policy today requires an examination of the political economy of interests and institutions. But as we show, it also entails an analysis of the specific industrial development challenges that policymakers confront in the sectors they are acting in. The paper focuses on developing the latter of these insights, but the result is an account that balances structure and agency so that we can be open to and make sense of the creative advance of industrial policy on display today.

## THEORETICAL FRAMEWORK

The literature on industrial policy, like that of political science generally, offers predominantly structural, state-level theories that situate policymaking within national institutions. The first wave of industrial policy scholarship in this tradition articulated a strong type: the East Asian development state. It sought to catch up to advanced industrial economies by shielding domestic capital markets to control the distribution of credit, erecting barriers to entry to help firms reach scale, and developing national champion firms through emulation, benchmarking, and punishment of low performers (Amsden 1989; Evans 1995; Johnson 1982; Wade 1990). Subsequent work on industrial policy sought to understand the effects of macroeconomic and political institutions on industrial policy choices (Dobbin 1994; Hall and Soskice 2001). Such theories, in their focus on national-level institutions, paid less attention to sectoral drivers of industrial policy, giving them less analytical purchase in a world where many governments use a variety of sectoral policy tools.

Existing social science theories struggle to explain the new global landscape of industrial policy, which has been altered by three factors: the emergence of climate change as a political–economy problem, the opening up of the ideological space after neoliberalism, and China's success in moving up global value chains.

Climate change shifted from being framed solely as an environmental problem that would impose costs on states to being understood as an economic opportunity (Allan and Meckling 2021). The collapse of the Kyoto regime and the dramatic cost declines in solar and wind supply chains showed the limits of market-based policy while demonstrating the potential of a technology-focused route (Cullenward and Victor 2020; Victor 2011). After the 2008 financial crisis, faith in liberal economic orthodoxy weakened, creating new space for state intervention in the economy (Blyth 2013).

Meanwhile, China successfully used industrial policy to secure strong positions in emerging clean energy supply chains. In critical sectors, rich advanced countries found themselves in the position of having to catch up, rather than maintain existing technological and market advantages. The UK Wind Strategy, the European Battery Alliance (EBA), the Inflation Reduction Act (IRA), the Korean Battery Alliance, and other strategies must be read in this context. They are responses to China's dominance in clean energy supply chains, which it had secured through policy support for wind, solar, mining, and electric vehicle (EV) sectors (Kennedy 2018; Lewis 2014; Nahm 2021). China, like some of its peers, also innovated in industrial policy design. It branched out beyond centralized forms of industrial policy to experiment with firm-driven innovation policies and market-based mechanisms. In part, such policies were a response to efforts to suppress industrial policy through the World Trade Organization (WTO). To work around global trade rules, countries pursued industrial policy in new forms, relying on market-based mechanisms, export credit, and R&D, which were all explicitly permitted by the WTO (Aggarwal and Evenett 2014).

Each of these structural changes created an impetus for a wide range of countries to engage in industrial policy in sectors critical to climate change. A more recent approach to growth and industrial development provides a better account of this new landscape of green industrial policy. This tradition shows how governments use a process of institutional experimentation that can, but does not have to, entail government intervention (Cullenward and Victor 2020; Hausmann, Rodrik, and Sabel 2008; Rodrik 2007; Sabel and Victor 2022).

Since each country differs in its political institutions, economic preconditions, and political actors, this approach begins with a process of experimental policy reforms in which states respond to their policy environment in nondeterministic ways. Working within and around political constraints, policymakers develop industrial policies in a dynamic way. Creativity, strategic choice, and learning shape the form and process of industrial policy (Breznitz 2007; Hausmann, Rodrik, and Sabel 2008; Meckling and Nahm 2022; Sabel and Victor 2022). States can and do design different industrial policy tools to meet the distinct challenges they face in specific sectors. This explains why we see sectoral variation in industrial policy rather than a broad divide between developing and advanced economies.

Our theoretical framework builds on the experimentalist tradition. We disaggregate the role of the state to understand and explain the current wave of green industrial policy. We develop a typology of the policy space by distinguishing between two kinds of state involvement: the orientation (are activities directed by government targets or open-ended) and the policy initiative (does the government or firms drive technological and financial decisions) of industrial policy. These dimensions emerge from our efforts to account for new forms of competitive industrial policy in East Asia (Chen and Naughton 2016; Fields 2012), a desire to overcome the dichotomy between industrial and innovation policy (Meelen, Herrmann, and Faber 2017), and the need to include collaborative forms of industrial policy where government and industry work together (Sabel and Victor 2022).

## What Is the Policy Orientation?

Along the first dimension, we distinguish between *targeted* and *open-ended* industrial policies. A targeted policy is directed by precise deployment, performance, or cost goals. States must have good-quality information to set such targets (Evans 1995). In catch-up development, a state sets performance benchmarks based on other economies' industrial development outcomes and subsequently establishes incentives and processes to achieve them. In the classic Korean case, the government set technology benchmarks based on Japanese success and enforced firm discipline through export targets (Amsden 1989, 16). In the case of China's EV subsidies, examined in this paper, the government used targets to prescribe which technologies must be produced or achieved to receive the incentives. The government created a list of China-made EV batteries with technological standards that ensured the vehicles were eligible for state support (Kennedy 2018).

Open-ended policies, by contrast, explore the technological and political space for novel solutions. They do not have specific goals because the benchmarks are unknown. Open-ended policies can take the form of an incentive that encourages sectoral innovation without specifying the precise form of that innovation (Kemp and Never 2017; Ornston 2013). The state can also create a specific institution or organization with a broad mandate to stimulate the development of an ecosystem or sector, but without specific output and development targets.

In practice, the operationalization of this dimension is not binary. While governments sometimes establish clear quantitative targets and technological specifications, they often move toward more open-ended policy metrics incrementally.

## Who Takes the Initiative?

Contemporary industrial strategy is no longer exclusively centralized or top-down. In the classic East Asian cases, states drove investment through state-owned banks and initiated projects through five-year plans (Amsden 1989, 16, 50–1). But modern industrial policies take a number of forms. In some cases, decisions are delegated to firms that must develop project proposals and drive investment (Felipe 2015). Hence, the second dimension of our framework captures who makes key technological and financial decisions in targeted or open-ended policy orientations.

We distinguish between three broad possibilities for the division of labor between public and private actors in industrial policymaking. First, policies can be *government-driven.* In a government-driven process, government agencies play an active role in directing investment, coordinating supply chains, tasking firms with priority actions, and making technology decisions. There are strong financial and regulatory incentives for firms to enact the government's plans at the project level. Deliberation councils and other discussion forums are mainly used to collect and disseminate information.

Second, in a *firm-driven* process, the private sector initiates projects and makes technological and investment decisions. The government may create a framework or provide financial and regulatory incentives, but it is a passive funder or supporter. Firm-driven strategies include market reform strategies in which states use exposure to the market to discipline and shape industries. This strategy was deployed by East Asian states (Chen and Naughton 2016; Fields 2012). There is a temptation to dismiss such strategies as not industrial policy proper, but the definition of industrial policy is open-ended: any policy intended to restructure industries counts.

Third, in a *collaborative* industrial policy process, governments and firms work together to formulate goals, strategies, and investment decisions and create projects. Collaboration can be facilitated by a deliberation council or intermediary organization that fosters a robust two-way flow of information and serves as the locus for strategy and learning. Such institutions have been the foundation of European corporatist industrial policy (Neven and Seabright 1995; Ornston 2013).

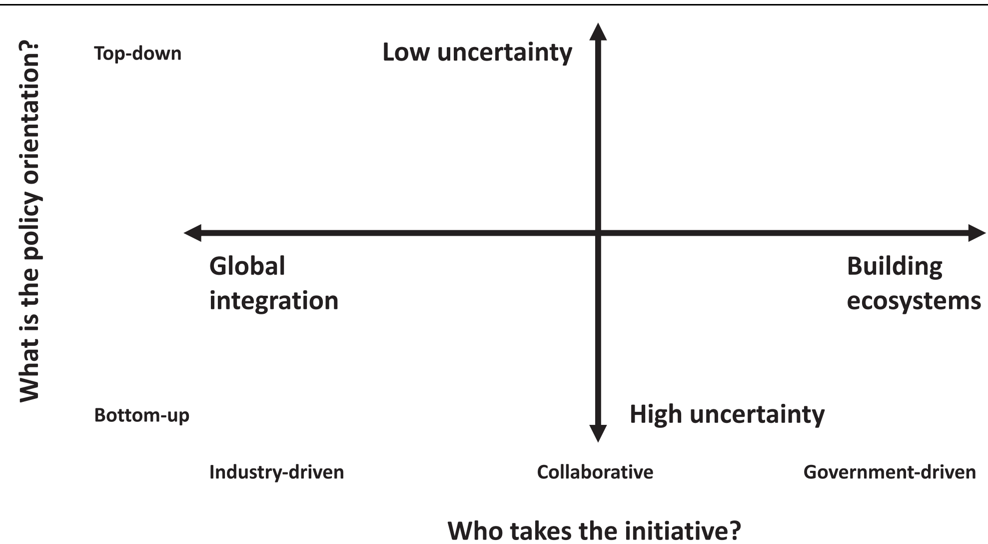
To operationalize this dimension, we examine who makes investment and technology decisions and who originates specific proposals for action. In government-driven cases, these are informed by a clear plan or strategic initiative or by a governmental agency. In collaborative cases, where origination and investment are shared, we assess whether collaborative forums and decisions are controlled by industry or government to determine a precise placement in the policy space (see Figure 2).

Combining these two dimensions allows us to map different strategies for positioning firms in global supply chains (Figure 1). Options range from targeted, state-led industrial policy frameworks—akin to those of the classic late developers—to open-ended, firm-driven industrial policy tools that support exploratory processes in which decisions are largely driven by the private sector. Yet, importantly, they also include other, intermediate possibilities. Such intermediate outcomes include open-ended, exploratory industrial policy measures in which key decisions are nonetheless driven by the state, and targeted industrial policy measures, in which firms nonetheless make investment decisions and drive technology choices.

## STRATEGIES OF GREEN INDUSTRIAL POLICY

Why do states pursue one strategy for green industrial policy rather than another? We begin with policymakers

**FIGURE 1. Varieties of Green Industrial Policy**



who are working to bolster their domestic economy via sectoral strategies. The choice to pursue industrial policy within the context of climate is taken as exogenous (Meckling et al. 2015). In the context of the current global economy, this means supporting their firms to lead the formation of or break into global value chains.

In this task, policymakers are creative problem solvers working under domestic and global political constraints. Policymakers work with firms, experts, and civil society organizations to identify policy solutions that are both politically and technically viable. In the neoliberal era, the effort was constrained by ideological guardrails, but many states still pursued active policies. With those guardrails weakened or removed, the features of the sector itself can shape policy development.[2] Driven to respond to climate change and compete with China, policymakers are now finding ways to creatively act. When they do so without ideological constraints, they must grapple with the specific conditions they find in the industries they are seeking to establish or change.

We highlight two salient sectoral features: uncertainty and the global position of the industry that the government is trying to boost. When uncertainty is low, states can set clear targets and benchmarks to guide action. When uncertainty is high, they tend to employ open-ended strategies that do not specify technological or deployment outcomes. When states seek to build supply chains and industrial ecosystems, they take an active role in coordinating firms and generating investment. When they aim to integrate firms into global supply chains, they delegate investment and technology decisions to firms. Figure 1 presents an overview of the argument.

## Uncertainty: Technological and Socioeconomic Unknowns

The first element of the strategic context is the need to grapple with uncertainty. Industrial policies, especially those aiming to build low-carbon or net-zero industries, are forged in the face of uncertainty about future technological and socioeconomic developments (Hughes, Strachan, and Gross 2013; Sabel and Victor 2022). Technological uncertainties are unknowns about which solutions will work efficiently and reliably. Socioeconomic uncertainties are unknowns about what solutions will work within social, economic, and political landscapes (Geels et al. 2017). These combine to produce important unknowns surrounding which technologies are likely to work at a commercial scale, which downstream markets those technologies will feed into, and how competition between technologies and transition pathways will play out in light of policy and consumer preferences. These forms of uncertainty shape the choice of a targeted or open-ended policy orientation.

In the classic East Asian cases, uncertainty over which technology systems needed to be created was low: Japan and Korea were benchmarking to existing technologies and supply chains in the West (Amsden 1989; Johnson 1982). In such cases, states recognize or learn that a targeted approach is feasible and likely to be effective. Some supply chains in the energy transition, such as those for critical minerals, are mature enough to be subject to targeting.

By contrast, at the technological frontier, where uncertainty is high, states cannot benchmark. Targets are difficult to set and are likely to be irrelevant to the task at hand. In such a situation, states can deploy open-ended tools that function as search processes. Industrial policies at the technological frontier explore the possibility space through research and experimentation (Sabel and Victor 2022). States deploy open-ended policies when there is high uncertainty about what technologies will be successful in positioning domestic firms in global industries.[3]

## Global Position: Building Domestic Supply Chains and Global Integration

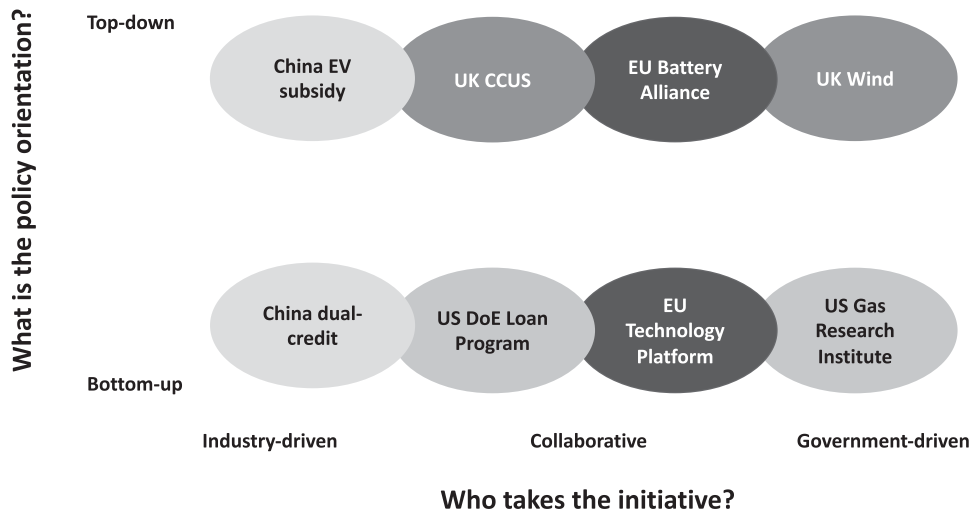
The second element is the global position of the domestic industry in relation to global supply chains. Is the industry nascent or mature in the country, and is the global value chain nascent or mature? This has important effects on state strategies. First, the challenges of building nascent low-carbon or net-zero industries and their supply chains require more active and collaborative strategies. For instance, the need to create new markets in a short period of time requires aligning and sequencing supply-push and demand-pull strategies (Nemet 2009). In addition, governments have learned that complex manufacturing and production technologies are best established in regional development clusters that need government support (Berger 2013; Piore and Sabel 1984). These tasks require coordination. In order, for instance, to establish a full domestic EV supply chain, states often need to build entire ecosystems of domestic firms. This means incentivizing the creation of new firms along the supply chain, coordinating among private sector firms, and establishing the R&D base to support the development and commercialization of new technologies.

Second, states can use firm-driven policies to integrate mature industries into global value chains by fostering competition either between domestic firms or against foreign firms. This insight builds on the

[2] The microfoundations of our argument bring together creative, Deweyan satisficers (not rationalist optimizing agents) with the practical characteristics of the sector itself—the degree of technological and sociopolitical uncertainty and the structure of the industry domestically and globally. Our assumption is that in a pure search, Deweyan policymakers will find a workable (not optimal) solution that maps to the industrial development challenges they face, while using and adapting the institutions and ideas at hand. In this sense, solutions are shaped to the characteristics of the problem as posed (a key theme in Dewey), but in a path-dependent way. See Allan and Meckling (2021), Berk and Galvan (2009), Dewey (1921), Kalyanpur and Newman (2017), and Sabel and Victor (2022).

[3] Importantly, uncertainty is not an exogenous property of the world but is experienced relationally in the context of specific problems (Dewey 1921, 181–2, 309–10). This means that uncertainty can rise as a sector or industry develops.

**FIGURE 2. Case Selection**




literature on market reforms in East Asian developmental states (Chen and Naughton 2016; Fields 2012). In Taiwan, South Korea, and China, states used "competitive industrial policies," which selectively deployed market pressures to shape industries. Such interventions are still industrial policy because the state is creating a framework to channel firm behavior in certain directions, but ultimately decisions about what to invest in or prioritize are left to firms. China, a case we examine in this paper, created a green production market for EVs that increased the cash flow of favored firms while allowing market signals to drive learning across the industry.

States employ government-driven tools when they aim to establish entire domestic supply chains in ways that require coordination and planning. States are only likely to foster competition when supply chains and regional development clusters are already formed and operating effectively. Under these conditions, firm-driven policies can allow the industry to scale domestically and internationally.

## RESEARCH DESIGN AND CASE SELECTION

This study is designed to build theory and map the possibility space of green industrial policymaking beyond the targeted, state-driven approaches that informed much existing scholarship on industrial policy. The research design aims to explain the varieties of green industrial policy on display by demonstrating the effects of sectoral-level characteristics on policy choice. We argue against alternative explanations that emphasize ideology (whether or not state intervention is considered appropriate or effective) and institutions (centralized or decentralized economic policymaking). Such explanations cannot account for the new generation of green industrial policy because now the same states use different strategies, at times within the same sector. Even if ideology and institutions restrict certain states to using only a part of the policy space, states still have room to maneuver.

For the purposes of building theory, we select cases that cover the policy space and exhibit both horizontal and vertical variation (George and Bennett 2005; Gerring 2007; Ragin and Schneider 2011). Our cases are drawn from traditionally liberal countries (United States and UK), a more statist policymaking country (China), and the European Union (EU), which has historically been a steward of the liberal economy but is developing statist orientations and institutions (McNamara 2023). However, these classifications are dated, if they were ever accurate. To support the disconfirming national-level claim, we include two cases from each country to show that the same jurisdictions use approaches with differing levels and kinds of government intervention. To support the positive sectoral-level argument, the mix of cases includes one least-likely case for each of the four policy types: targeted (UK), open-ended (China), government-driven (USA and UK), and firm-driven (China) (Gerring 2007, 237–9). In addition, we explore a negative case (the EU's response to the U.S. Inflation Reduction Act) to help refine the theory.

Our case selection includes two instances of horizontal variation (UK and USA) and two cases of vertical variation (China and EU) (see Figure 2) to illustrate how different strategies are used to address distinct industrial policy challenges. In doing so, we emphasize the role of uncertainty in driving within-sector variation in China and the EU. We focus on the role of the relative position in global supply chains in cross-sector variation in the UK and the USA (see Table 1).

By matching cases along these two dimensions, we provide a map of the strategic choices faced by industrial policymakers and the options they have available to them. We recognize that ideology and institutions can constrain the policy space and return to these constraints in the case discussion and conclusion.

**TABLE 1. Case Summary**

| Country | Variation | Case | Key factor and goal |
|---|---|---|---|
| China | Orientation/ vertical | Dual credit (2022) | Uncertainty high: shift from catch–up to compete at EV technology frontier |
| | | EV subsidies (2009) | Uncertainty low: China targeting catch–up with Western EV leaders |
| European Union | Orientation/ vertical | Battery Alliance (2018) | Uncertainty low: Europe targeting catch–up with China in known supply chains |
| | | Technology Platform (2022) | Uncertainty high: compete at EV technology frontier |
| United Kingdom | Initiative/ horizontal | CCUS (2020) | Global integration: CCUS has incumbents and existing ecosystem but must compete |
| | | Offshore Wind (2013) | Nascent global position: build domestic ecosystem for offshore wind |
| United States | Initiative/ horizontal | Gas Research Institute (1976) | Nascent industry: build entire ecosystem for natural gas |
| | | DOE Loan Program (2008) | Global integration: commercialize and scale U.S. firms |
| European Union | Negative case | Hydrogen strategy (2023) | Institutional constraints prevent government–led response needed to build ecosystem |

## GREEN INDUSTRIAL POLICY IN COMPARATIVE PERSPECTIVE

The cases show that industrial policy is not conducted solely by centralized and hierarchical government bureaucracies with dirigiste approaches to governing the domestic economy. Some traditionally statist governments use market-based incentives, and liberal market economies use state-led industrial policies. They also show that policymakers design policies adapted to the industrial development challenges they confront in the sector. However, under uncertainty and with a variety of institutional and interest group pressures impinging on the process, industrial policy choices are not predetermined. They exhibit the agency and work of policymakers.

### China: The Dual Credit System and EV Subsidies

China has used a variety of policy tools to build a competitive domestic EV industry. We focus on the targeted subsidies with technological requirements for EVs in place before 2017 and the relatively open-ended credit system instituted to replace them. In addition to these measures, China also used research institutes and universities to lead open-ended research programs on battery chemistry, among other industrial policy measures to reduce reliance on global automotive sectors by building a domestic EV alternative (Kennedy 2018). The key policy shift of interest in this paper is the shift from subsidies to the dual credit policy. The variation between the two time periods marks an important transition from highly targeted to a more open-ended industrial policy, reflecting changing levels of technological and socioeconomic uncertainty in China's EV sector (Table 1). As China's firms moved closer to the global technological frontier in battery technology, it became imperative to innovate new vehicle models to create customer demand for EVs in ways that could not be fully benchmarked. In our framework, this case of vertical movement is explained by changing forms of uncertainty.

Creating a competitive domestic automotive supply chain has been an industrial policy objective in China going back to the 1980s, when the central government in Beijing began inviting foreign auto manufacturers to form joint ventures (JVs) with domestic firms to encourage technology transfers. Until recently, few independent Chinese manufacturers were able to compete. In this context, China's central government embraced the electrification of transport as an opportunity to build competitive independent auto manufacturers. After a period during which green industrial policies for China's EV sector targeted state-chosen technologies through benchmarking, the 2017 dual credit scheme was technologically agnostic and let firms make decisions about the vehicle types to invest in. The dual credit system, run by the Ministry of Industry and Information Technology (MIIT), asked car manufacturers to sell a percentage of their overall fleets as EVs (Kennedy 2018). The central feature of the policy was that automakers had to earn credits equivalent to a percentage of their overall car sales in China, set at 10 percent in 2019 and increasing to 18 percent by 2023 (Kennedy 2018). Although the government did not prescribe the use of specific battery technologies or other technological features, it did include incentives to reward greater range and lower energy consumption of vehicles with additional credits. Based on the characteristics of China's EV fleet, the policy requirement boosted EV sales to 3 percent of overall car sales in 2019 and 4 percent in 2020 (ICCT 2018).

Previous top-down industrial policy initiatives created strong incentives for domestic auto and battery firms to improve their technological capabilities and catch up with global competitors. Such measures included direct subsidies that were available only for vehicles made by domestic manufacturers using batteries that met certain technology criteria. However, once domestic firms began to meet the technological standards of their foreign competitors, benchmarking became both more difficult for the state and less productive for the development of a domestic industry. At this point, consumer adoption of EVs depended on far more uncertain choices about what types of cars to sell. The dual credit system sought to maintain a domestic market for EVs as direct subsidies were being phased out. Importantly, in contrast to the previous benchmarking of battery technologies, it lets firms choose their vehicle portfolio, their business models, and make technological choices (Kennedy 2018).

Although the policy was agnostic on battery chemistry and other technologies that car manufacturers chose, it did provide a significant advantage to manufacturers that did not produce cars with conventional combustion engines. Carmakers that exceeded their credit requirements were allowed to sell credits. Automakers falling short, by contrast, needed to purchase such additional credits to avoid penalties that included production caps for future years. Manufacturers that only produced EVs benefited because they far exceeded their credit requirements. Except for Tesla, all of them were domestic Chinese firms, which were able to secure substantial revenue streams as a result. Tesla alone announced credit sales worth USD 1.6 billion in 2020. Chinese EV companies were reportedly selling vehicles below cost and using credit sales to reach profitability (Yang 2021). Opening the credit system to foreign companies like Tesla may appear counterintuitive, but it ensured that domestic carmakers did not fall behind technologically and continued to compete with one of the world's most advanced EV manufacturers. The more open-ended and firm-driven policy fostered competition among domestic and foreign firms while ensuring that these firms explored the uncertainty regarding consumer preferences.

The choice of an approach that leaves both technological and investment decisions to the firms themselves contrasts sharply with the industrial policies that the dual credit system replaced. China's domestic subsidy system for EVs, first piloted in select cities in 2009, had detailed eligibility rules based on technical criteria and manufacturing locations that largely discriminated against foreign battery producers. To qualify for the subsidy, EV models were required to utilize batteries from a manufacturer listed on a government White List, which, in turn, included primarily domestic Chinese battery firms. In addition to technical requirements for safety measures and energy consumption, vehicle batteries also had to meet battery density requirements, which further narrowed the battery chemistries manufacturers were able to choose from (ICCT 2019). Although subsidies were supposed to be fully replaced by the dual credit system in 2020, the COVID-19 pandemic and the subsequent economic recession led to their extension through 2022, albeit with stricter technical requirements.

The shift between different industrial policy strategies reflects the growing uncertainties and domestic technical capabilities at two stages in the development of China's domestic EV industries in the broader global auto sector. Stricter benchmarking and technical requirements were used during a period in which China was actively seeking to catch up to foreign manufacturers. Benchmarking was possible, as China was actively catching up to foreign, more advanced battery manufacturers. Once battery technology had matured, the dual credit system encouraged auto manufacturers to instead focus on exploring which model portfolios could increase market demand, while retaining incentives for longer-range models. The challenges addressed by different industrial policy choices can occur simultaneously: with both a subsidy program with strict technical requirements and the dual credit system in place until 2022, the central government was using different tools to shape different aspects of industrial development as it positioned its domestic EV supply chain in the global automotive industry.

## Europe: European Battery Alliance and Technology and Innovation Platform

Prompted by China's dominance in EVs and their highest-value components, batteries, the EU employed several industrial policy tools to build a domestic battery supply chain. We focus here on two elements of the EU's industrial policy for batteries that address two distinct policy challenges: first, the EU Battery Alliance (EBA), which attempts to replicate a domestic supply chain in a process of catch-up development, and second, the EU Technology Platform, which seeks to develop new battery technologies at the technological frontier. Both strategies use a collaborative approach to position domestic firms in global clean energy industries, but they vary by the level of uncertainty they confront. In trying to gain a foothold in the China-dominated battery industry, the EU chose to adopt a targeted approach. In order to maintain that competitiveness, long-term, open-ended policies to accelerate innovation at the frontier were necessary (Table 1).

In 2020, the EU overtook China as the world's largest market for EVs for the first time (IEA 2021), yet lacked a domestic battery industry. Batteries are the highest value-added component in battery electric cars. Despite the importance of the automotive industry to many European economies, Europe trailed Japan, South Korea, and China in battery R&D and manufacturing capacity. To build a domestic battery industry and reduce reliance on non-EU suppliers, the European Commission in 2017 launched the EBA as its central industrial policy initiative.

The EBA is a targeted, collaborative industrial policy that seeks to position existing European industrial actors along the entire battery supply chain and to financially support the establishment of manufacturing facilities on European territory (European Commission 2021). The European Commission estimated that, by 2025, the EU battery market will grow to EUR 250 billion annually. To capture this market domestically, an investment of

EUR 20 billion would be required to build ten to twenty gigafactories (European Commission 2018). The choice of a targeted industrial policy strategy was possible because the goal—a domestic battery supply chain—could be clearly defined and observed in other economies. A key target of the alliance was the positioning of domestic firms in the supply of raw and processed materials, cell component manufacturing, cell manufacturing, battery pack manufacturing, the production of battery EVs, and recycling. A collaborative, long-term approach allowed for the coordination of large numbers of existing industrial actors that needed to fill individual segments of the supply chain. These firms also needed to be supported financially in building R&D and production capacity to meet the EU's industrial development goals.

The alliance brought together the European Commission, the European Investment Bank (EIB), EU national governments, research institutes, and more than 500 industry actors along the entire battery supply chain. In collaboration with industry partners, the EBA established a strategic action plan. The plan focused on developing secure access to raw materials and refining capacity, establishing manufacturing capacity along the battery supply chain while reducing its environmental footprint, training a domestic workforce, and supporting R&D to both advance existing lithium-ion batteries and build European intellectual property for next-generation technologies (European Commission 2021). The EBA relied on different financial instruments to reach its targets, including loans from the EIBs, R&D funding from the European Innovation Fund, and direct support from the European budget. It also called on national governments to align their industrial policy strategies with targets of the alliance and established a novel funding mechanism for cross-border industrial policy initiatives. For so-called Important Projects of Common European Interest (IPCEI), including the establishment of a battery industry, the European Commission exempted national governments from the restrictions regarding state support to the private sector. Two EU-wide battery initiatives were approved under the IPCEI framework in 2020 and 2021. They were funded with EUR 3.2 and 2.9 billion, respectively, to support R&D collaborations between industry partners and research organizations along the battery supply chain. The EBA coordinated both national industrial policies and industrial actors along the battery supply chain and provided financing instruments to meet investment targets.

By 2021, public funding had led to the construction launch of 15 lithium-ion battery plants across Europe. The Swedish startup Northvolt, established in 2016 to commercialize a low-cobalt lithium-ion technology, was able to use an EIB loan to secure additional investment from financial institutions and automotive companies (Vaish 2019). With EUR 1.3 billion of public funding from France and Germany, a JV between the oil company Total and the automaker Groupe PSA began building two gigafactories in France and Germany (Parnell 2020). Several projects received loans directly from the EIB. The EIB also backed the construction of a factory for cathode active material in Poland by the Korean manufacturer LG Chem (EIB 2020).

The targeted benchmarking of the EBA differs from the open-ended, collaborative approach taken by the European Technology and Innovation Platform on Batteries (ETIP Batteries). ETIP Batteries brings together research and development actors in industry and research organizations to define a European research agenda on next-generation battery and battery manufacturing technologies. It issues calls for proposals to fund R&D projects on battery chemistry, materials, and manufacturing processes (European Commission 2022a). The platform takes on a long-term coordinating function among various actors. Because technological advances entail high degrees of uncertainty, it takes an open-ended approach to defining the research agenda for the European battery industry. Research priorities are developed by working groups and task forces ranging from battery technologies and raw materials to manufacturing and sustainability (European Commission 2022b). Although working groups are tasked with different topics, they themselves make decisions on promising research areas and technological developments in a collaborative fashion. While both cases are collaborative with strong government-driven elements, ETIP Batteries are is open-ended so that they can explore uncertainties at the technological frontier.

## The United Kingdom: Carbon Capture and Offshore Wind

Seeking to position its firms in emerging global net-zero supply chains, the UK launched industrial strategies for offshore wind, hydrogen, and carbon capture, usage, and storage (CCUS) (United Kingdom 2013; 2021a; 2021b). The wind and CCUS strategies are similar in their overall structure, but there are important differences that our framework can account for. Uncertainty in both cases is manageable because the technologies and their net-zero role are understood well enough to set clear deployment targets. However, the two cases differ on who takes the initiative in investment. Thus, the UK presents a case of horizontal variation that illustrates the importance of varying global positions, contrasting the establishment of a nascent supply chain with the global integration of domestic firms. The domestic wind industry was nascent and so a more active government-driven strategy was needed to build supply chains. In the case of CCUS, the target industry is oil and gas, which already has mature supply chains and firms. There, the government aims to support the growth of the industry and position it in global markets using a collaborative, but more firm-driven investment strategy (Table 1).

The 2017–18 UK industrial strategy identified CCUS as a priority and laid out the ambition that the "UK should have the option to deploy CCUS at scale during the 2030s, subject to the costs coming down sufficiently" (UK 2018, 7). Initially, the strategy aimed to catalyze cost reductions and cautioned that it would not deploy CCUS at any price. In 2019, the Johnson Government added a specific target "to capture 10Mt of carbon dioxide a year by 2030" (UK 2020, 22). This was backed by a GBP 1 billion fund to build four CCUS clusters and a revenue mechanism to incentivize UK business models. The explicit goal of these measures is a "new carbon capture industry, which could support up to 50,000 jobs in the UK by 2030" (UK 2020, 22). In 2021, the net-zero strategy increased the ambition to 20–30 Mt of $CO_2$ per year by 2030, following the Climate Change Committee's recommendation of 22 Mt capacity by 2030 (UK 2021b).

Although it seeks to orient the industry with targets, the UK government has been clear that it expects the private sector to lead on deployment and investment (UK 2022, 8). There is a political consideration at work here: a CCUS strategy risks being perceived as support for the oil and gas industry. This problem unwound previous efforts to enact a CCUS strategy (Green Alliance 2012; Kern et al. 2016). But in our framework, this is a key factor. The UK oil and gas industry already has a developed supply chain that can be adapted for CCUS. The UK's supply chain roadmap identifies the industry's strengths and aims to position it "at the forefront of global CCUS markets" where it can "bid for and win progressively larger major international projects" (UK 2021b, 8–9, 12).

The government's strategy is calibrated to incentivize investment by the incumbents in the industry. The government is steering investment through the CCS Infrastructure Fund (CIF), which makes funding available to any project proposed in identified regional clusters, which are selected via a competitive process. This selection process adds an element of government control. But once a cluster is set up, the application process for the CIF is open to any firm and any CCUS application. CIF applications are not directed by some larger cluster development strategy. In the end, firms make key choices about technology and investment.

The CCUS and the wind strategies differ in who takes the initiative. The UK government took a much more active role in wind in order to build a domestic ecosystem for the nascent UK wind industry. In the offshore wind scheme, investment was driven by government-coordinated lease agreements backed by the contract for difference (CfD). The CfD represents a significant financial commitment from the government. It backstops wind projects by guaranteeing a minimum price for wind energy.

The lease agreements are structured as co-investments or JVs with the Crown Estate—a crown corporation that while nominally independent reports to the Chancellor of the Exchequer. The Crown Estate provides financing and retains assets in the lease. In the early stages of wind development, the Crown Estate made the largest contribution (GBP 100 million) to a suite of funding schemes amounting to GBP 450 million of research and development, deployment, and supply chain activities (Kern et al. 2014, 641). In 2020–21 alone, the Crown Estate's marine portfolio increased 105%, from GBP 2 billion to GBP 4.1 billion due to the latest round of offshore leases (Crown Estate 2020).

The Crown Estate also serves as an independent agency that can house the expertise necessary for a successful industrial strategy. As a manager and operator of crown buildings and crown lands, it has experience managing complex assets and holding debt (Crown Estate 2021). It has in-house experts in investment, business development, and operations. With this endowment, it can step in and play the role of a small, nimble development agency to coordinate industry (Breznitz, Ornston, and Samford 2018). It now serves as the operational lead for the offshore wind sector strategy (Crown Estate 2021).

The operationalization of the wind strategy also demonstrates the importance of chance and the creative use of existing institutions to position domestic firms in new industrial sectors. The crucial role of the Crown Estate was an accident of history. The redeployment of the Crown Estate shows that creative policy entrepreneurs can make use of the tools at hand (Kalyanpur and Newman 2017). But the active role of the Crown Estate reflects the deeper fact that the nascent industry created an opportunity for a lead agency to step in and drive ecosystem development.

## The U.S. Gas Research Institute and the Department of Energy Loan Programs

The development of hydraulic fracturing for shale gas is a case where a collaborative, public–private partnership was used to drive an open-ended approach to creating new technologies and coordinating the development of a domestic supply chain. While natural gas will be difficult to integrate into truly net-zero energy systems, we include it in the universe of climate cases. Through 2016, it was regarded as a low-carbon solution, with much lower emissions than the coal-fired generation it replaced (e.g., White House 2016). For many, the USA serves as a least-likely case for the claim that states are converging on a broad menu of industrial policies.[4] Yet the natural gas case shows that the USA has a long history of industrial policy in the energy sector. Industrial policy to develop a hydraulic fracturing industry was an open-ended, but government-driven strategy to build a domestic ecosystem for a nascent industry. Uncertainty was high, since the prospects for natural gas production and consumer use were still unknown. We contrast the natural gas case with the U.S. Department of Energy Loan Programs, which are open-ended and firm-driven, since they seek to create domestic firms capable of integrating into global supply chains (Table 1) in highly uncertain technology domains.

During the 1970s energy crisis, the USA sought to bolster domestic energy supply chains. In this context, the government partnered with industry to create the Gas Research Institute (GRI) in 1976. The GRI was a public–private partnership commissioned by the Federal Energy Regulatory Commission and funded by a surcharge on interstate natural gas pipelines. Its

[4] On the hidden yet strong industrial policies of the USA, see Block (2008).

annual budget grew to USD 200 million in the mid-1980s and remained there through the 1990s (Trembath 2015). It spent billions of dollars of public money on highly visible, collaborative RD&D for natural gas development. It funded a wide variety of research projects across the supply chain from enhanced oil recovery to gas transportation to household appliances and building systems (Evans 1991).

The GRI had a clear mandate to develop solutions for the gas industry, but the government did not impose benchmarks and goals for the sector. The approach was open-ended because it was engaged in a search for uncertain technological and socioeconomic solutions all along the supply chain. It was a collaborative institution because although it deployed public funds, Marathon, Aramco, and Shell all sat on the Board of Directors. Projects were co-funded with industry players (Trembath 2015). This co-financing meant the process and investment decisions were shared between public entities and private businesses.

The GRI took a whole supply chain approach. It funded everything "from wellhead to consumer," including drilling experiments, the development of household appliances, and marketing campaigns (Golden and Wiseman 2015, 987). For example, from 1986 to 1992, the GRI funded the Gas Appliance Technology Center at Battelle (Locklin, Weaver, and Brown 1993). The Center conducted research on ranges, ovens, water heaters, furnaces, and infrastructure development. This kind of detailed work was essential to the market development and cost reductions necessary to make gas appliances competitive with electric alternatives.

The story of natural gas is usually presented as a hagiography of George Mitchell (Yergin 2021), the entrepreneur who first commercialized a combination of "slickwater" fracturing and horizontal drilling to access shale reserves. However, Mitchell benefited from the work of the GRI and learned from its predecessor, the Eastern Gas Shales Program (EGSP). The Shales Program spent USD 185 million to drill 35 experimental wells and pioneer the use of horizontal drilling (Golden and Wiseman 2015, 984). Studying these data allowed Mitchell to conclude that the Barnett Shale, long considered untappable, could be profitable (Golden and Wiseman 2015, 960). Mitchell then moved to secure land and mineral rights in the Shale. It was only after Mitchell had taken up substantial positions in the rights market that he approached the GRI, so as not to attract too much attention to his plan (Golden and Wiseman 2015, 1000–1).

After 1991, Mitchell worked closely with the GRI, which co-founded his first well in the Barnett Shale. By the late 1990s, Mitchell and the GRI had hit on a synthesis of hydraulic fracturing and horizontal drilling that recovered large amounts of gas at low cost. Due to the public nature of these collaborations, there was no patent protection for the technological synthesis developed (Cahoy, Gehman, and Lei 2012). Mitchell's play was to profit from appreciating land rights and rising gas prices. The play benefited from other federal policies as well: the creation of a national pipeline network under the authority of the Federal Energy Regulatory Commission, the deregulation of gas prices, and lenient rules for exploration rights that incentivized early action (Golden and Wiseman 2015, 982, 1002–3).

Contrast the GRI with the U.S. Department of Energy's (DOE) support for renewable energy and EVs through its Loan Programs, addressing a very different industrial development challenge. Between 2005 and 2020, the DOE managed three loan funds: one for new energy technologies, one for vehicles, and one for federally recognized Indian tribes. Together, these issued USD 35.69 billion in loans and loan guarantees between 2005 and 2020 (Department of Energy 2021). In this first iteration of the Loan Programs Office, the approach was open-ended and firm-driven. Private companies take the initiative by applying for a loan guarantee or low-cost financing backstopped by Treasury. The eligibility requirements for the program did not establish specific sectoral targets and were open to a range of technological options. The Renewable and Efficient Energy project stream, for instance, sought to fund new technologies for grid integration, biofuels, waste-to-energy, power generation upgrades, and energy efficiency projects. Even the Advanced Technology Vehicle Manufacturing (AVTM) fund, which targeted the auto sector, only required that vehicles improve fuel efficiency by 25% from a 2005 baseline or meet a fuel efficiency standard of 75 miles per gallon or equivalent with alternative fuels. These were not stringent or strategic technology standards. The program evaluation includes an indicator for greenhouse gas emissions avoided by the loans, but beyond that the program was not clearly targeted.

The difference in industrial position helps account for these differences. In the case of hydraulic fracturing, the USA employed a large RD&D institute because it needed to build an entire supply chain and ecosystem for natural gas. Government intervention was necessary to catalyze both supply and demand. However, targeting was not useful or possible due to uncertainty regarding the total addressable market. In addition, innovation was needed to improve competitiveness at each step from wellhead to consumer, driving the use of open-ended searches.

The Loan Programs, by contrast, were not designed to create ecosystems. They were established to support domestic firms that had conducted successful R&D but could not yet secure financial capital by helping them advance commercialization. Commercialization support would advance world-leading energy research and position American intellectual property in emerging supply chains. The desire to advance globally competitive industries in this context explains the use of a more firm-driven strategy.

## Green Industrial Policy after the Inflation Reduction Act

The U.S. Inflation Reduction Act (IRA) demonstrates the importance of theoretical frameworks that are open to the creativity of policymakers in a world of political possibility. The IRA has spurred strategic responses in many jurisdictions (e.g., Davies and Jun-a 2022). The EU's response to the IRA introduces a negative case because it defies our theories' expectations. By highlighting the role of institutions in constraining governments' ability to strategically respond to uncertainty and supply chain position, it refines the scope conditions and helps us balance the tensions between agency and structure in the theory.[5]

In 2020, it seemed doubtful that the USA would establish a world-changing industrial policy with robust targets and roadmaps in 27 sectors backed by powerful fiscal measures (e.g., Department of Energy 2023a). The main instruments in the IRA establish generous tax credits in critical areas and provide USD 400 billion in loan authority for the DOE's Loan Programs Office, which is now taking a more collaborative and active role than it did prior to 2020. In the case of hydrogen, for example, the IRA offers USD 3/kg, which could drive production costs below zero (Mulder 2023). The DOE will be using USD 8 billion from the Bipartisan Infrastructure Law to create targeted demand-side contracts to match the supply-push created by the tax credits (DOE 2023b).

After a strong negative initial reaction, the EU has mounted strategic responses in a number of areas (Di Carlo and Schmitz 2023; McNamara 2023). However, structural and institutional pressures have prevented the EU from developing responses in every sector, precluding, for instance, an active hydrogen strategy. While there is uncertainty about the size of hydrogen's contribution to a net-zero economy, it is clear that low-carbon hydrogen is needed to displace existing fossil-based sources of hydrogen and displace natural gas in heavy industry (especially steel and fertilizer). This degree of certainty allowed the EU to set a hydrogen target: produce 10 million tons and import 10 million tons by 2030 (European Commission 2022c). However, despite the need to create a whole ecosystem for hydrogen, the EU has yet to mount a government-led response to the IRA.

The European Commission is currently planning to support hydrogen with a passive subsidy mechanism built into the emissions trading system (Rotar, Soilihi, and Plotka 2023). The so-called carbon Contracts for Difference (CCfD) for hydrogen would cover the spread between low-carbon and gray hydrogen prices that remained after the carbon levy. As such, it provides only a passive instrument in which firms make investment decisions that are automatically subsidized. The implementing body is a variant of the Battery Alliance noted above, except the Hydrogen Alliance is far less active. The Hydrogen Alliance has a "project pipeline" of 750 projects, but it is simply an unprioritized list provided by Hydrogen Europe, a large industry group. Only small amounts of finance have been made available to support hydrogen.

Our theory expects a targeted strategy with a large government role to help build the hydrogen ecosystem. However, in practice, investment decisions are expected to be largely firm-driven and government fiscal support has been minimal. Why? The European Commission, which has the mandate for continent-wide industrial policy, is a weak federal institution. It has agenda-setting power and a small budget. Building a new industrial policy would require forging a difficult consensus. Thus, the EU is using an existing policy tool, the emissions trading system, to respond to the IRA. This is not ideal because it requires shoehorning a subsidy into a carbon market, which is designed to be firm-driven. In short, the EU's institutions are not easily adaptable to industrial policy, though capacity is actively being built and European collaboration may surprise the world again (McNamara 2023). This helps to specify the scope conditions of the argument as it shows the limits of sectoral features in driving outcomes when institutions and political structures are not easily adaptable.

## CONCLUSION

How do governments deploy industrial policy to strategically position their domestic economy in global green energy industries? This paper argues that the choice of industrial policy tools is not fully determined by national-level institutions and traditions along the statist–liberal continuum. Rather, policies are forged in sectors, where they are shaped by the industrial development challenges found there. In strategically and creatively navigating domestic and global political and economic landscapes, policymakers respond to pressures created by uncertainty and ecosystem needs. When they want firms to globally compete at the technological frontier, where uncertainty over future technological success is high, they can adopt open-ended tools. When they know what the end goals are, they can adopt more targeted measures. When entire supply chains or ecosystems need to be built, governments can take an active approach. When firms need to integrate into global supply chains, firm-driven strategies can be more appropriate.

Our framework refines work on comparative capitalisms that focuses on how interlocking sets of domestic institutions shape distinct sets of national political economies (Hall and Soskice 2001). It goes beyond the linear, more-or-less state dimensions of existing studies and helps explain the new landscape of industrial policy that has emerged in the context of climate change. Here, many kinds of governments deploy a wide variety of industrial policies. The coexistence of different types of intervention within the same industrial sector suggests that state–business relations can be problem-driven and context-specific. While national-level ideology and institutions can narrow the policy space in certain countries, states still have room to maneuver, as recent industrial policies in the USA have shown.

[5] Agency, expressed throughout this paper as the creativity of policymakers, is not unbounded. It is constrained by institutional, political–economic, and ideological structures.

The analysis opens several avenues for future research. The cases challenge long-standing views on the global relationships between countries with different levels of economic development. The imperative to catch up is no longer the domain of developing countries alone. Advanced industrialized economies are now benchmarking to the levels of green industrial development of developing economies such as China. At the same time, nations of all levels of economic development are more likely to reach the technological frontier in new low-carbon industries. This induces uncertainty and undermines the utility of policies designed to imitate others. Increasingly, states are moving through the policy space along multiple pathways in response to learning, shifting political dynamics, and ideological change. We highlight just a few of the potential trajectories here (catching up; heading to the technological frontier), and future work could uncover and theorize others.

As noted above, more work is necessary to show how institutional and political factors constrain the ability of governments to choose policies from across the possibility space. Deeper process tracing could reveal the detailed dynamics of politics and learning, allowing us to see the mechanisms of strategic choice in more detail. Such studies would help us better understand cases like the EU where interests, institutions, and ideas constrain the creativity of policymakers, balancing our understanding of agency and structure in this new world.

One institutional factor of particular interest is the interaction of financial systems and industrial policies. In South Korea's industrial policy, government-driven processes depended on government-controlled commercial banks (Amsden 1989). China, despite its use of firm-driven strategies for the EV industry, has also retained strong levers of financial control through the state-owned banking system. Financial systems can offer levers of influence over firm behavior even if the industrial policies themselves are hands-off.

For the purposes of this paper, we have bracketed the question of whether these strategies are likely to succeed. Further work is needed to evaluate the effectiveness of the ideal policy types we outline here under different sets of conditions. Nonetheless, this paper does have a normative dimension in that it offers a tool for policy action. Our framework outlines a menu of policy options for states and suggests a set of pressures and dynamics that might inform policy design. The goal should not be to provide a reductive formula. There are so many factors at play in the real world that simple rules will inevitably mislead. That does not mean social science theory is not useful. Decision-makers can use frameworks like the one presented here to improve policy. They can do so by understanding the dynamics and pressures they are likely to encounter and by learning how others have solved the industrial development challenges they confronted.

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## CONFLICT OF INTERESTS

The authors declare no ethical issues or conflicts of interest in this research.

## ETHICAL STANDARDS

The authors affirm this research did not involve human participants.

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