Perspective

The geoeconomic turn in decarbonization

https://doi.org/10.1038/s41586-025-09416-x

Received: 7 October 2024

Accepted: 16 July 2025

Published online: 24 September 2025

Check for updates

Jonas Meckling[1,2]✉

The rise of green industrial policy is transforming efforts to decarbonize the global economy and mitigate climate change. The first three decades of climate policy centred on international cooperation on dividing up the costs of mitigation. In the new era of green industrial policy, geoeconomic competition for the benefits of decarbonization has emerged alongside international cooperation on emissions reductions. Governments invest in the manufacturing and deployment of clean technologies to advance economic development, energy security and emissions cuts. Geoeconomic competition has the potential to accelerate global decarbonization by facilitating greater technology deployment, speeding up technology cost declines and, thus, lowering the barriers to climate action. However, it also creates major pitfalls by facilitating the rise of trade protectionism, creating international conflict, and reproducing economic divides between richer and poorer, yet growing, countries. It is thus uncertain how the geoeconomic turn will impact global decarbonization. Meanwhile, policymakers are asking fundamental questions about how to design industrial policy, manage politics, develop institutions, and deal with the trade-offs between economic, climate and security goals. This Perspective demonstrates the recent geoeconomic turn in decarbonization, lays out its implications for policymaking, identifies global spillovers and addresses research needs.

The world's effort to decarbonize the global economy has undergone a geoeconomic turn. The new era of decarbonization centres on economic benefits as opposed to costs, and on global competition as opposed to cooperation. Industrial policy is the primary tool in the new geoeconomics of decarbonization.

For 30 years, countries have focused on international cooperation on emission-reduction targets under the umbrella of the United Nations as their primary collective response to climate change. Decarbonizing has, by and large, meant shouldering economic costs today in exchange for lower adaptation costs in the distant future. International climate politics has long been centred on global collective action to facilitate 'burden sharing'. More recently, geoeconomic competition for the benefits of decarbonization has emerged alongside global cooperation to share the cost of mitigation (Fig. 1). Steep drops in the cost of clean energy technologies and China's dominance in clean energy supply chains have unleashed competitive dynamics among economies. Countries are vying for their stake in growing green industries by adopting industrial policies. These emphasize technological leadership and national competitiveness, not emissions cuts. Such industrial policy seeks to shift the structure of an economy from dirty to clean technologies. Supply-side policies promote research and development (R&D) and manufacturing, whereas demand-side policies increase the domestic use of clean technologies. Policy tools include public investment, trade policy, regulatory standards and government procurement.

Geoeconomic competition has the potential to accelerate global decarbonization while also creating major pitfalls—the outcomes are uncertain. Yet what is clear is that the rise of green industrial policy (GIP) competition has profound implications for policy practice and applied research on how to decarbonize the global economy. Policymakers are asking fundamental questions about how to design policy, manage politics, develop institutions, and deal with the trade-offs between economic and climate goals. The stakes are high: GIP puts substantial public resources to use and its historical record is mixed. If the rise of GIP leads to high costs without tangible economic and climate benefits, political backlash may ensue, setting back decarbonization. Meanwhile, the climate social sciences have paid—with few exceptions—scant attention to the role of geoeconomics in decarbonization[1,2]. They thus need to adapt their research agendas in the face of new empirical realities and changing demands from policymakers.

In this Perspective, I show what drives the rise of GIP and lay out its implications for domestic policymaking, discuss the global spillovers, engage with policy options to mitigate negative spillovers, and identify research needs.

The rise of GIP competition

The geoeconomic turn in climate policy has long been in the making. Yet it is the recent scale of the competitive response of the USA and Europe to China that transformed a trend into a turn. GIP has risen gradually since the beginning of the century. It started out with the diffusion of demand-side policies, such as feed-in tariffs, supporting the deployment of clean technologies[3,4], followed by the addition of supply-side policies supporting and protecting the production of clean technologies and inputs, with China in the lead[5] (Extended Data Fig. 1).

[1]Department of Environmental Science, Policy, and Management, University of California Berkeley, Berkeley, CA, USA. [2]Harvard Business School, Harvard University, Boston, MA, USA. ✉e-mail: meckling@berkeley.edu

	Cooperation	Competition
Costs	UN climate negotiations (GHG targets and timetables)	Exporting climate policy costs (for example, EU CBAM)
Benefits	Cooperative green industrial policy (for example, 'friendshoring' supply chains)	**Industrial policy competition (subsidies, trade barriers)**

Fig. 1 | From cooperation on costs to competition for benefits. The expansion of global climate policy from cooperation on costs to competition for benefits. CBAM, Carbon Border Adjustment Mechanism; GHG, greenhouse gas; UN, United Nations.

Economies beyond China began to adopt supply-side industrial policies in their 2009 stimulus packages[6,7]. These included some financial support for manufacturing, next to deployment incentives[8,9]. Subsequently, global GIP adoption grew substantially, accelerating in the late 2010s (Fig. 2a). Alongside subsidies for domestic industries, countries began to adopt tariff and non-tariff barriers on Chinese clean technology exports[10]. In the early 2020s, major economies scaled their GIP efforts, with the US Bipartisan Infrastructure Law of 2021, the US Inflation Reduction Act of 2022 and the European Union (EU) Clean Industrial Deal of 2025 as key policy packages.

Overall, China, the EU and the USA accounted for about 60% of all GIP measures in 2023 in the data for Fig. 2a, with China having 2.5 times and 3 times as many active measures as the USA and EU, respectively. About 65% of all measures in 2023 targeted low-carbon technologies and 35% targeted critical minerals (Fig. 2a). Among low-carbon technologies, electric vehicles—including batteries—have seen the greatest growth in GIP activity (Extended Data Fig. 2). Throughout the rise of GIP, strategic competitiveness and climate change have been the major motives policymakers reference in policy adoption (Fig. 2b). Three converging dynamics propelled the rise of GIP competition: cost declines, China's manufacturing dominance and political shifts in advanced economies.

First, some clean energy technologies have achieved or are close to achieving cost parity with fossil fuels. This includes solar and wind power, as well as electric vehicles. Relative cost reductions thus begin to transform the logic of decarbonizing the electricity and passenger transport sectors from cost to benefits. Admittedly, progress in these sectors is only part of the solution to climate change—electricity and transport account for only 38% of global greenhouse-gas emissions[11]. Yet the future cost competitiveness of other clean energy technologies—although by no means all—is in sight[12,13]. R&D, economies of scale and learning-by-doing have driven down costs[14]. Importantly, technologies vary in the cost reductions they achieve over time, that is, their learning curves. Small-scale and less-complex technologies tend to reduce their costs more rapidly than large-scale and complex technologies[15–17].

The industrial policies of first movers, including deployment incentives in Europe and China's expansion of manufacturing capacity, have facilitated cost declines. In turn, cost declines have changed the economic expectations of governments and companies for clean technologies, thus accelerating public and private investment.

Second, China's rise to dominance across clean energy supply chains kicked other major economies into gear to pursue their own green industrial strategies. The combination of government support and innovation in production processes led Chinese firms to rapidly scale solar and wind manufacturing in the 2000s, followed in the late 2010s by batteries and electric vehicles[18,19]. After the initial bottom-up emergence of industrial policies in Chinese provinces, the Chinese government officially identified 'new energy'—including solar photovoltaics and wind—and electric vehicles as 'strategic emerging industries' in 2010. In 2015, the national government adopted the 'Made in China 2025' strategy, ushering in a new wave of better-funded industrial policies with a focus on expanding innovative capabilities[20]. By 2023, China had accumulated more than two-thirds—and in many cases, above 90%—of global manufacturing capacity for major clean energy technologies, including solar photovoltaics, batteries, electric vehicles, electrolysers and heat pumps[21]. In addition, in 2023, China provided the majority of refined lithium, cobalt, graphite and rare earths globally, as well as holding substantial stakes in the markets for refined copper and nickel[22].

China's dominance in green industries propelled other major economies to pursue GIP for both economic and energy security reasons. Intensifying regime rivalry between China and Western powers turned overreliance on Chinese supply into a perceived security concern.

Third, emerging geoeconomic competition met conducive domestic politics, resulting in policy coalitions in support of GIP cutting across climate advocates, business and security interests. The Green New Deal movement advocated for public investment in decarbonization, pushing for a greater role of the state in the clean energy transition[23,24]. Business has often supported public investment in clean energy technologies over climate regulation such as carbon pricing or standards. Climate regulation imposes politically salient costs on companies and voters, whereas GIPs offer financial benefits to producers and consumers, while often spreading the cost across all taxpayers and thus making them less salient[25]. What some consider the relatively high political feasibility of GIP, others consider its vulnerability to rent-seeking and regulatory capture by industry[26,27]. Meanwhile, policymakers concerned with energy, economic or national security have championed GIPs. For example, European policymakers supported renewable energy policy, among other reasons, to reduce gas import dependence on Russia[28]. US legislators also adopted policies to advance alternative transport technologies such as the hydrogen fuel cell to reduce oil import dependence on the Middle East following the 9/11 attacks. In recent years, both the EU and the USA have advanced GIPs to reduce clean technology import dependence on China[6].

National GIP

Geoeconomic competition in green industries has led policymakers to grapple with how to develop and implement green industrial strategies that advance national competitiveness—including questions of policy goals and design, implementation capacity, and economic capabilities.

Policy goals and design

GIP combines climate mitigation with the economic goal to enhance national competitiveness, with countries exploring three types of strategy[29,30]. One is to develop competitive export industries. Major economies such as China, the EU, Japan, South Korea and the US have been developing industries that produce final products for export. Other countries export intermediate products and resources to feed global supply chains. Malaysia, for instance, is positioning itself in the global electric-vehicle supply chain, whereas Chile and Indonesia have emerged as mineral exporters. Emerging economies see clean energy technologies increasingly as an opportunity for industrial upgrading[31]. These technologies frequently exhibit lower barriers to market entry owing to lower technological complexity than incumbent technologies[32]. Some economies are also exploring the export of services, such as renewable energy project development[33].

A second strategy is to build domestic green industries to substitute for imports, specifically in economies with large domestic markets. Brazil and India are trying to develop a domestic solar industry to replace Chinese imports[34]. This extends to industrialized countries that are catching up in some industries—the EU and the USA are trying to develop domestic battery industries to substitute for imports from China, Japan and South Korea. While these first two strategies are

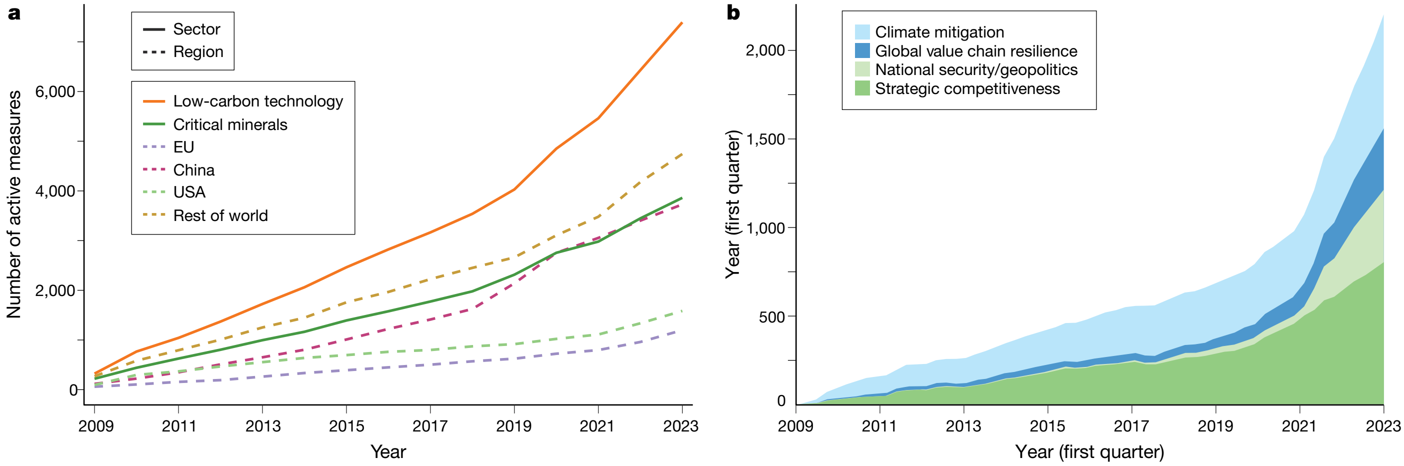


Fig. 2 | The rise of GIP. a,**b**, The active industrial policy measures for low-carbon technology and critical minerals by target sector and region (**a**) and motive policymakers ascribe to policy (**b**). Based on data from ref. 131. Panel **a** is based on annual data, **b** on quarterly data. See Supplementary Note 1.

focused on manufacturing, open questions relate to the importance of manufacturing for growth[35] and whether policymakers should focus on leveraging latent comparative advantages or develop new ones, or how to balance the two goals within a country's strategy[31,36].

A third strategy is to deploy renewables to reduce electricity cost to stimulate economic activity[37]. The widespread adoption of productivity-enhancing technologies across sectors has historically advanced national competitiveness[38]. Mexico, for instance, has prioritized cheap renewable electricity for industrialization over the creation of domestic renewable energy industries[39]. The electricity demand surge from the rise of artificial intelligence has increased interest in clean energy deployment to enable artificial intelligence expansion as a growth engine. It remains to be seen whether renewables and, for instance, battery storage, are general-purpose technologies that increase productivity across the economy by reducing electricity costs[40]. These three economic strategies increasingly interact with energy security goals focused on securing supply of clean technologies and critical minerals and limiting price volatility.

Policy design—including policy mix and trade openness—affects economic and climate outcomes (Table 1). First, GIP entails broad policy mixes of different instruments used together and sequentially[41]. Supply-side policies tend to be more important early on, whereas demand-side policies become more relevant as technologies diffuse[42]. Although research has examined what policy mixes are effective at advancing clean energy deployment and greenhouse-gas emission reductions[43,44], we need to better understand what policy combinations are best suited to create competitive green industries and in what sequence they are best deployed[45–48]. To be effective, it is important that policy mixes directly address the underlying market failures[36], including environmental externalities, technology spillovers, coordination failures and innovation path dependence[49–51], and be responsive to sector characteristics, such as capital intensity, technological complexity and need for product customization[45,52].

Second, GIPs can be open-economy or closed-economy policies, with important implications for whether geoeconomic competition is zero sum or positive sum[53]. Open-economy policies tend to be export-oriented and focus on integrating domestic firms in global supply chains[54]. Technology leaders often pursue open-economy policies and tend to adopt open-ended goals that allow for exploration at the technology frontier[55]. By contrast, closed-economy GIP uses tariffs and local content requirements to incentivize domestic production to reduce imports. Countries catching up with the technology frontier often resort to some level of protection, while providing specific guidance to industry. In recent years, the EU has pursued a relatively more open GIP, whereas the USA has leaned towards a more closed GIP with the Inflation Reduction Act. Yet both economies are catching up with China in several technologies and are facing protectionist pressures.

There are important additional design dimensions that affect policy effectiveness, including conditionalities that ensure that public investment delivers economic and climate outcomes[56–60], and compensation that helps mitigate opposition from the economic losers of green industrial change[61–64].

Institutional and fiscal capacity

Implementing GIP effectively requires high levels of state capacity, including institutional and fiscal capacity, both of which vary substantially across countries[65,66]. Advanced industrialized countries have largely lacked the institutional infrastructure for industrial policy and are now experimenting with institution building[67–70]. This includes setting up new agencies—such as the European Climate, Environment, and Infrastructure Investment Facility—and developing forms of public–private collaboration, for example, the European Battery Alliance[71,72].

Institutions for industrial policy need to perform a few core functions. First, policymakers need to learn about market and technology trends, given the fundamental information asymmetry between government and markets. This requires public–private interaction to ensure knowledge flows and learning, including through consultation, network building, and joint goal-setting and implementation[73,74]. Second, government actors must be sufficiently autonomous from business. This allows them to take risks and enforce conditionalities by, for instance, withdrawing funding if firms do not meet performance standards[75]. Without some level of autonomy, bureaucracies fall prey to rent-seeking and regulatory capture by industry[26,27]. These risks call for institutionalizing policy evaluation to enable governments to manage economic rents and adjust policies and programmes during their implementation[76]. Third, institutions need to be accountable to the public to maintain legitimacy[49]. However, they face an 'agility–accountability dilemma'—the more accountable an institution is, the less agile it is in taking risks[73]. Fourth, institutions need to help resolve coordination problems. These arise along the supply chain—for instance, between the supply and demand for electric vehicles—and between technologies and infrastructure, such as electric vehicles and charging infrastructure[77,78]. Extending earlier work on developmental and innovation agencies, scholars must identify effective institutional models for making GIP and clarify their scope conditions[7,79,80]. It is also critical to understand how to 'right-size' GIP to institutional and fiscal capacity constraints.

Cross-national variation in fiscal space—the ability to raise taxes and borrow debt—also matters to industrial policy outcomes. Although rich and poor countries differ in fiscal space, there is also variation among

Table 1 | Variation in GIP choices

	Open-economy GIP	Closed-economy GIP
Supply-side policy	Subsidies and/or tax credits for R&D, demonstration, manufacturing and infrastructure → develop export industry	Tariffs, joint venture requirements → substitute for imports
Demand-side policy	Deployment subsidies/ mandates, tax credits, public procurement, advanced market commitments → accelerate deployment and reduce electricity costs	Deployment subsidies and/or mandates, tax credits, public procurement—all with local content requirements → expand market for domestically produced technologies

rich countries. The EU, as a supranational institution, does not have the right to tax, limiting its ability to engage in industrial policy[69]. The USA stands out in its ability to borrow debt, given its central role in the dollar-dominated international monetary system, thus allowing it to use green public investment to a greater extent than other economies. Fiscal space constraints and ways to relax them will be central to the future of GIP. Revenue-generating policies such as a carbon taxes or emissions trading with auctioning can partially alleviate fiscal constraints by generating funds for climate investments.

Economic and firm capabilities

Governments' supply of GIP is only half of the equation; the other is the ability of economies and firms to respond to policy and generate green industrial change and competitive advantage. Economies vary in several dimensions that condition the opportunities for GIP: green complexity (a country's ability to competitively export clean technologies)[81], growth models (export versus consumption-led models are associated with different GIP goals)[82,83] and their financial structure, which impacts the supply of patient capital to invest in long-term structural economic change.

Firms—specifically incumbents versus start-ups—vary in the extent to which they benefit from and can shape GIP. Incumbents tend to outweigh start-ups politically. They create more jobs, generate greater tax revenue and are often politically better organized than challenger companies. Differences in political power stand in contrast to differences in incentives and capabilities to transition to clean technologies. Incumbents often have incentives to stick with fossil-fuel technologies, including the higher profit margins of brown versus green technologies[84]. Incumbents may thus resist GIPs or direct them towards technologies compatible with existing capabilities, as in the case of oil and gas firms that lobby for support for hydrogen, renewable fuels and carbon-capture-and-storage investments. The problem of inertia of incumbent firms has been particularly prevalent among state-owned enterprises that dominate the energy sector in emerging and developing countries[85]. Yet there is cross-sectoral variation in how easily incumbents can convert from brown to green assets[86,87], and some incumbents, such as the utility or manufacturing firms, may be more supportive of GIP[82]. In contrast, clean energy start-ups have limited political power, while having strong incentives to advocate for ambitious GIP as they tend to lead the technology frontier. So far, the majority of the largest clean technology firms are new entrants.

This portrait raises the question whether an economy's ability to create and scale clean technology start-ups is critical for developing national competitiveness in these industries. For policymakers, it centres the challenge of designing processes that give voice to both sets of firms. For firms, it puts an emphasis on how to organize collectively in trade associations and other forms of intermediaries to effectively participate in these processes[88,89].

Global spillovers and decarbonization

GIP competition can accelerate global decarbonization, while also creating major challenges to decarbonization, given the global interdependence of national policy choices[90,91]. Here, I discuss the positive and negative global spillovers of GIPs as well as unilateral and multilateral policies to mitigate negative spillovers. The central challenge in devising foreign and international GIP lies in managing the tension between national economic goals and global climate goals[92].

Positive spillovers

The industrial policy push could create a global race to the top—a positive feedback loop that accelerates technological change and facilitates global cooperation[28,93].

First, the global proliferation of supply-side and demand-side industrial policies could accelerate investment in the manufacturing and deployment of technologies. Just as the Cold War incentivized Western governments to invest in R&D to ensure technological leadership in nuclear energy and space technology, regime rivalry with China and other geoeconomic shocks such as the Ukraine War are now driving investment in a range of technologies, including clean energy technologies[94,95]. A critical question is how much countries' investments compete with each other, potentially creating beggar-thy-neighbour dynamics, or whether they are complementary. Countries pursuing supply-side policies to achieve technological leadership or energy self-reliance are also more likely to adopt demand-side policies to incentivize domestic deployment. Historically, increased competition in the international system has been associated with faster adoption of new technologies[96].

Growing public investment in manufacturing and deployment could facilitate technology cost declines—in particular if countries pursue open-economy industrial policies. Global trade and supply chains enable cost declines through economies of scale and learning-by-doing in manufacturing, as the solar case illustrates. These technology cost reductions benefit all countries, which may be more likely to adopt their own GIP as deployment costs drop and markets expand[97]. The result is a race to the top through uncoordinated, but interdependent, policy adoption[90].

Second, GIP competition can facilitate classic forms of international cooperation on emission reductions and targets. By reducing the cost of clean technologies, GIPs can lower the adjustment costs for countries to decarbonize their economies[98]. Countries may thus become more willing to adopt stricter emission-reduction targets. For instance, the decline in the cost of renewables throughout the 2010s contributed to broader and deeper cooperation on the Paris Agreement compared with the Copenhagen Accords[99]. In addition, countries that invest in clean technology manufacturing have an incentive to advocate for more stringent international emission-reduction targets to expand demand for their export products[100].

Geoeconomic competition in green industries is also giving rise to new forms of industrial policy cooperation aimed at creating and scaling clean technology markets (Fig. 1, lower-left quadrant). These are often bilateral or plurilateral forms of cooperation that focus on technology development and diffusion by facilitating the development and reconfiguration of global supply chains, pooling buyer demand and setting technological standards[101–103]. Beyond these sector- or technology-specific forms of cooperation, new fora for coordination on industrial policy more broadly are needed[104]. For instance, an international forum on industrial policy could help mitigate negative spillovers, including by redirecting investments from one country to another[105].

At this juncture, we need to understand what effective global cooperation on GIP looks like, also learning from historical cases such as the European Steel and Coal Community. This extends to questions on how narrow and novel forms of cooperation fit within the existing landscape of global economic governance and whether they can complement or transform existing institutions.

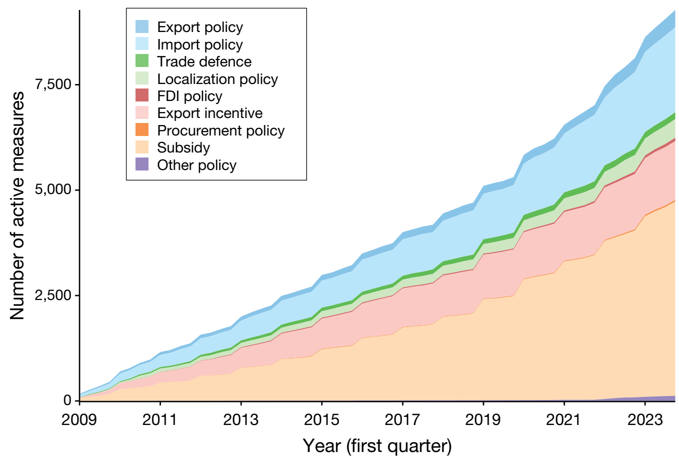


Fig. 3 | GIP instruments, including trade policies. Active GIP measures by type of instrument adopted for low-carbon technology and critical minerals. FDI, foreign direct investment. Based on quarterly data from ref. 131. See Supplementary Note 1.

Negative spillovers

The geoeconomic turn could also lead to a race to the bottom by increasing technology costs and global conflict, and by leaving growing economies behind.

First, trade barriers increase costs and create conflict. As trade in clean technologies has expanded, so have trade barriers for clean energy technologies and resources, including import and export barriers and localization policies (Fig. 3). They have led to a wave of trade disputes since 2010[10]. Trade barriers fragment markets and hinder global innovation dynamics, thus increasing the cost of clean technologies compared with an open economy. They run the risk of slowing the pace of decarbonization. For example, in a world with trade barriers, solar module prices will be 20% to 30% higher in 2030 compared with a scenario with globalized supply chains[106].

Politically, the rise in trade protection increases conflict, which challenges global climate cooperation, while undermining global trade institutions directly. The US–China solar trade war, for instance, presented challenges for US–China cooperation in the context of the Paris Agreement. We therefore need to better understand how much trade conflict risks to impede climate cooperation.

Policymakers weigh the negative spillovers of trade protection with potential domestic economic and political benefits[107]. Potential economic benefits include the growth of infant green industries and security of supply. Governments seek to protect nascent green industries by combining subsidies with trade protection, following the example of late industrializers such as China, Japan and South Korea. This path requires an understanding of which technologies and supply-chain segments a country can be expected to successfully compete in. Domestic production could also mitigate potential risks of supply disruptions stemming from overreliance on foreign supply, but the likelihood of such disruptions varies substantially across technologies and diversifying supply is an alternative strategy to import substitution[108]. To the extent that protected green industries create jobs, trade barriers could also increase support among voters for decarbonization in general and deployment policies in particular[100]. However, trade protection has cross-cutting effects on green jobs: it may harm clean technology firms that export or import[109]. Apart from securing jobs, policymakers have used trade protection to secure the industrial base for dual-use technologies, such as automobiles. US and EU efforts to protect incumbent automakers from Chinese electric-vehicle imports has both economic and security drivers.

Policy proposals to manage the trade-offs between low-cost clean energy technologies and green-manufacturing jobs vary in the extent to which they consider different costs and benefits. Some focus on the benefits of free trade, suggesting ways to reform the world trade regime to allow for green subsidies while reducing trade barriers for environmental goods and services. A Green Free Trade Agreement—modelled after a trade agreement for information technology—could revive the World Trade Organization and halt the trend towards ever-greater trade barriers in clean-energy-technology markets[110]. Other proposals focus on mitigating the negative impacts of trade barriers on clean technology adoption. For instance, policymakers could use revenues from tariffs to subsidize domestic clean energy deployment, or they may attach time limits to tariffs for infant industries[111].

Second, larger, richer economies—such as China, the EU, Japan and the USA—are pulling ahead in clean technology manufacturing and deployment, whereas poorer and smaller economies lag behind, resulting in a global divide in green industrialization[7,31,112,113]. In fact, 90% of trade in low-carbon technology occurs among high-income countries[114]. Yet, it is emerging economies that will grow their energy demand most until 2050 as their populations gain access to electricity and their economies grow[115].

There are two broad paths for developing countries to participate in green industries. One is the deployment of clean technologies produced by richer economies, supported by bilateral and multilateral finance[116]. China's Belt and Road Initiative has expanded export opportunities for Chinese multinationals in clean technologies[117,118]. A second path is that middle-income countries engage in industrial upgrading in clean energy supply chains. The United Arab Emirates have, for instance, emerged as a producer of green aluminium. Green industrial upgrading may generate political support for deployment policies in those countries. Industrial upgrading generally requires both financing and knowledge transfer[112]. China, for instance, developed wind and solar industries through joint ventures with European manufacturers. Those joint ventures transferred know-how to the country, along with foreign direct investment[119]. One open question is how much relaxing intellectual property rights for clean technologies could facilitate industrial upgrading in developing countries[112].

Globalizing GIP through both financial and technology transfer is at an early stage. Just Energy Transition Partnerships are a nascent model whose outcomes remain to be seen[120]. Other ideas revolve around climate clubs that provide substantial benefits in the form of finance and technology transfer, while requiring members to adopt, for instance, carbon import tariffs. Although the history of development aid suggests severe constraints to financial and technology transfer, the growing interest in diversifying clean energy supply chains beyond China indicates that economic security concerns may motivate some support. The US–China regime rivalry is likely to shape financial and technology transfer to emerging and developing countries, requiring recipients to align with either power.

The future of GIP

This Perspective has argued that the rise of industrial policy marks a geoeconomic turn in the politics of decarbonization: global competition for the economic benefits of decarbonization has emerged alongside global cooperation on the costs of mitigation. Macro forces suggest that this will probably be a sustained shift. Nationalism and great power rivalry are fuelling it. It remains unclear whether the rise of GIP will deliver on economic development and decarbonization, with a range of possible scenarios[121,122]. At least three major uncertainties exist.

First, it is unclear to what extent industrial policy will remain green. A global race to the top of green public and private investment is not guaranteed to continue. So far, this is a story of decarbonizing the electricity and passenger transport sectors, and these transitions could be increasingly market-driven in the future. Continued government support is, however, needed to drive down the costs of a broader range of technologies essential for decarbonizing other sectors. This need for longer-term public investment is set against two countervailing forces: right-wing populism and fiscal pressures. Right-wing populism is on the ascent globally and has started to mobilize against climate policy, defending the fossil-fuel economy. The USA is phasing out early key, although not all, Inflation Reduction Act incentives, which raises questions about the intensity of the US green industrial push and a pivot towards nuclear and geothermal energy over the next few years. Meanwhile, other economies continue to push ahead forcefully with GIP. China has staked a significant part of its economic development project on green industries and is likely to continue to foster export markets for its green products, as are the EU, Japan and South Korea. At the same time, fiscal pressures are growing in both rich and poor countries. Public debt loads are by and large high, and governments face spending pressures from factors such as ageing societies and defence needs. Taken together, these factors could result in the highly fragmented and intermittent pursuit of GIP[121], with blocs of countries pursuing growth through clean energy or fossil fuels[123].

Second, the implementation of GIP is highly challenging, with a mixed record of success[124,125]. The paradox is that although adopting a GIP is easier than carbon pricing, implementing it is harder than a carbon tax. Key questions are whether countries can build sufficient state capacity while experimenting with GIP or are able to right-size industrial policy efforts to their existing capacity. The bankruptcy of the solar firm Solyndra—which received loan guarantees from the Obama administration—led to substantial public backlash against investments in green industries. This raises the spectre of large-scale public backlash if government investments fail or fall short in delivering benefits[92]—in particular, as green investments increasingly compete with other major investment needs, such as defence and social welfare, under tight fiscal constraints. Next to state capacity, the availability of critical minerals may be a bottleneck for the successful implementation of GIP. Projected supply–demand imbalances vary across minerals, with supply shortfalls most likely in copper and lithium[22].

Third, a major uncertainty is how much political space policymakers can create to develop open-economy and cooperative industrial policies that scale global markets for clean energy technologies beyond today's clean energy champions. This is a tall order given that the rise of GIP has both contributed to and suffers from cracks in the global economic order and that the current US administration is toppling that very order. What is needed is a transformation of global economic governance to reflect the new industrial policy reality and integrate green goals into economic policy. This entails both reforming existing institutions and building new ones, such as a coordination body or a sectoral trade agreement. Much of the new forms of cooperation are likely to occur in clubs under 'preferential plurilateralism', reinforcing the trend towards new economic blocs and alliances to balance China's dominance in clean technologies[126]. One central question is how competition with China affects patterns of GIP cooperation. There are forms of cooperation with China, such as in Mission Innovation, and beyond China, such as the Minerals Security Partnership. Although competition is the fuel powering the rise of GIP, its practice must be better embedded into new forms of cooperation to fulfil its promises. A 'Green Cold War' scenario—with mercantilist competition at full force—is a possible scenario that would probably fail to deliver on global decarbonization.

How these three major uncertainties play out will impact whether GIP will deliver on economic and climate goals. Achieving economic goals means creating politically salient economic benefits in terms of jobs, lower energy costs or economic growth. Delivering on climate goals means that increasing green industrialization and growing clean technology deployment must lead economies to reduce emissions and eventually phase out fossil fuels. GIP is successful when it facilitates the adoption of climate policy sticks in the form of increasingly stringent emission-reduction targets, supported by a carbon price and/or regulatory standards. Only a combination of investment and some form of regulatory stick is effective at promoting deep decarbonization[43]. Green industrial policies sometimes pave the way to the adoption of such regulatory sticks[127–130]. The new dynamic of GIP competition thus needs to feed back into climate policy as we know it by incentivizing and enabling deeper emission cuts over time.

Data availability

The data are available from the original authors upon request. For ref. 131, contact Adam Jakubik (ajakubik@imf.org); for ref. 132, contact Nathan Lane (nathaniel.lane@economics.ox.ac.uk).

1. Scholten, D., Bazilian, M., Overland, I. & Westphal, K. The geopolitics of renewables: new board, new game. *Energy Policy* **138**, 111059 (2020).
2. Blondeel, M., Bradshaw, M. J., Bridge, G. & Kuzemko, C. The geopolitics of energy system transformation: a review. *Geogr. Compass* **15**, e12580 (2021).
3. Binz, C., Tang, T. & Huenteler, J. Spatial lifecycles of cleantech industries—the global development history of solar photovoltaics. *Energy Policy* **101**, 386–402 (2017).
4. Lewis, J. I. Green industrial policy after Paris: renewable energy policy measures and climate goals. *Glob. Environ. Polit.* **21**, 42–63 (2021).
5. Nahm, J. *Trailing—or Governing—the Market? Two Decades of Industrial Policy for China's Solar Sector.* Working Paper No. 1 (UC Institute on Global Conflict and Cooperation, 2023); https://ucigcc.org/publication/trailing-or-governing-the-market-two-decades-of-industrial-policy-for-chinas-solar-sector/.
6. Meckling, J. & Nahm, J. When do states disrupt industries? Electric cars in Germany and the United States. *Rev. Int. Polit. Econ.* **25**, 505–529 (2018).
7. Meckling, J., Galeazzi, C., Shears, E., Xu, T. & Anadon, L. D. Energy innovation funding and institutions in major economies. *Nat. Energy* **7**, 876–885 (2022).
8. Carley, S. Energy programs of the American Recovery and Reinvestment Act of 2009. *Rev. Policy Res.* **33**, 201–223 (2016).
9. MacNeil, R. Between innovation and industrial policy: how Washington succeeds and fails at renewable energy. *Prometheus* **34**, 173–189 (2017).
10. Lewis, J. I. The rise of renewable energy protectionism: emerging trade conflicts and implications for low carbon development. *Glob. Environ. Polit.* **14**, 10–35 (2014).
11. IPCC *Climate Change 2022: Mitigation of Climate Change* (eds Shukla, P. R. et al.) (Cambridge, Univ. Press, 2022).
12. Way, R., Ives, M. C., Mealy, P. & Farmer, J. D. Empirically grounded technology forecasts and the energy transition. *Joule* **6**, 2057–2082 (2022).
13. *World Energy Outlook 2024* (IEA, 2024).
14. Nemet, G. *How Solar Energy Became Cheap: A Model for Low-Carbon Innovation* (Routledge, 2019).
15. McNerney, J., Farmer, J. D., Redner, S. & Trancik, J. E. Role of design complexity in technology improvement. *Proc. Natl Acad. Sci. USA* **108**, 9008–9013 (2011).
16. Trancik, J. E. Scale and innovation in the energy sector: a focus on photovoltaics and nuclear fission. *Environ. Res. Lett.* **1**, 014009 (2006).
17. Sweerts, B., Detz, R. J. & van der Zwaan, B. Evaluating the role of unit size in learning-by-doing of energy technologies. *Joule* **4**, 967–970 (2020).
18. Nahm, J. & Steinfeld, E. S. Scale-up nation: China's specialization in innovative manufacturing. *World Dev.* **54**, 288–300 (2014).
19. Lewis, J. I. The climate risk of green industrial policy. *Curr. Hist.* **123**, 14–19 (2024).
20. Naughton, B. *The Rise of China's Industrial Policy, 1978 to 2020* (Universidad Nacional Autónomica de México, Facultad de Economía, 2021).
21. *Energy Technology Perspectives 2024* (IEA, 2024).
22. *Global Critical Minerals Outlook 2024* (IEA, 2024).
23. Green, F. Green New Deals in comparative perspective. *Wiley Interdiscip. Rev. Clim. Change* https://doi.org/10.1002/wcc.885 (2024).
24. Meckling, J. & Allan, B. B. The evolution of ideas in global climate policy. *Nat. Clim. Change* **10**, 434–438 (2020).
25. Meckling, J. A new path for U.S. climate politics: choosing policies that mobilize business for decarbonization. *Ann. Am. Acad. Pol. Soc. Sci.* **685**, 82–95 (2019).
26. Helm, D. *Net Zero: How We Stop Causing Climate Change* (HarperCollins, 2020).
27. Segerson, K. et al. A cautious approach to subsidies for environmental sustainability. *Science* **386**, 28–30 (2024).
28. Zysman, J. & Huberty, M. *Can Green Sustain Growth?* (Stanford Business Books, 2014).
29. Aiginger, K. & Ketels, C. Industrial policy reloaded. *J. Ind. Compet. Trade* **24**, 7 (2024).
30. Bordoff, J. & O'Sullivan, M. L. The age of energy insecurity: how the fight for resources is upending geopolitics. *Foreign Aff.* **102**, 104 (2023).
31. Lebdioui, A. *Survival of the Greenest: Economic Transformation in a Climate-conscious World* Elements in Development Economics (Cambridge Univ. Press, 2024).
32. Surana, K., Doblinger, C., Anadon, L. D. & Hultman, N. Effects of technology complexity on the emergence and evolution of wind industry manufacturing locations along global value chains. *Nat. Energy* **5**, 811–821 (2020).
33. Steffen, B., Matsuo, T., Steinemann, D. & Schmidt, T. S. Opening new markets for clean energy: the role of project developers in the global diffusion of renewable energy technologies. *Bus. Polit.* **20**, 553–587 (2018).
34. Hochstetler, K. *Political Economies of Energy Transition: Wind and Solar Power in Brazil and South Africa* (Cambridge Univ. Press, 2020).
35. Haraguchi, N., Cheng, C. F. C. & Smeets, E. The importance of manufacturing in economic development: has this changed? *World Dev.* **93**, 293–315 (2017).
36. Harrison, A., Martin, L. A. & Nataraj, S. Green industrial policy in emerging markets. *Annu. Rev. Resour. Econ.* **9**, 253–274 (2017).
37. Collins, M. Energy in the era of competitive decarbonization. *Forum Q. J.* **143**, 12–15 (2025).

38. Ding, J. *Technology and the Rise of Great Powers: How Diffusion Shapes Economic Competition* (Princeton, Univ. Press, 2024).
39. Matsuo, T. & Schmidt, T. S. Managing tradeoffs in green industrial policies: the role of renewable energy policy design. *World Dev.* **122**, 11–26 (2019).
40. Huberty, M. & Zysman, J. An energy system transformation: framing research choices for the climate challenge. *Res. Policy* **39**, 1027–1029 (2010).
41. Schmidt, T. S. & Sewerin, S. Measuring the temporal dynamics of policy mixes—an empirical analysis of renewable energy policy mixes' balance and design features in nine countries. *Res. Policy* https://doi.org/10.1016/j.respol.2018.03.012 (2018).
42. Grubb, M. et al. Induced innovation in energy technologies and systems: a review of evidence and potential implications for CO_2 mitigation. *Environ. Res. Lett.* **16**, 043007 (2021).
43. Stechemesser, A. et al. Climate policies that achieved major emission reductions: global evidence from two decades. *Science* **385**, 884–892 (2024).
44. Rogge, K. S. & Reichardt, K. Policy mixes for sustainability transitions: an extended concept and framework for analysis. *Res. Policy* **45**, 1620–1635 (2016).
45. Malhotra, A. & Schmidt, T. S. Accelerating low-carbon innovation. *Joule* **4**, 2259–2267 (2020).
46. Criscuolo, C. & Lalanne, G. A new approach for better industrial strategies. *J. Ind. Compet. Trade* **24**, 6 (2024).
47. Pegels, A. & Altenburg, T. Latecomer development in a "greening" world: introduction to the special issue. *World Dev.* **135**, 105084 (2020).
48. Pless, J. *Are Complementary Policies Substitutes? Evidence from R&D subsidies in the UK*. Working Paper (MIT, 2023).
49. Rodrik, D. Green industrial policy. *Oxf. Rev. Econ. Policy* **30**, 469–491 (2014).
50. Vogt-Schilb, A., Meunier, G. & Hallegatte, S. When starting with the most expensive option makes sense: optimal timing, cost and sectoral allocation of abatement investment. *J. Environ. Econ. Manag.* **88**, 210–233 (2018).
51. Acemoglu, D., Aghion, P., Bursztyn, L. & Hemous, D. The environment and directed technical change. *Am. Econ. Rev.* **102**, 131–166 (2012).
52. Meckling, J. & Biber, E. A policy roadmap for negative emissions using direct air capture. *Nat. Commun.* **12**, 2051 (2021).
53. Noll, B., Steffen, B. & Schmidt, T. S. Domestic-first, climate second? Global consequences of the Inflation Reduction Act. *Joule* **8**, 1869–1873 (2024).
54. Kuznetsov, Y. & Sabel, C. F. in *Making Innovation Policy Work: Learning from Experimentation* (eds Dutz, M. A., Kuznetsov, Y., Lasagabaster, E. & Pilat, D.) 35–48 (OECD and World Bank, 2014).
55. Allan, B. B. & Nahm, J. Strategies of green industrial policy: how states position firms in global supply chains. *Am. Polit. Sci. Rev.* https://doi.org/10.1017/S0003055424000364 (2024).
56. Amsden, A. H. *Asia's Next Giant: South Korea and Late Industrialization* (Oxford Univ. Press, 1989).
57. Mazzucato, M. & Rodrik, D. *Industrial Policy with Conditionalities: A Taxonomy and Sample Cases* (UCL Institute for Innovation and Public Purpose, 2023).
58. Meckling, J. & Strecker, J. Green bargains: leveraging public investment to advance climate regulation. *Clim. Policy* https://doi.org/10.1080/14693062.2022.2149452 (2022).
59. Bulfone, F., Ergen, T. & Kalaitzake, M. No strings attached: corporate welfare, state intervention, and the issue of conditionality. *Compet. Change* **27**, 253–276 (2022).
60. Schmitz, L., Seidl, T. & Wuttke, T. The costs of conditionality. IPCEIs and the constrained politics of EU industrial policy. *Compet. Change* https://doi.org/10.1177/10245294251320675 (2025).
61. Gaikwad, N., Genovese, F. & Tingley, D. Creating climate coalitions: mass preferences for compensating vulnerability in the world's two largest democracies. *Am. Polit. Sci. Rev.* https://doi.org/10.1017/s0003055422000223 (2022).
62. Meckling, J. & Nahm, J. Strategic state capacity: how states counter opposition to climate policy. *Comp. Polit. Stud.* **55**, 493–523 (2022).
63. Finnegan, J. J., Lipscy, P. Y., Meckling, J. & Metz, F. The institutional sources of economic transformation: explaining variation in energy transitions. *J. Politics* https://doi.org/10.1086/735439 (2025).
64. Beckfield, J. & Evrard, D. A. The social impacts of supply-side decarbonization. *Annu. Rev. Sociol* **49**, 155–175 (2023).
65. Juhász, R. & Lane, N. The political economy of industrial policy. *J. Econ. Perspect.* **38**, 27–54 (2024).
66. Meckling, J. & Benkler, A. State capacity and varieties of climate policy. *Nat. Commun.* **15**, 9942 (2024).
67. Allan, B., Lewis, J. I. & Oatley, T. Green industrial policy and the global transformation of climate politics. *Glob. Environ. Polit.* **21**, 1–19 (2021).
68. Thurbon, E., Kim, S.-Y., Tan, H. & Mathews, J. A. *Developmental Environmentalism: State Ambition and Creative Destruction in East Asia's Green Energy Transition* (Oxford Univ. Press, 2023).
69. McNamara, K. R. Transforming Europe? The EU's industrial policy and geopolitical turn. *J. Eur. Public Policy* https://doi.org/10.1080/13501763.2023.2230247 (2023).
70. Allan, B. B. Industrial policy and the green state: forging a world after growth. *Rev. Int. Stud.* **50**, 888–897 (2024).
71. Wei, Y., Ang, Y. Y. & Jia, N. The promise and pitfalls of government guidance funds in China. *China Q.* https://doi.org/10.1017/S0305741023000280 (2023).
72. Geddes, A., Schmidt, T. S. & Steffen, B. The multiple roles of state investment banks in low-carbon energy finance: an analysis of Australia, the UK and Germany. *Energy Policy* **115**, 158–170 (2018).
73. Storper, M., Nicholas Ziegler, J., Botelho, A. J. J. & Ornston, D. On Mariana Mazzucato's Mission Economy: a Moonshot Guide to Changing Capitalism, London, Allen Lane, 2021. *Socioecon. Rev.* **20**, 1501–1511 (2022).
74. Victor, D. G. & Carlton, E. K. Technology to solve global problems: an emerging consensus for green industrial policy? *Environ. Res. Lett.* **18**, 091006 (2023).
75. Evans, P. *Embedded Autonomy. States and Industrial Transformation* (Princeton Univ. Press, 1995).
76. Schmitz, H., Johnson, O. & Altenburg, T. Rent management—the heart of green industrial policy. *New Polit. Econ.* **20**, 812–831 (2015).
77. Markard, J. & Hoffmann, V. H. Analysis of complementarities: framework and examples from the energy transition. *Technol. Forecast. Soc. Change* **111**, 63–75 (2016).
78. Dugoua, E. & Dumas, M. Coordination dynamics between fuel cell and battery technologies in the transition to clean cars. *Proc. Natl Acad. Sci. USA* **121**, e2318605121 (2024).
79. Anadón, L. D. Missions-oriented RD&D institutions in energy between 2000 and 2010: a comparative analysis of China, the United Kingdom, and the United States. *Res. Policy* **41**, 1742–1756 (2012).
80. Block, F. Swimming against the current: the rise of a hidden developmental state in the United States. *Polit. Soc.* **36**, 169–206 (2008).
81. Mealy, P. & Teytelboym, A. Economic complexity and the green economy. *Res. Policy* **51**, 103948 (2022).
82. Kupzok, N. & Nahm, J. The decarbonization bargain: how the decarbonizable sector shapes climate politics. *Perspect. Polit.* **22**, 1203–1223 (2024).
83. Driscoll, D. Comparative green advantage: growth regimes and public investment in renewable energy R&D. *JCMS J. Common Mark. Stud.* https://doi.org/10.1111/jcms.13485 (2023).
84. Christophers, B. *The Price Is Wrong: Why Capitalism Won't Save the Planet* (Verso Books, 2024).
85. Jaffe, A. M. et al. Green innovation of state-owned oil and gas enterprises in BRICS countries: a review of performance. *Clim. Policy* **23**, 1167–1181 (2023).
86. Kelsey, N. Industry type and environmental policy: industry characteristics shape the potential for policymaking success in energy and the environment. *Bus. Polit.* **20**, 615–642 (2018).
87. Turnheim, B. & Sovacool, B. K. Forever stuck in old ways? Pluralising incumbencies in sustainability transitions. *Environ. Innov. Soc. Transit.* **35**, 180–184 (2020).
88. Sovacool, B. K., Turnheim, B., Martiskainen, M., Brown, D. & Kivimaa, P. Guides or gatekeepers? Incumbent-oriented transition intermediaries in a low-carbon era. *Energy Res. Soc. Sci.* **66**, 101490 (2020).
89. Puente, I. & Schneider, B. R. Business and development: how organization, ownership and networks matter. *Rev. Int. Polit. Econ.* **27**, 1354–1377 (2020).
90. Meckling, J. & Hughes, L. Global interdependence in clean energy transitions. *Bus. Polit.* **20**, 467–491 (2018).
91. Meckling, J. Making industrial policy work for decarbonization. *Glob. Environ. Polit.* **21**, 134–147 (2021).
92. Hansen, S. T. & Moe, E. Renewable energy expansion or the preservation of national energy sovereignty? Norwegian renewable energy policy meets resource nationalism. *Polit. Geogr.* **99**, 102760 (2022).
93. Mehling, M. A. *Good Spillover, Bad Spillover? Industrial Policy, Trade, and the Political Economy of Decarbonization*. Harvard Project on Climate Agreements. Discussion Paper ES 2024-12 (2024).
94. Campbell, K. M. & Sullivan, J. Competition without catastrophe. *Foreign Affairs* **98**, 96–110 (2019).
95. Babić, M. & Mertens, D. Decarbonization under geoeconomic distress? Energy shocks, carbon lock-ins, and Germany's pathway toward net zero. *Regul. Gov.* https://doi.org/10.1111/rego.12634 (2024).
96. Milner, H. V. & Solstad, S. U. Technological change and the international system. *World Polit.* **73**, 545–589 (2021).
97. Rodrik, D. Don't fret about green subsidies. *Project Syndicate* https://www.project-syndicate.org/commentary/green-subsidies-justified-on-economic-environmental-and-moral-grounds-by-dani-rodrik-2024-05 (2024).
98. Hale, T. & Urpelainen, J. When and how can unilateral policies promote the international diffusion of environmental policies and clean technology? *J. Theor. Polit.* **27**, 177–205 (2014).
99. Falkner, R. The Paris Agreement and the new logic of international climate politics. *Int. Aff.* **92**, 1107–1125 (2016).
100. Driesen, D. M., Mehling, M. A. & Popp, D. Industrial policy, populism and the political economy of climate action. *Nat. Clim. Change* **14**, 414–416 (2024).
101. Aisbett, E., Raynal, W., Steinhauser, R. & Jones, B. International green economy collaborations: chasing mutual gains in the energy transition. *Energy Res. Soc. Sci.* **104**, 103249 (2023).
102. Oberthür, S., Hermwille, L. & Rayner, T. A sectoral perspective on global climate governance: analytical foundation. *Earth Syst. Gov.* **8**, 100104 (2021).
103. Victor, D. G., Geels, F. W. & Sharpe, S. *Accelerating the Low Carbon Transition: The Case for Stronger, More Targeted and Coordinated International Action* (Brookings Institution, Washington DC, 2019).
104. Hoekman, B. M. & Nelson, D. Industrial policy and international cooperation. *World Trade Review* **24**, 136–152 (2025).
105. Aiginger, K. & Rodrik, D. Rebirth of industrial policy and an agenda for the twenty-first century. *J. Ind. Compet. Trade* **20**, 189–207 (2020).
106. Helveston, J. P., He, G. & Davidson, M. R. Quantifying the cost savings of global solar photovoltaic supply chains. *Nature* **612**, 83–87 (2022).
107. Pancotti, E. & Tucker, T. Tariffs are a necessary backstop of the clean energy transition. *J. Policy Anal. Manage.* **44**, 323–328 (2024).
108. Davidson, M., Karplus, V., Lewis, J. I., Nahm, J. & Wang, A. Risks of decoupling from China on low-carbon technologies. *Science* **377**, 1266–1269 (2022).
109. Hughes, L. & Meckling, J. The politics of renewable energy trade: the US–China solar dispute. *Energy Policy* **105**, 256–262 (2017).
110. Hanson, G. H. & Slaughter, M. J. How commerce can save the climate: the case for a green free trade agreement. *Foreign Aff.* **102**, 119 (2023).
111. Wu, M. & Salzman, J. The next generation of trade and environment disputes: the rise of green industrial policy. *Northwest. Univ. Law Rev.* **108**, 401–474 (2014).
112. Bradlow, B. H. & Kentikelenis, A. Globalizing green industrial policy through technology transfers. *Nat. Sustain.* https://doi.org/10.1038/s41893-024-01336-4 (2024).

113. Quitzow, R. et al. The COVID-19 crisis deepens the gulf between leaders and laggards in the global energy transition. *Energy Res. Soc. Sci.* **74**, 101981 (2021).
114. Bandara, P., Ray, R., Lu, J. & Gallagher, K. P. Developing countries locked out of low-carbon technology trade. *Science* **388**, 248–250 (2025).
115. *BP Energy Outlook 2024* (BP, 2024); https://www.bp.com/content/dam/bp/business-sites/en/global/corporate/pdfs/energy-economics/energy-outlook/bp-energy-outlook-2024.pdf.
116. Deese, B. The case for a clean energy Marshall Plan: how the fight against climate change can renew American leadership. *Foreign Aff.* **103**, 106 (2024).
117. Colgan, J. D. & Miller, N. L. The rewards of rivalry: US–Chinese competition can spur climate progress. *Foreign Aff.* **101**, 108 (2022).
118. Nedopil, C. *China Belt and Road Initiative (BRI) Investment Report 2023* (Griffith Asia Institute, 2024).
119. Nahm, J. *Collaborative Advantage: Forging Green Industries in the New Global Economy* (Oxford Univ. Press, 2021).
120. Simpson, N. P., Jacobs, M. & Gilmour, A. *Taking Stock of Just Energy Transition Partnerships*. ODI Policy Brief (ODI Global, 2023).
121. Mehling, M. *In the Vortex of Great Power Competition: Climate, Trade, and Geostrategic Rivalry in U.S.–China–EU Relations* (Harvard Project on Climate Agreements, 2025).
122. Goldthau, A. & Westphal, K. How the energy transition will reshape geopolitics. *Nature* **569**, 29–31 (2019).
123. Moore, S. *Climate Action in the Age of Great Power Rivalry: What Geopolitics Means for the Climate* (Kleinman Center for Energy Policy, 2024).
124. Pegels, A. & Lütkenhorst, W. Is Germany's energy transition a case of successful green industrial policy? Contrasting wind and solar PV. *Energy Policy* **74**, 522–534 (2014).
125. Pegels, A. *Green Industrial Policy in Emerging Countries* (Routledge, 2014).
126. Campbell, K. M. & Doshi, R. Underestimating China: why America needs a new strategy of allied scale to offset Beijing's enduring advantages. *Foreign Aff.* **104**, 66–81 (2025).
127. Meckling, J., Kelsey, N., Biber, E. & Zysman, J. Winning coalitions for climate policy: green industrial policy builds support for carbon regulation. *Science* **249**, 1170–1171 (2015).
128. Meckling, J., Sterner, T. & Wagner, G. Policy sequencing toward decarbonization. *Nat. Energy* **2**, 918–922 (2017).
129. Linsenmeier, M., Mohommad, A. & Schwerhoff, G. Policy sequencing towards carbon pricing among the world's largest emitters. *Nat. Clim. Change* **12**, 1107–1110 (2022).
130. Keohane, R. O. & Victor, D. G. Cooperation and discord in global climate policy. *Nat. Clim. Change* **6**, 570–575 (2016).
131. Evenett, S. et al. *Industrial Policy Since the Great Financial Crisis*. Working Paper (International Monetary Fund, 2025).
132. Juhász, R., Lane, N., Oehlsen, E. & Pérez, V. C. *The Who, What, When, and How of Industrial Policy: A Text-Based Approach* Working Paper (NBER, 2023).
133. *Renewables 2007: Global Status Report* (REN21, 2007).
134. *A Climate for Recovery: The Colour of Stimulus Goes Green* (HSBC, 2009).
135. Nahm, J. M., Miller, S. M. & Urpelainen, J. G20's US $14-trillion economic stimulus reneges on emissions pledges. *Nature* **603**, 28–31 (2022).

Acknowledgements I thank K. Ahuja, D. Hart, R. Keohane, S. Ladislaw, G. Trumbull, T. Tucker and M. Yildirim for valuable comments; and A. R. Jacobsen and S. Malo for excellent research support. The following authors generously shared their data: S. Evenett, A. Jakubik, J. Kim, F. Martín, S. Pienknagura and M. Ruta[131]; and R. Juhász, N. Lane, E. Oehlsen and V. Pérez[132]. I acknowledge funding from the Center for Innovation and Sustainability in Business; the William and Flora Hewlett Foundation, grant 2022-01804-GRA, regranted by the Climate Program of the Berkeley Economy and Society Initiative; and the United States Department of Agriculture (USDA) National Institute of Food and Agriculture, Hatch Project accession number 1020688.

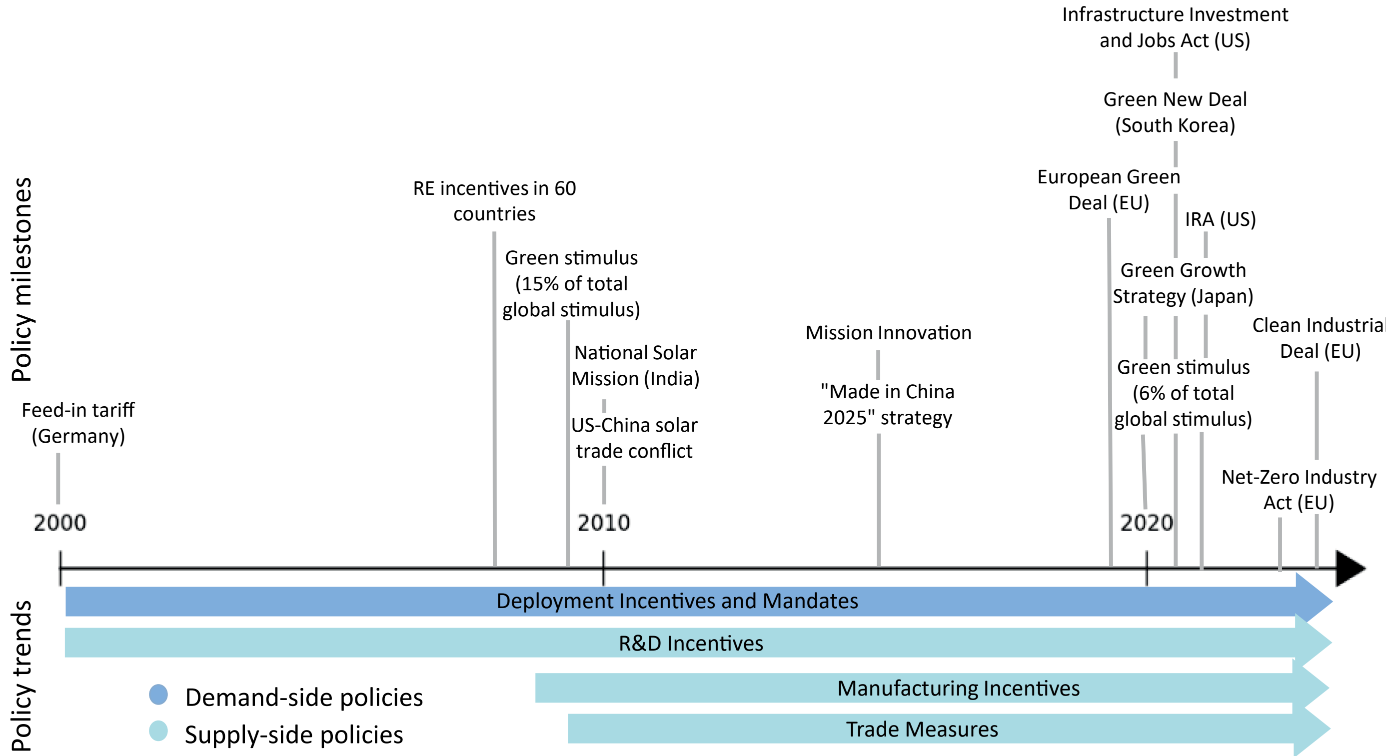
Competing interests The author declares no competing interests.

Additional information

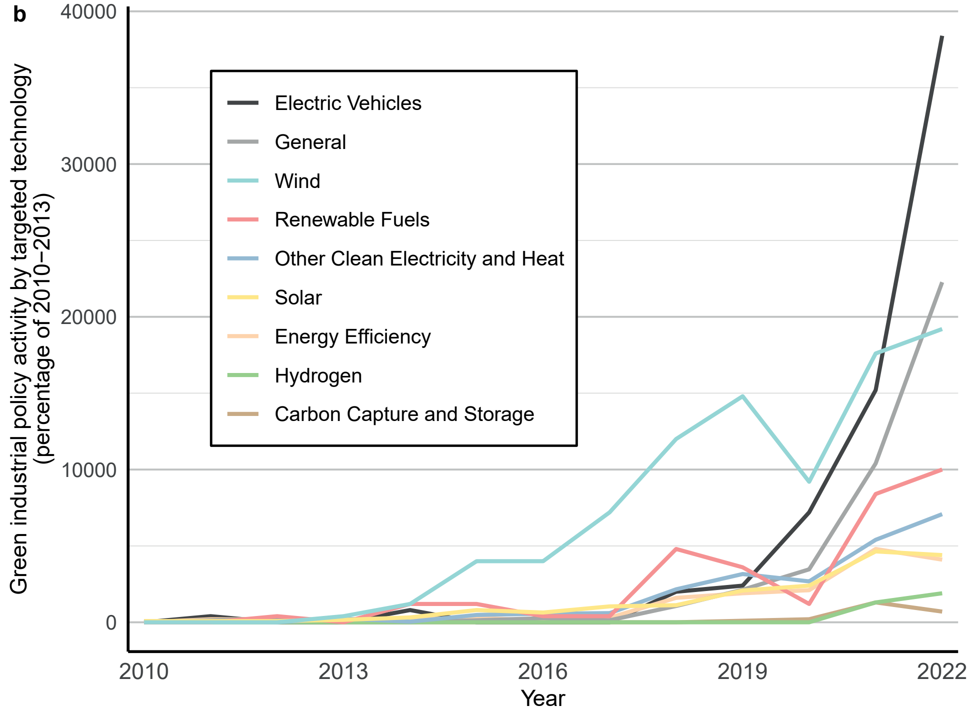
Supplementary information The online version contains supplementary material available at https://doi.org/10.1038/s41586-025-09416-x.

Correspondence and requests for materials should be addressed to Jonas Meckling.

Peer review information *Nature* thanks Espen Moe, Ida Dokk Smith and the other, anonymous, reviewer(s) for their contribution to the peer review of this work.



Extended Data Fig. 1 | The evolution of green industrial policy. Policy trend bars indicate diffusion of policy type beyond initial adopter. Based on data from[133–135].



Extended Data Fig. 2 | The growth of green industrial policy measures by targeted technology. Shows annual policy activity relative to the baseline of the average policy activity in 2010–13. Based on data from ref. 132; see Supplementary Note 2.