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Perspective

Green industrial policy can strengthen carbon pricing but not replace it

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ABSTRACT

Carbon pricing has received prominent support as the key policy to reduce greenhouse gas emissions. Yet, in the context of heightened geopolitical tensions and risks of supply chain disruptions, policy makers are increasingly resorting to green industrial policies to support the deployment of clean energy technologies. This Perspective discusses whether this development represents a paradigm shift in the design of climate policies and assesses arguments for and against carbon pricing and green industrial policies. Our analysis addresses implications for economic efficiency, security of supply, distributional concerns and political economy issues. We find that green industrial policies can support carbon pricing by lowering market barriers for clean technology diffusion and strengthening political support for climate policy. Yet, we also emphasize that a carbon price should be an essential element in any effective climate mitigation policy mix and the key is to find the optimal policy mix for carbon pricing and green industrial policies for the unique context of each location. In the EU, green industrial policy should mainly be employed to complement carbon pricing and deal with additional market barriers. In the US, by contrast, green industrial policy could be used strategically to try to build political support for and reduce resistance to a carbon price.

1. Introduction

Carbon pricing has received broad support in the academic literature and policy circles as an economically efficient policy to mitigate greenhouse gas emissions. The EU has put a price on carbon by means of an emissions trading system for stationary sources from the power sector and certain energy-intensive industries since 2005 [1] and has recently announced the introduction of another, separate, emissions trading system for road transportation and buildings [2]. By contrast, in the US, the bipartisan Waxman-Markey bill, which aimed to put a price on carbon via a nation-wide emissions trading system in 2009, was not brought to the Senate because it was clear that it would be voted down [3]. Thus emissions pricing remains restricted to a few US states that have introduced it locally [4]. As an alternative measure to reduce emissions, the Biden administration introduced the Inflation Reduction Act (IRA) to provide financial support for activities that are crucial for the energy transition [5]. Some estimates suggest that the IRA could mobilize roughly USD 1 trillion for renewable energy technologies, batteries, electric vehicles and green hydrogen [6]. This is expected to result in emission reductions of 33-40 % from 2005 levels in 2030 [7].

The IRA has caused concern in the EU regarding the competitiveness of green technology manufacturing, in addition to the security of supply issues that came to dominate the political agenda after Russia's invasion of Ukraine [8]. As a response, the Net-Zero Industry Act (NZIA) has been formulated as a strategy to boost climate-neutral industries in the EU. Its central aim is to ensure that at least 40 % of technologies that are required to meet the EU's net-zero targets will be produced domestically [9].

In this Perspective, we discuss whether these developments in the EU and the US can be regarded as a paradigmatic shift in climate policy from carbon pricing to green industrial policy. We first assess the advantages and disadvantages of the two approaches and the relationship between carbon pricing and green industrial policy. We then examine potential future developments of carbon pricing and green industrial policies in the EU and the US, both of which are central global climate policy actors and both of which have recently adopted green industrial policies. Finally, we analyze the international implications of green industrial policies adopted at the national level.

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2. Carbon pricing in theory and practice

Economists have frequently hailed carbon pricing as the preferable policy to reduce greenhouse gas emissions [10–12], reasoning that such a market-based approach provides the flexibility to abate emissions where reductions can be achieved at the lowest costs. Carbon pricing hence holds the promise of economic efficiency. A carbon price reflecting the social cost of carbon – that is, the economic damages of climate impacts – could guide the decisions of economic actors and help achieve socially optimal outcomes. Carbon pricing can be implemented by means of a carbon tax or a cap-and-trade system, in which the price is determined on the market for tradable emission permits. To date, 68 carbon pricing schemes covering more than 23 % of global emissions are in place [13]. Yet, with a weighted average price of about USD 6 per ton of CO_2, emission prices fall short of the USD 50–100 that have been suggested necessary to reach the Paris Agreement targets for 2030 [14]. Recent estimates of climate damages put the social costs of carbon, and thus the price level policy makers should optimally set, even higher at between USD 44 and 413 per ton of CO_2, with a median of USD 185 [15].

The empirical evidence indicates that emission growth in countries with a carbon price has on average been around 2 % lower than in countries without one [16] and a recent meta-review of peer-reviewed studies on 21 existing carbon pricing schemes shows that these have reduced covered emissions by 4 % to 15 % [17]. Several studies have demonstrated that the most advanced carbon pricing systems, the EU Emissions Trading System (ETS) [18–20] and the UK Carbon Price Support scheme [21–23], have resulted in significant emission reductions for covered entities. There is also some evidence that the EU ETS has increased the efficiency of fossil fuel plants [24] and that carbon pricing has spurred technological innovation in clean technologies the EU and China [25,26]. It can be expected that a stronger and more predictable price signal, for instance by introduction of a minimum carbon price, would provide additional incentives for low-carbon investment [27]. Recent evidence further underscores the economic efficiency of carbon pricing in the EU, demonstrating that there is no indication of negative effect of this instrument on employment or GDP growth [28].

Emissions pricing adopted by only a few frontrunners could spark carbon leakage, i.e. relocation of energy-intensive activities to jurisdictions with less stringent climate policies [29]. Yet, this issue arises for every unilateral climate policy that raises costs for firms and is thus not a particular feature of a carbon prices [30]. In the past, carbon leakage has not played a big role, but leakage rates could increase with higher carbon prices [31]. Countries with significant carbon prices that are not matched by others will thus likely need to implement anti-leakage measures, such as carbon border adjustment mechanisms. For countries employing other strategies to reduce their emissions, such as performance standards, implementing such a scheme entails the challenge of determining the mitigation costs of domestic firms, which are not directly observable [32]. A carbon border adjustment mechanism without a domestic carbon price would also likely violate international trade rules [33]. An additional advantage of introducing a carbon price is that it increases the probability of adoption in other countries, possibly due to reduced concerns related to carbon leakage [34].

3. The case for green industrial policy

Several recent contributions call into question the effectiveness of carbon prices to reduce emissions. A meta-review of the empirical literature finds that only limited emission reductions that have hitherto been achieved by carbon pricing [35]. Rosenbloom et al. [36] argue that carbon prices "tend to promote the optimization of established business models and technologies but neglect more fundamental system change" (p. 8665) and instead recommend alternative policies that foster radical innovation while at the same time instigating a managed decline of the fossil economy. Other authors take a similar perspective, arguing that carbon pricing has incentivized fuel switching, but failed to stimulate innovation and zero-carbon investment [37]. A less severe, but still relevant critique of carbon pricing is that if there are other market imperfections that interact with the carbon price, other policies, such as clean energy standards, can achieve a similar outcome to a carbon price, or an even more efficient one [38].

In any case, policies that complement a carbon price can be justified as a means to address market failures other than greenhouse gas emissions externalities. Policies to incentivize structural economic change are often labeled "industrial policies", as traditionally they have most frequently been employed to increase productivity in industries regarded as central for economic development [39]. Industrial policies can in general be understood as "government actions to alter the structure of an economy, encouraging resources to move into particular sectors that are perceived as desirable for future development" [40] (p. 2).

Recent years have witnessed a trend towards more active industrial policies in general. Since 2017, the number of industrial policies around the world has grown more than sixfold, mainly in industrialized countries [41]. The most common measures include state loans, financial grants, loan guarantees and trade finance, with countries at different levels of per-capita income implementing different types of industrial policies (see Fig. 1). Governments use different kinds of industrial policies to strategically integrate firms into global supply chains, in particular with regard to nascent low-carbon industries that are regarded as important for future economic development [42].

Multiple technological, political, institutional and behavioral barriers (which often reinforce each other) make it difficult to escape from "carbon lock-in" [44]. Hence, green industrial policies can address important barriers that hinder the energy transition [45,46] – see Table 1 for some examples for barriers, policies to address them and examples of their implementation. In the wake of increasing geopolitical rivalries, industrial policies are also employed to lower the risk of supply chain disruptions for raw materials and technologies that are critical for decarbonization [47]. In the EU and US, reducing import dependence on China, which holds a dominant market share for most key materials and technologies, is seen as central in this regard [48].

An important challenge for the design of industrial policies consists in avoiding an overly narrow focus, as governments may be influenced by vested interests and have insufficient information to successfully identify specific technologies that will eventually prevail [49]. Therefore, green industrial policy needs to be conducted within an appropriate institutional framework that counters political meddling and overcomes informational constraints by transparently stating what objectives the policy shall achieve and in which manner [50,51]. Proponents of active industrial policy further emphasize the importance of an entrepreneurial state that acts as an innovation co-investor and risktaker [52] and argue that public support for innovation can mobilize additional private investment [53].

4. The relationship between carbon pricing and industrial policies

Carbon prices alone may indeed be insufficient to achieve a net-zero economy. The question of whether policymakers should rely on a carbon price or a different policy is only relevant if they have to choose between these instruments. However, in most instances policymakers combine policies that complement each other [54,62] and scholars have repeatedly argued in favor of a policy mix for climate policy [63–65]. Applying a combination of policies might also increase the credibility of climate commitments and increase their resilience against reversal of individual policies [66,67].

An analysis of how different policies have reduced emissions in the G20 countries finds that even though on average renewable pledges had the strongest effect, most G20 countries also include a carbon price in their portfolio of climate mitigation measures [68]. Likewise, a recent study highlights that approaches that have successfully reduced

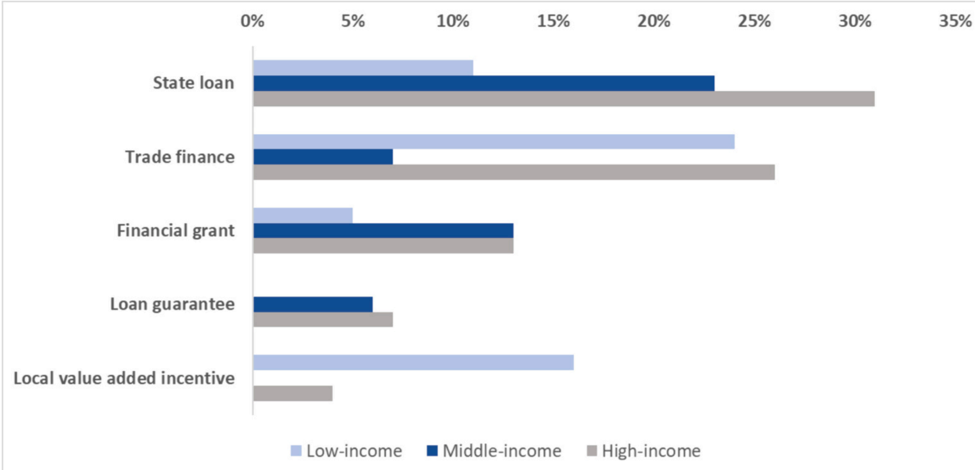

Fig. 1. Share of industrial policies that are deployed by the respective measure. The figure shows the top five measures for low-, middle- and high-income countries, respectively. Own depiction based on Juhász et al. [43].

Table 1
Overview of some of the most important market barriers, policies to address them and examples of their implementation.

Market barriers	Policies to address them	Examples
Technology spillovers related to research and development and learning-by-doing in production.	Financial support for research, development and pilot projects by the private sector, or by direct public investment in these activities [54]	Feed-in-tariffs to support deployment of renewable energy sources [55]
Network externalities and Coordination failures (i. e. "chicken-and-egg problems")	Green lead markets, green premiums, public procurement [56]	In many countries the government is the most important consumer of climate-friendly products and services [57]
Financial market frictions and risk aversion above the socially optimal level	Policy de-risking and financial de-risking [58]	Carbon Contracts-for-Difference guaranteeing a certain carbon price in the future (55)
Labor market frictions due to matching issues and social policies reducing incentives to seek different employment	Supporting the build-up of green industries in regions that are most severely affected; helping workers find new occupations [59]	Just transition commissions, task forces and policies to phase out coal implemented in numerous countries [60]
Competitiveness and leakage concerns due to less stringent policies in other countries	Applying environmental standards for imports or requiring a certain share of production to be sourced domestically [29]	Carbon border adjustment mechanisms to level the playing field between domestic and foreign producers [61]

emissions in the transport sector have included a carbon price alongside other policies, such as vehicle taxes or road charges [69].

The right balance between a carbon price and green industrial policies depends on the characteristics of the covered sector as well as the political and institutional context. Recent research suggests that even moderate carbon prices can achieve sizable efficiency gains, with diminishing benefits as carbon prices rise [70]. A carbon price can thus be regarded as essential inasmuch as it should be part of any policy portfolio. By contrast, other polices, such as innovation polices or measures to remove barriers for the uptake of low-carbon solutions, are highly sector- and context-specific [71,72]. Hence, it is crucial to understand the interplay of different elements of the policy mix [73] and align it with the multiple policy objectives pursued, such as environmental quality, employment, industry competitiveness and reduced import dependence [74].

Until recently, carbon prices were in most instances quite low, and low-carbon alternatives to fossil fuels were expensive. In view of the massive price decline of clean energy sources over the past two decades, it seems likely that emissions pricing will have stronger effects in the future, especially with carbon prices that are substantially above their historical values. Yet, empirical evidence suggests that past attempts to increase gasoline prices by means of higher taxes or reducing existing subsidies were often unsuccessful [75]. Cullenward and Victor [76] emphasize the political challenges of introducing a sufficiently high carbon price, arguing that the "politics of creating and maintaining market-based policies render them ineffective nearly everywhere they have been applied".

One line of criticism of carbon pricing concerns its distributional outcomes [77]. Assuming that low-income households tend to spend a higher share of their income on energy, carbon pricing is often regarded as being regressive. However, this is only the case for countries with high per-capita incomes. In poorer countries, in which the lower segments of the income distribution spend relatively little on energy, carbon pricing is in most cases progressive [78]. In addition, other policies, such as subsidies and performance standards, also have distributional implications, which might be even worse for low-income households than a carbon price [79,80]. Another critique is that carbon prices do not achieve sufficient buy-in from powerful interest groups, such as industry associations and trade unions. As Stokes and Mildenberger [81] write: "We can build successful political coalitions around climate policy when we give people something to fight for. If jobs and benefits are front and center, support for action will follow". Designing climate policies in a way that takes into account the objectives of key stakeholders is indeed essential [82]. Nevertheless, there is no compelling reason why politically feasible policy packages should not also include a carbon price. Moreover, as will be discussed in more detail in the next section, carbon pricing could generate revenues that can be used to advance key policy objectives.

A further issue concerns the salience of carbon prices. As price hikes for fossil fuels are directly experienced by consumers, for instance at the gas pump, they create more resistance than regulations whose costs are hidden to consumers [83]. But while the costs of non-market policies may be less visible, these policies tend to be more costly than market-based policies [84]. The political costs of implementing climate policy can be understood as a combination of salience and economic costs. With increasing climate policy ambition, the costs of non-market instruments rise more steeply than the costs of market-based policies, whereas salience can be expected to vary little with mitigation effort. Hence, above a critical level of climate policy stringency, an instrument's economic costs become a more important factor for the political costs than its salience (see Fig. 2). Non-market policies are thus only easier to implement if one assumes that ambitious climate targets are infeasible to achieve in the first place. For instance, Jenkins [85] finds that the willingness-to-pay for climate policy of US households is below USD 200 per year, which he equates to an upper limit for a carbon price of about USD 8 per ton of CO_2. Yet, such low willingness-to-pay does not only constrain the politically viable level of the carbon price; rather, it will make any ambitious climate measures infeasible to achieve, regardless of the instruments used to implement them – insofar as consumers understand what is going on. In addition, policies with higher salience can also have the beneficial effect of triggering a larger demand response than policies that entail an identical price increase, for instance for transport fuels, but are less visible to consumers [86].

5. Finding the right balance between carbon pricing and industrial policies

Some of the distributional concerns can be alleviated by appropriate redistribution of the revenues generated by a carbon price, for example in the form of tax breaks for firms and households or financial support for low-income households [87]. As a consequence, appropriate recycling schemes could greatly increase public support for carbon pricing [88,89]. Nevertheless, citizens are frequently unaware of the payoffs they receive from recycling of carbon pricing revenues [90] and wrongly perceive themselves as losers, arguably because of ideological reservations against climate policy [91]. Policy makers and civil society will need to step up their efforts to clarify some common misconceptions and explain to the public how the net costs of a carbon price are distributed across different social groups.

Experimental evidence further suggests that citizens favor earmarking of carbon pricing revenues for green spending [92]. Using carbon pricing revenues to fund green industrial policies could hence have the double benefit of increasing public support for carbon pricing while at the same time increasing its effectiveness by addressing important barriers to the innovation and deployment of climate-friendly technologies. For instance, of the about USD 30 bn of revenues generated by auctioning emission permits in the EU ETS in 2022, 76 % was spent on climate and energy (either directly by EU member states or through EU vehicles such as the Innovation Fund or the Modernization Fund) [93]. By contrast, climate policies that predominantly rely on financial support for clean technologies, such as the US IRA, need to finance spending from the general budget. Without the revenues from a carbon price, this either means cuts for other types of spending or increasing public debt, which can both raise political resistance and call into doubt the scheme's fiscal sustainability. This is especially relevant as industrial policies that are applied without a carbon price in place will require substantially more public spending compared to a case in which some emission reductions are achieved by a carbon price.

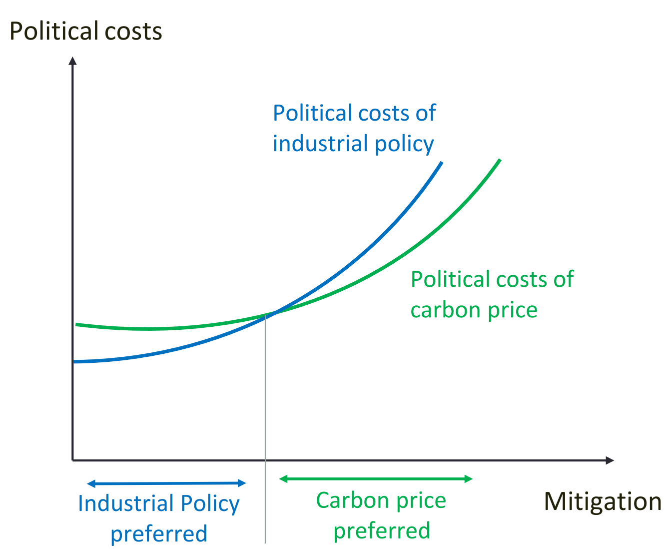

Fig. 2. Political costs are a combination of salience and economic costs. Carbon prices have higher salience, but lower economic costs. For low levels of ambition, the political costs of carbon pricing is higher than those of less visible instruments. For high levels of ambition, however, lower economic costs are decisive for making carbon pricing politically feasible.

How much of the revenue from a carbon price can be allocated to industrial policies will crucially depend on its level. With a higher carbon price, financial support will likely need to focus more on hard-to-abate sectors and a larger share of the revenues will need to be used to alleviate social hardships. Moreover, policy makers may resort to measures that avoid excess costs or make costs less salient. An example of such an approach is the Market Stability Reserve in the EU ETS, which dampens fluctuations in the price of emission permits [94].

Carbon pricing would also inflict sizable losses on a few industries closely tied to fossil fuels while at the same time creating benefits that are distributed across a wider set of actors and which are – at least to some extent – uncertain. In this constellation, it might indeed be easier to introduce policies that generate clear and visible winners, such as support schemes for clean energy. Nevertheless, this form of green industrial policy entails substantial challenges in terms of targeting the right technologies and may create lock-ins by subsidizing unsuccessful endeavors or maintaining financial support for mature technologies. More promising in this regard is to use these policies as a means to create winning coalitions supportive of carbon pricing, for instance by strategically using industrial policies to build up manufacturing capacities in clean technologies [95,96]. Industrial policies can also be used to achieve a just transition for workers in activities that would be most severely affected by phasing out fossil energy sources, such as coal mining [60]. Empirical evidence for the UK's Regional Selective Assistance suggests that such place-based industrial policies can have large effects on investment and employment [97].

For the EU, member states can engage in strategic planning and co-financing to strengthen key industries [98]. The main challenge to achieve a balanced policy portfolio is to focus on green industries in which domestic firms can become competitive on the global market [99] to ensure that green industrial policies are well-targeted [100]. For the US, by contrast, even though the massive financial support provided by the IRA can be expected to drive innovation and adoption of clean technologies, strategies exclusively aiming to foster alternative energies without disincentivizing fossil energy use are unlikely to succeed because of their high economic costs [101]. For this reason, for the US the main challenge will probably consist in finding a way to use the IRA to increase the chances of adopting a price on greenhouse gas emissions (in fact, a carbon tax was already debated during the negotiations over the design of the IRA). Strategically using the IRA to create winners (such as cleantech companies) and compensate losers (such as regions that depend on revenues from the coal, oil or gas industries) could alter the political balance and make it possible to introduce a carbon price. Likewise, lowering the cost of clean energy will also shield consumers to at least some extent against rising prices for fossil energy sources resulting from a carbon price and thus reduce political opposition to carbon pricing. The US government is already applying a "shadow carbon price" of USD 51 per ton of CO_2 to assess the costs and benefits of public investment projects and is considering the application of a substantially higher figure in the future [102]. This might serve as an entry point to attempt to extend carbon pricing to the private sector as well. The difference between the EU and the US can yield important general insight on the division of labor between carbon pricing and industrial policies. For countries that already have a carbon price in place, industrial policies can make carbon pricing more effective by lowering market barriers, e.g. for the diffusion of clean technologies. For other countries the most important objective for industrial policy might be to substitute for carbon pricing and reduce political resistance against a price on emissions.

6. The international dimension of industrial policies and carbon pricing

Green industrial policies create competition between countries to gain a first mover advantage in nascent markets for clean technologies. This could create the political momentum to speed up decarbonization but also creates an impulse for trade protectionism and may complicate international climate diplomacy [45,103]. Hence, green industrial policies need to allow individual countries to build on their particular strengths in the effort to expand clean technologies globally [104]. For instance, the price decline of solar power can be attributed to crucial innovations in different countries along the value chain [105]. It therefore makes sense for countries to design their green industrial policies to take into account the global context and to ensure that they can benefit from lower production costs for key inputs in other countries [106], e.g. by creating lead markets for green basic materials that are open to all producers [107]. In addition, trade agreements will need to include provisions that create policy space for green industrial policies by specifying which kind of technology support is deemed legitimate [108]. Finally, climate frontrunners could support green industrial policies in third countries with financing, technology transfers, capacity building and access to their markets [109]. Such benefits could be made contingent on a carbon price in the recipient country [110,111]. In this way, support for green industrial policies could have a double benefit by directly reducing emission intensity while at the same time softening political resistance to carbon pricing by lowering the costs of carbon-neutral alternatives. Proposals to establish climate clubs of front-runners with ambitious climate policies centered on carbon pricing [112] have so far gained little traction in climate diplomacy. As a consequence, it has been suggested to focus on cooperation to decarbonize energy-intensive industries, such as steel [113]. If these efforts were to succeed, they might open up new opportunities for international cooperation on carbon pricing.

7. Conclusions

This Perspective has argued that green industrial policies are not a silver bullet that can substitute for a carbon price and thus bypass the associated political challenges. Nevertheless, industrial policies can play an important role in a broader policy mix to address other market barriers and increase political support for (or political resistance against) climate policies. The climate policy discussion hence does not require a paradigm shift from carbon pricing to green industrial policies but rather an assessment of how these policies can be optimally combined in a policy mix.

Future research can help to identify synergies between carbon pricing and industrial policies. First, it is crucial to get a clear understanding of relevant market barriers to decarbonization and their interaction. Only then can policies be designed to address them. Second, ex-post evaluation of different approaches to carbon pricing regimes will contribute to a better understanding of their respective synergies and trade-offs with green industrial policies. Third, increased attention to the political economy and social acceptance of different climate policies in different country settings would help to design economically and politically optimal measures within existing political constraints.

CRediT authorship contribution statement

Michael Jakob: Writing – original draft, Investigation, Conceptualization. **Indra Overland:** Writing – review & editing, Validation, Conceptualization.

Declaration of competing interest

We declare that we are not aware of any conflicts of interest relevant to this manuscript.

Data availability

Data will be made available on request.

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