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Industry Transition to Climate Neutrality: Comparing Policy Approaches in Times of Geopolitical Fragmentation

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Abstract: European climate policy was traditionally pursued in the expectation of global policy convergence, ensuring equal opportunities for domestic and foreign firms in achieving climate neutrality. However, increasing geopolitical fragmentation has disrupted this expectation. Across the globe, national strategies increasingly favor economic policies that benefit domestic industries and coercive economic networks, altering the effectiveness of climate measures along international value chains. This study evaluates three policy approaches governing the transition to a climate neutral basic materials sector – (i) polluter pays, (ii) dedicated policies targeting both production and use, and (iii) green demand – to assess their political viability in the context of European policy in a fragmented world. Our analysis suggests that in a fragmented world, both the polluter pays and green demand policy approaches face significant challenges in achieving climate neutrality at sufficient stringency. A decarbonization approach based on separate but coordinated policies for material production and use appears to be more politically viable.

Keywords: Industrial decarbonization, Industrial policy, Climate policy, Geopolitical fragmentation, Value chains, Statutory incidence, Economic incidence

JEL Classification: F59, P18, Q58, Q59

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1. Introduction

The European Union expected climate policy to follow the path of broader economic policies toward global convergence. It was based on the understanding that all countries would be better off if each country implemented economic and climate policies that provide equal economic opportunities for domestic and foreign firms. However, increased global decoupling and geopolitical fragmentation with strong implications for climate policy is putting this expectation into doubt. Rivalry between China, the US, and the EU has risen, resulting in a fragmented geopolitical landscape where governments are faced with the challenge of balancing economic concerns with the protection of strategic industries and national security (Germann, 2023; Ding, 2024; Doppen et al., 2024; Lavery, 2024). Countries are not only increasingly implementing economic policies that primarily benefit their domestic firms, such as local content requirements or preferential access to capital (Allan et al., 2021; Lewis, 2014, 2021), but are also deploying economic networks as tools of coercion, leveraging strategic dependencies to assert political influence – a phenomenon known as weaponized interdependence (Farrell & Newman, 2019). The presidency of Donald Trump will most likely exacerbate this geopolitical rivalry, leading to a further escalation of trade barriers and an even stronger focusing of industrial policy on national interests.

These developments prompt questions related to how the increasing fragmentation of the climate policy landscape affects the political acceptance and, thus, viability of different policy instruments to achieve the objective of a transition to climate neutrality. Climate policy instruments implemented in one country impact other countries because the economic effects propagate via trade channels. The effects of these international interactions matter for domestic firms, consumers, and public administrations as much as for other countries and, thus, impact the political viability of their implementation.

In a converging climate policy landscape, a carbon pricing mechanism, for example on steel production, would propagate first to firms using steel in construction or manufacturing and then to final consumers. Higher steel prices incentivize efficient material use, material choice, and recycling. The higher steel prices would also generate additional revenues, allowing firms to finance clean production facilities. The steel producers are legally obliged to pay the carbon price (statutory incidence)[1] which creates economic incentives – including costs as well as benefits – for the entire value chain (economic incidence) if the producer is able to increase the price by (part of) the amount of the tax.

However, in a fragmented climate policy landscape, carbon pricing is only implemented in some countries. The resulting asymmetry encourages a relocation of production and emissions to countries with less stringent carbon pricing. Furthermore, international competition from firms in third countries prevents the pass-through of the carbon price to product prices. This partially mutes incentives for efficient material use, choice, and recycling while preventing the generation of additional revenues for climate neutral production.

In the years when most actors expected a global convergence of economic and climate policies, these international interactions through trade channels had little impact on the choice and the design of climate policy instruments. They merely triggered the implementation of temporary fixes, like the free allocation of allowances under the EU Emissions Trading System (EU ETS). It was clear that these temporary fixes also muted many of the desired incentives for greenhouse gas mitigation. Yet, this was found to be acceptable for a brief transition period only. In the context of global convergence, little importance was attributed to the difference between statutory and economic incidence of climate policies. This neglect

[1] The concept of the difference between statutory and economic incidence goes inter alia back to Musgrave (1959).

was driven by the well-established theoretical result that the statutory incidence of a policy does not matter for its economic incidence in a closed economy or in a world of globally harmonized policies (Kotlikoff & Summers, 1987; Anderson et al., 2001; Weyl & Fabinger, 2013). In such a world, the ultimate economic impact of a policy would, in principle, only depend on the market structure and not on the legal assignment of compliance responsibility. The costs and benefits of a carbon price imposed on emitters, would propagate and create incentives for decarbonization along the entire value chain.

In a fragmented world, the statutory incidence of climate policies – whether placed on material producers or on material users – shapes the distribution of costs, benefits, and incentives along the value chain. This, in turn, influences which actors support or oppose these policies, making it a key factor in assessing their political viability.

With the expectation of an extended fragmentation of the global climate policy landscape and economic policies increasingly tilted to benefit domestic firms, public administrations are reconsidering their choice of climate policy instruments. To assess these developments, we propose to structure these options along three policy approaches (see Figure 1). We choose to focus our analysis on climate policies dedicated to basic material production and use: Basic materials, like steel, cement, and bulk chemicals, comprise about 60 percent of industrial greenhouse gas emissions (Bashmakov et al., 2022). Moreover, their high carbon intensity and commodity nature makes them particularly exposed to differences in carbon costs and, thus, to implications of a fragmented global climate policy landscape.

First, the polluter-pays approach makes the emitters directly liable for their carbon emissions via carbon pricing and is often highlighted as the first-best solution in the literature(Fischer & Newell, 2008; Baranzini et al., 2017; Gugler et al., 2021; Van Den Bergh et al., 2021). Implementing this approach means that the statutory incidence is with basic material producers, and a border-adjustment mechanism is implemented to protect domestic competitiveness and to ensure that the costs can be passed through along the domestic value chain. Thus, the economic incidence propagates along the value chain. If costs for conventional material production increase due to a higher carbon price, the resulting higher basic material prices create incentives for efficient material use and encourage more material efficiency, circularity, and substitution of conventionally produced materials with other (clean) materials.

Second, many scholars acknowledge the reality of a dedicated policy approach comprising a mix of tailored policies (Bertram et al., 2015; Jakob & Overland, 2024; Richstein et al., 2024; Jakob & Mehling, 2025; Weber et al., 2025). We foresee a separation of policies for material production and material use – each with the statutory incidence targeted to the actor for which the economic incidence is desired. This can comprise, for example: (i) support for clean basic material production, (ii) incentives for efficiency improvements of conventional basic material production through emission trading with free allowance allocation, and (iii) resource or climate charges on material use to enhance incentives for efficient material use and circularity. These dedicated separate policies may well be coordinated, e.g. to ensure revenues from a resource or climate charge can fund incremental costs of clean production process.

Third, a green demand approach, by contrast, uses policy instruments that encourage or oblige material users to use a share of climate neutrally produced materials that is increasing over time (see e.g. Bataille et al., 2018; Vogl et al., 2021; Trollip et al., 2022). Hence, the statutory incidence of green demand instruments such as a green quota or green public procurement rests with material users. Further, these policies are designed with the expectation that the economic incidence propagates along the value chain to material producers – providing incentives for material producers to invest in, and to use, clean and circular production processes. The additional costs incurred by users of materials create incentives for enhanced material efficiency or substitution with alternative materials. In principle, the statutory incidence again propagates – this time from the user of materials along the entire value chain to the producer.

In this paper, we assess the political viability of each of the three policy approaches. To allow for comparability, we assume each is implemented with the stringency necessary to achieve climate neutrality in the basic material sectors. We assess the political viability by analyzing whether the policy approach affects key stakeholders' objectives in such a way that the stakeholder supports or objects to the implementation of the elements of the policy package.

We first define a specific example of a policy package for each policy approach, building on existing policy instruments, primarily from the European climate policy context. We then examine how the objectives of key stakeholders - consumers, industry, and public administration – are impacted by the policy approaches. This ultimately determines their political viability as these stakeholders may object to the implementation if their objectives are significantly hampered by the policy approach. In our assessment of the policy approaches' impact on stakeholders' objectives, we pay particular attention to the discrepancy of statutory and economic incidence of policies in a fragmented world (see section 2). We contribute to the literature by focusing the assessment on the divergence of climate policies' statutory and economic incidences in a geopolitically fragmented world. While this was of limited importance in a globally converging world, understanding this discrepancy is paramount in a fragmented world with differing economic and climate policy instruments across countries.

We find that it may be challenging to continue to pursue the polluter pays policy approach in a geopolitically fragmented world, if the objective is to implement the policy with sufficient stringency for a transition to climate neutrality. Equally, it seems difficult to rest the hopes on a green demand approach. We recommend a policy approach relying on separate but coordinated policies for production and use of materials, as it seems to be more politically viable than the former two approaches when implemented with sufficient stringency for a transition to climate neutrality.

2. Analytical framework

To analyze the political viability of the three policy approaches, we combine a simple representation of key actors' objectives with a dual incidence framework, in which we carefully analyze the statutory and economic incidence of each policy approach. The statutory incidence ('Who is regulated?') refers to the legal obligations imposed by a policy, which are often not congruent with the ultimate economic impacts of the policy. The economic incidence ('Who is impacted?') refers to the real economic or financial impacts experienced by the stakeholders due to the policy.

To identify the key actors' objectives, we focus on the most important actor or stakeholder groups with the power to influence, facilitate, or block public policies: we distinguish between industry (represented by their interest groups) (Gilens & Page, 2014; Macher & Mayo, 2015), consumers (represented by their interest groups) (Allen, 2013), and public administration (Egeberg, 1995; Bach, 2021). We presume that the industry focuses on maintaining competitiveness and enhancing profitability, consumers prioritize reliable access to affordable goods, and the administration focuses on minimizing administrative complexity of regulation and on reducing strain on public budgets. We argue that all three stakeholder groups have significant influence in the public policy process (Levy & Egan, 2003; Gullberg, 2008; Hughes & Urpelainen, 2015) and would have the power to undermine a policy approach if it strongly impedes their objectives. Therefore, we consider a policy approach to be politically viable if it is compatible with all three actors' objectives.

We are aware that this is a simplistic representation of the public policy process and that there are other elements that must be taken into consideration for a holistic assessment of the viability of a policy approach. A policy process in the realm of climate change is not only guided by the actor's objectives, but also by how well these interests are articulated via lobbying and rent-seeking behavior (Helm, 2010). Furthermore, electoral dynamics and incumbencies (Geels, 2014; Fankhauser et al., 2015) are also crucial in the process. For example, Fankhauser et al. (2015) highlight that even governments with a strong executive are reluctant to pass climate change legislation at the end of an electoral cycle. Institutional factors are also of utmost importance, such as the institutional capacity of a government to shape climate policy instruments (Willems & Baumert, 2003; Hughes & Urpelainen, 2015), the level of democracy (Bättig & Bernauer, 2009; Levi et al., 2020), political corruption and the perception thereof (Rafaty, 2018), and the legal and constitutional guarantees for freedom of expression (Tjernström & Tietenberg, 2008). Further literature investigates in depth the conditions under which similar policies are adopted across jurisdictions (Urpelainen, 2013; Fankhauser et al., 2016), and under which they diverge internationally (Lachapelle & Paterson, 2013). Building on this literature, Jakob et al. (2020) develop a generalized AOC (Actors, Objectives, Context) political economy framework to guide and facilitate cross-country comparisons of how economic structures, political institutions, and the broader political environment shape policy outcomes.

We use a simplified representation of public policy process to allow for a focus on the deviating statutory and economic incidences of policy instruments in a politically fragmented world.

Statutory and economic incidence with a fragmented policy landscape:

It is a well-established theoretical result that the economic incidence of a policy is independent of the statutory incidence in many economic settings (Anderson et al., 2001; Kotlikoff & Summers, 1987; Weyl & Fabinger, 2013): the incentives created by a policy (economic incidence), in principle, only depend on the market structure and not on the legal assignment of compliance responsibility (statutory incidence). In theory, the irrelevance of the statutory incidence holds in a closed economy if prices adjust smoothly and if economic agents make decisions based purely on net payoffs. These conditions are generally met in simple, transparent markets with minimal friction, where market forces can freely distribute the economic burden of compliance according to the relative elasticities of supply and demand (Kerschbamer & Kirchsteiger, 2000). The reason for the irrelevance of the statutory incidence in such settings is that the costs and incentives of a climate policy will propagate along the value chain according to elasticities of supply and demand at each point in the value chain.

The propagation along the value chain reflects one of the core "principles of incidence" (Weyl & Fabinger, 2013), which is defined as cost pass-through. It is a measure for how firms change their product prices in response to cost changes. If there is an industry-wide cost shock, hence, if all firms in a market are affected symmetrically, the extent of pass-through depends on the relative elasticities of supply and demand while it is independent of who bears the legal responsibility to comply with the climate policy.[2] For example, if unit production costs increase by 10 EUR due to the introduction of a carbon price and firms subsequently increase their product prices by 6 EUR, the corresponding cost-pass through is 60%. For the basic material industries we consider in our analysis, empirical evidence suggests near-full cost pass-through for industry-wide cost increases (Miller et al. 2017, Genesove & Mullin 1998, Borenstein et al. 1997). Meanwhile, firm-specific cost shocks can only be passed on to a

[2] In general, cost pass through increases the higher the elasticity of supply relative to the elasticity of demand. For example, a flat marginal cost curve (fully elastic supply) results in 100 percent cost pass-through. However, even in a harmonized world, the statutory incidence can matter due to market frictions or oligopolistic behaviour that can reduce or escalate the propagation of the economic effect (see for example Auerbach 2019).

much lower extent, as material users can easily switch to other suppliers if the firm experiencing the cost shock increases its price above the market price (Muehlegger & Sweeney, 2022).

Using harmonized "global carbon pricing" has been a stated hope in much of the climate policy discourse (Baranzini et al. 2017; Cramton et al. 2017, p.7). It can be compared to industry-wide cost-shocks as all market participants would be exposed to a similar carbon price. Thus, with harmonized global carbon pricing, the economic incentives and costs created would, in principle, be independent of their statutory incidence as the effects will propagate along the value chain according to the relative elasticities of supply and demand. By contrast, in a fragmented world, when a climate policy instrument is only implemented in some jurisdictions, it may have the effect of a cost-shock that only applies to a subset of the market. The resulting cost-pass through would be smaller than an industry-wide and larger than a firm-specific cost-shock. National or regional climate policies, where the statutory incidence of a policy is with the material producer, tend to correspond to such a cost-shock affecting only a subset of the market. For example, if carbon intensive industries face statutory obligations to comply with stringent carbon regulation in a country, then this could create a competitive disadvantage to industries in another country, increasing the risk that the associated production may be relocated ("carbon leakage") (Kimmel, 1992; Demailly & Quirion, 2006). Consequently, the capacity to pass through carbon costs compared to an industry-wide cost increase is smaller because consumers will respond to increasing prices by buying from other firms within the same product market but that produce in unregulated jurisdictions. Neuhoff and Ritz (2019) illustrate in a theoretical Cournot competition model, where firms compete in quantity, that a large share of unregulated firms limit the scope of carbon cost pass-through. This is also confirmed by empirical evidence for the US (Muehlegger & Sweeney, 2022). In contrast, national or regional climate policies with statutory incidence at the level of final purchaser of the goods, have the economic effect of an industry wide cost shock. In practice, the statutory incidence of (semi-) fiscal instruments is typically anchored where compliance can be (easily) monitored and verified. Hence the statutory incidence of policy instruments like excise charges is typically with the producers of the goods. As excise charges are levied at standardized values, irrespective of production process or location, they can also be applied to imports and are typically waived where products are exported. Thus, they do not distort trade or cause carbon leakage. The use of standardized values also avoids incentives for firms to redirect their readily available clean products to regulated markets to reduce charges. This so-called resource shuffling does not result in real carbon abatement. As the cost shock remains largely limited to domestic firms. it would again differ from an industry-wide cost shock and bring the policy closer to the case of a firm-specific shock with lower cost pass through.

Structure of analysis:

We discussed that the statutory incidence is a relevant factor in determining how actors are economically affected by a policy as well as how costs and incentives are distributed along the value chain in an economically integrated, albeit politically fragmented world. Thus, when analysing how the different policy approaches affect the stakeholders' economic objectives, we explicitly focus on the effects of the allocation of statutory incidences which differs across the outlined approaches.

For each actor group, we analyse how the policy approaches affect their objectives by applying the dual incidence framework. Within the dual incidence framework, we distinguish between material producers and users (see Figure 1). Actors of industry can fall into both categories, material producers and material users, while consumers only fall into the category of material users.[3]

For comparability, we assume that the different policy approaches are implemented at a stringency required for a transition to climate neutrality.

Finally, and going beyond the analysis of the policy approaches' impact on key actors' objectives, we also discuss the international context. In particular, we consider and evaluate how third-country governments may react to the implementation of the respective policy approaches.

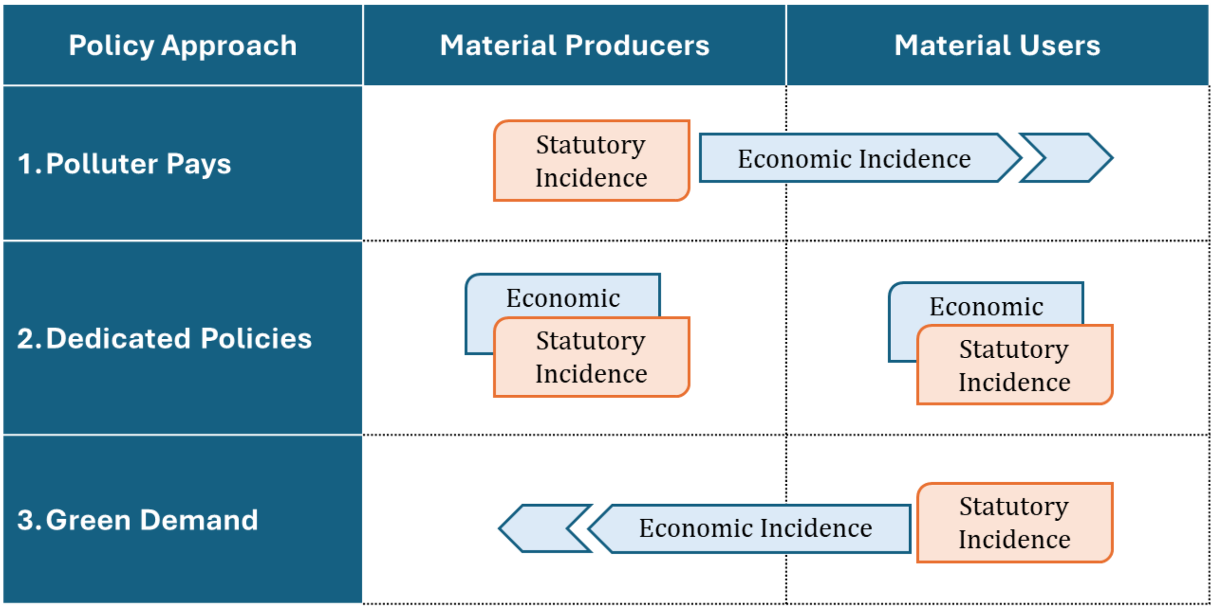

Figure 1: Overview of policy approaches and their statutory vs. economic incidence along the value chain

[3] For example, while steel producers are only accounted for as 'material producers', downstream industries such as the automotive industry as well as final consumers are material users.

3. Assessment

In the following section, we assess each of the proposed policy approaches. We start by describing each policy approach and its intended effect in relation to the decarbonization to net zero. Subsequently, we assess the political viability of the policy approach by evaluating its real-world impact on our defined stakeholders and their ensuing support of or opposition to it.

Policy approach 1: Carbon pricing implemented for production of materials

A basic approach of environmental policy is the polluter pays principle: greenhouse gas emitters are liable to pay for their emissions. Carbon prices create incentives for installations to reduce their greenhouse gas emissions, thus saving carbon costs. A carbon border adjustment mechanism (CBAM) extends the carbon price to material imports from third countries, ensuring that producers internalize carbon costs in material prices. Hence, the subsequent stages of the value chain should be incentivized to improve material efficiency, substitute with alternative materials, or adopt circular options (see Figure 2). Additionally, as conventionally produced materials bear carbon costs, the competitiveness of (near) climate-neutral production processes increases.

Most Emission Trading Systems, including the EU Emission Trading Systems (EU ETS), comprise free allocation of allowances to basic material producers, to avoid the risk that firms relocate emissions-intensive production (carbon leakage) instead of reducing emissions (Verde, 2020; Grubb et al., 2022). However, along with providing carbon leakage protection, free allowance allocation also largely mutes the carbon price reflected in basic material prices, thus reducing the incentives for material efficiency, substitution, circularity, and a shift to clean production processes.

To allow for a phase out of free allowance allocation and to reinstate effective carbon price incentives, the EU has agreed to implement CBAM (European Parliament and Council, 2023). The objective of the mechanism is to level carbon cost differentials, thus avoiding the incentives for relocation of production and of emissions. The EU CBAM envisages, at the time of full implementation in 2034, that importers are liable to surrender CO_2 certificates for emissions related to the production of basic materials and basic material products imported into the EU.

The experience with the EU ETS is also characterized by large and unpredictable price variations linked to economic and political developments (Hintermann et al., 2016; Bolton et al., 2023). These translate to significant investment risks. Therefore, countries like the Netherlands and Germany have already implemented hedging instruments underwritten by the government to support investors in managing this regulatory and market uncertainty; other countries, like the UK, are following (BMUV, 2021; RVO, 2021; UK Department for Energy Security & Net Zero, 2024). Hence, in this policy approach, we also assume that carbon contracts for difference (CCfDs) are auctioned for investments in (near) climate neutral basic material production technologies to address concerns of investors that carbon prices may be too uncertain to allow for financing and continued operation of climate neutral production technologies.

The statutory incidence of EU ETS and the carbon contracts for difference is with domestic producers. To address carbon leakage risks, a CBAM is assumed to be part of the policy approach. The CBAM creates a statutory incidence for importers. For every imported good, they need to provide a verified report of the carbon emissions caused and carbon price paid at the production site. This information serves as the calculation base for the CBAM levy that importers must pay, thus affecting the price they can offer foreign material producers, ultimately extending the economic incidence to foreign producers. The CBAM intends to expose imported materials to the same carbon costs as domestically produced materials. As an economic incidence is created also imported goods, domestic producers (facing international competition) can pass through their carbon costs to material prices, thereby extending the economic incidence to the value chain (see Figure 2).

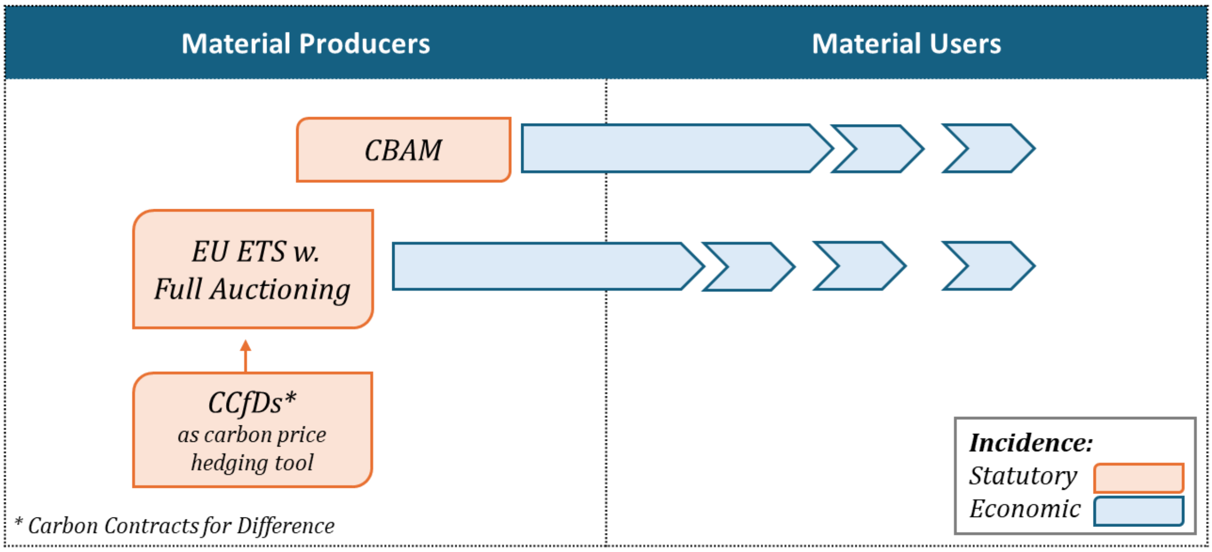

Figure 2: Polluter Pays instruments (Approach 1)

Assessment:

In the following, we evaluate whether the needs of three key stakeholder groups—industry, consumers, and public administration—are adequately addressed. The evaluation aims to determine the viability of implementing the policy approach at sufficient stringency to reach the climate neutrality target without their strong opposition.

Industry: The domestic industry is unlikely to support a stringent implementation of this policy approach. This is largely linked to concerns that CBAM does not effectively address the carbon leakage risk, e.g. to avoid the relocation of production and emissions to third countries. Hence, while the statutory incidence lies on both – domestic producers and importers – CBAM does not fully act as an industry-wide cost shock and therefore does not enable full carbon cost pass-through given the reasons specified below.

First, the CBAM creates (unintended) incentives for resource shuffling (European Commission, 2021a). For example, European importers now selectively attribute their low-carbon or green "assets" (such as cleaner production facilities or operations using renewable energy) or recycled materials to their exports to the EU. This means that foreign firms would benefit from reduced CBAM payments compared to their EU competitors with the same average emission intensity of production, resulting in a competitive disadvantage for the local primary producers.

Second, it was considered administratively too costly for public and private actors to trace and verify the emissions incurred for each of the components in manufactured products comprising multiple materials (European Commission, 2021a). Therefore, the value chain is not entirely covered by the CBAM. Thus, the domestic manufacturing industry faces higher costs for materials than their international competitors with whom they compete in the product market without an adjustment of carbon costs.[4]

Third, the CBAM does not refund carbon costs incurred on exports and, thus, results in a competitive disadvantage in export markets in third countries for domestic material producers and manufacturers. This limitation has a legal basis, as refunding input costs to production processes is seen as problematic under WTO rules. Moreover, if carbon intensive material producers could get their carbon costs refunded, they would dedicate their particularly carbon intensive production to exports rather than the domestic market thus avoiding carbon costs and incentives for mitigation. Each of the shortcomings implies that there are incentives for the relocation of emissions-intensive production to regions outside of the EU, hindering global efforts to achieve climate neutrality (Stede et al., 2021).

Further, there is an additional regulatory barrier: the time inconsistency of political commitment. While carbon pricing has long been established as a key policy measure to incentivize the adoption of climate-friendly technologies and cleaner production processes, its full implementation has been subject to repeated delays (Laing et al., 2017). When the EU ETS was established, it was based on the principle that there would eventually be a shift to full auctioning of carbon allowances and a complete phase out of free allowances (European Commission, 2008), which also aligns with global best practices in carbon pricing (Borghesi & Montini, 2016). However, the transition to full auctioning has been delayed repeatedly, creating uncertainty for firms' decisions. While the commitment to the principle of full auctioning is still in place – reflected in the current objective of full auctioning by 2034 – the delays in its implementation undermine confidence in the system. Thus, companies are uncertain about the true timeline for these higher carbon costs to materialize, making it difficult for them to plan and justify the large-scale transformative investments needed for decarbonization.

Consumers: Consumers are indirectly affected by the policy approach to the extent that carbon costs are passed through to final product prices. So far, cost pass-through and therefore the effect has been limited, so it is difficult to project future acceptance. For the case of full pass through, the statutory incidence translates to an economic incidence along the value chain and, ultimately, is reflected in increased product prices. At EU ETS carbon price levels as of 2024 of about 60 Euro/t CO_2, low-income households' cost for purchasing the same product basket would be 0.5% of their total expenditure, increasing for high-income households to 0.6% (Stede et al., 2021).[5]

The scale of the effect is moderate and smaller for low-income households which should be positive for consumer acceptance. Public acceptance of carbon pricing could, however, decline if the EU's implementation of carbon pricing on transport and buildings (known as ETS 2) triggers broader public opposition: ETS 2 induces a far larger cost increase for low- than for high-income households. The impact additionally varies within income segments due to differences in mobility needs and building stock, potentially amplifying cost exposure for certain groups and exacerbating concerns about the policy's fairness. Thus, any opposition to carbon pricing triggered by ETS 2 could also spill over, undermining public acceptance of effective industrial carbon pricing.

Overall, consumer support for carbon pricing will depend largely on how informed they are about the costs and benefits (Douenne & Fabre, 2020; Levi, 2021). Therefore, acceptance may suffer the most if incremental costs paid by consumers are funding resource shuffling rather than climate action.

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[4] If the sector has a high potential for resource shuffling, then the carbon cost increase for material users may be reduced.

[5] The authors model a price increase assuming carbon costs of 30 EUR/t, reflected in material prices and all products comprising basic materials.

Public administration: European governments have signed up to the vision of an EU ETS based on the polluter pays principle. It offers an opportunity to address their constituencies' demands for climate policy with a policy instrument that academics and policy advocates have long claimed to be efficient and effective. In addition, the transition from free allowance allocation to full auctioning and CBAM offers the prospect of additional revenue that could fund climate action, either to increase its scale or to free up the public budget. It is politically appealing to adopt the "polluter pays" principle, implementing an instrument which assigns the statutory incidence with firms and reaches consumers "only" through the propagation of the economic incidence along the value chain.

International considerations: Third countries are exposed to the economic effects of the CBAM. Large countries will likely benefit from this policy approach as their producers can sell their products at the increased European market prices, while reducing the costs they bear for the CBAM through, for example, resource shuffling. Because European demand is typically only a fraction of their total production, they can attribute the production from their most efficient plants or from recycled materials to European exports (CRU, 2021). Industry in third countries also obtains a cost advantage in their domestic market and further unrelated countries, compared to European exporters that will not get their carbon costs rebated when exporting.

Direct concerns from third countries focus on the non-price barriers created by the Monitoring, Reporting, and Verification (MRV) requirements under the CBAM for delivering basic materials and related products to the EU. These administrative obligations increase compliance costs. Additionally, the unilateral intention to extend the EU's economic reach extraterritorially, without prior consultation with third countries, raises further concerns. Whether this approach undermines climate cooperation or demonstrates a commitment to using trade measures to support climate action remains unclear.

Policy approach 2: Dedicated policies for production and use of materials

In a fragmented world, the incentives from production-based policies do not fully propagate along the value chain. An alternative policy approach combines dedicated policies (i) for the production and (ii) for the use of basic materials. The policies are designed such that the statutory incidence is located at the level of intended action whereby the creation of the economic incidence along the value chain is deliberately restricted by the choice of policies (see Figure 3). Regarding the former, a variety of policies exists to support the transition to climate neutral production of materials. First, the Inflation Reduction Act comprises production – and other tax credits for investments in climate neutral material production (IRS, 2022). Second, direct subsidies and preferential loans have been granted to some firms for investments in climate neutral production, for example as part of the EU recovery program (European Commission, 2021b). Third, CCfDs are designed to cover the incremental costs of clean production plants, with provisions that insulate investors in such plants from future carbon price developments or changes to free allocation rules (Richstein et al., 2024). Fourth, the current EU emission trading system creates incentives to decrease the carbon intensity of conventional production processes. However, the free allocation of allowances linked to production volumes limits the carbon cost pass-through and, thus, hinders the propagation of the economic incidence along the value chain. In the future, free allocation will be partly conditional on the development and implementation of transition plans by firms, giving management the incentives and motivation for shifting to climate neutral production processes.

To ensure that the economic incidence of carbon pricing falls partially on those who use materials, a system would need to be implemented where the statutory incidence for carbon costs is placed on entities that introduce materials into domestic circulation. A climate contribution could serve this purpose (Brzeziński & Śniegocki, 2020; Neuhoff et al., 2025). Like other excise charges, it is levied on all imported and domestically produced materials or products comprising those materials and waived whenever those materials or products are exported again. The climate contribution is levied at the scale of free allowance allocation to producers of the corresponding material, e.g. per ton of steel, cement-clinker, or high-value chemical. This would ensure incentives for efficient material use and recycling and would provide a revenue stream for governments required to fund the incremental costs of climate neutral production, for example through carbon contracts for difference.

It is sometimes argued that a variety of other instruments are already in place to support efficient material use and circularity (Grubb et al., 2023; Sun & Neuhoff, 2025). However, facilitating the transition and ensuring credible compliance is challenging without an economic incentive stemming from the internalization of carbon costs (Brand et al., 2023). Hence, we consider these instruments as complementary to a price-based policy, like a climate contribution, that would be required to secure a stable revenue stream for climate neutral primary material production.

The policy approach comprises EU ETS with free allocation and carbon contracts for differences where the statutory and economic incidence is at the level of material production, and a climate contribution where the statutory and economic incidence is with material use (see Figure 3). The climate contribution is linked to the carbon price from EU ETS, which determines the level and revenue stream of the instrument.

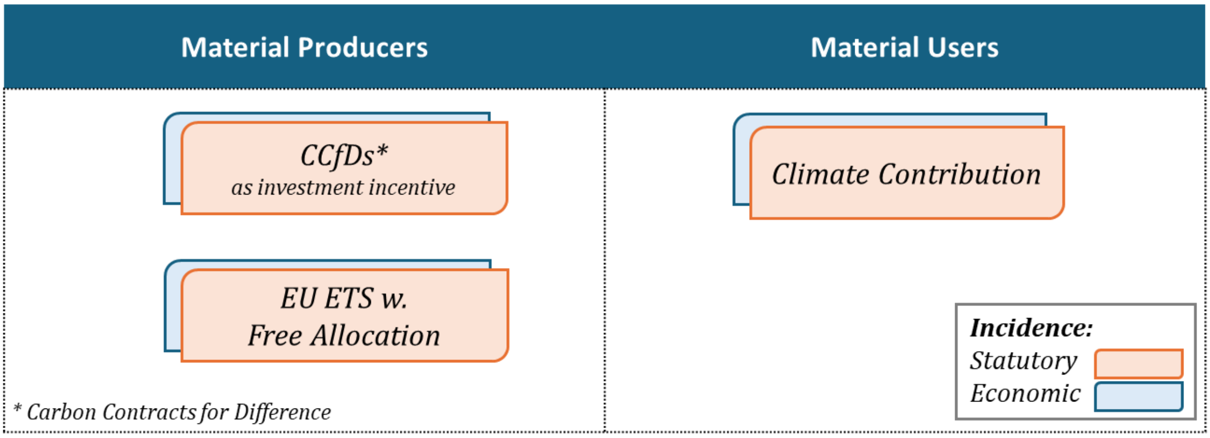

Figure 3: Dedicated Policies targeting both Production and Use (Approach 2)

Assessment:

Industry: The proposed policy approach introduces a dedicated funding stream through the climate contribution, which can enhance market confidence in the government's ability to tender sufficient carbon contracts for differences (CCfDs). This mechanism supports the transition to climate-neutral production processes by addressing the current investment limbo: carbon-intensive reinvestments are increasingly unattractive, while climate-neutral investments lack a viable business case. By providing predictable funding, the climate contribution helps mitigate these challenges.

However, concerns remain regarding the reliance on government-backed CCfDs funded through public budgets. Not all countries may have sufficient budgetary capacity to support future tenders of CCfDs at the necessary scale. Uncertainty about the long-term implementation and scope of future tenders could discourage firms from developing investment pipelines and deter equipment suppliers from scaling up and innovating green materials. These risks are mitigated if a climate contribution is implemented, as it provides a stable revenue stream, enabling both current and future governments to issue CCfD contracts with greater reliability.

Additionally, the policy approach safeguards international cost competitiveness. Under the EU ETS, continued free allocation ensures that basic material producers following a transition pathway will not face additional costs. These pathways remain financially viable with the availability of CCfDs. The competitiveness of industries using basic materials is also protected through the climate contribution, which is applied equally to domestic production and imports but waived for exports. By levying the contribution at a standardized value, the policy also avoids creating incentives for resource shuffling.

Thus, the approach has attractive economic features for industry and hence we observe first indications of their support.[6]

Consumers: The policy approach will have very similar direct economic effects for consumers in terms of cost increases as an EU ETS with carbon costs passed on to consumers. The impact is below a 0.5% cost increase relative to total consumer expenditure (Stede et al., 2021); thus progressive, while variations within income groups are moderate. Domestic consumers might react negatively because the climate contribution of this approach would be charged per ton of material which more explicitly translates to a cost increase for consumers than a carbon price. . However, the policy's appeal could be enhanced by providing transparent communication on the benefits for consumers, employees, and society. It will likely be crucial that the revenues are allocated to funding tangible climate action while strengthening the long-term competitiveness of industry and preserving associated jobs. Furthermore, the avoidance of resource shuffling incentives avoids associated acceptance risks anticipated under approach one. Thus, overall, it should be viable for policy makers to gain public acceptance for the approach.

Public administration: The policy approach presents significant opportunities but also challenges for the public administration. It provides resources to support both national and international climate action, with a particular focus on driving industrial transformation policies. These resources can enable governments to fund initiatives that align with their climate commitments and foster innovation in key sectors. The use of a standardized value also simplifies public and private administration and allows application along the value chain. However, there are concerns about the increased responsibility for designing effective tenders for carbon contracts for difference. This added responsibility requires careful planning and execution to ensure the policy delivers the intended outcomes, adding to the complexity of its implementation. Given a global landscape of comparable levels of government programs in other major economies, this will likely also gain support from the public administration.

International: The approach follows the philosophy of the Paris Agreement for national policy makers to take responsibility for its CO_2 emissions resulting from both the production and from the use of carbon-intensive products – in this case of materials.

It also is firmly in line with the principles and jurisprudence of the World Trade Organization. Hence, in principle, it should not raise concerns with climate and trade partners. It can also be argued that the approach follows the Common but Differentiated Responsibilities (CBDR) by ensuring and supporting a national transformation potentially also ahead of other countries.[7] However, any change of approach does require careful communication and explanation to avoid the risk of triggering opposition. In particular, the support granted to domestic climate neutral production processes with carbon contracts for difference can raise concerns with respect to the capacity of emerging economies and developing countries to follow such a transformation. Thus, it is therefore highly advisable to earmark a portion of

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[6] This perspective was highlighted during the LSE webinar *"Industrial Decarbonisation in a Fragmented World: An Effective Carbon Price with a Climate Contribution"* held on March 19, 2025, where industry representatives expressed their views on the climate contribution's potential benefits and challenges.
[7] See Article 4 paragraph 2 of the Paris Agreement (United Nations, 2015).

the revenue generated for international climate finance, particularly to support the transition including circularity and climate neutral production processes in partner countries.

Policy approach 3: Green demand

Policies that create a "green demand" for climate neutrally produced materials have captured increasing attention (Agora Industry, 2024). Their statutory incidence resides with firms selling final products to customers in the EU (see Figure 4).

A prerequisite for green demand policies is that the materials or products are appropriately labeled to provide information regarding whether the incorporated materials are produced with a climate neutral production technology and, if not, how carbon intensive the production process was.

In principle, green demand could be promoted by voluntary demand or by mandatory measures like green public procurement, quotas for the use of green basic materials, or product carbon requirements.

Voluntary green demand is unlikely to provide sufficient incentives to bring the basic material industry to net zero. If consumers have a higher willingness to pay for products comprising green instead of carbon intensive materials (green willingness to pay), then a price premium for green products may emerge (green premium). In principle, a sufficiently high green premium could incentivize firms to decarbonize their basic material production. Even though there is ample evidence that environmental motives play a role for some consumers' purchasing decisions (Jalil et al., 2020; Sundt & Rehdanz, 2015; Tilling, 2023), it seems that a large share of consumers has only a low green willingness to pay, or no green willingness to pay at all (Köveker et al., 2023). For these reasons, consumers' voluntary green willingness to pay is unlikely to provide sufficient incentives for transformative investments needed to achieve climate-neutral basic material production (ibid.).

Hence, a policy approach based on green demand must be backed by mandatory government policies for the use of green basic materials, e.g. a mandatory green quota. A green quota prescribes that all final products sold to private or public consumers within a country's jurisdiction must contain a certain share of green basic materials. Thus, the statutory incidence would be with firms selling final products to consumers in Europe. These firms would have to ensure compliance with the quota in their input portfolio. The economic incidence would propagate along the value chain to basic material producers (see Figure 4).

To qualify as green, a basic material must meet a pre-defined emission-intensity threshold.[8] Currently, only a limited amount of green basic material production capacities is available. Therefore, the quota would start at lower levels and increase over time, eventually reaching 100 percent, requiring all basic materials used in final products to be green.

[8] One could consider setting the threshold at the EU ETS emission intensity benchmarks, which reflect the average emission intensity of the 10% cleanest plants in a sector. Over time, the threshold would decrease until eventually reaching climate neutrality, which is when only basic materials that emit zero CO_2 emissions qualify as green.

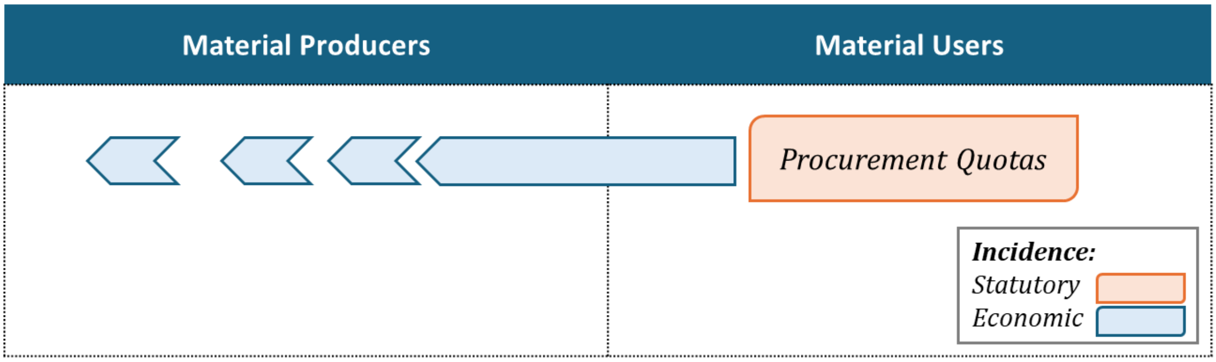

Figure 4: Green Demand (Approach 3)

Assessment:

Industry: Under the simple design of a green quota described above, the statutory incidence of the green quota is placed on firms selling final products to customers. The economic incidence arises along the value chain, thus also impacting intermediate and basic material producers. Foreign producers may however be able to redirect existing low-carbon production capacities (e.g., recycling) to serve the EU market (resource shuffling). As a result, domestic basic material producers may face a cost disadvantage compared to foreign firms. In sectors with much potential for such resource shuffling, it may threaten the competitiveness of domestic basic material producers which would then oppose this approach. Additionally, another type of resource shuffling could threaten the approach's effectiveness for domestic decarbonization: Domestic producers may partly redirect emission-intensive production to export markets (without a green quota) instead of decarbonizing their processes to serve the domestic market (with a green quota).[9]

A further aspect to consider is whether a green quota provides a sufficiently reliable additional revenue stream to encourage investments and facilitate operation of climate neutral production (Butler & Neuhoff, 2008). Two decades ago, green quotas were a prominent policy instrument to support deployment of renewable electricity generation. They, however, struggle to create a credible investment framework as governments could later relax them to reduce consumer costs, coming at the expense of investors. It is also difficult to calibrate green quota targets, for example because of existing climate neutral primary and recycled secondary material production. This contributes to a volatile supply-demand balance and price, implying that resulting revenue streams for new climate neutral investments will also be uncertain. The uncertainty undermines the business case for new climate-neutral

[9] There exist several options to amend the design of the green quota to address resource shuffling concerns: (i) implementing export provisions, (ii) shifting the statutory incidence to producers, or (iii) crediting only domestic climate-neutral production. (i) Export provisions would prevent emission-intensive production from being redirected abroad. While this would strengthen the quota's effectiveness for domestic decarbonization, it would undermine basic material producers' competitiveness on export markets thereby further increasing their opposition to this policy approach. (ii) Shifting the statutory incidence to producers (i.e. a green production quota) would require that domestic basic material producers ensure that a share of their output is climate neutral. However, this would increase costs for domestic producers compared to foreign competitors and again raise opposition to the approach. (iii) Alternatively, only domestic climate-neutral production could be credited toward the green quota. As the quota increases towards 100%, this would effectively restrict the volume of basic materials that can be contained in imported products thereby acting as a strong trade barrier. Each of these options to address resource shuffling entails other challenges that would likely contribute to undermining the political viability of the green quota.

investments. Hence, it is unclear whether green quotas would really gain strong political support as a central policy instrument for the transition to climate neutrality by industrial actors.

Consumers: If domestic producers can maintain their domestic market shares, then final good prices will increase due to higher production costs of green basic materials. In most final goods, the share of production costs that are attributable to basic materials is rather low (Pauliuk et al., 2016). Furthermore, the share of green production will only gradually increase and, hence, the costs to consumers will only be moderate in the initial years. Eventually, it will increase to a similar level as in the previous two policy approaches. However, any incremental costs paid by consumers – induced by the green quota – should be associated with actual decarbonization of production instead of a mere reshuffling of existing production capacities. The significant risks of resource shuffling under a green quota may thus undermine its public acceptance. It would therefore be essential to develop measures to effectively address resource shuffling concerns to limit opposition by consumers to a green quota.

Public administration: Applying such a quota is administratively complex. On the domestic side, as the statutory incidence is based with the large number of actors that ultimately deliver the product to domestic consumers, compliance by this large number of firms needs to be monitored. This is more challenging than if the statutory incidence is with material producers. Basic materials contained in imported products and their emission intensity must be monitored, traced, and verified, which is especially challenging for complex products (such as cars). Similar to the current difficulties of the EU in applying the CBAM to more complex products, it would also very challenging to apply the green quota to the entire value chain (Spinaci, 2023). This administrative challenge is one reason why not the entire value chain is currently part of EU CBAM (European Commission, 2021a; Sakai & Barrett, 2016). However, to effectively lead to climate neutrality of basic material production, the green quota must be applied to the entire value chain. The associated challenges may raise major concerns among those parts of the administration responsible for implementation.

International: A green demand approach based on a mandatory green quota for final products can be attractive from the perspective of large exporting countries that can play the market with resource shuffling; i.e. they can redirect their already available low carbon production (e.g. existing recycling capacities) to serve the EU market at low or no incremental costs (CRU, 2021). For small exporting countries, compliance with such a green quota is more challenging as they have less capabilities to use resource shuffling (CRU, 2021). Thus, they may be concerned about losing market access if they cannot comply with the quota and, therefore, oppose the approach. As the quota must be applied to imports, it would come along with Monitoring, Reporting, and Verification requirements, which may be disconcerting for all countries exporting to the EU.

4. Concluding discussion

In a world marked by increasing geopolitical fragmentation, climate policy implementation has become increasingly complex. As a global carbon price has failed to materialize, countries have developed different instruments to achieve their CO_2 reduction targets. Hence, comparison and assessment of the effectiveness of these instruments is challenging. To address this issue, we categorize the climate policies along the lines of statutory and economic incidence.

Statutory incidence refers to the legal obligation associated with a particular policy, while economic incidence captures the actual impact on different parties involved, regardless of formal responsibility. We analyze how different stakeholders are affected by policies, enabling a detailed understanding of both the statutory and economic incidences along the value chain.

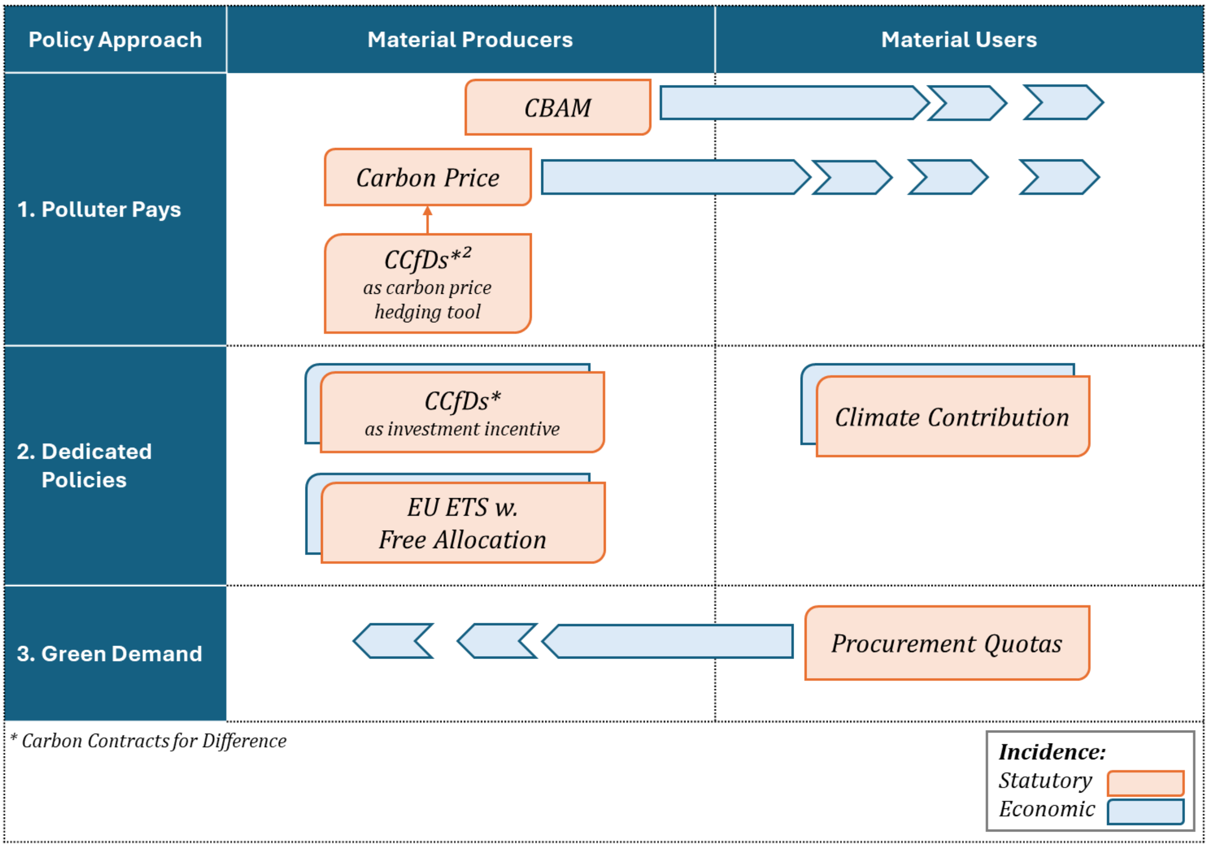

Figure 5: Summary of our policy approaches and selected instruments

In our analysis, we categorize instruments around three distinct approaches (see Figure 5):

1. Polluter-pays: This approach centers on implementing carbon pricing mechanisms such as emissions trading systems and carbon taxes. Furthermore, we categorize any instrument complementing the explicit carbon prices under this approach: Carbon border adjustment mechanisms aim to level the playing field by imposing a carbon price on imports, reducing the risk of carbon leakage. Carbon contracts for difference insulate investors from carbon price uncertainties. While the public administration may favor the approach for its revenue-generating potential and alignment with the polluter-pays principle, domestic industries often oppose it due to competitiveness concerns. Final consumers would be impacted from a shift to CBAM and full auctioning with moderate and regressive cost increases at the scale of 0.5%. However, so far competitiveness concerns of industry have prevented such outcomes.

2. <u>Dedicated policies targeting both production and use:</u> This approach combines separate policies for production of basic materials and for material use, with revenue from material use policies funding climate-neutral material production. It includes measures like carbon contracts for difference and climate contributions, as well as an ETS with free allocation of permits. It may gain support from industry due to its dedicated funding stream for the transformation to green production processes and public administration appreciate its ability to drive industrial policy. However, it will require governments to continue to take some responsibility for industry strategy through ongoing tenders for CCfDs. Despite similar budgetary effects to the first approach, consumers may prefer this approach as the dedicated use of revenue for tangible investments in climate neutral production appeals to public interest in sustainability and securing domestic jobs.

3. <u>Green Demand:</u> This approach focuses on creating demand for climate-neutral materials through measures like mandatory green quotas or explicitly labelling green products. While it may appeal to foreign suppliers due to the benefits they can gain from resource shuffling, domestic basic material producers may oppose it due to competitive disadvantages. Governments face administrative challenges in its implementation due to complex monitoring and verification. Consumers may only face moderate price increases but may be concerned of the environmental integrity.

By categorizing policies in this manner, we contribute to an improved understanding of how different policy approaches target various levels of the value chain and how they compare to each other given a fragmented international playing field.

Our framework allows policymakers to better assess the potential impacts and stakeholder reactions to different policy options. Furthermore, it provides a structure for identification of policy instruments, potentially leading to more effective and politically viable climate policy implementation in a fragmented global landscape.

The three policy approaches focus on the financial incentives that make the transition to climate neutral choices economically viable for actors. They differ in the extent to which they may encourage firms to realize these opportunities rather than follow business as usual practices. We observe various design choices within these policy approaches as well as complementing policy instruments that are being deployed to help encourage the shift to clean technologies and practices. For example, free allowance allocation under EU ETS is conditional on the development of a climate-neutrality plan for some firms (European Commission, 2024). Reporting requirements for real economy firms and in financial markets such transition plans are also increasingly emphasized and developed as part of environmental, social and government reporting (ESG) and prudential regulation. This further encourages the managers of real economy firms to engage with the transition, not least because of a final element to be mentioned here: Product carbon requirements could ultimately be used to ban the use of carbon intensively produced materials. The prospect of such future product standards would provide additional encouragement for firms to ensure access to green technologies and prioritize green opportunities as a risk management strategy.

For the analysis, we structured the existing policy options into three policy approaches. In practice, we observe combinations of these approaches as well as gradual shifts between policy approaches. For instance, there is an ongoing shift from a polluter-pays approach toward the dedicated policy approach, with various dedicated support mechanisms for clean material production and emerging discussions on measures like resource charges or a climate contribution.

The currently observed gradual shift from a very focused polluter pays approach toward more dedicated policies for production and use of materials also raises questions for future research. First, the implications for domestic and international governance of such dedicated policies warrant further analysis, for example with regards to targets formulation and indicator use. Second, assuming the current shift towards dedicated policies production and use of materials continues, what could be future circumstances and pathways that may facilitate a return to a polluter-pays or green demand approach.?

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