Sustainability Blog

By PwC Deutschland | 30. April 2026

The true cost of carbon: quantifying carbon exposure across global value chains

Carbon pricing is expanding globally. Using the EU's Carbon Border Adjustment Mechanism (CBAM) as a lens, robust modelling reveals the real exposure most companies miss: the costs hidden deep in their supply chains.

Content

1. Carbon costs are here and growing 3

2. Why supply chain carbon costs matter 4

3. CBAM and its supply chain channel 5

4. What the numbers tell us and what they don't 8

5. From exposure to action 9

Carbon costs are rising globally, and keeping track of direct costs across an ever-changing regulatory landscape is hard enough. But that is only part of the picture. Much of the real exposure is hidden in the supply chain. Take CBAM: companies do not need to import a single tonne of covered goods into the EU to face costs. If their suppliers do, these costs end up in procurement. Robust modelling can quantify exactly where these costs sit and reveal both the financial stakes and where decarbonisation has the greatest impact.

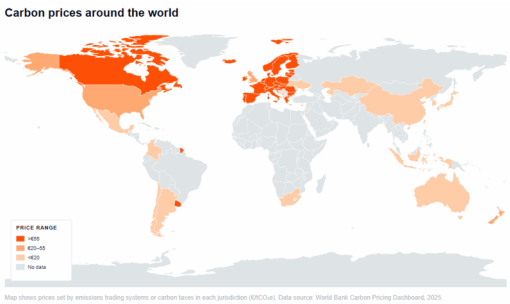
1. Carbon costs are here and growing

Carbon pricing is no longer an experiment. According to the World Bank's State and Trends of Carbon Pricing 2025, approximately 28 % of global greenhouse gas emissions are now covered by an explicit carbon pricing mechanism. The EU Emissions Trading System (EU ETS), the UK ETS, China's national ETS and carbon taxes in Canada, the Nordic countries, South Africa, and a growing number of other jurisdictions have established carbon pricing as a permanent feature of the policy landscape.

For companies, the implications go beyond compliance. Carbon costs are becoming a permanent component of production costs, shaping competitiveness at both company and country level. Companies whose products carry lower embedded carbon costs will hold a structural advantage as pricing mechanisms expand. Those that lack visibility on where carbon costs sit in their value chains will struggle to manage them.

But managing these costs requires knowing where they actually occur. They may be concentrated in the country where final goods are produced or far upstream in the supply chain, embedded in raw materials, energy inputs or intermediate components sourced from entirely different jurisdictions. Most companies today have no clear picture of this distribution.

This challenge is particularly complex because of the degree of fragmentation. Carbon prices range from below €1 per tonne of CO? in several emerging markets to over €120 per tonne in Sweden, with the EU ETS at around €65–90 per tonne and China's national ETS at roughly €10–12. While jurisdictions with a direct carbon price represent almost two thirds of global GDP, many economies, in particular across large parts of the Middle East, operate no carbon pricing mechanism at all.



Graph 1: Current carbon prices around the world
Source: World Bank Carbon Pricing Dashboard (2025)

The direction of travel is unambiguous. Established systems are tightening: the EU continues to cut free allocations, the UK is phasing out free allowances ahead of its own CBAM, and China expanded its ETS in March 2025 to cover steel, cement, and aluminium. New mechanisms are emerging in Brazil, Turkey, and across ASEAN. Meanwhile, border carbon adjustments, led by the EU CBAM but now being explored by at least eight other jurisdictions, are carrying carbon costs across borders and into global supply chains.

This fragmentation creates three interrelated risks:

- **Competitive distortion.** Producers in high carbon price jurisdictions face a structural cost disadvantage relative to competitors in unpriced regions. This is the classic carbon leakage concern.
- **Hidden subsidy to carbon-intensive imports.** Goods produced without a carbon price that enter markets where domestic production bears that cost carry an implicit subsidy, one that CBAM is explicitly designed to eliminate.
- **False security for downstream companies.** For companies outside heavy industry, in sectors such as automotive, electronics, food processing or construction, direct carbon costs under current regimes may appear negligible. Many face no direct ETS obligation and pay carbon costs only indirectly through energy bills. This creates a misleading picture of low exposure.

It is this third risk that warrants close attention. For most companies, the direct carbon costs they see today are not a reliable indicator of the carbon costs embedded in what they buy.

2. Why supply chain carbon costs matter

Most large companies have begun to assess their direct carbon cost exposure. Operators of cement kilns, steel blast furnaces or power plants in jurisdictions with an active carbon price know what they pay. Many finance teams have already integrated these costs into operating budgets and forward projections.

But this captures only a fraction of the picture.

For the vast majority of companies, including those in manufacturing, automotive, electronics, pharmaceuticals, food and beverage, retail and construction, the largest carbon cost exposure lies in their supply chains: in the steel they procure, the chemicals used in their formulations, the electricity their suppliers consume, the fertiliser applied to their agricultural supply base and the aluminium in their packaging and components. These are the costs that carbon pricing regimes are increasingly designed to capture, and they are the costs that most companies have not yet quantified.

Most companies can quantify their direct carbon costs to the nearest euro. Almost none can say what

carbon costs are embedded in what they buy.

The mechanism is straightforward. When a supplier faces a higher carbon cost, whether through direct ETS obligations, a carbon tax or a CBAM charge on their own inputs, that cost enters their cost of production. In competitive markets, a significant portion is passed through to the buyer, either explicitly or embedded in input prices. The buyer, in turn, passes it further downstream. The result is a cascading cost propagation that can touch every tier of a value chain.

But quantifying something that cascades across multiple countries and hundreds of intermediate inputs requires a specific analytical framework. PwC's ESCHER (Efficient Supply Chain Emissions Reporting) model provides this framework.

About PwC’s ESCHER model

ESCHER is an environmentally extended multi-region input-output (MRIO) model built on the GTAP 11 database, covering 160 regions and 65 economic sectors. It allows carbon cost exposure to be traced not only at the level of a company's direct operations or first tier suppliers, but through the full depth of the global value chain, tier by tier, sector by sector and country by country.

In the analysis that follows, ESCHER is used to model the supply chain propagation of EU CBAM costs, tracing how carbon costs at the EU border cascade through upstream supply chains and accumulate in the price of goods, even for companies and sectors with no direct CBAM obligation. The focus is on procurement in three sectors: Iron and Steel, Electronic Equipment and Wheat, in selected EU countries (Germany, Spain, Poland, Sweden and Belgium) as well as in non-EU regions (the UK, Turkey, the USA, China and India).

3. CBAM and its supply chain channel

What CBAM does

CBAM requires importers to purchase certificates for the embedded emissions in six product categories: iron and steel, aluminium, cement, fertilisers, electricity and hydrogen. The certificate price mirrors the EU ETS, minus any carbon price already paid in the country of origin. The purchase of CBAM certificates will begin on 1 January 2027, with prices then calculated and published on a weekly basis. During the current transitional phase, the European Commission already publishes indicative quarterly reference prices. For the first quarter of 2026, this reference price stands at €75.36 per tonne of CO?.

The direct impact of CBAM is well understood. Importers of CBAM-covered goods from non-EU suppliers face a new cost at the border, and most compliance and procurement teams are already preparing for this.

However, the indirect impact is another part of the story.

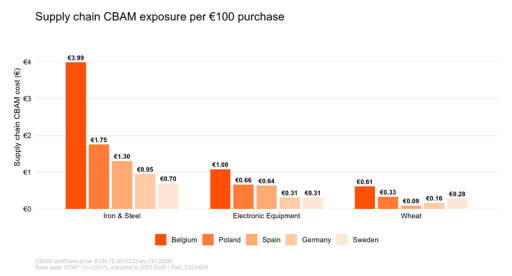
Exposure without importing a single tonne of CBAM-covered goods

Companies do not need to directly import CBAM-covered goods to face CBAM-related costs. If EU-based suppliers source raw materials, energy or intermediates from outside the EU, the resulting CBAM cost propagate through the value chain and ultimately appear in procurement costs.

Upstream cost pressure was modelled across three sectors, Iron and Steel, Electronic Equipment and Wheat, and across selected EU and non-EU countries. The results reveal material hidden costs that do not appear in CBAM compliance assessments focused solely on direct imports.

Inside the EU: supply chain CBAM exposure varies significantly by country

For EU-based purchases, there is by definition no direct CBAM obligation, as the goods are produced within the EU. However, producing steel, electronics or wheat requires inputs from CBAM-relevant industries outside the EU. The carbon costs that upstream non-EU suppliers face are passed down the chain. The figures that follow quantify the carbon cost exposure embedded in CBAM-affected supply chains, calculated by applying the current CBAM certificate price to the emissions associated with CBAM-border-crossing flows. They are best understood as an indicator of structural carbon cost exposure rather than an exact CBAM liability. This is a distinction explained in the methodology.



Graph 2: supply chain CBAM exposure per €100 purchase, EU countries

The variation across EU member states is striking:

- **Iron and Steel** shows the highest exposure. For every €100 spent on steel in Belgium, nearly €4 of supply chain CBAM exposure is embedded in procurement, reflecting Belgium's position as a major processing hub for imported steel and steel-containing intermediates. Poland (€1.75) and Spain (€1.30) also show significant exposure, while Germany (€0.95) and Sweden (€0.70) are lower, likely reflecting different import dependency profiles and energy mixes.
- **Electronic Equipment** shows a more moderate but still meaningful cost of €0.31-€1.08 per €100 across the five EU countries analysed. Belgium again leads, consistent with its role as a hub for

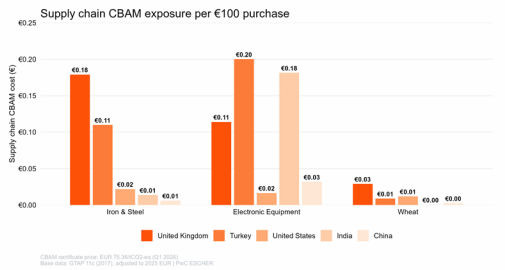
component assembly and re-export.

- **Wheat** registers the lowest but still non-trivial exposure (€0.09-€0.61 per €100). The main channel here is fertilisers, which are frequently imported from outside the EU and fall squarely within CBAM's scope.

This exposure is not mapped by most procurement teams. It does not appear in CBAM compliance assessments and represents a growing financial risk as CBAM's scope and price trajectory evolve.

Outside the EU: indirect costs travel further than expected

When companies import CBAM-covered goods directly from non-EU countries, the CBAM certificate price applies for every tonne of embedded emissions at the border. But even outside this direct channel, indirect effects persist. Producing steel in the UK, for example, may require inputs sourced from the EU, which in turn depend on CBAM-covered materials imported from third countries.



Graph 3: supply chain CBAM exposure per €100 purchase, non-EU countries

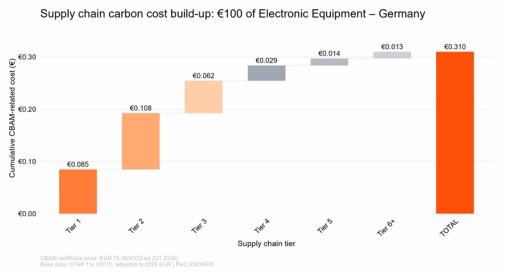
Among the non-EU countries analysed, the UK and Turkey show the highest indirect CBAM exposure:

- For **Iron and Steel**, the UK shows €0.18 and Turkey €0.11 in supply chain CBAM exposure per €100 spent, costs that are entirely invisible without supply chain modelling.
- For **Electronic Equipment**, Turkey leads at €0.20 per €100, with India showing a notable €0.18, reflecting India's integration into global electronics supply chains that transit through EU production networks.
- For **Wheat**, exposure outside the EU is minimal (€0.01–€0.03), consistent with shorter, more localised agricultural supply chains.

The pattern is clear: geographic proximity to the EU and deep supply chain integration with European production networks are the primary drivers of indirect CBAM exposure for non-EU countries.

Where in the supply chain do these costs accumulate?

A distinguishing feature of ESCHER-based analysis is the ability to decompose exposure by tier. For the sector Electronic Equipment, this decomposition is particularly revealing.



Graph 4: Supply chain CBAM exposure build-up: €100 of Electronic Equipment, Germany

For the sector Electronic Equipment produced in Germany, the total supply chain CBAM exposure amounts to €0.31 per €100.

- Tier 1 (direct suppliers) accounts for €0.085, roughly 27 % of the total.
- Tier 2 contributes €0.108, the single largest tier and the point at which CBAM-covered materials such as steel and aluminium are most likely imported into the EU and embedded in components.
- Costs continue to accumulate through tiers 3 to 6 and beyond, adding a further €0.118, so that by tier 6 the cumulative total reaches €0.31.

The implication is clear: focusing CBAM compliance and cost management solely on direct imports misses the exposure embedded in supply chains. Carbon costs can lie deep within these supply chains. For Electronic Equipment in Germany, nearly three quarters of these costs originate at tier 2 or deeper.

4. What the numbers tell us and what they don't

The preceding analysis used CBAM as a lens, but the underlying dynamic is not limited to CBAM. Whenever carbon costs rise in any part of the global economy, whether through emissions trading, carbon taxes or border adjustments, those costs propagate through supply chains. CBAM makes this visible at the EU border, but the underlying mechanism of cost cascading across supplier tiers and jurisdictions is universal.

CBAM and similar instruments are designed to close the gap in carbon costs between jurisdictions. But carbon price equalisation is not cost equalisation. Energy prices, labour costs, access to raw materials, state

subsidies and scale economies vary significantly across regions. In carbon-intensive sectors like steel, non-carbon differentials can be large enough for an overall production cost advantage to persist, even after carbon price differences have been fully taken into account.

Supply chain carbon intelligence quantifies not only financial carbon cost exposure, but, more importantly, reveals where emission intensities are highest and where decarbonisation will deliver the greatest impact. The suppliers, inputs and geographies with the highest embedded emissions also offer the greatest leverage for emissions reduction. In this sense, the cost map and the decarbonisation roadmap are one and the same. PwC's ESCHER framework is designed to deliver both: to quantify where carbon cost exposure sits today and to identify where targeted action will deliver the greatest financial and environmental return. In a world of rising carbon costs, companies that decarbonise fastest will not just reduce their risk but will structurally lower their cost base.

5. From exposure to action

Carbon cost exposure is larger than most companies realise, concentrated in supply chains and set to grow regardless of which policy path materialises. The question is no longer whether carbon costs will affect business, but whether the response is shaped proactively or margins are left to absorb the impact.

What this means in practice:

- **Understand exposure.** Most companies know their direct carbon costs. Far fewer have mapped the carbon costs embedded in what they buy. ESCHER was built to show where supply chain carbon costs stand today and how they shift under different scenarios.
- **Don't optimise for today's price signals alone.** The current cost advantage of sourcing from low carbon price jurisdictions is built on a regulatory gap that is being closed from multiple directions. What appears to be a stable cost differential today may not be one in five years.
- **Turn insight into decarbonisation action.** The same analysis that reveals the highest cost exposures also identifies where decarbonisation efforts will have the greatest impact. Companies that act early build both resilience and competitive advantage, rather than waiting for costs to materialise.

Turning this analysis into company-specific action requires granular data, scenario capability and the ability to connect carbon cost intelligence to procurement, finance and decarbonisation strategy.

Get in touch. We work with you to analyse your specific carbon cost exposure, identify where the risks concentrate in your value chain, and develop a clear path from insight to action.

Translating this insight into action can be supported by PwC through services such as:

- **Carbon cost exposure assessment:** Supply chain modelling using ESCHER MRIO framework to

quantify specific exposures by product, supplier and region

- **CBAM compliance and strategy:** From regulatory readiness and reporting to strategic cost management and CBAM certificate procurement
- **CBAM cost management and hedging:** Designing hedging strategies for CBAM certificate exposure, including position definition, choice of instruments and integration into the existing commodity risk and governance framework
- **Supply chain decarbonisation:** Identifying the highest-impact levers to reduce embedded carbon costs in sourcing
- **Climate target setting:** Defining science-aligned emission reduction targets and developing credible transition plans in line with the GHG Protocol, SBTi and ESRS
- **Scenario-based financial planning:** Integrating carbon cost scenarios into business cases, investment decisions and M&A due diligence
- **Sustainable procurement:** Embedding carbon criteria into sourcing scorecards, supplier evaluation and contract design
- **Climate risk assessment:** Identifying, quantifying, and managing physical and transition risks across the value chain, aligned with ESRS and EU Taxonomy

Methodology and assumptions

Data foundation. The analysis is based on the GTAP 11 database, which provides harmonised economic and greenhouse gas data for 160 regions and 65 economic sectors with a base year of 2017. All monetary values have been adjusted to 2025 euros, correcting for inflation and exchange rate movements. Carbon costs are expressed per €100 of output purchased.

CBAM sector mapping. ESCHER's sectoral classification was mapped to the product categories covered by EU CBAM. A conservative mapping approach was applied, limiting CBAM relevance to five sectors with a clear and direct correspondence to CBAM-covered goods: iron and steel, non-ferrous metals (aluminium), non-metallic minerals (cement), chemicals (fertilisers), and electricity. Because several of these sectors are broader in ESCHER's classification than in the current CBAM regulation the full sector was included to avoid underestimating exposure from supply chain linkages. This introduces a degree of overestimation for those specific sectors and reinforces the upper-bound interpretation of the results. CBAM scope is likely to expand over time to additional products and downstream goods.

CBAM certificate price. All calculations apply the Q1 2026 CBAM certificate price of €75.36 per tonne of CO?-eq, as published by the European Commission. No adjustment was made for carbon prices already paid in countries of origin, meaning the results reflect gross CBAM exposure before any deductions for foreign carbon pricing. This reinforces the conservative, upper-bound interpretation for jurisdictions that already operate carbon pricing mechanisms, while remaining accurate for imports from jurisdictions with no explicit carbon price.

Calculation approach. The analysis uses a multi-regional input-output (MRIO) framework based on a restricted Leontief inverse. For each target product and country, the ESCHER model identifies the full EU-internal production cascade required to deliver the final good. Within this cascade, the model locates all entry points at which non-EU inputs from CBAM-covered sectors cross the EU border. These are the points at which CBAM certificates are, or will be, required. The model then applies the full cradle-to-gate greenhouse gas intensity of these border-crossing flows and values the resulting emissions at the Q1 2026 CBAM reference price.

Scope interpretation. The reported figures quantify the embedded carbon cost exposure associated with CBAM-affected supply chain flows, valued at the current EU carbon price. This is a deliberately broader concept than the strict CBAM regulatory scope. Our figures include the full upstream emissions associated with CBAM-border-crossing inputs. The figures should therefore be read as an indicator of structural carbon cost exposure under current EU carbon pricing, rather than as an estimate of immediate CBAM certificate liability under today's regulatory perimeter. Actual CBAM payments under the current regulation will typically be lower; the gap between the two represents the transition risk embedded in current sourcing patterns.

Scope limitations. The analysis does not account for dynamic market responses such as supplier switching, demand substitution or changes in trade patterns that may occur as CBAM is implemented. No adjustment is made for carbon prices already paid in countries of origin. This reinforces the upper-bound interpretation for jurisdictions that already operate carbon pricing mechanisms, while remaining accurate for imports from jurisdictions with no explicit carbon price. The results reflect 2017 trade structures and do not capture subsequent shifts in global supply chains related to COVID-19, the energy crisis or trade policy changes. An update of the model to a 2023 base year is planned for May 2026.

Further links:

- ESCHER – Understand your Supply Chain’s Carbon Emissions
- Hidden Costs of Carbon
- CO2 Grenzausgleichsmechanismus
- CBAM im Einkauf: Wie Importeure CO?-Kosten mit smarten Beschaffungs- und Hedging-Strategien steuern
- CBAM-Regelphase gestartet: Kostensenkung durch strategische Steuerung
- Carbon Border Manager from Check your Value Chain

To further PwC Blogs

Schlagwörter

EU-Klimapolitik, Sustainable Supply Chain

Kontakt

Maria Halm

Leipzig

maria.halm@pwc.com