WORK PACKAGE 6

New Normal Scenarios

TWIN SEEDS

Acknowledgments

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Executive summary

WPs 1 – 5 of the TWIN SEEDs project studied the historic (WP1) trade development patterns, the COVID-19 effects on trade and GVCs configuration (WP2), and their effects on employment (WP3), environment (WP4) and economic growth (WP5). Thanks to the results of this analysis, in this WP report, entitled "New Normal Scenarios", we present future foresights on the way in which trade will impact on economic performance and the environment.

The long-term and forward-looking perspective of this scenario was already very interesting when we wrote the project proposal in 2020. The capacity to look forward and present the effects of alternative future trade trends and policy choices in the field of environment (like the European Green Deal's "Fit-for-55" package) and of the economy (like the Recovery and Resilience Facility after the COVID-19) was extremely important. After the election of President Trump, with his weaponization of trade policy, and the reinforced idea of Europe of the need of an Open Strategic Autonomy (OSA), the construction of future perspectives for Europe on the effects of the profound changes in trade policy has raised the interest in simulation exercises to increase awareness of policy makers of the risks associated with the normative tendences that prevail.

In this sense, with respect to the project proposal, WP6 has been enriched with analyses capturing the long-term future effects of actions like Trumps' tariffs war, the Ukraine-Russia and Middle East war and their consequences in terms of restructuring of trade patterns towards friendly countries if OSA is implemented. The simulation exercises do not aim at evaluating policies like the European Green Deal, Trump's tariffs strategy or OSA. They have a more limited but extremely useful aim to underline the main consequences that these policies could generate on economic productivity, environment and inequalities, so to raise awareness of the risks such policies entail.

The scenarios built are of two types. First, the report presents thematic scenarios (i.e. simulations) that are intended as single-dimensional logics driving the exercise. Second, the report presents integrated scenarios, where single-dimensional trajectories of driving forces are logically related one another, and cross feed-back effects are taken into consideration in building the scenarios.

In the single-dimensional logic, simulations are built on single driving forces. In particular:

- an increase in trade tariffs that incentivize FDI to leave Europe on productivity increases (chap. 2);
- an increase in trade tariffs in the US and of the retaliation of different major trading blocs on real wage levels and welfare (chap. 3);

- the effects of situations like Covid-19 and the war in Ukraine on energy consumption levels and patterns by residents (chap. 4);
- the implementation of fiscal policies, like the Recovery and Resilience Facility, on global emissions (chap. 5);
- the effects of the Carbon Border Adjustment Mechanism on trade, welfare, real wages and CO_2 emissions (chap. 6).

These single-dimensional logic exercises are followed by an integrated scenario, with the aim to show the effects of a New Normal Trade Policy Scenario on European competitiveness and inequalities among countries and regions (chap. 7). In this case, driving forces are more than one, and represent the conditional assumptions behind the New Normal Trade policy based on the idea that if the EU wants to continue reaping the benefits of international trade, it must assertively defend its interests, protecting the EU economy from unfair trade practices, and ensuring a level playing field.

Lastly, the report presents a critical analysis of the challenges to EU trade and investment in the New Normal Trade context and presents the possible policy implications that stem from the TWIN SEEDs research (chap. 8).

The key messages of the report can be summarized as follows.

For what concerns **the effects on European productivity growth under the assumption that US FDI are disincentivized by trade barriers and leave Europe**, the results are quite scarring for Europe (chap. 2). Policies that reduce trade and investment flows are associated with slower productivity gains. The disruption of GVCs because of the more protectionist trade and investment policies implemented by the EU and the US will generate economically relevant adverse effects on EU regions. Indeed, a reduced participation in GVCs will translate into less sustainable patterns of technological advances, less functional proximity to the extremes of the smile curve and, lastly, slower productivity dynamics in the European regions. Regions more severely affected by these adverse effects are those were US-controlled subsidiaries concentrate the most, for obvious reasons. This result is even more striking if one thinks that only a limited number of regions have experienced over the last years either an upgrading or downgrading process. After these changes, in 2022 the EU counted a very small number of regions specialised in the high value-added pre-production activities, i.e. 26 out of 52 in 2007.

Moreover, over the past, upgrading patterns were quite heterogeneous across regions. EU regions followed different upgrading patterns, all able to generate productivity spillovers. However, the magnitude of such spillovers may vary according to the nature of the process, i.e. functional or process upgrading, the way along the smile curve, i.e, right- vs left-hand upgrading, and the presence of headquarters in a given region. More specifically, functional upgrading, i.e. the movement upward the smile curve, proved to be more conducive to productivity growth than process upgrading or horizontal movements within the smile curve, as well as left-upward movements ensure a faster productivity growth than right-upward movements along the smile curve. In contrast, functional downgrading did not generate any spillover effect on the regions' productivity growth. Moreover, outward FDI may condition productivity spillovers from participation in GVCs. More in detail, only regions hosting a low- or medium-level of EU MNEs' headquarters get an extra productivity growth from participation in GVCs. Headquarter regions, instead, do not obtain extra advantages, at least in terms of productivity growth rates.

For what concerns **the effects of the increase in trade tariffs by the US on real wage levels and welfare** (chap. 3), results show clearly a substantial negative real wage effect in the US of the imposition of US (initial 'factual') tariffs which get further negatively impacted by retaliatory impositions of 'strategic' tariffs by the EU 27 and further by the US on the EU27, as a result of the price effect of tariffs. Moreover, imposing the initial ('factual') tariffs also negatively affects the real wage in China significantly but much less so than in the US which shows the higher dependence of the 'real wage basket' in the US on Chinese imports. The real wage effect in the EU27 is much less but cumulates over the further retaliatory stages.

Moreover, if the Trump administration follows its strategy of imposing 'reciprocal tariffs' (which is a concept covering much more than what is traditionally defined as 'tariffs') EU should experience a trade diversion effects (i.e. significant trade flows from China being diverted from the US to other markets) (chap. 3). This is an important policy issue in the relationship between China and the EU: on the one hand, both these two entities would like to maintain a relatively liberalised international trading system, but, on the other hand, a significant redirection of trade flows from China to EU markets can generate serious challenges for EU producers, especially in particular sectors. Hence a quantitative assessment with a model such as ours of such trade diversion effects are important for negotiations with China about a reasonable reaction to the Trump 'disruption' of the international trading system. A possible outcome of such negotiations could be so-called "voluntary export restrictions" (VER's) which were negotiated by the US vis-à-vis Japanese car producers in the 1980s and could set a precedent for such negotiations between the EU and China.

For what concerns **the environmental effects (changes in CO_2 emissions) of changes in energy demand for residents caused by external shocks like COVID or the war in Ukraine** (chap. 4), results show that changes in households final demand can have an impact on CO_2 emissions and even under extreme circumstances, such reductions tend to be short-lived. This underscores the need for more assertive and sustained policy action. Reductions in household emissions should not be taken for granted - even in the presence of current incentives. Stronger, more targeted interventions are required to induce lasting behavioral and structural shifts in consumption patterns. For example, time-limited stimulus measures during Covid-19 temporarily altered spending habits, but emissions quickly rebounded once restrictions were lifted.

Moreover, to ensure long-term effectiveness, policies must be complemented by broader systemic changes. These include investments in public transportation and shared mobility, renovation of existing buildings, and widespread public education efforts to promote low-carbon lifestyles. Fair-transition considerations should be at the core of climate policy. As the capacity to adapt and shift consumption varies greatly across income groups, policies must avoid disproportionate burdens on lower-income households. This calls for the integration of social support or compensation mechanisms, such as targeted rebates or progressive carbon pricing models. Finally, emerging uncertainties—such as shifts in global trade patterns, geopolitical tensions, and climate-related disruptions—may introduce new shocks to household demand and emissions. While the projected impacts of such shocks have so far been modest, they highlight the need for flexible, adaptive policy frameworks capable of responding quickly to both risks and opportunities.

For what concerns **the impact of fiscal stimuli on the emissions intensity and the impact that the tariffs announced by the US would have on the EU emissions** (chap. 5), a scenario has been built considering that the US has imposed tariffs on strategic sectors globally (Canada, México, and the EU27); and, in response to this situation, some affected countries have announced retaliation tariffs. Despite the negative impacts of tariffs on countries' trade and GDP, results show that tariffs could have a positive environmental impact, allowing for a reduction in EU emissions. Specifically, a total reduction of 1.14% of EU emissions is estimated, which differs by country depending on the composition and volume of production and its sectoral carbon intensity. This tariff war occurs in a context where current trade policy creates a global implicit subsidy to CO_2 emissions in internationally traded goods and contributes to climate change. This is because import tariffs and non-tariff barriers are substantially lower on carbon-intensive industries than on clean industries. Therefore, to the extent that the new tariffs focus more significantly on carbon-intensive products, such as steel and aluminium, it can also be an opportunity to apply similar trade policies to clean and dirty goods, thereby reducing carbon emissions without causing significant income reductions.

For what concerns the **implications of the EU Carbon Border Adjustment Mechanism (CBAM) on trade flows, welfare, real wages and CO2 emissions** and their implications for the EU member states and non-EU countries (chap 6), results show that the overall effects of CBAM on trade and emissions seem minimal, consistent with previous studies. CBAM is a climate policy aiming to reduce 55% of carbon emissions compared to 1990 by 2030 and make Europe the first climate-neutral continent by 2050. All 27 EU member states experience welfare gains from the CBAM implementation, as it enhances economic competitiveness while effectively mitigating carbon leakage. Furthermore, the design of CBAM and CO_2 prices might affect the impact of this climate policy to achieve climate neutrality within the EU. Results lead to claim that the EU must balance its strategic choice between climate goals and its industry viability, ensuring global competitiveness while reducing emissions. Last, but not least, policy makers should consider integrating incentives for clean technologies (carrots) to achieve both environmental and economic objectives.

For what concerns the **New Trade Policy scenario and its effects on GDP growth** (chap. 7), the work shows how recent geopolitical conflicts in Europe and the Middle East, coupled with a geopoliticization of trade, triggered the transition towards a new trade policy, moving away from managing interdependencies to managing dependency through Open Strategic Autonomy. While a New Normal trade policy may be fundamental in restoring the European level playing field in international trade, it will not be exempt from costs that will affect regions differently, as geoeconomic fragmentation may significantly hurt low-income regions, negatively affecting living standards. Results show the aggregate gross costs of this policy. Despite the EU's commitment to supporting reshoring efforts for over a decade, evidence from past experiences suggests that these costs may be substantial, as economic forces often resist policy interventions. As consequence, only minimal manufacturing may have been actually reshored from GVCs towards North America and Europe, and this, only under dire technological constraints that make reshoring viable and profitable only for firms in specific industries.

Moreover, the estimated gains turn out to be spatially heterogeneous. Regions growing fastest include non-capital urban areas, Western European regions, manufacturing regions, and regions with strong institutions. Growth drivers differ, with high-level functions boosting Western regions, while Eastern regions focus on production-related ones. Between-country disparities increase, yet within-country inequalities tend to grow less due to the advantages of non-manufacturing areas in Western countries; overall these trends would lead to a slowdown in territorial inequalities.

A summary of lessons learnt in this WP is proposed in chap 8. The EU is facing a very uncertain global environment and future research will certainly be required to support efforts to create optimal trading partnerships and monitor (and sometimes revise) the new emerging policy measures. Our analysis highlights how these pressures are driving selective decoupling from traditional partners and reshaping GPNs. The EU's capacity to anticipate and adapt to emerging challenges—while ensuring fairness across regions and sectors—will determine the resilience and sustainability of its future trade relations.

Three possible scenarios lie ahead:

- **a proactive strategic realignment** emphasizing green and secure partnerships; the EU deepens its commitment to 'open strategic autonomy,' focusing on enhancing resilience, and fostering industrial ecosystems which are less vulnerable to geopolitical blackmail or environmental degradation. This would imply strengthening trade ties with its regional allies and the near-abroad, building green trade alliances, and recalibrating value chains to favour sustainability and proximity.
- **a passive approach** which is likely to increase internal and external tensions. In this case, regulatory uncertainty and policy fragmentation could exacerbate asymmetries across EU regions and sectors, slowing progress towards EU goals on both decarbonisation and resilience.
- **a hybrid model balancing strategic autonomy with selective engagement**. The EU could pursue selective decoupling while maintaining pragmatic cooperation in critical areas such as green tech, raw materials, and industrial standards, especially with key partners like China and the US. In this scenario, trade and investment policy would become an even more complex balancing act, demanding agility, strategic foresight, and robust mechanisms for policy coordination and impact monitoring.

Core policy proposals are highlighted (chap. 9) and presented in Table 1 below.

Table 1. Core policy proposals from WP6

Geopolitical crises	TWIN SEEDS findings	Policy implications
US trade tariffs	Retaliation is more effective in certain sectors (pharma, transport, chemicals) than others (food, beverages). Decoupling from the US will have differential impacts across EU regions. Some will gain, but others will lose. The EU needs to diversify partnerships	Retaliation needs to be more strategic and less symbolic. Restructuring of GPNs requires accompanying regional policies. The EU needs to intensify efforts to create bilateral and multilateral agreements.
Russian invasion of Ukraine	Decoupling from Russia also has differential impacts across the EU. Recoupling with Ukraine will have stronger effects in some sectors (agriculture, heavy industry) than others. EU needs to build stronger linkages to the near abroad through FTAs and/or enlargement.	Countering Russian threats requires stronger engagement with the near abroad and, potentially enlargement. This will have differential effects across EU regions and will require accompanying policies

Geopolitical crises	TWIN SEEDS findings	Policy implications
China derisking and selective engagement	Decoupling from China has differential effects across the EU. There are clear potential benefits from sectoral engagement, particularly in green industries and applications. China is both a key source of technologies and raw materials and a large investor in EU green industry.	In case of decoupling, accompanying policies will be required. Despite long standing challenges, there is a need to build positive engagement with China.
Rest of World	EU negotiations need to balance interests, international interactions, institutional constraints, values and power balances. Open strategic autonomy requires that the EU secures both markets and strategic inputs.	Values may need to be compromised in favour or wider strategic objectives. Clean trade and investment partnerships could provide relatively rapid outcomes with certain partners, but risk lacking impact.
Climate Crisis	**TWIN SEEDS findings**	**Policy implications**
CBAM	CBAM should reduce global carbon emissions by a small amount, but it will likely increase the EU's direct carbon emissions. If non-EU suppliers just reorient carbon intensive production to other markets the global effect will be minor or even negative. CBAM will have important effects on downstream GPNs.	CBAM needs to be accompanied by greater uptake of low carbon technologies in the EU. Carbon leakage is a real risk, global trade flows need to be monitored, and bilateral or multilateral solutions are likely to be needed. The impact of CBAM on the competitiveness of downstream users of CBAM goods needs to be addressed.
EUDR	EUDR is subject to the same risks of resource shuffling as CBAM. In addition, there are wide differences in downstream coverage across the different products covered (wood vs palm oil). This creates a risk of trade diversion from raw material to finished goods in countries at risk of deforestation.	Impacts of EUDR on deforestation rates needs to be examined. Trade flows of downstream products should be monitored and any trade diversion effects addressed, through bilateral agreements or expanding the product list
CS3D	The high level of contestation on CS3D reflects different conceptions across policy makers, industry and civil society of the value chain and the responsibility of lead firms for potential abuses along it.	The Omnibus proposal to limit to Tier 1 risks undermining the effectiveness of the measure

1 Introduction

We are going through a period of turbulence caused by a series of shocks that, one after the other, affected the world economies, calling for drastic changes in the traditional growing patterns Europe and its countries and regions. The 2008 financial and economic crises, followed by the COVID-19 pandemic, the Ukraine-Russia conflict, the Middle East conflict and Trump's weaponisation of policy trade - in a period of deep technological revolution - generated (and still generate) socio-economic challenges, among which the deep restructuring of Global Value Chains and trade patterns, whose long-term effects are far from being identified.

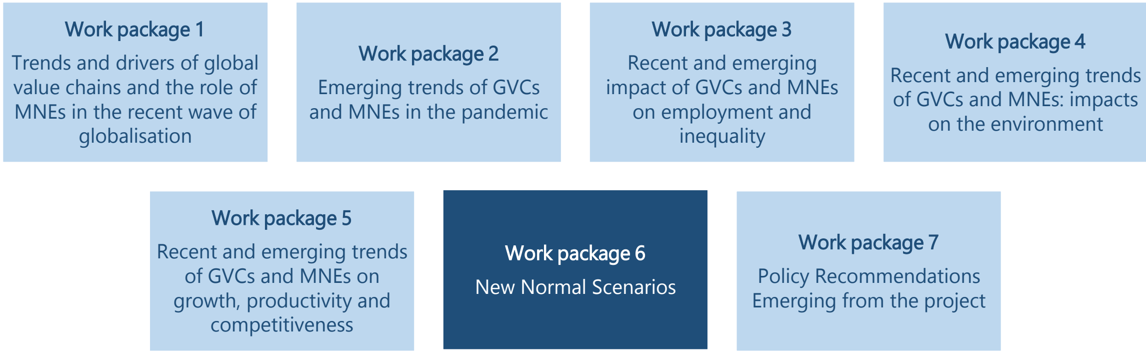
The TWIN SEEDs project had the aim to analyse the GVCs' reorganisation in a historic perspective (WP1), the role of COVID-19 in the reorganization patterns (WP2) which at the time of the project's submissions were of high interest, and the effects of GVCs' reorganisation on employment (WP3), environment (WP4) and economic growth (WP5). Thanks to the results of this analysis, in this WP report, entitled "New Normal Scenarios", we present future foresights on the way in which trade will impact on economic performance and the environment.

This report presents the results of WP6, which aims at building scenarios basing its conceptual assumptions on the results of the first five WPs. In particular, the WP presents the New Normal Scenario that the present geopolitical situation is imposing to Europe. The reality is that Europe is in search for a new level playing field for international trade partnerships, and the possibility to foresee the effects of the New Normal Trade Policy on its competitiveness is not trivial.

In this report, the project enters indeed in its final phase (Fig. 1) and reflects on the New Normal Trade scenario that can be envisaged for Europe. Such a scenario has to reflect the tension between long-term global integration based on value chains, on the one hand, and ongoing longer-term challenges, on the other. The latter are generated by changing geo-politics, new strategic orientations of the main global actors affecting international trade policies, policies regarding the environment, as well as the recent experience of the pandemic.

No period could be more timely to speak about a New Normal Trade Policy scenario. During the development of the project (2022-2025), important novelties came to the fore, that were fundamental to be taken into account. We envisaged the Ukraine-Russia and Middle East conflicts that exacerbated, among other things, trade relationships. In the last months, the second Trump's Presidency with its protectionist strategy imposed the project to take this policy action into account and envisage its effects and the retaliation of the different countries into account.

Figure 1.1. Summary of the TWIN SEEDS project and its Work Packages



WP6 report develops around two main tasks. **The first task** (Part A of this report) has the aim to develop thematic scenarios, i.e. single-dimensional logic simulations in which the impact of one single driving force is analysed. In this respect, the report deals with a variety of driving forces. The first two chapters simulate the effects of the increase in trade tariffs by the US on productivity growth, via the effects of FDI leaving Europe (Chap. 2) on the one hand, and on real wage levels on the other (Chap. 3). The second group of chapters, instead, focus their attention on environmental impacts of: i) external shocks affecting energy demand for residents (like COVID-19 and the war in Ukraine) (Chap. 4); ii) the implementation of fiscal policies, like the Recovery and Resilience Facility (Chap. 5); and iii) the effects of the Carbon Border Adjustment Mechanism on trade, welfare, real wages and CO_2 emissions (Chap. 6).

The second task of WP6 (Part B of this report) is instead devoted to integrated scenarios (Chap. 7). The complexity of this task resides firstly in moving beyond the single-dimensional logic of thematic scenarios towards a multi-dimensional logic required for integrated scenarios. In the latter, the various single-dimensional trajectories must be related to each other, and cross feed-back effects must be taken into consideration. This requires a clear cause-effect logic which keeps assumptions carefully separate from effects, and hypotheses on the appearance of certain conditions distinct from results. Moreover, the assumptions on the driving forces should be as differentiated as possible, sometimes even opposite to each other, so as to yield differentiated images of the future on which to reflect.

The New Normal Trade policy scenario is developed on the basis of a series of driving forces that represent the conditional assumptions for the trade policy to occur (chap. 7). The philosophy behind the New Normal Trade policy is that if the EU wants to continue reaping the benefits of international trade, it must assertively defend its interests, protecting the EU economy from unfair trade practices, and ensuring a level playing field. Therefore, the New Normal Trade policy scenario envisages an industrial policy oriented at the reinforcement of the strategic core European industries, identified as those with an already competitive edge and potential to be frontrunner.

The core industries are supposed to be reinforced through boosting EU's technological global leadership by promoting the development of key competitive advantage. President Trump's "US first" policy and his aggressive protectionist tariff policy with China are used by the US Government to deploy its geopolitical power to re-orient and secure supply chains. This shift is leading to a decreased trade dependence of the EU on global markets. Innovation is supposed to be boosted in key areas, guaranteeing support to the competitiveness of strategic sectors, for the efficient production of critical products and raw materials. Translated into quantitative targets, the above mentioned conditional (qualitative) assumptions are included in the regional macroeconomic growth forecasting model (MASST) able to endogenously distribute income variations induced by the change in the trade relationships among regions.

A chapter is proposed with the aim to explore how Covid-19, the subsequent geo-political shifts and emerging crises facing the EU (sometimes termed the Polycrisis) are changing its trade and investment policy. In the post-Covid 'New Normal', growing political tensions both with countries that have long represented strategic challenges – like Russia – and former allies – like the US, require the EU to reassess its integration with Global Production Networks (GPNs) and reorient its dependencies. This type of 'geo-political' decoupling is not new (Blazek and Lypianin, 2024), but the current context has been particularly challenging in terms of the rapid speed of deterioration of relations, first with Russia and now with the US. Traditional and novel policy responses are needed. The chapter explores these policy changes and highlights how key aspects of these shifts will likely reshape GPNs, encouraging new forms of decoupling and recoupling (chap. 8).

A concluding chapter is proposed where policy implications are summarised (chap. 9).

PART A. Thematic Scenarios

In this part, we present the results of the first Task of WP6, namely the results of the single-dimensional logic simulations in which the impact of one single driving force is analysed.

The report deals with different types of simulation exercises, with the aim to cover different new policies that directly or indirectly affect new normal trade. Moreover, the different simulations affect either economic or environmental outcome, producing a large spectrum of effects that are of interest for the future of the European economy.

Chapter 2 deals with the effects on European productivity growth assuming that US FDI are disincentivized by trade barriers and leave Europe. The results are quite scarring for Europe, as the simulation shows that lower FDI in Europe would turn to a decrease in productivity growth rates especially in the two highest value-added types of functions, namely R&D activities and decision-making functions.

Chapter 3 simulates the effects of the increase in trade tariffs by the US on real wage levels in three subsequent scenarios, simulating the impact of an escalating tariff war between trading blocs (US and EU). It presents three consequent scenarios in which different blocs of countries retaliate one after the other. In particular: (i) in the first step USA imposes the structure of ‘Trump tariffs’ announced on ‘Liberation Day’ (ii) in the second scenario, the EU retaliates by finding an ‘optimal/strategic’ structure of tariffs that imposes maximum costs on the US (measured in ‘welfare’ effects) and minimises effects on own welfare (iii) in the third phase the US retaliates in turn.

Chapter 4 enters the environmental issues and focuses on the effects of changes in energy demand for residents caused by external shocks like COVID or the war in Ukraine on CO_2 emissions. It provides a deeper analysis of the CO_2 effects from recent changes in final demand from EU households. The Covid-19 crisis represents a real-life example of a major decrease in demand coupled with a drastic reduction in transport. These simulations are used to apply the lessons learned from the change in emissions during the pandemic and its aftermath to potential policies directed towards households. The Eighth Environment Action Programme (European Parliament and the Council, 2022) calls for the European Union to significantly reduce its consumption footprint. While the reductions in 2020 and 2021 were short-lived, we set scenarios for the mid and long terms, based on current EU objectives: private transport electrification, reduction in households´ energy use and US tariffs.

Chapter 5 presents scenarios for quantifying the impact of fiscal stimuli on the emissions intensity by sector and country and total emissions and the impact that the tariffs announced by the US would have on the EU emissions, that ush for a relaunch of European production. The chapter evaluates: i) the environmental “short-term” effects of the European Union’s Recovery and Resilience Facility (RRF) which is the largest component of Next Generation EU, and which pushes towards a relaunch of investments and production, as in the case of US tariffs, and ii) the "medium-term" impacts of the climate change mitigation policies adopted by the EU, which have been catalysed by this substantial fiscal effort, among other factors. In essence, this study endeavours to quantify the net balance of emissions that will emerge during the implementation of the most significant stimulus package ever financed in Europe, with the overarching goal of ensuring a greener and more resilient Europe, and to assess the likelihood of achieving the "Fit for 55" strategy.

Chapter 6 deals with the implications of the EU Carbon Border Adjustment Mechanism (CBAM) on trade flows, welfare, real wages and CO2 emissions and their implications for the EU member states and non-EU countries. The EU’s Carbon Border Adjustment Mechanism (CBAM) is a climate policy aiming to reduce 55% of carbon emissions compared to 1990 by 2030 and make Europe the first climate-neutral continent by 2050. This is scheduled for full implementation in 2026 as part of the European Green Deal’s (EGD) “Fit-for-55” package. This climate policy aims to reduce 55% of carbon emissions compared to 1990 by 2030 and make Europe the first climate-neutral continent by 2050, but it effects on trade flows, welfare, real wages and CO2 emissions are still unknown.

2 Moving up the ‘Smile curve’: which advantages for European regions?

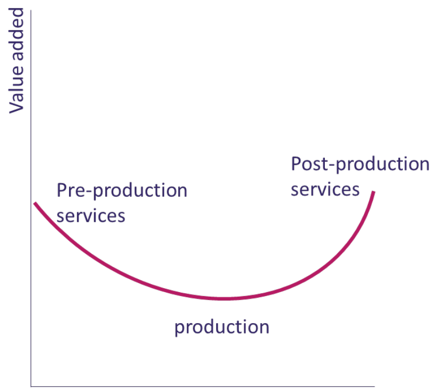
Contextual background and research objectives

As already emerged within the Twin Seeds project, the current phase of globalisation is characterised by the strengthening and diffusion of Global Value Chains (GVCs) across sectors and space, and their reorganization. Indeed, production processes are increasingly geographically fragmented, as technological advances in ICT have made it possible to slice up the value chain and to move activities previously carried out in one place to other locations, according to their specific characteristics, in order to reduce costs and increase efficiency. The outsourcing of intermediate and final production gives rise to increased exports and imports. Multinational firms (MNEs) and their Foreign Direct Investment (FDI) are key actors in this process, coordinating production and distribution across many countries and shifting activities according to changing demand and cost conditions. In this context, the value chain is the sequence of productive (value-adding) activities vertically integrated into hierarchical Global Production Networks (GPNs).

In the “New Normal scenario for Europe” developed on the basis of the experience of the pandemic, the ongoing geopolitical conflicts, and the return of the rhetoric of populism about the adverse effects of globalisation in most developed countries, the benefits of economic integration is questioned, downsizing the potential role that participation in GVCs via FDI can play as an opportunity for faster economic growth and development. To these premises, knowing winners and losers from GVC participation is a necessary information to identify the potential “future” losers and where to implement place-based policies to counteract the adverse effects of the disruption of GVCs. Moreover, given the increased uncertainty on the future stance towards free trade and investments of the big international players – USA, and China *in primis* but also the EU – we simulate the potential consequences in terms of “missed” productivity gains EU regions may experience if US MNEs no longer consider advantageous to locate some stages of the production process in the EU.

In order to simulate the effects of a lower attractiveness of Europe for US MNEs, the analysis of GVCs and the opportunity for increasing productivity growth they may offer refers to the concept of the “smile curve” (Shih, 1990; Kummiritz et al., 2017), which states that value generation is higher at the early and final stages of the production process because of the higher skills needed to perform pre- and post-production activities. Pure production activities, instead, represent the less profitable segment of the curve (Figure 2.1). The smile curve concept suggests, on the one hand, that potential benefits link to GVC participation are not homogenous along the curve but may depend on participants' functional specialisation (Gereffi et al., 2005); on the other hand, dynamic specialisation and upgrading are crucial to gain more value-added (Pleticha, 2021).

Figure 2.1. The smile curve



According to the literature (e.g. Humphrey & Schmits, 2002; Timmer et al., 2019), to gain more value added, one can either improve the productivity of the current task (process upgrading) or move to the part of the value chain with greater value added (functional upgrading). However, the magnitude of these improvements may depend on the distance from the global technological frontier (Saia et al., 2015).

We contribute to this line of research by investigating whether and to what extent participation in GVCs has offered opportunities for upgrading to EU regions. In doing so, we systematically and critically present the nature and evolution of GVC participation, unveiling the heterogeneous sub-national nature of GVC participation.

The empirical analysis of GVC participation usually follows an input-output approach, which takes into account the inter-industry circular flow of goods and services to measure the foreign value-added share of gross exports (e.g. Los et al., 2015; Timmer et al., 2014; Capello and Dellisanti, 2024). Although this aggregated method is suitable for sufficiently detailed analysis of the development of GVC participation at the country level, it presents some limitations when applied to sub-national level research because input/output tables are highly aggregated at the sectoral level, infrequent in time, and not available for the most recent years. To partially overcome these limitations and to account for the importance of MNEs for GVCs, in this work, we adopt a microeconomic approach to GVC and measure regional participation by looking at the business functions carried out by foreign subsidiaries hosted by each EU region.

Although we cannot make any inference about causality, our analysis offers a more nuanced picture of the potential benefits of GVC participation. In particular, it highlights that GVC participation effects are not uniform across space since they depend on their position within the hierarchy of GVC, besides differences in capability among participants (Kaplinsky, 2000; Pleticha, 202).

To highlight to what extent may a reduction of participation in GVCs via FDI from the US affect EU regions' opportunities for upgrading, the chapter goes through two main questions:

1) Has the EU regions' participation in GVCs evolved? Did EU regions move along the smile curve, or did they reinforce their specialisation at the same stage?
2) Was process upgrading more advantageous than functional upgrading? Moreover, are there winners and losers from these processes?

The replies to these questions open the way to the simulation exercise that allows to reply to the aim of the chapter.

Methods of analysis and data

To capture the nature and the functionality of EU regions' participation in GVCs, we focus on FDI, i.e. the backbone of GVCs. Information comes from Orbis Datahub, one of the world's most powerful comparable data resources on private companies across the globe. It provides different types of quantitative and qualitative information, like firmographics and extensive and detailed ownership corporate structures, making it particularly suitable for this work. We use data from 2007 to 2022 to trace FDI at the regional level and to link each foreign company's activity (NACE Rev. 2.2, 4 digits) to a specific functional stage of the value chain (Nielsen, 2011; Stollinger, 2019; Sturgeon, 2013). Table A 2.1 in the Appendix provides the categorisation of NACE (4-digit) sectors into GVC functional stages.

Regional data on FDI projects are used to build the "European global space of foreign-controlled enterprises", a tool that measures proximity between different NACE 4-digit sectors, according to the following formula:

$$\Phi_{i,j} = \min\left(P(i|j), P(j|i)\right) \quad (1)$$

where *P(i|j)* is the conditional probability that a region specialised in sector *j* is also specialised in sector *i*; and *P(j|i)* is the conditional probability that a region specialised in sector *i* is also specialised in sector *j*. Next, we compute the relatedness density of sector *i* in region *r* at time *t*:

$$\boldsymbol{\psi}_{\boldsymbol{i},\boldsymbol{r},\boldsymbol{t}} = \frac{\sum_{j \in r, j \neq i} \Phi_{i,j}}{\sum_{j \neq i}} \quad (2)$$

This indicator captures how strongly a sector is related to the production structure of the region. To assess the regional proximity to the technological frontier (defined as the set F of frontier sectors), we compute the regional relatedness to the frontier as:

$$\boldsymbol{RelDens}_{r,t} = \frac{\sum_{i \neq f, f \in F} \psi_{i,r,t}\, \phi_{i,f}}{\sum_{i \neq f, f \in F} \psi_{i,r,t}} \qquad (3)$$

Finally, we measure variation the index over time to capture potential movements along the smile curve:

$$\Delta \boldsymbol{Frontier\_relatedness}_{r,t} = \boldsymbol{RelDens}_{r,t} - \boldsymbol{RelDens}_{r,t-1} \qquad (4)$$

Within this space, we identify the “extremes” of the smile curve — i.e., knowledge- and technology-intensive activities that are part of pre- and post-production functions. Then, using economic complexity metrics, we compute the distance from the technological frontier for each foreign subsidiary located in EU regions. This relatedness-based indicator is used to track movement along the smile curve and offers the advantage of analysing changes at a highly granular level. By aggregating this information at the regional level, we obtain a measure of the average position of each EU region within GVCs and how it evolves over time — either through functional upgrading (movement along the smile curve) or process upgrading (increased value added within the same stage).

To understand whether participation in GVCs is beneficial to EU regions, we proceed in three steps. First, we estimate the potential association between participation in GVCs and regional economic performance, proxied by variation in regional gross value added per worker. Participation in GVCs is proxied by the relatedness-based indicator described above. A higher index indicates that a region is specialised in pre- and post-production functions, while a lower value implies specialisation in low-value-added production activities. The regression is estimated using Ordinary Least Squares (OLS) with region (NUTS2) and time fixed effects, in order to mitigate omitted variable bias. We also include other potential determinants of productivity, such as agglomeration economies (proxied by population density), regional GDP per capita (as a proxy for development level), population size, and regional endowments of human and physical capital. All explanatory variables are lagged by one year to reduce endogeneity concerns and are expressed in first differences.

Second, we assess whether the average effect of GVC participation varies depending on a region’s functional specialisation. To do so, we interact our relatedness-based indicator with categorical dummies identifying the three GVC stages: production, pre-production, and post-production. The sign and magnitude of the estimated coefficients inform us, on the one hand, about whether GVC participation is associated with productivity improvements and, on the other, about the extent to which these benefits depend on a region's initial position within the value chain.

Third, we explore the differential productivity effects of process versus functional upgrading, by interacting GVC participation with the type of transition observed for each region during the period under analysis.

We further investigate whether the presence of EU-based MNE headquarters moderates these effects. Regions hosting headquarters are typically specialised in high-value-added administrative and management functions (pre-production), and control broader segments of the value chain. This may provide them with a comparative advantage in capturing the benefits of GVC participation.

Finally, we simulate the impact of a potential reduction in US MNE presence in the EU, in light of recent FDI screening policies implemented by the EU under the Open Strategic Autonomy framework, and rising tariff uncertainty linked to US re-shoring incentives. While tariff changes apply across the EU, the impact of such a protectionist shift is likely to vary geographically, depending on the local concentration of US-owned subsidiaries and the type of business functions they perform.

Findings and discussion

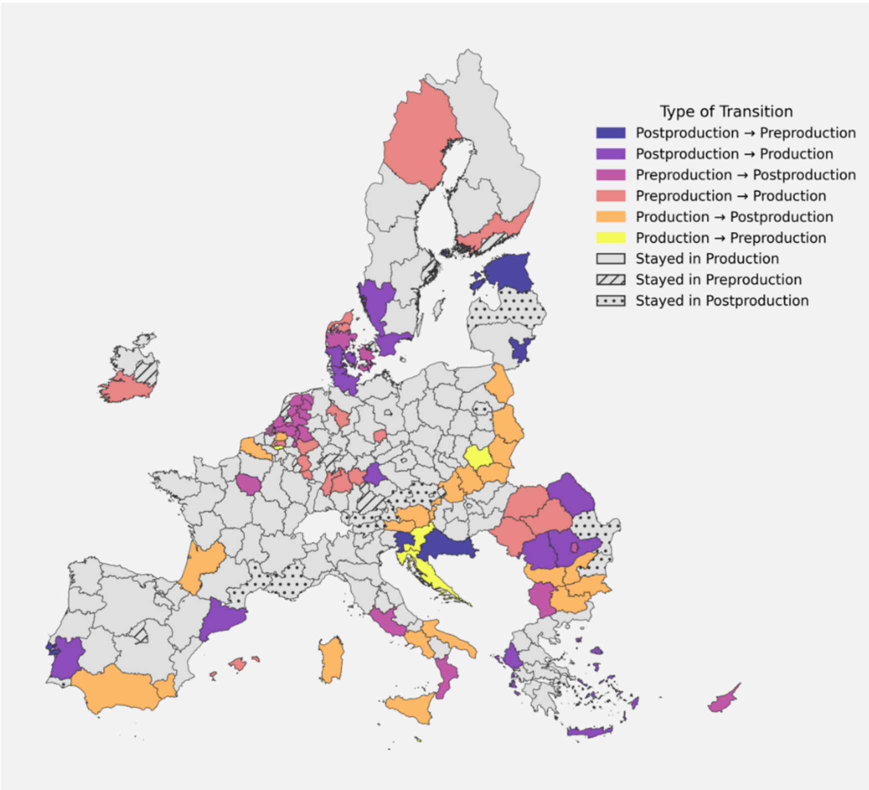
EU regions' position within the GVC: descriptive evidence

This section presents and discusses trends of EU regions' functional specialisation in GVC from 2007 to 2022. Functional specialisation results from GVC engagement. The latter has been computed by considering foreign subsidiaries hosted by each region and their relative concentration in one of the business functions characterising the smile curve, i.e. pre-production, post-production and production activities (similar to Timmer et al., 2019). Each region is allocated to a group according to the function in which it had the highest concentration index in a given year, so that groups are mutually exclusive. In Table A 2.2 we provide a transition table for business functions from 2007 to 2022.

The matrix's diagonal cells contain most regions, i.e. 156 out of 241, indicating that specialisation patterns evolved slowly over the sample period (Table A 2.2). However, some regions have changed specialisation, as indicated by the non-diagonal cells. In particular, 27 regions graduated from being specialised in production towards pre- and post-production activities, while 26 changed their specialisation from pre(post-) to post-(pre-)production activities. This implies that functional upgrading has been accompanied by horizontal movements from the two extremes of the smile curve. After these changes, the number of EU regions specialised in pre-production activities halved from 2007 to 2022, while the number of regions specialised in post-production activities increased. The number of regions specialised in production activities remained almost stable.

Some EU regions experienced functional downgrading, moving from the extremes, i.e. pre- or post-production activities, to the central part of the smile curve where low value-added activities are carried out. It is, for example, the case of the Vest region in Romania (RO42) or Syddanmark in Denmark (DK03) among others, as indicated by Figure 2.2. The latter also shows that regions that experienced movements along the smile curve belong mainly to the east and south periphery, including various Central and Eastern EU countries, such as Poland, Bulgaria, Slovenia and Croatia, whose dynamic regions moved from production to pre/post production activities, as well as countries like Italy and Spain. Instead, regions that do not change their functional specialisation are mainly those previously specialised in production activities and mainly localised in Spain, France, Germany, Austria, and Northern Italy. Overall, these findings suggest that persistency is a peculiarity of more advanced countries and regions' functional specialisation.

Figure 2.2. Functional and process upgrading in the EU regions (2007-2022)



Benefits from process and functional upgrading

For what concerns the benefits from process of functional upgrading, results (based on pooled OLS regression) indicate that, on average, the closer a region gets to the smile curve's frontier, the larger the gain in productivity it obtains, regardless of the functional specialisation within the value chain, as indicated by the positive and significant sign of our variable of interest (see Table A 2.3 in the Appendix for estimation results of the first step). The economic size of these gains is relevant, since a one per cent increase in the relatedness to the smile curve's frontier implies an increase in the productivity growth rate of about 0.78 per cent.

Once the relatedness to the frontier variable is interacted with the initial position of regions in the smile curve, the heterogeneity of the interplay between GVC participation and gains in terms of productivity is obtained (Table A 2.4). Indeed, the results show that movements from the production-related GVC participation provide disproportionate benefits with respect to movements from the extremes of the smile curve. Indeed, a one per cent increase in the relatedness to the technological frontier generates a further increase in the productivity growth rate of about 1.15%. These findings indicate that participation in GVC seems to be a positive game: all regions enjoy increased productivity growth rates, though benefits are larger for regions specialised in production activities at the beginning of the period.

To provide a more detailed answer to research question n. 2, we compare the benefits accruing to EU regions from functional upgrading with those potentially generated by process upgrading (Table A 2.5). In doing so, we distinguish not only upgrading from downgrading, but also right-hand movements, i.e. from production to post-production activities, from left-hand upgrading, i.e. movements from production to pre-production activities. Not surprisingly, we find that functional upgrading towards pre-production activities generates the most significant benefits, about a 4% increase in productivity growth, all else equal. A possible explanation is that pre-production activities include knowledge- and technology-intensive activities (such as R&D and related technical services) that need a highly specialised labour force and contribute the most to the value of the final products. Right-hand functional upgrading is associated with increases in productivity growth rates similar to those associated with process upgrading. Both of them are close to the average effect shown in Table A 2.3.

We do not find evidence that variations in size, the degree of urbanisation or the capital accumulation rate are associated with faster productivity growth rates. Instead, we find a negative and significant association between GDP per capita and human capital. These results may be explained by diminishing returns to scale in the regional production function.

Heterogeneity by Number of GUOs

To explore the heterogeneous effect of outward FDI, we examine whether productivity spillovers from proximity to the technological frontier may in some way interact with the presence of EU parent houses (i.e. Global Ultimate Owners, GUOs) headquartered in a given region — a key aspect of outward FDI not directly analysed in the rest of the paper. We do this by interacting our relatedness-to-frontier indicator with terciles of the regional distribution of GUOs.

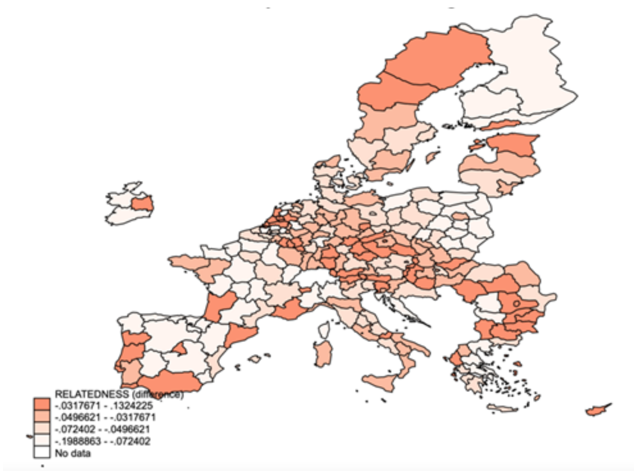
Interestingly, the results (Table A 2.5) display an inverted U-shaped relationship. Indeed, productivity spillovers are positive and statistically significant in regions hosting a very small number of GUOs (the lowest GUO tercile), with a coefficient of approximately 0.005. This effect becomes stronger and remains significant for middle-tercile regions, reaching a peak at around 0.3. However, the coefficient becomes statistically insignificant in regions hosting a large number of GUOs (the highest tercile). These findings suggest the presence of diminishing marginal returns to internationalisation. While having some outward FDI activity is associated with productivity gains, beyond a certain threshold the additional benefit of proximity to the technological frontier appears to taper off — possibly due to saturation effects or coordination inefficiencies in regions already highly integrated into global corporate structures.

More restrictive trade and investment policy: a simulation exercise

Last, but not least, the work has developed a simulation of more restrictive trade and investment policies on productivity growth, generated by the reshoring of EU firms controlled by US corporate groups in response to the reciprocal tariff policy imposed by the new American administration and a tightening of the FDI screening implemented by the EU within the Open Strategic Autonomy.

To run the simulation, we removed all European subsidiaries with a US parent company from the operative sample. Then, we recalculated the EU region's relatedness to the technological frontier of the value chain. As expected, the new values are lower. In particular, we find that eliminating US subsidiaries would reduce, on average, by about 5.4 percentage points the relatedness of the EU regions' functional specialisation to the technological frontier of the value chain, with some variability across NUTS2 regions, as indicated by Figure 2.3.

Figure 2.3. Variation in proximity to the technological frontier due to the reshoring of US activities



In terms of the expected impact on productivity, this suggests that - given the estimated coefficient of about 0.008 reported in Table A 2.3 - the loss of relatedness would lead to an average decline in regional productivity growth of about 0.043% compared to the previous value. Although the average effect on aggregate productivity appears modest, this scenario highlights how the presence of US subsidiaries is relevant to sustaining technological advances, functional proximity to the extreme of the smile curve and, indirectly, the productivity dynamics in the European regions. In the event of reshoring, regions more exposed to American investments would face a higher risk of deterioration in their relative technological position. Indeed, about 25 regions present a difference greater than 0.1, with six regions—mainly Spanish and Greek - reaching values close to 0.2. This loss of relatedness would translate into an estimated regional productivity decline of approximately 0.16%. Considering this is a short-term variation measured in first differences, the cumulative effect over multiple periods or in a context of slow technological recovery could be significantly larger, indicating a potential risk of economic divergence for the most affected regions.

Main findings

Three main findings are achieved in this work. Firstly, specialisation patterns evolved slowly in the EU, especially as far as most advanced regions specialised in production activities are concerned. Indeed, only a limited number of regions have improved their functional specialisation by moving from production activities towards the extreme of the value chain and, in particular, towards post-production services activities. Only a few regions have experienced a downgrading process. After these changes, in 2022 the EU counted a very small number of regions specialised in the high value-added pre-production activities, i.e. 26 out of 52 in 2007.

Secondly, upgrading patterns were quite heterogeneous across regions. EU regions followed different upgrading patterns, all able to generate productivity spillovers. However, the magnitude of such spillovers may vary according to the nature of the process, i.e. functional or process upgrading, the way along the smile curve, i.e, right- vs left-hand upgrading, and the presence of headquarters in a given region. More specifically, functional upgrading, i.e. the movement upward the smile curve, proved to be more conducive to productivity growth than process upgrading or horizontal movements within the smile curve, as well as left-upward movements ensure a faster productivity growth than right-upward movements along the smile curve. In contrast, functional downgrading did not generate any spillover effect on the regions' productivity growth. We also uncover that outward FDI may condition productivity spillovers from participation in GVCs. More in detail, we found that only regions hosting a low- or medium-level of EU MNEs' headquarters get an extra productivity growth from participation in GVCs. Headquarter regions, instead, do not obtain extra advantages, at least in terms of productivity growth rates.

Thirdly, and directly linked to the aims of this work package, policies that reduce trade and investment flows are associated with slower productivity gains. The disruption of GVCs because of the more protectionist trade and investment policies implemented by the EU and the US will generate economically relevant adverse effects on EU regions. Indeed, a reduced participation in GVCs will translate into less sustainable patterns of technological advances, less functional proximity to the extremes of the smile curve and, lastly, slower productivity dynamics in the European regions. Needless to say, regions more severely affected by these adverse effects are those were US-controlled subsidiaries concentrate the most.

Conclusions and policy implications

In this study, we have investigated the association between GVC participation and EU regions' and illustrated the heterogeneity of GVC participation effects. Overall, our findings suggest that participation in GVCs is a positive-sum game, conducive for productivity spillovers for all participants. However, the magnitude of these benefits is not homogenous across space, being mediated by the nature of the patterns of upgrading followed by the EU regions (functional vs. process upgrading), their initial position within the value chain and the size of outward FDI flows.

Taken together, these findings are suggestive of the importance of FDI, both inward and outward, to reap the advantages of GVC participation, and of local conditions, which determine not only the position within the value chain that a region may have but also the characteristics of the upgrading process that a region may follow. Thus, to help regions reaping productivity spillovers from GVC participation, a mix of targeted innovation policies, industrial policy, education and active labour market policies should be considered as tools for required functional upgrading.

Last but not least, these results open a broader discussion on the risks associated with the disruption of GVCs driven by more protectionist trade and investment policies. Because their adverse effects on EU regions' relatedness to the technological frontier of the value chain, re-shoring strategies pursued by American companies should be monitored carefully and complemented by internal policies able to stimulate technological and knowledge advances of EU companies or by promoting foreign investments by countries with at least the same technological level of the USA. Moreover, place-based policies able to sustain productivity growth dynamics are needed. Again, a mixed of place-based innovation and educational policies, as well as incentive to capital accumulation may be considered.

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Technical appendices

Table A 2.1. Categorisation of NACE sectors into functional activities within the value chain

Economic activity	**GVC function (narrow categories)**	**GVC function (broad categories)**
R&D services	R&D and related services	pre-production services
Engineering and related technical services		
Specialty design services		
Business services	Headquarter services	
ICT services		
Manufacturing	production	production
Recycling		
Extraction		
Freight transport services (agency included)	Distribution and logistics	post-production services
Cargo handling services		
Storage and warehousing services		
Marketing services	marketing, sales and after sales services	
Advertising and related services		
Market research and public opinion polling services		
Trade show assistance & organization services		
Call centre services		

Source: Nielsen, 2011; Stollinger, 2019

Table A 2.2. Transition matrix (2007-2022)

Year		2022			
		Pre-production	Production	Pos-production	total
2007	Pre-production	15	17	20	52
	Production	5	114	22	141
	Post-production	6	15	27	48
	Total	26	146	69	

Table A 2.3. Baseline regression results

	(1)
VARIABLES	D.productivity
LD.Frontier_relatedness	0.00788***
	(0.00258)
LD.pop	0.0634
	(0.0726)
LD.gdp_pc	-0.125***
	(0.0336)
LD.popdens	-0.103
	(0.0641)
LD.edu	-0.0228**
	(0.0111)
LD.ind_capex	-0.00334
	(0.00374)
Constant	-0.0253***
	(0.00265)
Observations	2,936
Number of regions	219
R-squared	0.346
Region FEs	YES
Years FEs	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A 2.4. The role of the initial position within the value chain

VARIABLES	D.productivity
1.post2007#LD.Frontier_relatedness	0.00634***
	(0.00241)
2.production2007#LD.Frontier_relatedness	0.0115
	(0.00744)
3.pre2007#LD.Frontier_relatedness	0.00897**
	(0.00445)
LD.pop	0.0629
	(0.0727)
LD.gdp_pc	-0.125***
	(0.0337)
LD.popdens	-0.103
	(0.0641)
LD.edu	-0.0228**
	(0.0111)
LD.ind_capex	-0.00328
	(0.00375)
Constant	-0.0254***
	(0.00266)
Observations	2,936
Number of regions	219
R-squared	0.346
Region FEs	YES
Region FEs	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A 2.5. The nature of the transition process

VARIABLES	D.productivity
LD.Left-Functional upgrading	0.0426***
	(0.0118)
LD.Right-Functional upgrading	0.00851*
	(0.00476)
LD.Functional downgrading	0.00788
	(0.00569)
LD.Process upgrading	0.00741**
	(0.00351)
LD.pop	0.0870
	(0.0764)
LD.gdp_pc	-0.120***
	(0.0375)
LD.popdens	-0.109
	(0.0689)
LD.edu	-0.0267**
	(0.0112)
LD.ind_capex	-0.000361
	(0.00305)
Constant	-0.0262***
	(0.00268)
Observations	2,749
Number of regions	205
R-squared	0.347
Region FEs	YES
Region FEs	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table A 2.6. The mediating role of outward FDI

	(1)
VARIABLES	D. productivity
Non Headquarters*Relatedness	0.00595**
	(0.00239)
Intermediate Headquarters*Relatedness	0.0295***
	(0.00811)
Headquarters*Relatedness	-0.00417
	(0.0120)
Population	0.0553
	(0.0741)
gdp_pc	-0.119***
	(0.0340)
Population Density	-0.110*
	(0.0629)
Education	-0.0212*
	(0.0108)
Ind_capex	-0.00280
	(0.00379)
Constant	-0.0249***
	(0.00263)
Observations	2,908
Number of nuts	215
R-squared	0.353
Region FEs	YES
Region FEs	YES

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

3 A World of 'Strategic Tariff Setting' and its implications for GVC trade

Contextual background and research objectives

The tariff war put in place by the second Trump Presidency is well known to everybody, and trade policy conflicts have become a prominent area of analysis. In this chapter, the simulations of the impact of tariff setting between the different major trading blocs (USA, EU, China) are presented. Two main research questions are addressed: (i) What are the implications of an escalating trade policy conflict between the USA and the EU? (ii) What are the implications of the prohibitive tariff walls between the USA and China on international trade flows (trade diversion effects) and specifically how does it affect the EU?

The replies to the research questions come from two types of simulations. The first simulation presents the impact of an escalating tariff war between the EU and the USA (which could happen in the wake of the July deadline of the 90 days moratorium declared by President Trump in April 2025). The second simulation undertaken refers to the analysis of the impact of prohibitive tariff walls between China and the USA (as they have currently been erected). The particular interest here was to see to which extent such prohibitive tariff walls between China and the USA led to trade diversion effects, especially of increased trade flows from China unto EU and other markets.

Both these two simulation exercises with the estimated model covers a highly relevant topic of trade policy scenarios which have a big impact on international trade flows, differential impacts on sectors (the model output allows a breakdown by sectors and also for each EU economy) and on overall macro-variables, such as on real wages (given the price effects and income effects of tariff setting), and on 'welfare' (which combines real income effects and tariff income).

Methods of analysis and data

The study uses a sophistic model along the lines of Caliendo and Parro (2015). The main estimated equations relating trade flows to the characteristics of the exporting and importing countries mimic a structural gravity equation. However, contrary to structural gravity models (such as described in Yotov et al. (2016) and Grübler and Reiter (2021)), the Caliendo and Parro model does include input-output linkages. This means that an increase in exports of a certain good will also increase the flows of its intermediate inputs which may again be international trade flows. As a result, with this model we can specifically examine the effects of trade policy changes on global value chains - a capability not possible with traditional structural gravity models. See also Mendoza et al. (2024) for a recent application of this model to the EU carbon border tax (CBAM) issue.

The model is based on the OECD inter-country input-output database, see OECD (2023). It covers 77 countries and 45 industries. This database includes data for nearly all model variables, such as international trade flows, input-output coefficients, shares in final demand and so forth.

Furthermore, we use estimated trade elasticities from Fontagné et al. (2022) and Eppinger et al. (2023) for the goods-producing industries while the elasticities for the service sectors are taken from Freeman et al. (2021). These elasticities are computed for the long-term. Since we are interested in short-term impacts, we divide them all by four, as proposed in Baqaee et al. (2024). Finally, trade data is collected from the WITS platform of the World Bank (2023) which has been cleaned and used in Cie and Ghodsi (2024).

We use data from the year 2020, which is the latest year for which all data sources are available.

Findings and discussion

As mentioned above there are two separate exercises which are reported in this paper. Exercise (i) analyses the features and implications of 'strategic tariff' setting or, in other words, a retaliatory escalation of a tariff war between the US and the EU. Exercise (ii) looks at the implications of the near complete trade collapse between the US and China through a regime of prohibitive bilateral tariffs (as they are place now with the US imposing an average tariff of 145% on Chinese imports and China having retaliated with an average tariff of 125% on US imports to China; although for the simulations we use for simplicity reciprocal tariff rates of 145%). The focus here was on analysing the impact on trade diversion of Chinese exports to other markets as a result of this prohibitive trade regime with the US, and particularly the trade diversion effect for the EU.

While detailed results from both these two exercises are reproduced in the Technical Appendix, here some summary insights obtained:

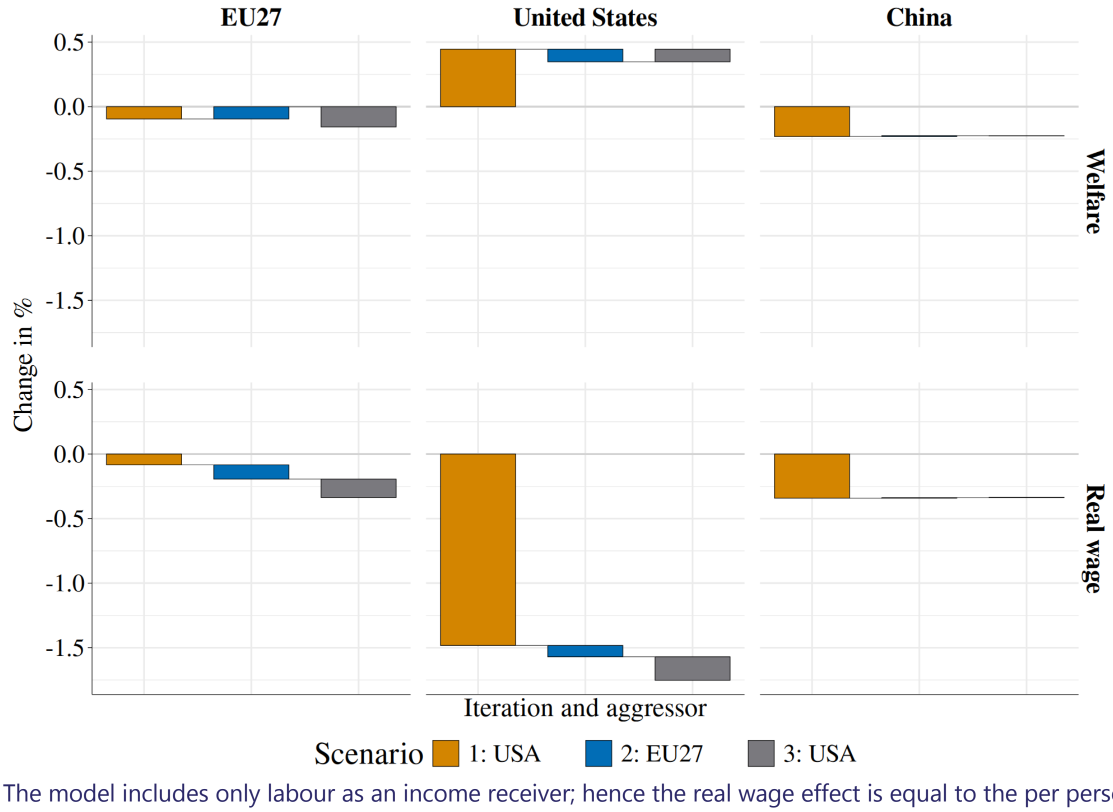
Exercise (i) Retaliatory tariff war between the USA and the EU27

The exercise starts off with the state of play as the imposition of tariffs was announced by mid-April (after 'Liberation Day) by both the US and also by China. These amounted – apart from the earlier imposition of 25% tariffs on steel and aluminium plus on cars and car parts – to additional 20 pp. tariff rates on top of the existing tariff rates on imports from the EU to the US (for details see Technical Annex 1). These tariff structures (we refer to these additionally imposed tariff structures as 'factual' vs. 'baseline') are shown in Appendix Tables A 3.2 and A 3.3 respectively for a representative EU economy in Table A 3.2 and for China in Table A 3.3.

We then simulate 'strategic tariff' setting in 2 stages: Stage 1: The EU responds by retaliating (to the additional 'factual' tariffs set by the US) by imposing a structure of sectoral tariffs on US imports which aims to impose maximum damage to US 'welfare' and minimises the impact on EU 'welfare' (includes the impact both on real personal income plus the tariff income which in turn gets distributed to households). Stage 2: The US responds by further changing sectoral tariff rates (from 'factual') vis-à-vis the EU by correspondingly imposing maximum damage to EU welfare and minimising the impact on US welfare.

The macro (% change) impacts on the 'welfare and the 'real wage' positions of the three economies (EU27, USA and China) of the imposition of the initial ('factual) tariffs by the USA, then Stage 1 (where EU27 retaliate) and then Stage 2 (where USA counter-retaliates) can be seen from Figure 3.1.

Figure 3.1. Real Income and Welfare results for the big players ('factual' USA scenario; EU27 retaliation; USA counter-retaliation)



Note: The model includes only labour as an income receiver; hence the real wage effect is equal to the per person real income effect – prior to any disbursement of tariff income to households. The 'welfare' effect includes the impact on real incomes plus the tariff income which gets distributed in turn to households.

In this figure we want to point to the substantial negative real wage effect in the US of the imposition of the US (initial 'factual') tariffs (in orange) which get further negatively impacted by the two next stage retaliatory impositions of 'strategic' tariffs by the EU27 (in blue) and further by the US on the EU27 (in grey). This is due especially to the price effect of tariffs. We can also see that imposing the initial ('factual') tariffs also negatively affects the real wage

(=real income per capita) in China significantly, but much less so than in the US which shows the higher dependence of the 'real wage basket' in the US on Chinese imports than vice versa. The real wage effect in the EU27 is much less but cumulates over the further retaliatory stages.

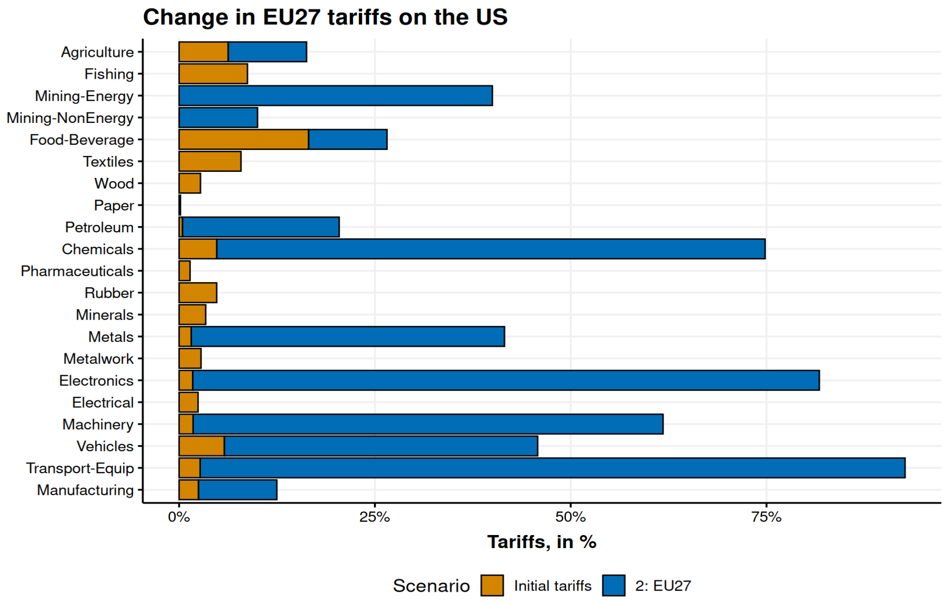
In welfare terms (which includes – as mentioned above – the real income effect and tariff income), the starting ('factual') imposition of tariffs by the US gives its 'welfare' a positive boost (the effect of the additional significant tariff income) which then gets reduced during the retaliatory stages, but remains positive. The welfare effects of the 'factual' tariff scenario (compared to the baseline) is negative for the EU27 (bigger for China as initial 'factual' tariffs imposed by the US are significantly higher than those imposed by the US on the EU27) and remains so over the following stages of retaliatory tariff setting.

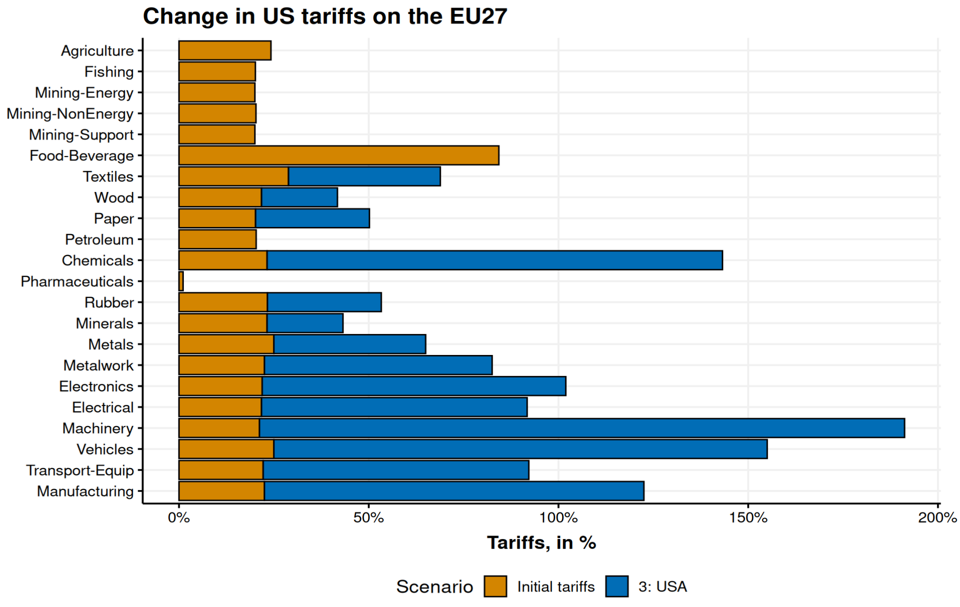
The next issue which we want to show are the results from our estimations of *"optimal" strategic retaliatory tariffs* – those that maximise damage to US welfare and minimises welfare in the EU27 when imposed by the EU27 on US imports; and vice versa when imposed by the US on EU 27 imports. The resulting tariff structure (on top of the 'factual' tariffs) are presented in Figure 3.2.

We can see from Figure 3.2 that "optimal strategic tariffs" from the EU27 side on US imports would be imposed mostly on chemicals, electronics and transport equipment; while from the US side the "optimal" retaliatory additional (from 'factual') tariffs would be imposed especially on chemicals, machinery and vehicles. This is the picture when we limit retaliatory tariffs only on goods imports. Overall, the coverage of retaliatory tariff increases by the US is somewhat more even across industries than those imposed by the EU27. We can, however, see that this retaliatory ('non-cooperative') game of strategic tariff setting leads to extremely high tariff rates for some industries. Hence, the model suggests that if there is no switch towards a more cooperative resolution of the trade policy dispute between the US and the EU, there is still much to go in increasing tariff walls between these two major trading countries/regions.

There is another interesting result we would like to show and this refers to a – also currently discussed – trade policy strategy when we include two services industries in this retaliatory tariff setting game. I.e. when we consider the possibility to impose retaliatory tariffs also on the *IT services* industry and the *Finance* industry when calculating what the 'optimal' strategic tariff setting would be in addition to including tariffs on goods (which was all that we included in the previous analysis). These results are depicted in Figure 3.3.

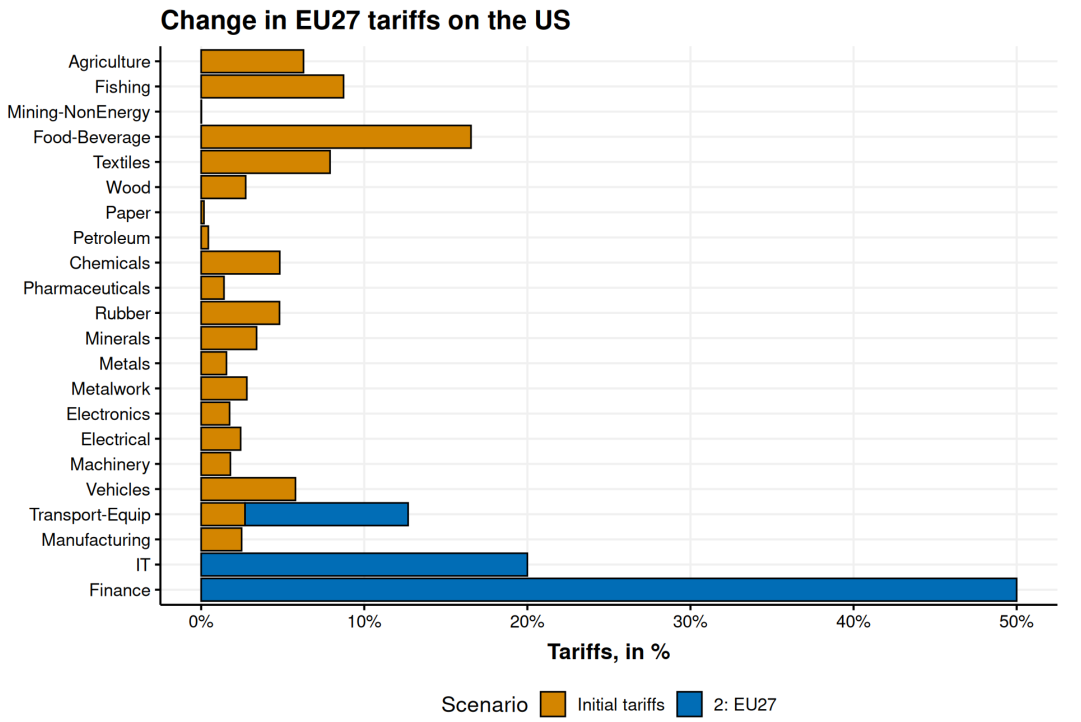
Figure 3.2. Results from strategic tariff setting (EU27 tariffs on the US – top graph; and US tariffs on the EU27 – bottom graph) by industry – always from 'factual' baseline. Only tariffs on goods imposed.

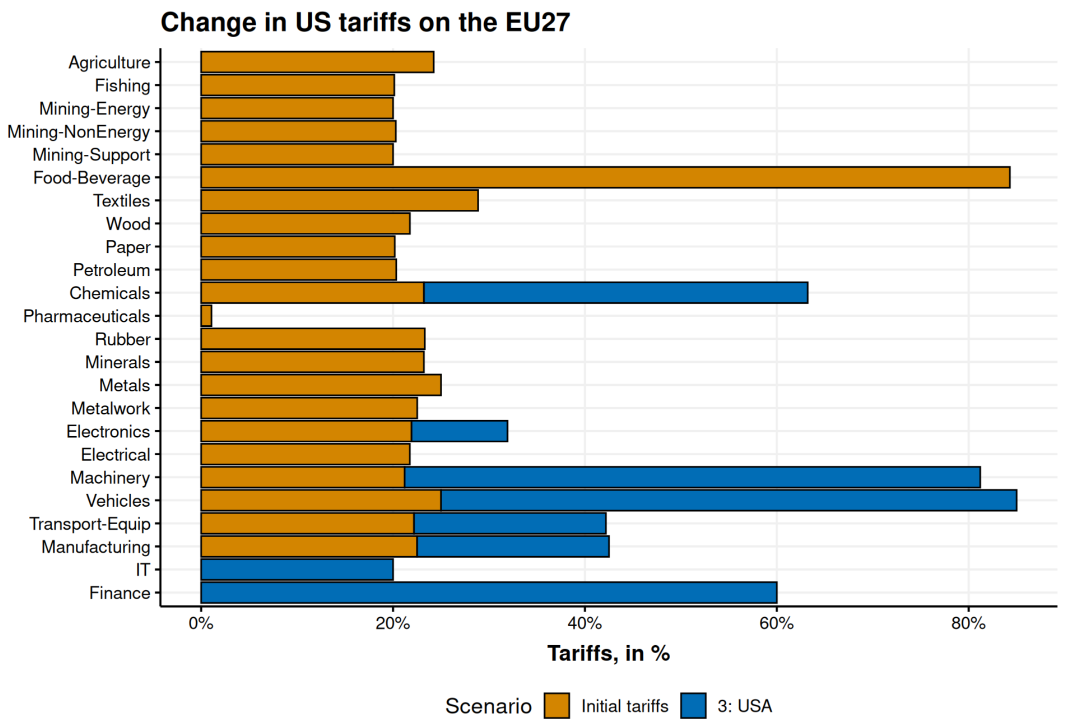




Note: 'Manufacturing' refers only to 'Other Manufacturing'

Figure 3.3. Results from strategic tariff setting (EU27 tariffs on the US – top graph; and US tariffs on the EU27 – bottom graph) by industry – always from 'factual' baseline. Algorithm calculates 'optimal' strategic tariffs on the range of goods, but also on two services industries, IT and Finance.





The results are rather striking: following the same algorithm to calculate the optimal tariff structure as before (i.e. inflicting maximal welfare damage to the trading partner and the minimal welfare damage to oneself) the following emerges:

- In this case the optimal strategic tariff structure shifts dramatically towards the two services industries, IT and Finance, as far as the imposition of 'optimal' tariffs from the EU27 on the US is concerned. The algorithm shows that in this case, amongst additional tariffs on goods imports from the US, only the transport equipment industry remains part of such an 'optimal retaliatory tariff' strategy. This means that from the EU27 perspective including these services industries, or even only one of them (i.e. IT or Finance[1]) in retaliating would lead definitely to a superior 'optimal' retaliatory tariff structure than concentrating only on imposing additional tariffs on goods imports.
- From the US side the inclusion of IT and Finance in calculating an 'optimal' strategic tariff structure makes less of a difference to the 'goods' only scenario as the US would still retaliate with additional tariffs on a range of manufacturing EU industries (chemicals, machinery, vehicles, transport equipment and other manufacturing).

This result shows the distinct specialisation structures inherent in US-EU trade relationships (i.e. that in the US exports to the EU IT and Financial Services play a much more important role than trade in the other direction) and their relative vulnerabilities in such a tariff war.

Exercise (ii): The impact of prohibitive tariff walls between the USA and China

Exercise (ii) simulates a scenario in which both the US and China impose tariffs of 145% on bilateral goods imports (while EU-US tariffs stay at the current 'factual' level; see the detailed scenario imposed can be seen in Technical Annex A2). The attention in this analysis is on which type trade diversion effect this produces. The results from this simulation (in per centage point difference from 'factual' base) are depicted in Table 3.1.

Table 3.2 shows the changes in inter-country/inter-regional trade flows in absolute (USD) amounts.

There are two factors driving these results: (a) the impact which the dramatic increase in tariff barriers between the US and China has on GDP developments by interrupting trade flows and thereby especially affecting real incomes through the price effects (see the impact on the real wage rate in Figure 3.4) (b) trade diversion effects of Chinese exports to other markets (to EU27 and 'Other').

[1] We can supply also the results when only one of the two services industries (IT or Finance) is included in the calculation of the 'optimal' strategic tariff structure.

Table 3.1. Trade Flow Matrix: % changes due to imposition of 'factual' tariffs

Exporter	EU27	United States	China	Other	Sum
EU27	-0.1	2.3	-5.3	-0.4	-0.7
United States	-5.6	3.1	-46.6	-5.8	-9.9
China	2.2	-69.5	-2.4	1.9	-8.8
Other	0.1	2.0	-4.9	-0.3	-1.2
Sum	-0.7	-9.9	-8.8	-1.2	-4.1

Table 3.2. Trade Flow Matrix: changes due to imposition of 'factual' tariffs (in USD)

Exporter	EU27	United States	China	Other	Sum
EU27	-30551330	7458421	-15893444	-6783231	-15218254
United States	-24978312	856827341	-89258051	-70976189	-185212552
China	7850989	-217088525	-756092390	26821521	-182416015
Other	1908708	24417544	-77264913	-163550112	-50938662
Sum	-15218615	-185212560	-182416408	-50937899	-433785482

Figure 3.4. Welfare and real income (=real wage) results from prohibitive US-China tariff walls – changes in %

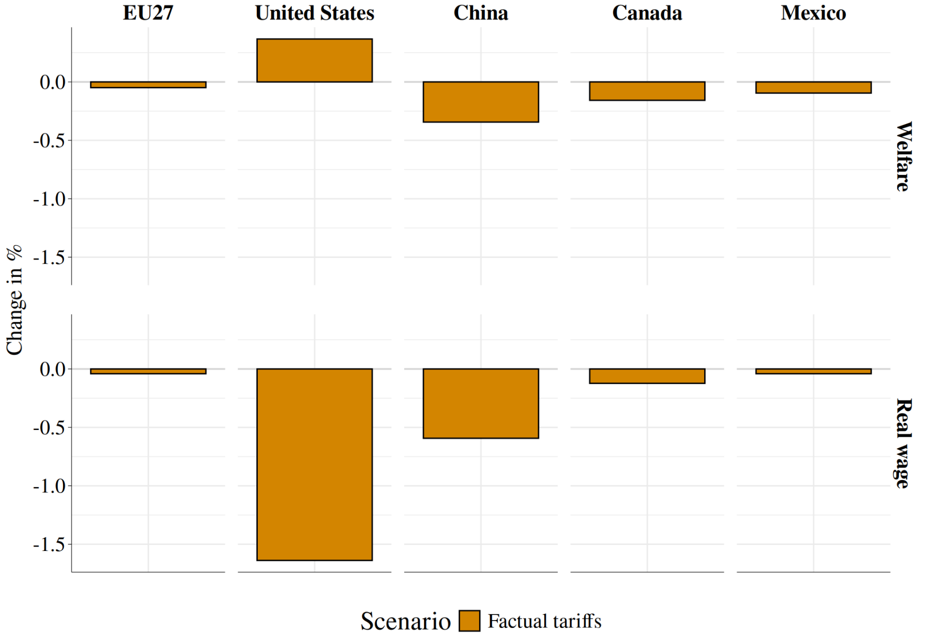


Table 3.3. Changes in welfare and real income (=real wage) in % from prohibitive US-China tariff walls

Region	Welfare	Real wage
EU27	-0.049	-0.041
United States	0.367	-1.639
China	-0.344	-0.593
Canada	-0.157	-0.123
Mexico	-0.095	-0.041

We can see that imposing a prohibitive tariff wall on US-China trade does generate very significant real income p.c. (=real wage) effects on the US and Chinese economies, but the impact on the latter is only about one third than that on the US economy – reflecting the stronger dependence of the US economy on Chinese imports than the other way round). On the other hand, we can see that the 'welfare' effect (which is particularly driven by the strongly increased tariff income) is positive for the US, while negative for the Chinese economy. In the latter the decline in export earnings is not compensated by increased tariff income from US imports (which are – to start off - much lower than the US imports from China). The intra-US trade (i.e. sales on the domestic market – in green; in Table 3.1) is also substantially increased because of the high tariff walls towards Chinese imports. This is another aspect which makes the outcome for the US different from that for China.

As regards, the *trade diversion effects*: while trade collapses between the US and China (Chinese exports to US by -69.5 p.p. and US exports to China by 46.6 p.p.; in blue in Table 3.1), Chinese exports to the EU 27 increase by 2.2 p.p. and to 'Other' global markets by 1.9 p.p. (in yellow in Table 3.1). Detailed effects by individual countries (individual member countries of the EU and other global trading partners of the US and China) can be obtained upon request.

Conclusions and policy implications

The current situation in the global economy is far from settled. The second Trump Presidency has dramatically changed the trade policy regime which affects in international trade relations and inter-bloc relationships more generally. The situation is still evolving and hence the analysis of various policy scenarios is vital to understand the implications of different policy regimes and also to design (from the EU's point-of-view) what the right policy responses should be and what their implications would be.

This chapter has attempted to analyse in detail two scenarios which are core scenarios for understanding and designing relevant policy issues especially from the EU's perspective in a well-specified – state-of-the-art – trade model which covers international trade and production linkages across 77 trading partners and can look at the implications at the detailed sector level. The two scenarios of policy relevance are: (i) If the Trump administration follows its strategy of imposing 'reciprocal tariffs' (which is a concept covering much more than what is traditionally defined as 'tariffs'), what could the EU's 'optimal strategic tariff response' be, given that a non-cooperative policy setting persists; and (ii) what are the implications for the EU if prohibitive tariff walls would seriously bring down trade relations between the US and China?

With regard to (i) we have shown that a tariff war between the EU27 and the US – where each trading partner tries to inflict maximum damage to the 'welfare' of the other while minimising the impact on its own welfare – in a non-cooperative setting could, firstly, significantly drive up tariff rates further. Secondly, for the EU's perspective it would be important to include in such a situation important services industries (where the US has a comparative advantage) in the calculation of retaliatory tariffs.

For (ii) where US-China trade collapses due to prohibitive tariff walls between these two economies, what would be specifically relevant for the EU are trade diversion effects (i.e. significant trade flows from China being diverted from the US to other markets). This is an important policy issue in the relationship between China and the EU: on the one hand, both these two entities would like to maintain a relatively liberalised international trading system, but, on the other hand, a significant redirection of trade flows from China to EU markets can generate serious challenges for EU producers, especially in particular sectors. Hence a quantitative assessment with a model such as ours of such trade diversion effects are important for negotiations with China about a reasonable reaction to the Trump 'disruption' of the international trading system. A possible outcome of such negotiations could be so-called "voluntary export restrictions" (VER's) which were negotiated by the US vis-à-vis Japanese car producers in the 1980s and could set a precedent for such negotiations between the EU and China.

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Technical appendices

Annex 1

Details on the cumulative tariff scenario imposed as a starting point for Scenario 1 ('factual' tariffs before imposing retaliatory tariffs by EU27 on US imports and following this of the US on the EU27:

Scenario 1: Trump introduces a smorgasbord of tariffs ("factual tariffs"):

- The US imposes a tariff of 25% on steel and aluminium products on all countries.
- At the moment, we do not explicitly model the tariffs the US imposed on Canada and Mexico (on products that are not covered by the USMCA agreement), because these detailed product level tariffs cannot appropriately be modelled here.
- We further include the additional 20% tariffs on China.
- Chinese retaliation tariffs are also included here: mining products from the US will be charged a 15% tariff, while the tariffs on machinery, vehicles and transport equipment will be increased to 10%. After the latest 10% tariff increase on Chinese goods by the US, China furthermore announced tariffs of 15% on agricultural goods.
- Trump announces 25% on cars and car parts.
- Trump announces "reciprocal" tariffs that are country-dependent. EU has, e.g., a tariff of 20%. Some industries are exempted, e.g. copper, pharmaceuticals, semiconductors, and lumber articles. Also, steel and aluminium and vehicles/car parts are exempted. For easy modelling, we only exempt pharmaceuticals, metals and vehicles. https://www.whitehouse.gov/fact-sheets/2025/04/fact-sheet-president-donald-j-trump-declares-national-emergency-to-increase-our-competitive-edge-protect-our-sovereignty-and-strengthen-our-national-and-economic-security/
- China announced it will impose 34% tariffs on US exports as retaliation to reciprocal tariffs. https://www.theguardian.com/us-news/live/2025/apr/04/us-business-stock-markets-nyse-blog-trump-tariffs-asian-markets

Table A 3.1. Investigating trade diversion effects from imposing 'factual tariff' (from baseline) – pct 1; followed by 'strategic tariff setting' by the EU27 on US imports – pct2; followed by 'strategic tariff setting' by US on EU27 imports - trade matrix for selected countries

	Change due to pct 1				
Exporter	EU27	United States	China	Other	Sum
EU27	-0.5	-2.5	-3.9	-0.7	-1.4
United States	-7.3	3.8	-32.2	-7.3	-9.8
China	0.9	-41.7	-1.9	0.2	-6.0
Other	-0.2	-3.7	-3.3	-0.8	-2.3
Sum	-1.4	-9.8	-6.0	-2.3	-4.1

Change due to pct 2

Exporter	EU27	United States	China	Other	Sum
EU27	0.1	-5.2	-4.4	-1.2	-2.1
United States	-18.5	3.1	-31.0	-6.0	-11.6
China	2.8	-42.8	-1.7	0.2	-5.8
Other	1.5	-5.4	-3.0	-0.6	-2.1
Sum	-2.1	-11.6	-5.8	-2.1	-4.5

Change due to pct 3

Exporter	EU27	United States	China	Other	Sum
EU27	-0.8	-25.2	-3.2	-0.2	-4.1
United States	-21.1	4.0	-32.1	-7.1	-13.0
China	0.7	-41.0	-1.8	0.3	-5.8
Other	-0.2	-2.6	-3.1	-0.6	-2.0
Sum	-4.1	-13.0	-5.8	-2.0	-5.1

Table A 3.2. Tariffs before and after the US has imposed ('factual') tariffs on EU27

	baseline_USA	factual_USA	baseline_EU27	factual_EU27
Agriculture	4.23	24.23	6.28	6.28
Fishing	0.13	20.13	8.73	8.73
Mining-Energy	0.00	20.00	0.00	0.00
Mining-NonEnergy	0.29	20.29	0.02	0.02
Mining-Support	0.00	20.00	0.00	0.00
Food-Beverage	64.29	84.29	16.54	16.54
Textiles	8.86	28.86	7.90	7.90
Wood	1.75	21.75	2.73	2.73
Paper	0.18	20.18	0.17	0.17
Petroleum	0.34	20.34	0.44	0.44
Chemicals	3.22	23.22	4.82	4.82
Pharmaceuticals	1.08	1.08	1.40	1.40
Rubber	3.31	23.31	4.80	4.80
Minerals	3.21	23.21	3.40	3.40
Metals	1.27	25.00	1.55	1.55
Metalwork	2.52	22.52	2.80	2.80
Electronics	1.93	21.93	1.74	1.74
Electrical	1.75	21.75	2.42	2.42
Machinery	1.21	21.21	1.79	1.79
Vehicles	3.45	25.00	5.78	5.78
Transport-Equip	2.19	22.19	2.69	2.69
Manufacturing	2.51	22.51	2.48	2.48
Energy	0.00	0.00	0.00	0.00
Water-Waste	0.62	0.62	1.24	1.24
Construction	0.00	0.00	0.00	0.00
Retail	0.00	0.00	0.00	0.00
Land-Transport	0.00	0.00	0.00	0.00
Water-Transport	0.00	0.00	0.00	0.00
Air-Transport	0.00	0.00	0.00	0.00
Warehousing	0.00	0.00	0.00	0.00
Postal	0.00	0.00	0.00	0.00
Hospitality	0.00	0.00	0.00	0.00

	baseline_USA	factual_USA	baseline_EU27	factual_EU27
Publishing	0.03	0.03	0.00	0.00
Telecom	0.00	0.00	0.00	0.00
IT	0.00	0.00	0.00	0.00
Finance	0.00	0.00	0.00	0.00
Real-Estate	0.00	0.00	0.00	0.00
Professional-Svc	0.00	0.00	2.80	2.80
Admin-Svc	0.00	0.00	0.00	0.00
Public-Admin	0.00	0.00	0.00	0.00
Education	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00
Arts	0.00	0.00	0.00	0.00
Services	1.40	1.40	0.00	0.00
Household-Activ	0.00	0.00	0.00	0.00

Table A 3.3. Tariffs before and after the US has imposed ('factual') tariffs on China

Tariffs before and after the US has imposed tariffs

	baseline_USA	factual_USA	baseline_CHN	factual_CHN
Agriculture	3.82	57.82	11.17	49.00
Fishing	0.12	54.12	7.97	41.97
Mining-Energy	0.02	54.02	2.69	49.00
Mining-NonEnergy	0.29	54.29	2.45	49.00
Mining-Support	0.00	54.00	0.00	34.00
Food-Beverage	44.17	98.17	12.91	46.91
Textiles	8.95	62.95	7.27	41.27
Wood	1.74	55.74	4.13	38.13
Paper	0.18	54.18	4.70	38.70
Petroleum	0.35	54.35	5.58	39.58
Chemicals	3.05	57.05	7.30	41.30
Pharmaceuticals	0.75	20.75	4.05	38.05
Rubber	3.32	57.32	9.05	43.05
Minerals	3.19	57.19	10.01	44.01
Metals	1.31	21.31	4.90	38.90
Metalwork	2.58	56.58	7.89	41.89
Electronics	1.93	55.93	4.99	38.99
Electrical	1.72	55.72	6.78	40.78
Machinery	1.20	55.20	7.00	44.00
Vehicles	3.45	25.00	9.92	44.00
Transport-Equip	2.19	56.19	7.33	44.00
Manufacturing	2.56	56.56	6.52	40.52
Energy	0.00	20.00	2.50	36.50
Water-Waste	0.76	0.76	4.44	4.44
Construction	0.00	0.00	0.00	0.00
Retail	0.00	0.00	0.00	0.00
Land-Transport	0.00	0.00	0.00	0.00
Water-Transport	0.00	0.00	0.00	0.00
Air-Transport	0.00	0.00	0.00	0.00
Warehousing	0.00	0.00	0.00	0.00
Postal	0.00	0.00	0.00	0.00
Hospitality	0.00	0.00	0.00	0.00

	baseline_USA	factual_USA	baseline_CHN	factual_CHN
Publishing	0.03	0.03	1.99	1.99
Telecom	0.00	0.00	0.00	0.00
IT	0.00	0.00	0.00	0.00
Finance	0.00	0.00	0.00	0.00
Real-Estate	0.00	0.00	0.00	0.00
Professional-Svc	0.00	0.00	7.27	7.27
Admin-Svc	0.00	0.00	0.00	0.00
Public-Admin	0.00	0.00	0.00	0.00
Education	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00
Arts	0.00	0.00	2.48	2.48
Services	1.40	1.40	15.00	15.00
Household-Activ	0.00	0.00	0.00	0.00

Annex 2

Details on the cumulative tariff scenario imposed as a starting point for Scenario 2 ('factual' tariffs before imposing 145% tariff rates by US on Chinese imports and by China on US imports:

Scenario 2: Trump introduces a smorgasbord of tariffs ("factual tariffs"):

- The US imposes a tariff of 25% on steel and aluminium products on all countries.
- At the moment, we do not explicitly model the tariffs the US imposed on Canada and Mexico (on products that are not covered by the USMCA agreement), because these detailed product level tariffs cannot appropriately be modelled here.
- Chinese retaliation tariffs are also included here: mining products from the US will be charged a 15% tariff, while the tariffs on machinery, vehicles and transport equipment will be increased to 10%. After the latest 10% tariff increase on Chinese goods by the US, China furthermore announced tariffs of 15% on agricultural goods.
- Trump announces 25% on cars and car parts.
- Trump announces a pause to the reciprocal tariffs, instead all countries receive a 10% (assumed additional) tariff. We simply assume that all countries and industries that had a non-zero reciprocal tariff have now a 10% tariff and add that to the already existing tariffs. Trump also announced a tariff exemptions for laptops and mobile phones, we implement this as zero tariffs for the "Electronics" industry.
- At the same time, Trump is imposing 125% on China. We assume this is the new absolute value (we don't add it, we simply set tariffs for China to 145%).
- China has shown not to back down, thus we assume China's retaliation will be in kind: 145%.

Tariffs before and after the US has imposed tariffs

	baseline_USA	factual_USA	baseline_CHN	factual_CHN
Agriculture	3.82	145.00	11.17	145.00
Fishing	0.12	145.00	7.97	145.00
Mining-Energy	0.02	145.00	2.69	145.00
Mining-NonEnergy	0.29	145.00	2.45	145.00
Mining-Support	0.00	145.00	0.00	145.00
Food-Beverage	44.17	145.00	12.91	145.00
Textiles	8.95	145.00	7.27	145.00
Wood	1.74	145.00	4.13	145.00
Paper	0.18	145.00	4.70	145.00
Petroleum	0.35	145.00	5.58	145.00
Chemicals	3.05	145.00	7.30	145.00
Pharmaceuticals	0.75	145.00	4.05	145.00
Rubber	3.32	145.00	9.05	145.00
Minerals	3.19	145.00	10.01	145.00
Metals	1.31	145.00	4.90	145.00
Metalwork	2.58	145.00	7.89	145.00
Electronics	1.93	145.00	4.99	145.00
Electrical	1.72	145.00	6.78	145.00
Machinery	1.20	145.00	7.00	145.00
Vehicles	3.45	145.00	9.92	145.00
Transport-Equip	2.19	145.00	7.33	145.00
Manufacturing	2.56	145.00	6.52	145.00
Energy	0.00	0.00	2.50	2.50
Water-Waste	0.76	0.76	4.44	4.44
Construction	0.00	0.00	0.00	0.00
Retail	0.00	0.00	0.00	0.00
Land-Transport	0.00	0.00	0.00	0.00
Water-Transport	0.00	0.00	0.00	0.00
Air-Transport	0.00	0.00	0.00	0.00
Warehousing	0.00	0.00	0.00	0.00
Postal	0.00	0.00	0.00	0.00
Hospitality	0.00	0.00	0.00	0.00
Publishing	0.03	0.03	1.99	1.99
Telecom	0.00	0.00	0.00	0.00
IT	0.00	0.00	0.00	0.00
Finance	0.00	0.00	0.00	0.00
Real-Estate	0.00	0.00	0.00	0.00
Professional-Svc	0.00	0.00	7.27	7.27
Admin-Svc	0.00	0.00	0.00	0.00
Public-Admin	0.00	0.00	0.00	0.00
Education	0.00	0.00	0.00	0.00
Health	0.00	0.00	0.00	0.00
Arts	0.00	0.00	2.48	2.48
Services	1.40	1.40	15.00	15.00
Household-Activ	0.00	0.00	0.00	0.00

4 The scarring effects of the COVID-19 pandemic on global carbon chains through changes in final demand

Contextual background and research objectives

Recent years have started to see a process of deglobalization and reshoring, meaning the increase in the share of imported intermediate inputs seen before 2008 has slowed down or even reversed for some industries and countries, as all WPs in the TWIN SEEDs project have shown. This process of restructuring of GVC is likely to continue, given the risks that became apparent during the pandemic and other recent disruptions, and that have reoriented trade policy. Both the US and the EU were implementing so-called reindustrialization packages (EU, 2024; European Commission, 2022, 2023; European Commission et al., 2021; European Parliament, 2024; US Congress, 2022), aimed at bringing back some previously offshored critical manufacturing activities, even before Trump's second-term tariffs came into the picture.

This reconfiguration of GVCs has impacts on emissions, also those linked to final demand, as changes in input sourcing can decrease embodied CO_2, for example, if GVCs for products consumed by EU households reduce their China share and raise US, UK, or, even more, EU inputs. Variations in the pattern of consumption by households interact with those trade trends, as a shift towards goods with less embodied emissions along their GVCs will decrease pollution without the need to reduce the level of consumption. Furthermore, policies directed at reducing emissions from households require a change in the demand for some specific final goods (for example, EVs and heat pumps versus combustion cars) and energy products and, as a consequence, a greater reliance on some critical inputs and GVC that are being targeted in the reindustrialization policies.

This chapter provides a picture of the carbon footprint (CF) of EU households, identifying how the recent changes in their spending, together with the evolution of GVC, have impacted their contribution to CO_2 emissions. The method used allows us to combine the effect of changes in final demand with the reorganization of GVC, as it takes into account the changes in origin for inputs and final goods and services. The main sources and factors affecting households' emissions, which is key to identifying where policies can be directed, are analyzed and it provides real-life results of drastic changes in demand, showing the potential for reduction policies.

Also changes in households´ emissions due to some EU policies, included in the EU Green Deal, are calculated: private transport electrification and increased efficiency of products and buildings. These measures aim to favour the decoupling between consumption and emissions, so the first may continue to grow while emissions are reduced. This is particularly relevant when considering the importance of a fair, clean transition.

More in depth, the interest of the chapter lies in the shocks to households' consumption that alter the level and pattern of demand, affecting emissions. These are non-intended changes that come from external shocks that can move household behaviour in the direction of reducing emissions. This is the case in recent years of Covid-19 and the war in Ukraine that have significantly changed the EU residents' consumption levels and patterns, even if temporarily. Covid-19 led not only to a drastic decrease in final demand but also concentrated disproportionately on transport (both private and public), entertainment (cultural, sports activities), hotels and restaurants. The energy crisis from the war in Ukraine generated a spike in gas prices and a decrease in general consumption, and energy products in particular.

This chapter intends to provide a deeper analysis of the CO_2 effects from recent changes in final demand from EU households, using the Covid-19 crisis as a real-life example of a major decrease in demand coupled with a drastic reduction in transport. What happened in that period could give an idea of what would happen in front of a drastic decrease in the final demand of households. The lag in available data means this is a relatively new subject, with only a few papers discussing its effects on emissions at length.

Changes in individual and social behaviour are a factor that is increasingly considered when designing policies aiming at reducing emissions (Creutzig et al., 2018; Creutzig et al., 2022; Duarte, Miranda-Buetas, & Sarasa, 2021; Lee, Shigetomi, & Kanemoto, 2023; Lévay, Vanhille, Goedemé, & Verbist, 2021; Song, Qu, Taiebat, Liang, & Xu, 2019). This is the case even when analysing the economic and environmental effects of global value chains (GVCs), as final demand is combined with changes in technology and GVCs to determine the amount and origin of the goods and services produced.

Those changes can affect CO_2 emissions through changes in levels of consumption, pattern of final consumption, or changes in the CO_2 multiplier. In this study, a structural decomposition analysis (Dietzenbacher & Los, 1998; Distefano, Lodi, & Biggeri, 2024; Feás, 2023; Hubacek, Chen, Feng, Wiedmann, & Shan, 2021; Pan, Wang, Shen, & Song, 2022; Su & Ang, 2012) is carried out to know the effects of each of those factors.

This is not the only purpose of our work, as we aim to apply the lessons learned from the change in emissions during the pandemic and its aftermath to potential policies directed towards households. The Eighth Environment Action Programme (European Parliament and the Council, 2022) calls for the European Union to significantly reduce its consumption footprint. While the reductions in 2020 and 2021 were short-lived, we set scenarios for the mid and long terms, based on current EU objectives: private transport electrification, reduction in households´ energy use and US tariffs.

As data takes time to be released, there is very little evidence in the literature on the impact of recent shocks, such as Covid-19 and, particularly, the ulterior recovery (Bacchetta et al., 2021; Baker, 2020; Cazcarro et al., 2022; Osorio, Cadarso, Tobarra, & García-Alaminos, 2023). Furthermore, the inclusion of different scenarios, both reflecting the latest situation (such as Trump's tariffs) and current policy commitments to analyse the potential impact on CO_2 emissions, can help with policy design.

As mentioned above, households' consumption is often pointed out as an important factor that can help to reduce emissions in the pursuit of decarbonisation objectives for 2030 and 2050. It is not only what and how we produce but also what, how much and where from we demand that define our environmental impacts. Sometimes, changes to household demand happen slowly, following long-term trends, for example, when they are motivated by demographic variations. But in some cases, external shocks generate quick shifts in demand with bigger CO_2 effects. Given the EU's aim to reduce the households' CF, it is important that we measure the relationship between changes in the level, the pattern and the origin of products with their environmental impact and use it as a starting point to analyse the effect of different policies.

The aim of the chapter is twofold. First, it has the aim to analyse how COVID-19 has changed consumption patterns in the EU and impacted emissions. To answer this question, this work analyses the carbon footprint of EU households in detail for the most recent data available to identify the main trends in their demand and its effects on direct and indirect emissions. Secondly, the chapter dels with how changes in households' final demand can become an opportunity to reduce the EU carbon footprint. We calculate the carbon footprint for different scenarios of household consumption patterns and levels based on recent policy proposals: electrification of private transport, reduction in household energy use, and changes in tariffs.

In this chapter, we are able to provide updated results of EU households' CF with respect to previous literature, such as Ivanova (2017), covering the recent shocks to final demand. We first isolate and then analyse the effects of the different components of changes in households' demand in the CF using structural decomposition analysis. We then introduce different scenarios (two for policies that are already projected, private transport electrification and households' energy use reduction, and one related to the present trade tariffs) and analyse the potential changes in emissions from EU households.

Methods of analysis and data

The core model of this research is an environmentally extended multiregional input-output model. We use the FIGARO database provided by EUROSTAT in its last update (2024 edition, last updated in January 2025) (Remond-Tiedrez & Rueda-Cantuche, 2019), which offers data for 45 countries and a "Rest of the World" region, and 64 industries, in nominal million euros valued at basic prices (Eurostat, 2025). Specifically, we use multiregional input-output tables from 2018 to 2022 and households' carbon footprint for the same years. We also use the final consumption expenditure of households from NAMA, classified by COICOP categories for more recent data, up to 2023 (EUROSTAT, 2018-2022), and information for direct CO_2 emissions (heating/cooling, private transport and other activities) (Eurostat, 2024).

This extended MRIO allows us to analyse the households' carbon footprint in this period, considering the changes in consumption patterns and their impacts on emissions. Furthermore, we develop a structural decomposition analysis to explain the importance of different factors in changing the emissions: on the one hand, we calculate the changes in emissions multipliers and on the other hand, the part explained by the changes in final demand, distinguishing between those derived from variations in final demand level, and those due to changes in the consumption pattern (by means of origin distribution and sector ratios).

Additionally, we propose three scenarios, each designed to explore different pathways for reducing household-related emissions in the European Union between 2022 and 2030 and the effects of recent geopolitical events and their impact on global supply chains and consequent effects on emissions. These scenarios focus respectively on the electrification of private transport, the reduction of household energy consumption, and the potential impact of global trade disruptions, such as those triggered by renewed tariff policies. Each scenario integrates a range of data sources - from national targets and energy consumption statistics to sector-specific technical parameters - and is grounded in real-world policy frameworks or plausible geopolitical developments. Table 4.1 provides a detailed overview of the scenarios implemented, including their scope, timeframes, and data sources.

Table 4.1. Scenarios description

	Scenarios	Description	Period	Data sources
1	**Private transport electrification**	Based on a reduction in direct transport emissions and indirect fuel emissions, combined with an increment in indirect electricity emissions	2022-2030	Data on national vehicles fleet by source (ACEA, 2025) National objectives for the share of electric vehicles over total vehicles (National energy and climate plans, 2021-2030) Average Kwh/km for electric cars (DGT, 2023) Final household consumption of energy goods related to road transport (EUROSTAT, 2022a) Gasoline, diesel and electricity prices (excluding taxes) (EUROSTAT, 2022c)

	Scenarios	Description	Period	Data sources
2	**Households' energy use reduction**	Based on a reduction in direct heating/cooling and appliances emissions, and indirect fuel and electricity emissions as well	2022-2030	National objectives for reduction of energy consumption by households (EUCommission, 2024) Final consumption households of refined oil products and electricity (EUROSTAT, 2022b) Refined oil products, natural gas and electricity prices (excluding taxes) (EUROSTAT, 2022d)
3	**Impact of Trump's tariffs on households**	Based on different changes in indirect emissions due to reconfigurations in global trade. It includes three simulations depending on the trade war intensity.	2025	Results in income, expenditure and trade from tariff scenarios (Reiter, 2025) FIGARO database (Eurostat, 2025)

Source: Own elaboration

Findings and discussion

Household demand

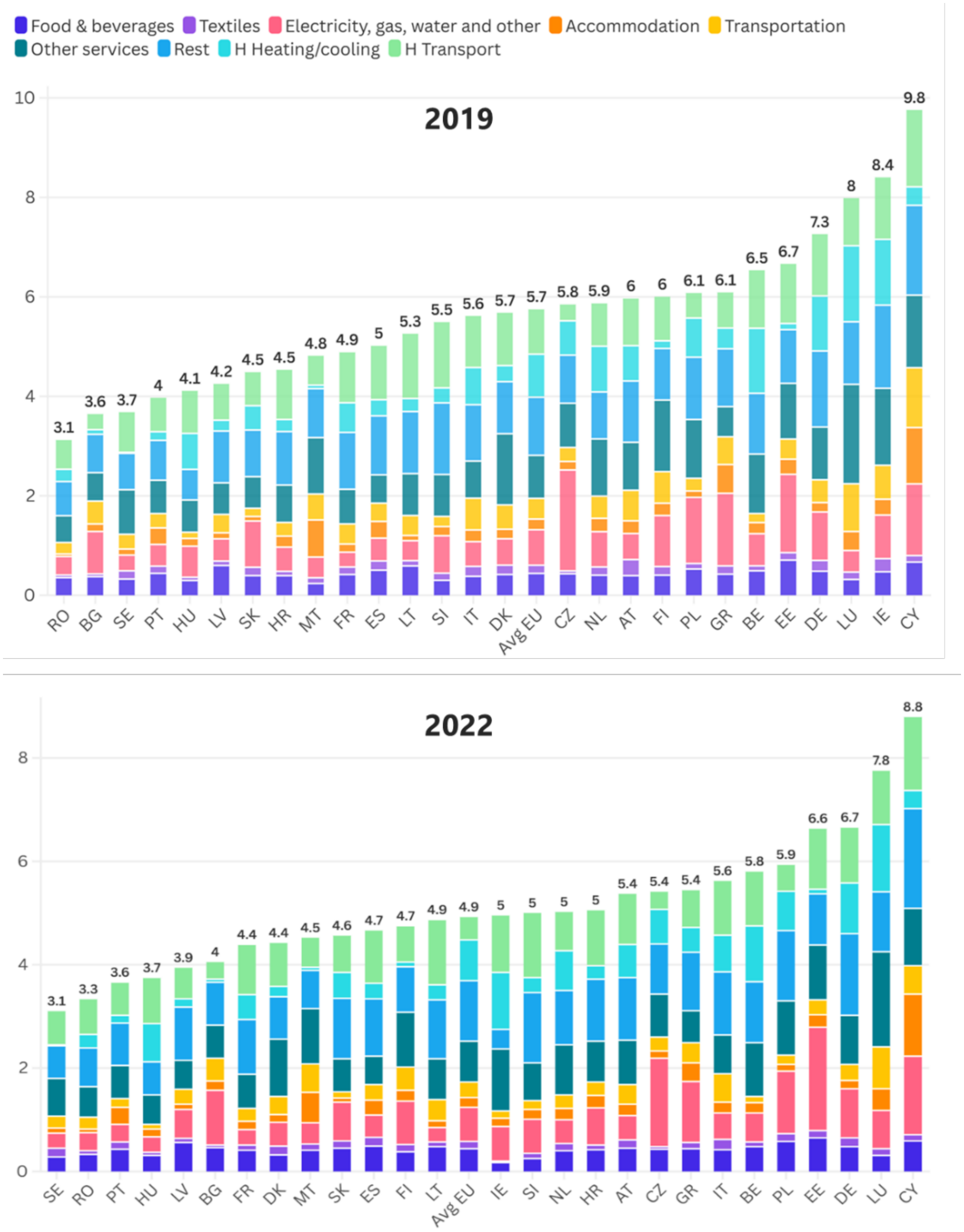
European households' demand has been growing at an annual rate of nearly 2% since 2014, but recent shocks changed both the level and pattern of consumption (see Figure A 4.1 in Appendix II). Firstly, due to Covid-19, the EU consumption decreased by –9% in 2020. In the following years, EU consumption experienced an annual growth of 5%, which was curbed, once again, in 2023. Specifically, consumption only grew by 0.7% in the last year. By product, from 2020 to 2023, there has been a significant increment in Food Services & Accommodation (67%) and in Passenger transport (74%). In contrast, a reduction in expenditure on Food & beverages (-4%) and in Electricity & gas (-5%) has taken place. Regarding EU household demand for energy goods, it was on a rising trend from 2016 until 2019, when it started to decline and continued to fall in the two following years (see Figure A 4.2 in Appendix II). Nevertheless, in 2022, demand rebounded to above pre-covid levels. Over the entire period, demand for Solid fossil fuels dropped by 29%, and Oil & petroleum products fell by 14%. In contrast, the use of alternative energy sources grew significantly. For example, Heat pumps increased by 173%, Solar thermal by 33%, Natural gas by 20%, Electricity by 12% and Other renewables by 12%. Concerning the distribution of energy uses by countries (Figure A 4.3 in Appendix II), the main energy product in countries such as Italy, Germany, Hungary and the Netherlands is natural gas, whereas in Bulgaria, France, Spain, Malta and Sweden the main source is electricity. It is noteworthy that the top energy source in Estonia, Croatia, Latvia, Romania and Slovenia are other renewable energies, meanwhile Ireland stands out due to its significant use of oil and petroleum.

Households' direct and indirect emissions

Housing emissions are clearly on a downward trajectory driven by the use of more efficient and less polluting energy sources, despite the raise experienced in 2021. By contrast, emissions from transport showed a positive tendency, which stopped in 2020 due to Covid-19 lockdowns and reduced mobility, and after that, the emissions experienced an important rebound, but have not reached pre-pandemic levels. As mentioned above, the overall reduction in the use of Oil & petroleum and increase in spending on transport services, should be reflected in slow reductions in EU direct emissions from transport, rather than a return to previous levels. This, however, depends on the country under analysis. In Sweden, Finland, Portugal and Bulgaria, the per-capita direct emissions associated with housing are already insignificant, meanwhile, in Ireland, Luxembourg and Belgium housing emissions are above one tCO_2. Other countries such as Spain, Lithuania, Slovenia, Cyprus, Italy, Estonia stand out due to their high direct transport emissions.

Regarding per-capita carbon footprint (direct and indirect impact) by countries, our results show that the majority of European countries have reduced their emissions since 2019, and the average per-capita EU carbon footprint has decreased from 5.7 to 4.9 tCO2 (see Figure 4.1)

Figure 4.1. Comparison of direct and indirect emissions distribution by products in EU countries (per capita values, tons CO2, 2019 and 2022)



Source: Own elaboration. Note: This Figure shows indirect emissions from the production of goods and services for households' demand (Accommodation; Electricity, gas, water and other; Food & beverages; Other services, Rest, Textiles, Transportation) and direct emissions due to consumption of energy goods by households (Activities of Heating/cooling and Private Transport).

On average, out of the total EU per-capita carbon footprint in 2022, 3.7 tCO_2 corresponds to indirect emissions and 1.24 tCO_2 to direct emissions (64% from housing and 36% from private vehicles), although it varies by country. Delving into the evolution by countries in the period, Northern European countries have reduced their carbon footprint per capita the most. Specifically, Ireland has reduced its impact by 41%, followed by Denmark (-22%), Finland (-21%), Sweden (-16%) and Netherlands (-14%). In contrast, some countries have increased their footprint over the same period, such as Hungary (12%) and Bulgaria (11%) and Romania (7%), although these countries stand out for having an impact significantly below the EU average, so it would be important to keep it at this level.

Decomposition of changes in households' emissions

A deeper understanding of the different drivers behind the change in emissions requires a decomposition analysis, as presented in the Method section. This structural decomposition allows us to isolate the changes in the emissions into four changes: in the emissions multiplier (Me), in the level of final demand (Y), in the pattern of products demanded (T), and in the origin of those products (R). We consider two periods and analyse the difference in emissions between them: the first one, 2018-2020, and the second one, 2020-2022, with the aim of analysing the whole picture before and after Covid-19. The main results are:

- between 2018-2020 emissions decreased mainly due to the reduction in Me and Y, while the change in T is also significant (see Figure A 4.4 in Appendix II). The restrictions of COVID-19 influenced demand, causing notable reductions in some sectors, like restaurants or transport, that have, particularly the last one, important effects on emissions;
- in the next period, 2020-2022 (see Figure A 4.5 in Appendix II), emissions increased due to the recovery of demand levels (Y) and the rise in demand in sectors that had reduced their expenditure in the previous period, like transport, so, changes in pattern (T) are also important here. Me continues to contribute to a reduction in emissions (per monetary unit of production, total direct and indirect emissions generated are increasingly lower);
- changes in emissions are much higher in countries with higher demand levels: Germany, France, Italy and Spain.

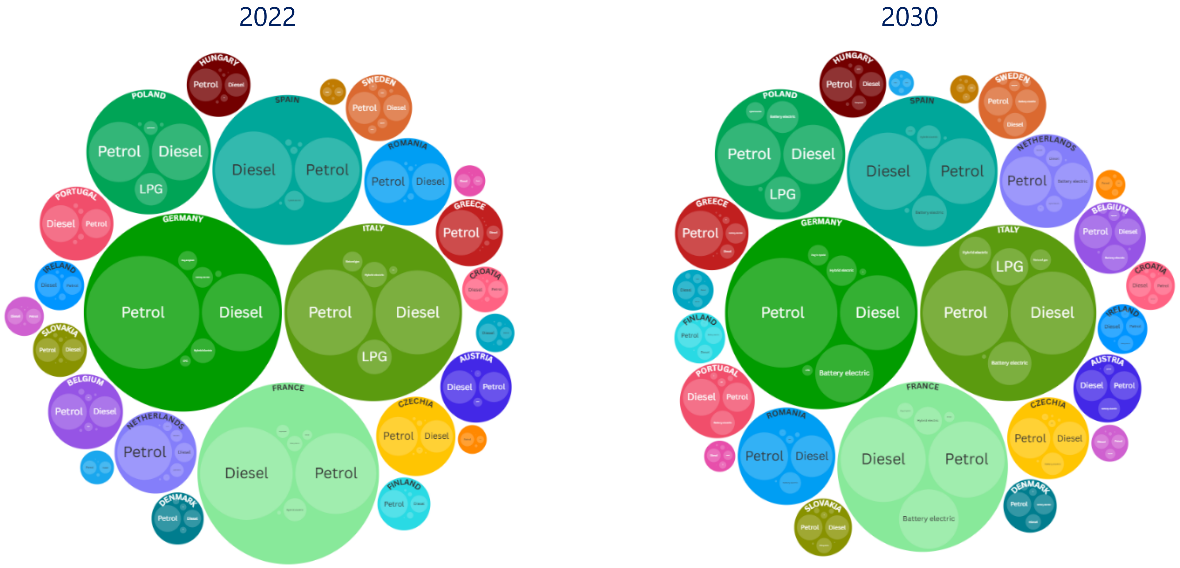
<u>SCENARIOS</u>

Scenario 1: Private transport electrification

The evolution of cars by power source in the EU varies significantly between 2022 and 2030 due to the increase of electric cars imposed in the national energy plans of different countries to reduce emissions. We can highlight the strong growth in battery electric cars, which represent only 1.2% of total cars in 2022, and it reaches 17.7% in 2030, significantly increasing in the last years of this period. This implies an important reduction in petrol and diesel cars, both decreasing by 10 percentage points approximately (See Figure A 4.6 in Appendix II).

Analysing vehicle fleet data in the EU countries in 2022 and projecting it in 2030 enables us to compare how car power source changes by country and which countries are more important by volume (Figure 4.2). We can see the increase in battery electrics is a result of the rise of electric cars, as hybrid electrics grow in this period but less intensively, and a strong decline occurs in petrol and diesel cars. Five countries concentrate most of the EU's vehicle fleet: Germany, France, Italy, Spain and Poland represent 70% of the total.

Figure 4.2. Evolution of EU's vehicle fleet by countries and type of vehicle (2022-2030)



Source: Own elaboration

This evolution of the number and share of different types of vehicles in the EU from the scenario of electrification has its impact on direct and indirect emissions from private transport. Most emissions for households' transport are directly generated when burning fossil fuels in their cars, followed by a long way by the indirect emissions for those fuels (CO_2 caused by the production process of those fuels). From 2022 to 2030, there is an important reduction in direct and indirect oil emissions since oil petroleum products and gasoline and diesel cars are less consumed, decreasing by 9%, as the decarbonization process requires. Indirect CO_2 from electricity, however, increases due to the growth in EVs, partially compensating that reduction from oil products (Figure A 4.7 in Appendix II). The efficiency improvement in the energy sector and the increase in renewables bring about a fall in emissions in the generation of electricity.

In this scenario of increasing EVs (and decreasing gasoil cars), the results of the changes in emissions by country from 2022 to 2030 indicate that Germany, Italy, France and Spain are the countries that continue to concentrate most EU emissions (60% of total emissions in electrification transport). France is the country that experiences the greatest decrease, but also in Germany, Spain and Italy there is also reduction in emissions in this scenario. Other countries where emissions fall notably are Estonia, by a wide margin from the rest of countries, then Sweden, and Finland. There are, however, other countries, like Romania or Cyprus, where emissions increase in this scenario. This is the result of the projected rise in the number of total vehicles in those countries (Table A 4.1 in Appendix II).

Scenario 2: Households' energy use reduction

In this scenario, the energy use in EU households from 2022 to 2030 has been estimated by type of product according to the guidelines of the European regulation on energy efficiency of residential buildings, Directive EU 2024/1275 (http://data.europa.eu/eli/dir/2024/1275/oj), that indicates that the average reduction of primary energy in all countries must be 16% by 2030. The evolution of energy use in EU households in the period 2015-2030 is different depending on the products: in general, the energy use grows for renewables and decreases for the rest of the products (Figure A 4.8 in Appendix II).

The top energy product consumed by households is natural gas, and the reduction between 2015-2030 is only 14%, because there is an important increase until 2021 of about 20%. We must also highlight the fall of fossil fuels (44%) and oil and petroleum products (23%), mostly due to the decrease in gasoil and diesel oil. The consumption of electricity reduces in 11% (Figure A 4.8 in Appendix II). The importance of the effects of Covid-19 period on energy produce significant peaks in those years.

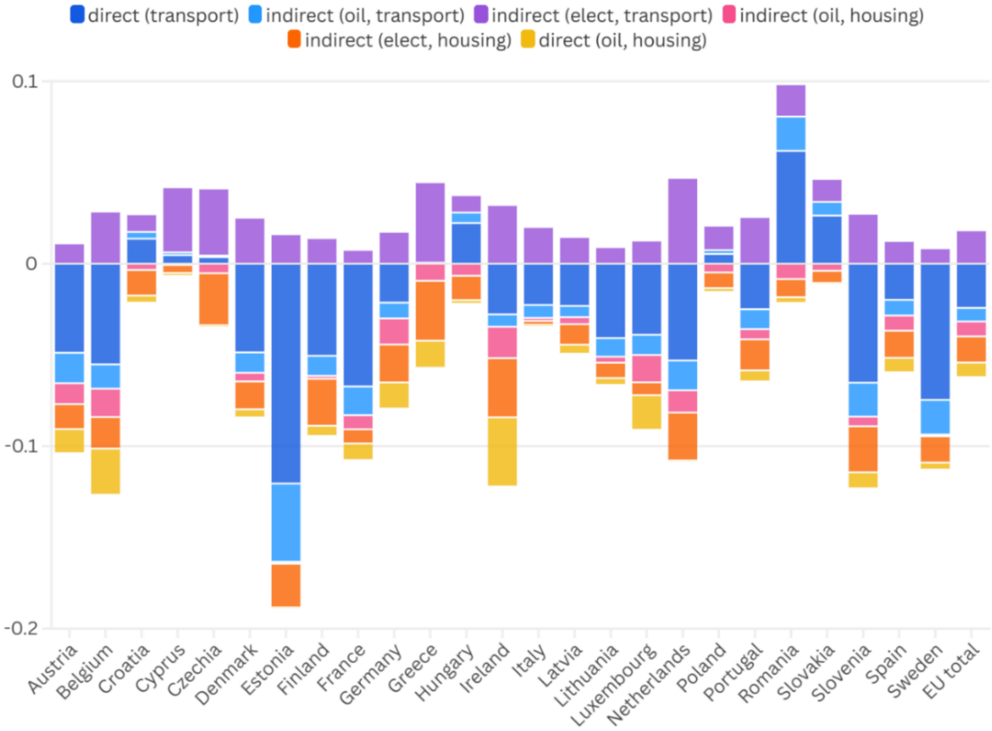
Figure 4.3 presents the weight of different changes in emissions generated combining both scenarios of transport electrification and reduction of energy use in housing by country.

The first point that can be highlighted here is that direct CO_2 transport emissions are the most significant, decreasing notably in the majority of the EU countries; the second point is that only indirect CO_2 from electricity (Scenario 1) increases for all the countries. The rest of emissions; CO_2 direct and indirect from oil to housing activities, indirect CO2 from oil for transport and indirect electricity to housing activities would decrease according to our estimations.

Scenario 3: US Tariffs (based on REITER, 2025)

The last scenario we consider is related to recent changes in US tariffs, following the information provided by (Reiter, 2025), based on the model by researchers at the Vienna Institute for International Economic Studies (WIIW) for TWIN SEEDS (see chap. 3). This model provides data on output, expenditure and trade for different potential tariff scenarios. The range of impacts on output from several settings of US trade policy is wide for countries like the US, Mexico, Canada and China, but far more limited for the EU for the most likely configurations. Out of those scenarios, we calculate emissions from changes in final demand and find that for increases in tariffs to world steel and aluminum and to countries like Mexico, Canada and China, the change in emissions from EU households' demand is very close to zero in the short term. Only when significantly high US tariffs are directly set on EU exports, do emissions from European final demand decrease in a relevant amount. In a scenario of 15% tariffs for EU products, output and expenditure in European countries decrease by around 1%, and that, together with the rest of world tariffs, results in a fall of 1.23% in EU households' emissions.

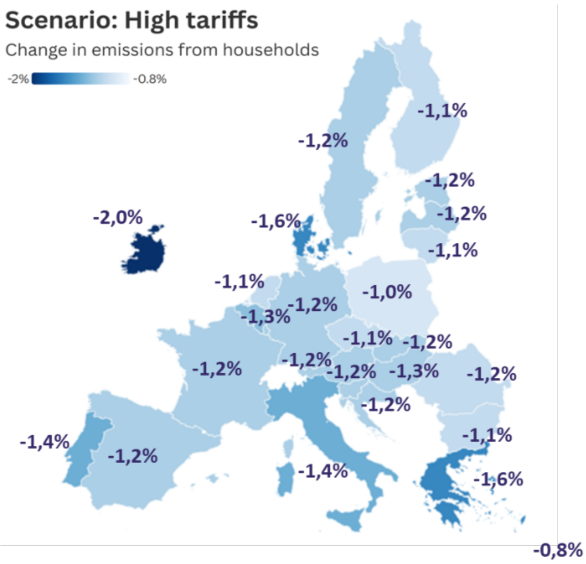
Figure 4.3. Estimated changes in total emissions according to Scenarios 1 and 2



Source: Own elaboration

This decrease is still small compared to the potential decrease in households' emissions from countries like Mexico (between 7 and 8%) and Canada (2.5-3.2%) if 25% US tariffs were to be imposed on them. The impact on emissions varies by country, mostly depending on their exposure to trade with the US, ranging from a decrease of 2% for Ireland to 1% for Poland and 0.8% for Cyprus, with most countries around 1.1-1.2% (Figure 4.4).

Figure 4.4. Change in households' CO2 emissions (Scenario 3, high tariffs on EU exports to the US) by countries.



Source: Own elaboration, based on data from Reiter (2025)

Two major results emerge from what we have just written. First of all, our results show a surprisingly rapid recovery in demand observed after the Covid-19 crisis and the return to spending on food services and hotels, and transport services. Covid-19 has not profoundly altered either the level or the pattern of expenditure after 2022. Since then, a drop in electricity and gas consumption can be noticed, linked to the energy crisis following the war in Ukraine, together with other factors.

Secondly, another unexpected result is how changes to household demand, such as the electrification of private transport, have relatively small impacts on emissions unless they are combined with changes in production technology, in this example, the generation of electricity.

Conclusions and policy implications

Recent events have demonstrated two key insights: (1) changes in household final demand can have a substantial impact on emissions, and (2) even under extreme circumstances, such reductions tend to be short-lived. This underscores the need for more assertive and sustained policy action. Reductions in household emissions should not be taken for granted—even in the presence of current incentives. Stronger, more targeted interventions are required to induce lasting behavioral and structural shifts in consumption patterns. For example, time-limited stimulus measures during Covid-19 temporarily altered spending habits, but emissions quickly rebounded once restrictions were lifted.

Differences in per-capita emissions are shaped not only by technological efficiency and trade structures, but also by deeply rooted economic and social characteristics, such as income distribution, urban/rural form, and lifestyle preferences. Therefore, policy design must be sensitive to these differences and should focus on high-emission spending categories, such as mobility, housing, and diet. Tailoring interventions at the national or regional level - e.g., through differentiated taxes rates, subsidies, or public awareness campaigns - can enhance their effectiveness.

Regarding direct emissions, policies such as the EU regulation requiring all new cars and vans to be zero-emission by 2035, along with incentives for reducing household energy consumption, are essential for meeting the 2050 net-zero objective. However, their impact will remain limited unless accompanied by a parallel and ambitious decarbonization of the electricity sector. In countries where electricity generation is still heavily reliant on fossil fuels, the environmental benefits of electrification may be significantly diluted.

To ensure long-term effectiveness, policies must be complemented by broader systemic changes. These include investments in public transportation and shared mobility, renovation of existing buildings, and widespread public education efforts to promote low-carbon lifestyles.

Fair-transition considerations should be at the core of climate policy. As the capacity to adapt and shift consumption varies greatly across income groups, policies must avoid disproportionate burdens on lower-income households. This calls for the integration of social support or compensation mechanisms, such as targeted rebates or progressive carbon pricing models.

Finally, emerging uncertainties—such as shifts in global trade patterns, geopolitical tensions, and climate-related disruptions—may introduce new shocks to household demand and emissions. While the projected impacts of such shocks have so far been modest, they highlight the need for flexible, adaptive policy frameworks capable of responding quickly to both risks and opportunities.

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Appendix I. Methods

Multi-regional input-output model and structural decomposition

A multi-regional input-output (MRIO) model includes effects along the whole global value chain, including all intermediate inputs regardless of their sector and county of origin (indirect effects) and in the last stage of the final products (direct effects) (Miller & Blair, 2022). In order to calculate CO2 emissions required for producing the goods and services demanded by households (EH), we will use an environmentally-extended MRIO model as follows:

$$\boldsymbol{E^H} = \boldsymbol{e}(\boldsymbol{I} - \boldsymbol{A})^{-1}\boldsymbol{y_H}$$

where e is the diagonalised vector of emissions coefficients (CO2 emissions per unit of production by industry and country), $\boldsymbol{L} = (\boldsymbol{I} - \boldsymbol{A})^{-1}$ is the Leontief inverse matrix (that shows the requirements of each input to provide one euro of final product for each good and service), and $\boldsymbol{y_H}$ is a block diagonal vector of household final demand. The multiplication of e and L gives as a result the matrix of emissions multipliers Me:

$$\boldsymbol{Me} = \boldsymbol{e}(\boldsymbol{I} - \boldsymbol{A})^{-1} = \mathbf{eL}$$

Me indicates the amount of emissions in matrix form per euro of final demand. When multiplied by $\boldsymbol{y_H}$, it allows us to obtain the matrix of emissions that read by columns provides the carbon footprint for each country and type of final demand (in our case, household demand) and by rows the producer emissions (total emissions by industry and country where they are generated).

$$\boldsymbol{E^H} = \begin{bmatrix} \boldsymbol{E}^{11} & \boldsymbol{E}^{12} & \boldsymbol{E}^{1r} \\ \boldsymbol{E}^{21} & \boldsymbol{E}^{22} & \boldsymbol{E}^{2r} \\ \boldsymbol{E}^{n1} & \boldsymbol{E}^{n2} & \boldsymbol{E}^{nr} \end{bmatrix} = \begin{bmatrix} \boldsymbol{P}^{11} & \boldsymbol{P}^{12} & \boldsymbol{P}^{1n} \\ \boldsymbol{P}^{21} & \boldsymbol{P}^{22} & \boldsymbol{P}^{2n} \\ \boldsymbol{P}^{n1} & \boldsymbol{P}^{n2} & \boldsymbol{P}^{nn} \end{bmatrix} \begin{bmatrix} \hat{\boldsymbol{y}}_H^{11} & \hat{\boldsymbol{y}}_H^{12} & \hat{\boldsymbol{y}}_H^{1r} \\ \hat{\boldsymbol{y}}_H^{21} & \hat{\boldsymbol{y}}_H^{22} & \hat{\boldsymbol{y}}_H^{2r} \\ \hat{\boldsymbol{y}}_H^{n1} & \hat{\boldsymbol{y}}_H^{n2} & \hat{\boldsymbol{y}}_H^{nr} \end{bmatrix}$$

Where n = s x r, s is the number of industries and r is the number of countries or regions.

In order to get the full amount of emissions due to households ($\boldsymbol{E^T}$), we need to add those generated as a result of the direct burning of fossil fuels for private transport and heating/cooling ($\boldsymbol{h}'$).

$$\boldsymbol{E^T} = \boldsymbol{E^H} + \boldsymbol{h}'$$

Furthermore, to try to disentangle the different effects that can impact the change in emissions embodied in the products demanded by households, we perform a structural decomposition analysis. This technique has been applied to calculations using input-output data in (Distefano, Lodi, & Biggeri, 2024; Feás, 2023; Pan, Wang, Shen, & Song, 2022; Xu, Zhu, Li, Wu, & Deng, 2024), just to mention some recent work. As for carbon footprints or emissions from demand, this has been used in recent articles, such as (Hubacek, Chen, Feng, Wiedmann, & Shan, 2021; Li, Li, Wang, Yang, & Liang, 2024), although with a different focus. We decompose the difference in emissions between two periods, called 0 and 1 in the subindices of our formula, into four changes: in the emissions multiplier (Me), in the level of final demand, in the pattern of products demanded, in the origin of those products.

There are a number of different combinations of those changes between the two years considered, giving slightly different results for the decomposition. Following (Dietzenbacher & Los, 1998), we calculate our results as the average of the two polar decompositions, A and B, as in these expressions:

Polar A:

$$\boldsymbol{E_1^H} - \boldsymbol{E_0^H} = \boldsymbol{\hat{e}_1 L_1 \hat{y}_{H1}} - \boldsymbol{\hat{e}_0 L_0 \hat{y}_{H0}} = \boldsymbol{\hat{e}_1 L_1 \hat{y}_{H1}} - \boldsymbol{\hat{e}_0 L_0 \hat{y}_{H1}} + \boldsymbol{\hat{e}_0 L_0 \hat{y}_{H1}} - \boldsymbol{\hat{e}_0 L_0 \hat{y}_{H0}} =$$
$$= \underbrace{(\boldsymbol{\hat{e}_1 L_1} - \boldsymbol{\hat{e}_0 L_0})\boldsymbol{\hat{y}_{H1}}}_{\Delta Me} + \boldsymbol{\hat{e}_0 L_0 \hat{y}_{H1}} - \boldsymbol{\hat{e}_0 L_0 \hat{y}_{H0}}$$

This first term (ΔMe) is the change in emissions due to changes in the emissions multiplier Me=eL.

We further decompose the second term, by looking at the final demand as the result of a multiplication of a ratio matrix (RT) by a diagonalised matrix of the total household demand for each country ($diagy_H$):

$$\boldsymbol{\hat{e}_0 L_0 \hat{y}_{H1}} - \boldsymbol{\hat{e}_0 L_0 \hat{y}_{H0}} = \boldsymbol{\hat{e}_0 L_0}(\boldsymbol{\hat{y}_{H1}} - \boldsymbol{\hat{y}_{H0}}) = \boldsymbol{\hat{e}_0 L_0} \quad (RT_1 diagy_{H1} - RT_o diagy_{H0}) =$$
$$= \boldsymbol{\hat{e}_0 L_0} \quad (RT_1 diagy_{H1} - RT_o diagy_{H1} + RT_0 diagy_{H1} - RT_0 diagy_{H0}) =$$
$$= \underbrace{\boldsymbol{\hat{e}_0 L_0 RT}_0 \big(diagy_{H1} - diagy_{H0}\big)}_{\Delta Y} + \boldsymbol{\hat{e}_0 L_0} \quad (RT_1 - RT_o\big) diagy_{H1}$$

This term ΔY indicates the change in emissions due to changes in the level of total household demand for each country ($diagy_H$).

We now decompose the remaining term, taking into account that matrix RT is the result of the product between two matrices: R is the (block diagonal) matrix that indicates the share of each sectoral demand (for the household demand of each country) that is bought from each country of origin, while T is the (diagonalised) matrix of the shares of each sectoral demand (regardless of the origin) over total household demand for each country:

$$\boldsymbol{\hat{e}_0 L_0} \quad (RT_1 - RT_0) diagy_{H1} = \boldsymbol{\hat{e}_0 L_0} \quad (R_1 T_1 - R_0 T_0) diagy_{H1} =$$

$$= \hat{\boldsymbol{e}}_{\boldsymbol{0}}\boldsymbol{L}_{\boldsymbol{0}} \; (R_1T_1 - R_0T_1 + R_0T_1 - R_0T_0)diagy_{H1} =$$
$$= \underbrace{\hat{\boldsymbol{e}}_{\boldsymbol{0}}\boldsymbol{L}_{\boldsymbol{0}} \; (R_1 - R_0)T_1 diagy_{H1}}_{\Delta R} + \underbrace{\hat{\boldsymbol{e}}_{\boldsymbol{0}}\boldsymbol{L}_{\boldsymbol{0}} \; R_0(T_1 - T_0)diagy_{H1}}_{\Delta T}$$

The term ΔR indicates the change in emissions that results from changes in the origin of products, keeping the rest of the components of demand constant (distribution between sectors and level of total household consumption). Finally, ΔT isolates changes in emissions due to changes in the distribution of household demand between the different sectors.

Polar B is the opposite decomposition, so exchanging 0 and 1 for the years of the calculation, as follows:

Polar B:

$$\boldsymbol{E}_{\boldsymbol{1}}^{\boldsymbol{H}} - \boldsymbol{E}_{\boldsymbol{0}}^{\boldsymbol{H}} = \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H1}} - \hat{\boldsymbol{e}}_{\boldsymbol{0}}\boldsymbol{L}_{\boldsymbol{0}}\hat{\boldsymbol{y}}_{\boldsymbol{H0}} = \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H1}} - \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H0}} + \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H0}} - \hat{\boldsymbol{e}}_{\boldsymbol{0}}\boldsymbol{L}_{\boldsymbol{0}}\hat{\boldsymbol{y}}_{\boldsymbol{H0}} =$$
$$= \underbrace{(\hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} - \hat{\boldsymbol{e}}_{\boldsymbol{0}}\boldsymbol{L}_{\boldsymbol{0}})\hat{\boldsymbol{y}}_{\boldsymbol{H0}}}_{\Delta Me} + \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H1}} - \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H0}}$$

This first term (ΔMe) is the change in emissions due to changes in the emissions multiplier Me=eL.
We further decompose the second term, by looking at the final demand as the result of a multiplication of a ratio matrix (RT) by a diagonalised matrix of the total household demand for each country ($diagy_H$):

$$\hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H}1} - \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\hat{\boldsymbol{y}}_{\boldsymbol{H}0} = \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}(\hat{\boldsymbol{y}}_{\boldsymbol{H}1} - \hat{\boldsymbol{y}}_{\boldsymbol{H}0}) = \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \; (RT_1 diagy_{H1} - RT_0 diagy_{H0}) =$$
$$= \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \; (RT_1 diagy_{H1} - RT_1 diagy_{H0} + RT_1 diagy_{H0} - RT_0 diagy_{H0}) =$$
$$= \underbrace{\hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}}\boldsymbol{RT}_1(diagy_{H1} - diagy_{H0})}_{\Delta Y} + \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \; (RT_1 - RT_0)diagy_{H0}$$

This term ΔY indicates the change in emissions due to changes in the level of total household demand for each country ($diagy_H$).

We now decompose the remaining term, taking into account that matrix RT is the result of the product between two matrices: R is the (block diagonal) matrix that indicates the share of each sectoral demand (for the household demand of each country) that is bought from each country of origin, while T is the (diagonalised) matrix of the shares of each sectoral demand (regardless of the origin) over total household demand for each country:

$$\hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \; (RT_1 - RT_0)diagy_{H0} = \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \; (R_1T_1 - R_0T_0)diagy_{H0} =$$

$$= \hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \quad (R_1T_1 - R_1T_0 + R_1T_0 - R_0T_0)diagy_{H0} =$$

$$= \underbrace{\hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \quad (R_1 - R_0)T_0 diagy_{H0}}_{\Delta R} + \underbrace{\hat{\boldsymbol{e}}_{\boldsymbol{1}}\boldsymbol{L}_{\boldsymbol{1}} \quad R_1(T_1 - \quad T_0) diagy_{H0}}_{\Delta T}$$

The term ΔR indicates the change in emissions that results from changes in the origin of products, keeping the rest of the components of demand constant (distribution between sectors and level of total household consumption). Finally, ΔT isolates changes in emissions due to changes in the distribution of household demand between the different sectors.

Scenarios performing

We propose three scenarios, each designed to explore different pathways for reducing household-related emissions in the European Union between 2022 and 2030 and the effects of recent geopolitical events and their impact on global supply chains and consequent effects on emissions. These scenarios focus respectively on the electrification of private transport, the reduction of household energy consumption, and the potential impact of global trade disruptions, such as those triggered by renewed tariff policies.

SCENARIO 1

The transition to electric transport in the European Union is essential for meeting climate goals, improving air quality, and reducing dependence on fossil fuels. The EU has set ambitious targets to cut emissions and increase the use of renewable energy, and transport electrification plays a key role in achieving these objectives. This is evident in each of the National Integrated Energy and Climate Plans, where each member state has defined a concrete target for the share of electric vehicles in its national vehicle fleet by 2030.

Scenario 1 has been constructed based on these targets, projecting the growth of the electric vehicle fleet (limited to battery electric vehicles only) by estimating the annual growth rate required to meet the 2030 objective. This percentage has been applied to the estimated vehicle fleet by power source for all EU countries, as provided by (ACEA, 2025), taking into account the average annual growth rate by country over the past five years.

Following these trends, most countries would see an increase in their electric vehicle fleets, although in some cases—such as Estonia and Slovenia—the total number of cars is projected to decrease. The underlying assumption is that the increase in electric vehicles comes at the expense of gasoline and diesel vehicles, in line with the existing fuel-type distribution in each country. After applying these growth rates, we obtain the projected total number of vehicles by power source for each country for the period 2022–2030.

The next step involves quantifying the emissions associated with the use of these vehicles. For gasoline and diesel cars, we use the number of thousands of liters of fuel consumed by

Spanish households for private transport, as reported by the Household Budget Survey conducted by the Spanish Statistical Office (INE, 2025). We use these figures as a reference for all EU countries, due to the lack of specific data on fuel consumption in their respective Household Budget Surveys. Based on this information, we calculate the average fuel consumption per vehicle, distinguishing between gasoline and diesel, which allows us to estimate the total liters of fuel consumed each year in each member state. Finally, by applying an emission factor in $KgCO_2$ per liter of gasoline or diesel in 2021 (MITECO, 2025), we estimate the annual direct emissions over the projection period.

With regard to emissions associated with electric vehicles, since they do not emit directly, we only consider indirect emissions, which we estimate based on the electricity consumption per kilometer driven provided by industry experts. This consumption is estimated at 16 kWh per 100 kilometers. This figure, combined with the average annual distance driven by electric vehicles, as reported by odometer readings collected by the Spanish Directorate-General for Traffic (DGT, 2023), allows us to calculate the total electricity consumption of electric vehicles in Spain in 2022. Dividing this value by the total number of electric vehicles in circulation in Spain that year yields the average electricity consumption per vehicle. Due to the lack of detailed data for most EU countries—particularly in terms of odometer readings—we apply the Spanish average to all EU member states. This enables us to estimate total electricity consumption by electric vehicles for each country throughout the projection period. Finally, by applying a price per kWh (EUROSTAT, 2022b), we convert these quantities into monetary units, which allows for their integration into the input–output model for the calculation of indirect emissions.

We apply the same approach using the prices per thousand liters of gasoline and diesel (EUROSTAT, 2022b) to convert fuel consumption into monetary terms, enabling the estimation of indirect emissions associated with fossil fuel vehicles through the input–output model.

SCENARIO 2

Directive (EU) 2024/1275 (EU Commission, 2024) establishes national targets to lower household energy consumption by prioritizing building renovations and encouraging the integration of renewable energy. Its primary goal is to ensure that all new buildings become net-zero carbon emitters by 2030, while progressively upgrading existing structures to meet comparable performance standards. Additionally, sets a binding target to improve the average energy performance of the national residential building stock by 16% by 2030, compared to 2020 levels, and by 20–22% by 2035, following nationally determined trajectories. Therefore, the directive requires Member States to implement measures to decarbonize heating systems and progressively phase out fossil fuels in both heating and cooling. The ultimate goal is to fully eliminate fossil fuel boilers by 2040. Starting in 2025, public subsidies for stand-alone fossil fuel boilers will be prohibited.

In this scenario, we assume a minimum 16% reduction in average primary energy consumption across all Member States by 2030 in all sources of energy use for housing (electricity, natural gas, oil and petroleum products and fossil fuels) use (EUROSTAT, 2022a), in line with the targets established by the directive.
Once an energy consumption projection for households has been obtained we apply a reference price for each energy source, as provided by EUROSTAT (2022c), in order to convert these physical units into monetary terms to be incorporated into the input–output model. This allows us to estimate the indirect emissions associated with household consumption of electricity and other energy sources across Europe. Direct emissions are calculated similarly to Scenario 1, using the appropriate emission factor in each source (MITECO, 2025).

SCENARIO 3

In order to provide some evidence on the potential effects of US changes in tariffs, we estimate the household emissions embodied in their demand using data on final demand changes from WiiW (Reiter, 2025). They consider different possible scenarios, given the high uncertainty of the current situation. Of those scenarios, we present results for three potential configurations of changes in trade:

1) A "factual" scenario, taking into account some of the first tariffs: 25% on steel and aluminium, 25% on Mexico and Canada, 20% on China (that, in turn, imposed 15% on gas imports, 10% on cars and 15% on agricultural products).
2) "Low reciprocal" scenario: this included the previous setting plus increasing all other tariffs to the same level as their counterparts if these were higher.
3) "High reciprocal" scenario: all the above plus 15% on imports from EU.

We apply the changes in trade calculated in those scenarios to household final demand and focus on the results for EU countries' CF.

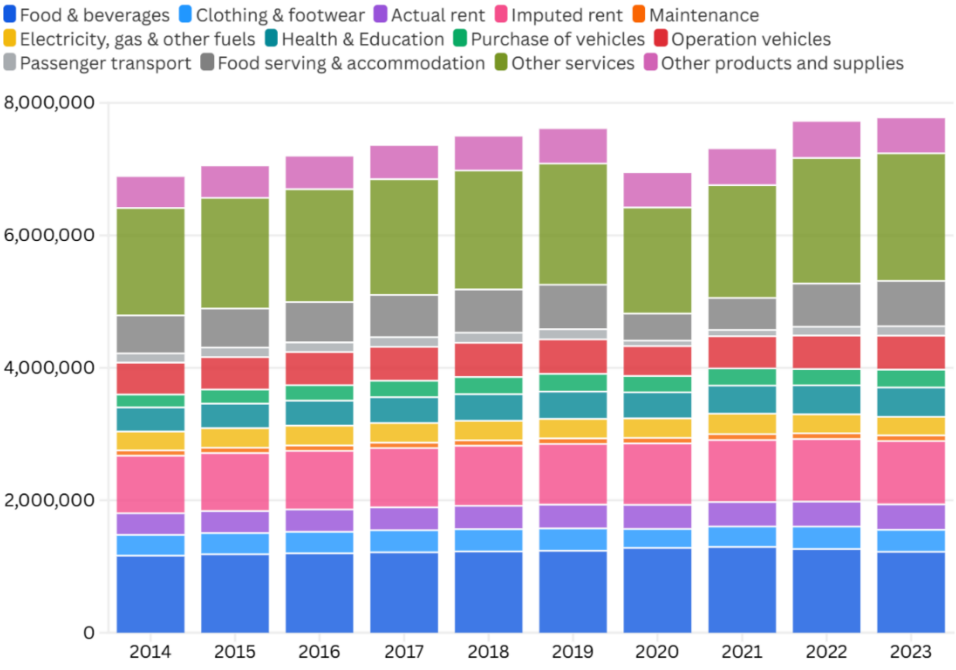
A variety of data sources were considered to feed our calculations. For the MRIO we mostly rely on EUROSTAT data, as this can be regarded as the most updated source for EU national accounts information. In particular, we use inter-country input-output data from the FIGARO database in its 2024 version. We focus on the industry-by-industry tables, as we also obtain our emissions data, to build our emissions coefficients e, from this source, that has been recently updated (January 2025) on an industry basis. These data are provided for 64 industries and 46 countries/regions, and we have focused on the period between 2018 and 2022, last year available in the database, to cover for the pre- and post-Covid periods for our analysis.

We have also obtained data on households' emissions from directly burning fossil fuels from EUROSTAT (Air emissions accounts by NACE Rev. 2 activity) that disaggregates those emissions in heating/cooling activities by households, transport activities by households, and other activities by households.

Deflators for value added were also obtained from EUROSTAT by industry for EU countries (Gross value added and income by main industry (NACE Rev.2), while OECD data was used for the rest of countries in the sample (same deflator for all industries).
These deflators are applied in order to get meaningful results for the structural decomposition analysis (SDA), but they are not required for the rest of the calculations of carbon footprints, as we compare physical units.

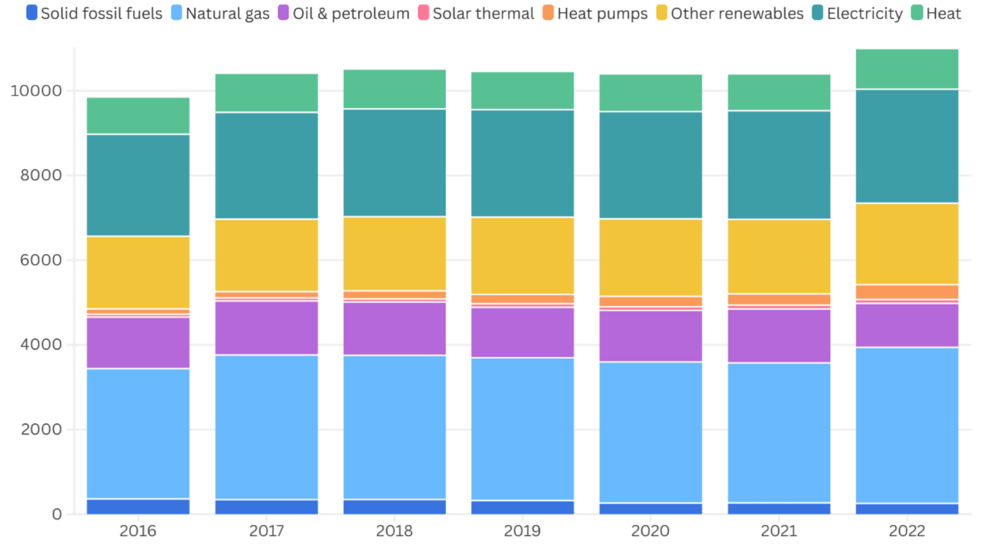
ANNEX A. EU HOUSEHOLDS' DEMAND

Figure A 4.1. Evolution of EU households' consumption corrected for inflation (EU-27, 2014-2023)



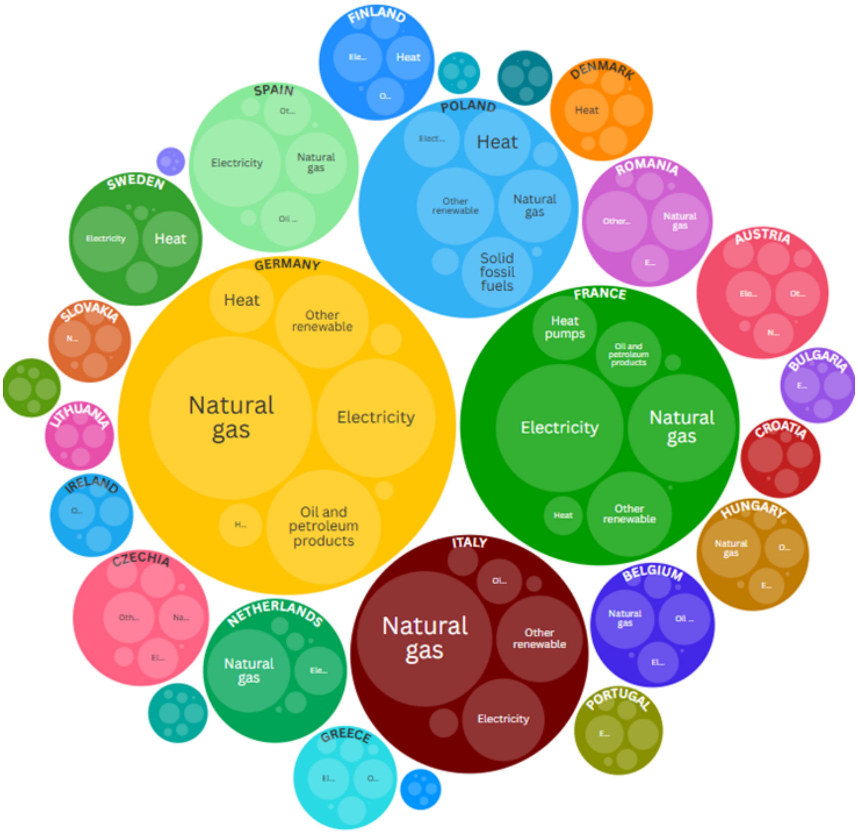
Source: Own elaboration from EUROSTAT data (nama_10_cp18__custom_13869123)

Figure A 4.2. Evolution of EU households' energy use, thousand TJ (2016-2022)



Source: Own elaboration from EUROSTAT data (nrg_d_hhq__custom_13827392).

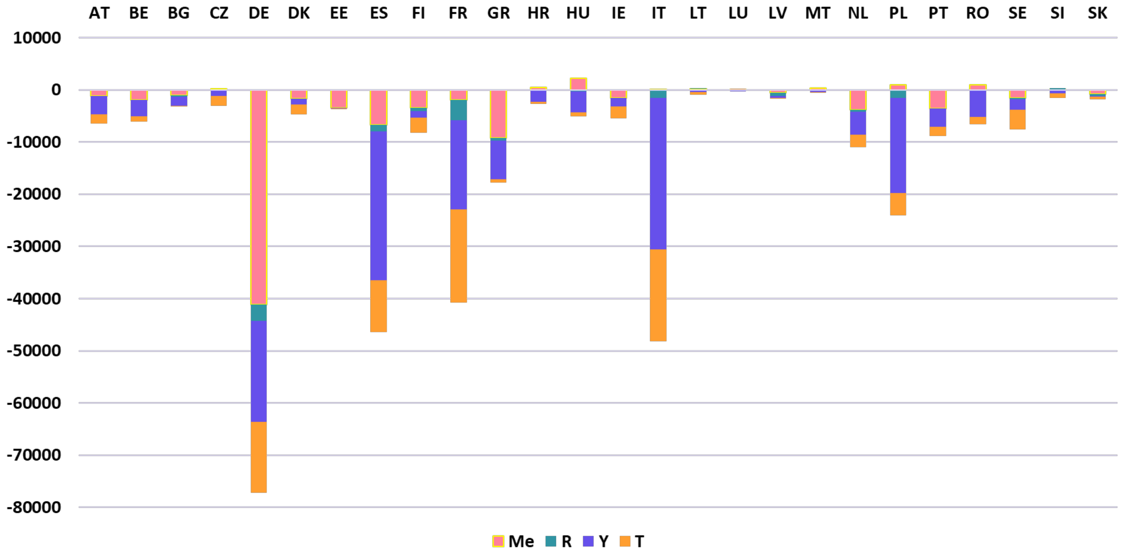
Figure A 4.3. Distribution of energy use by countries (2022)



Source: Own elaboration from EUROSTAT data (nrg_d_hhq_custom_13827392).

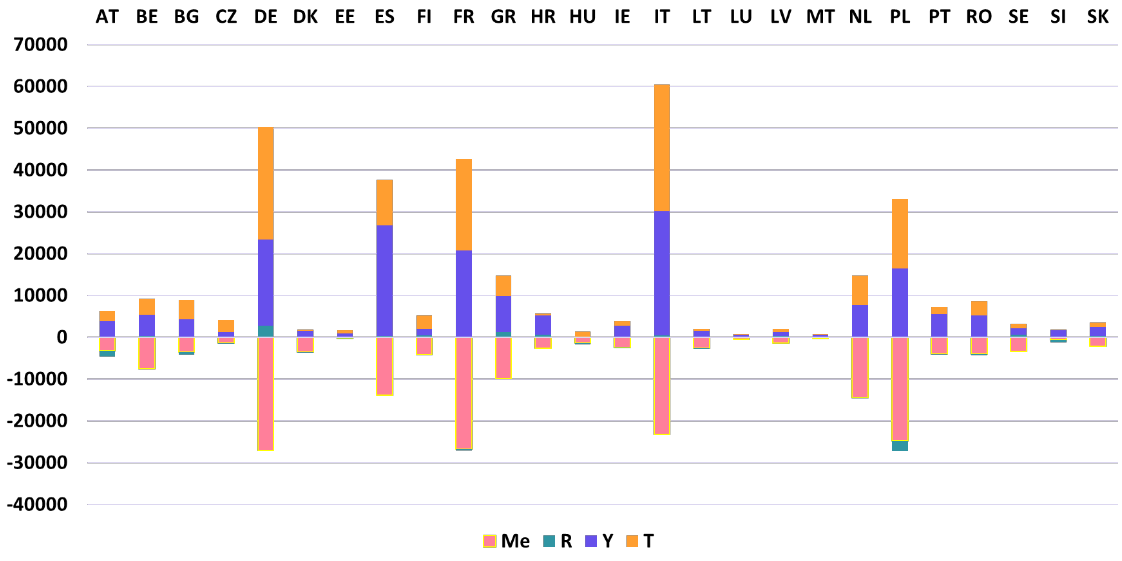
ANNEX B. STRUCTURAL DECOMPOSITION

Figure A 4.4. Structural decomposition of EU changes in CO2 emissions (2018-2020)



Source: Own elaboration

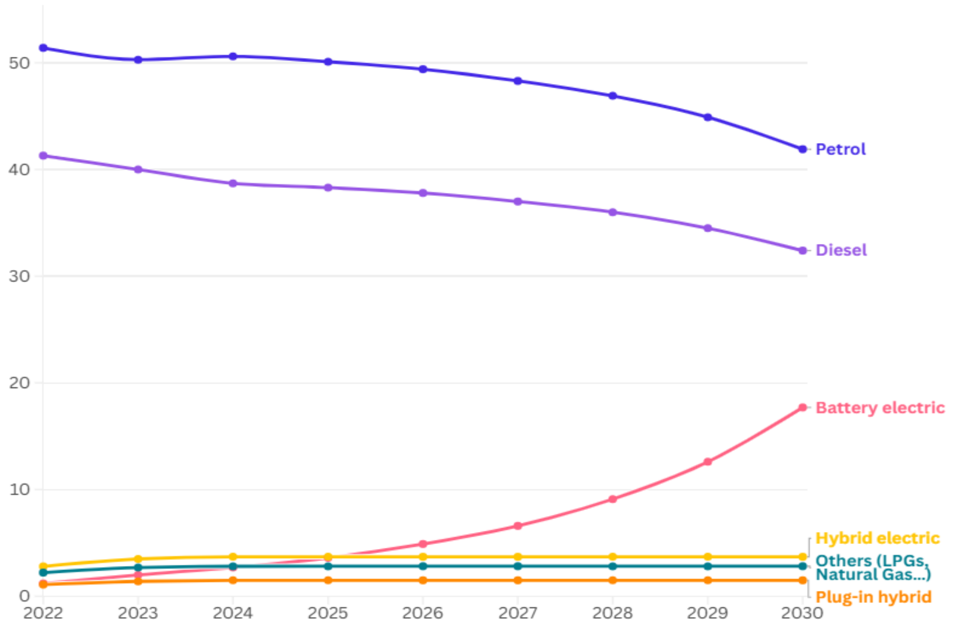
Figure A 4.5. Structural decomposition of EU changes in emissions (2020-22)



Source: Own elaboration

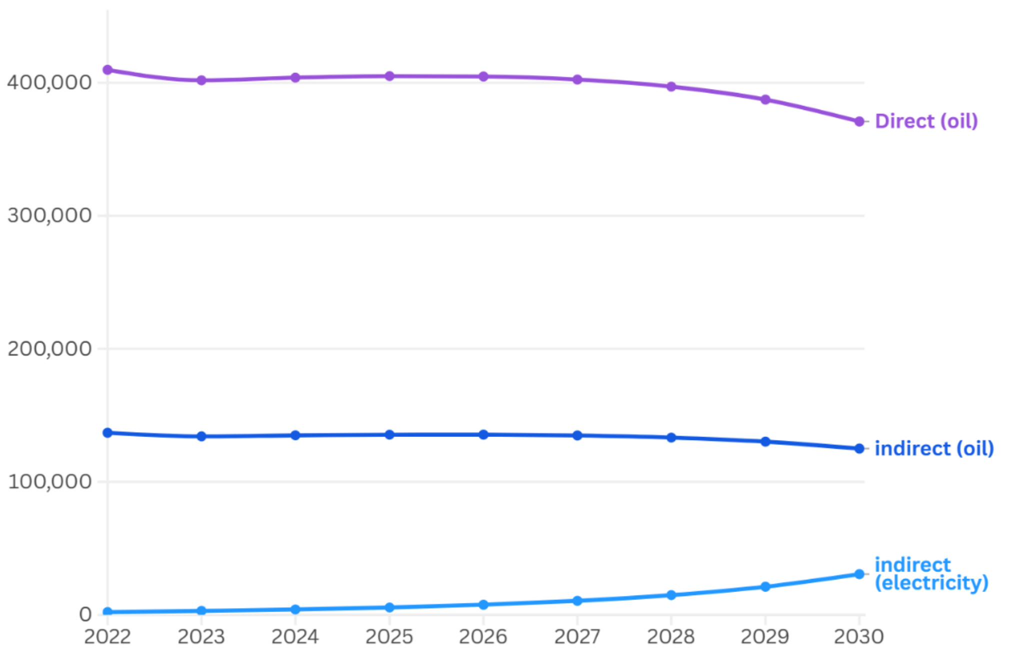
ANNEX C. SCENARIOS

Figure A 4.6. Evolution of EU transport products (2022-2030)



Source: Own elaboration

Figure A 4.7. CO2 emissions from households' transport electrification



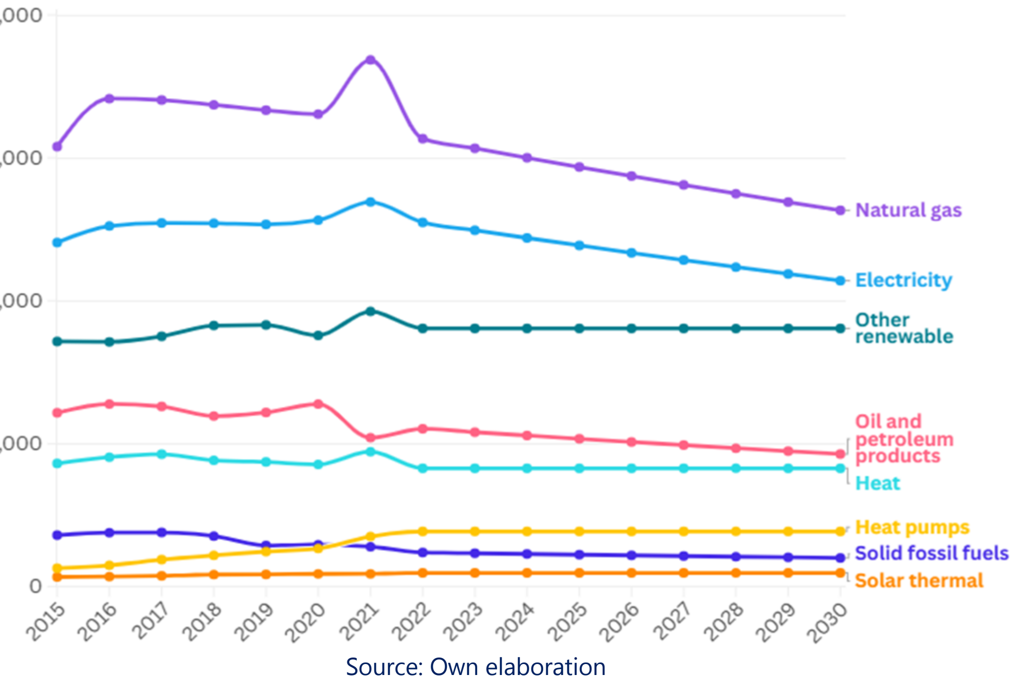
Source: Own elaboration

Table A 4.1. Changes in emissions by country (2022-2030) in Scenario 1

Country	Change
Estonia	-52.6%
Sweden	-22.5%
France	-18.5%
Finland	-18.0%
Austria	-15.1%
Slovenia	-15.0%
Lithuania	-14.3%
Luxembourg	-14.0%
Belgium	-13.8%
Denmark	-12.2%
Netherlands	-6.8%
Latvia	-5.7%
Germany	-4.2%
Spain	-4.1%
Italy	-2.8%
Portugal	-2.3%
Ireland	-0.8%
Hungary	8.0%
Poland	8.4%
Croatia	9.1%
Czechia	12.2%
Slovakia	13.4%
Greece	13.8%
Cyprus	17.7%
Romania	23.6%

Source: Own elaboration

Figure A 4.8. Evolution and projection of energy use in EU households by product (terajoules) (2015-2030).



Source: Own elaboration

5 In search of a European balance: how public funds can boost a smart and clean recovery

Contextual background and research objectives

In this chapter, a scenario is presented in order to analyse the environmental impact of the trade war initiated by the US administration, led by Donald Trump, at the beginning of 2025. As we will describe in detail later on, a "high intensity" scenario is modelled in which the US imposes tariffs on strategic sectors globally (Canada, México, and the EU27); and, in response to this situation, some affected countries announce retaliation tariffs.

To run such a simulation, we first analyse the fiscal policy implemented after COVID-19 to evaluate how public expenses that result from the COVID-19 crisis are, in the short and medium term, in the direction of deepening EU countries' commitment in the fight against climate change or not. The analysis carried out includes scenarios for quantifying the impact of fiscal stimuli on the emissions intensity by sector and country and total emissions and, last but not least, the impact that the tariffs announced by the US would have on the EU emissions.

More in details, this chapter addresses two primary objectives. Firstly, it aims to evaluate the environmental "short-term" effects of the European Union's Recovery and Resilience Facility (RRF) which is the largest component of Next Generation EU. Secondly, it seeks to assess the "medium-term" impacts of the climate change mitigation policies adopted by the EU, which have been catalysed by this substantial fiscal effort, among other factors. It is anticipated that the investment from the EU Next Generation will lead to an increase in emissions in the short term but will also enhance the environmental sustainability of the economies. In essence, this study endeavours to quantify the net balance of emissions that will emerge during the implementation of the most significant stimulus package ever financed in Europe, with the overarching goal of ensuring a greener and more resilient Europe, and to assess the likelihood of achieving the "Fit for 55" strategy.

Regarding the possibility of achieving EU targets via efficiency improvements, the International Energy Agency (IEA, 2025) and the European Environment Agency (EEA, 2025) have analysed how ambitious the state policies and the announced targets to meet the Net Zero emissions are. In particular, the European Environment Agency database provides projections of EU countries' emissions up to 2030 based on the impacts of existing mitigation measures and additional measures announced by countries. In our case, we evaluate the short and medium-term effects of the policies implemented by the EU to meet the Fit for 55% target in 2030 considering, two metrics: the direct EU's resident (RES) emissions by industries and also by households; and, the consumption carbon footprint (CCF), direct and indirect emissions associated with the final demand made by the country plus direct households' emissions. Therefore, the gap to be closed refers to the neglected importance of emission leakage in the emission reduction targets set by the European Union. Specifically, we assess to what extent these mitigation policies allow for the approximation of the committed domestic emission reductions for 2030 and, however, are insufficient to reduce the consumer footprint of various EU countries. Finally, we simulate the impact that the tariffs announced by the United States would have on the European Union' production-based emissions (PBA) or direct emissions made in the country by residential industries.

This work is useful for evaluating the trade-off in terms of emissions that occurs between the policies linked to the EU's RRF and the medium-term objectives of climate change mitigation policies. Secondly, it allows for the identification of which economic sectors' decarbonization is compatible with the Fit for 55% objectives and which require a greater reduction effort. Thirdly, it identifies the gap that exists between the commitments to reduce resident emissions and the EU's carbon footprint, and the main sectors responsible for this discrepancy. Finally, the environmental evaluation of an eventual trade war which is likely to happen in the forthcoming years.

The EU RRF was launched to tackle the devastating effects of COVID-19 and to promote a resilient economy. In this regard, the European Union urges countries to invest at least 37% of Next Generation funds in climate action, aligning these funds with the Fit for 55 European Climate Law (European Commission, 2021c). The consultancy service BRUEGEL conducted research in which the fiscal stimuli were classified according to the sectoral allocation and six pillars defined in RRF Regulation, disaggregated by EU countries (Darvas, 2023). According to BRUEGEL, most European countries invest more than 40% of total funds in green recovery (which includes all kinds of climate and environment-related spending items). In the short-term, fiscal stimuli would increase final demand and directly increase emissions -this have been addressed as our first research question. However, in the medium term, the outcome will depend on the strength, purpose, and structure of those incentives. Funds invested in the green economy should contribute to a reduction in energy and carbon intensity, and the assessment of these medium-term effects, have shaped our second analysis.

Specifically, the chapter evaluates whether the efficiency improvements are sufficient (or not enough) to reduce emissions to meet the targets set by the European Union. Different scenarios are developed based on the modelling of efficiency improvements provided by the European Environment Agency (EEA, 2025) and the GDP projections of the International Monetary Fund (International Monetary Fund, 2025) to quantify the potential emissions savings. To provide a broader picture, the emissions savings are first compared to the EU target of 55% reduction in emissions by 2030 compared to 1990 levels (under the territorial criteria) and then compared to more comprehensive and equitable emission allocation criteria, such as carbon footprint.

Lastly, based on data provided by (Reiter, 2025), the chapter includes a scenario analysing of the environmental impact of the trade war of Trump's Presidency at the beginning of 2025. Specifically, a "high intensity" scenario is taken into consideration in which the US imposes tariffs on strategic sectors globally (Canada, México, and the EU27); and, in response to this situation, some affected countries announce retaliation tariffs (see Appendix). We incorporate these global value changes reconfigurations in the environmentally- extended input-output model, to calculate the carbon impact under the production-based accounting (PBA) approach.

Methods of analysis and data

In this chapter, emissions are calculated by using an environmentally extended multiregional input-output model (E-MRIO), as in the previous chapter. Multiregional input-output models have been previously used to assess distinct impacts of fiscal stimuli (Le Quéré et al., 2021; Monsalve et al., 2018; Monsalve et al., 2016), social policies (Tang et al., 2024), as well as to evaluate fiscal measures' environmental impacts after Covid-19 and to analyse scenarios of efficiency improvements (Shan et al., 2021). In this study we use FIGARO database (European Commission et al., 2024) in its latest update to assess multiregional impacts in terms of greenhouse gas emissions (GtCO2eq). The database provides detailed information on 46 regions and 64 industries, which we aggregate to 23 sectors and 33 regions (EU, Rest of EU and Rest of the World) to enable scenarios and make interpretation easier.

We apply the model to estimate the short-term effect of fiscal stimuli, relying on BRUEGEL database (Darvas, 2023) and FIGARO database (2022). Furthermore, we assess the possible impacts of the mitigation policies (medium-term effects) proposed by the different EU member states, analyzing to what extent they will achieve the emission reductions announced for the year 2030 (see Appendix). In the context of uncertainty, different scenarios are carried out to assess the current and proposed efforts by countries to establish fiscal policies that have an impact on the green economy and energy efficiency improvements.

Regarding scenarios, in the medium-term we simulate a BAU scenario with projections from 2022 (year t) to 2030, using the GDP growth estimates provided by the IMF (International Monetary Fund, 2025) for different countries of the world economy, keeping technology and carbon intensity constant according to the information of *t* year. To calculate the projected final demand, we simulate a growth of domestic final demand for each country according to its GDP growth, while imports of final goods grow according to the GDP growth of the demanding countries. Secondly, we rely on the EEA database (EEA, 2025) to simulate two scenarios. EEA provides projections of EU countries' emissions up to 2030, using scenarios that are based on the impacts of existing mitigation measures (WEM scenario), and on the impacts of additional measures (WAM scenario) announced by countries. Combining this information with the BAU scenario data, it is possible to extract what the carbon intensity improvements of the EU countries are to be by 2030. Specifically, the EEA provides disaggregated information into the following sectors: Agriculture; Energy Industries; Road Transportation and Other Transports; Manufacturing and Construction; Industrial Process; Waste, Residential and Commercial. Different carbon efficiency improvement scenarios (WEM and WAM) are calculated that assess how ambitious policies need to be to not only meet the emission reduction targets under the direct EU's resident (RES) emissions by industries and by households, but also under the consumption carbon footprint (CCF) criterion, and thus avoid emissions leakage through international trade.

Lastly, based on data provided by (Reiter, 2025), a scenario is included in order to analyse the environmental impact of the trade war initiated by the US administration, led by Donald Trump, at the beginning of 2025. Specifically, a "high intensity" scenario is modelled in which the US imposes tariffs on strategic sectors globally (Canada, México, and the EU27); and, in response to this situation, some affected countries have announced retaliation tariffs (see Appendix). We incorporate these global value changes reconfigurations in the environmentally - extended input-output model, to calculate the carbon impact under the production-based accounting (PBA) approach.

Findings and discussion

Short-term effects

As Table 5.1 shows, significant investment has been made due to the RRF. It is worth noting the investments made in sectors such as the Manufacturing of Machinery and Transport (28%), Information and Communication (17%), Construction (13%), and Professional, Scientific, and Technical Activities (9.5%). The expected increase in carbon emissions, under a production-based approach, resulting from this fiscal stimulus is only 5% of the total, approximately 1% annualized, and has little negative impact on the reduction commitment targets outlined in the EU Green Deal of 55% by 2030 compared to 1990 (European Commission, 2019). By industry, the most significant carbon impacts are concentrated in Electricity, gas, steam and air conditioning supply (27%), Manufacturing of Machinery and Transport (22%), and Other Transport (13%), due to their high carbon intensity.

Medium term effects: BAU, WAM and WEM scenarios

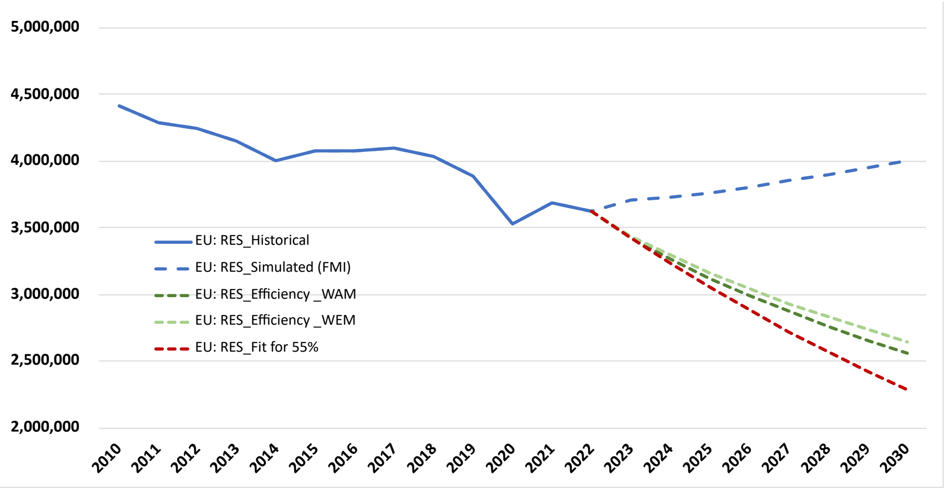
The results regarding EU carbon emissions considering residents' emissions (RES) are shown in Figure 5.1. It includes both the emissions from all economic sectors (82%) and those from households (18%). The evaluation of a Business as Usual (BAU) scenario reveals that the emissions significantly diverge from the European commitments by the year 2030, with a gap of nearly 36 percentage points (in the period 2023-2030). While emissions in the BAU scenario would increase by 10%, those in the Fit for 55% target would decrease by 37%.

Table 5.1. Sectoral analysis of investments and their carbon impacts (2022) (Investments in Millions €; Emissions in $KtCO_2e$)

	Sectors	Investment Function	%	Investment EU Emissions PBA	%	EU_PBA Emissions	INV / PBA Emissions
A	*Agriculture, forestry and fishing*	1,325	0.3%	1,195	0.8%	468,244	0.3%
B	*Mining and quarrying*	-	0.0%	-	0.0%	56,367	0.0%
C1	*Manufacturing: food, tobacco, textil*	-	0.0%	-	0.0%	98,926	0.0%
C2	*Manufacturing: chemicals, metals*	2,630	0.6%	1,731	1.2%	630,851	0.3%
C3	*Manufacturing: machinery, transport*	126,431	28.2%	32,433	22.3%	30,354	106.9%
D	*Electricity, gas, steam and air conditioning supply*	31,787	7.1%	39,389	27.0%	749,630	5.3%
E	*Water and waste management*	13,793	3.1%	11,666	8.0%	145,398	8.0%
F	*Construction*	59,581	13.3%	17,762	12.2%	51,317	34.6%
G	*Wholesale and retail trade; repair of motor vehicles*	3,158	0.7%	601	0.4%	96,383	0.6%
H1	*Road Transport*	772	0.2%	201	0.1%	155,768	0.1%
H2	*Other Transportation*	19,462	4.3%	20,158	13.8%	258,540	7.8%
I	*Accommodation and food service activities*	1,995	0.4%	420	0.3%	33,033	1.3%
J	*Information and communication*	78,266	17.4%	9,159	6.3%	14,070	65.1%
K	*Financial and insurance activities*	6,026	1.3%	324	0.2%	6,914	4.7%
L	*Real estate activities*	1,995	0.4%	158	0.1%	5,882	2.7%
M	*Professional, scientific and technical activities*	43,023	9.6%	5,117	3.5%	16,061	31.9%
N	*Administrative and support services*	-	0.0%	-	0.0%	25,074	0.0%
O	*Public administration and defence*	15,614	3.5%	1,790	1.2%	27,400	6.5%
P	*Education*	19,607	4.4%	1,174	0.8%	12,174	9.6%
Q	*Human health and social work activities*	8,141	1.8%	1,297	0.9%	27,601	4.7%
R	*Arts, entertainment and recreation*	8,143	1.8%	1,159	0.8%	10,586	10.9%
S	*Other service activities*	-	0.0%	-	0.0%	6,677	0.0%
T	*Activities of households*	6,959	1.6%	1	0.0%	239	0.3%
	Total	448,708	100%	145,734	100%	2,927,490	5.0%

Source: Own elaboration. Note: The "investment function" column reflects the investment effort of the Recovery and Resilience Facility according to the sectors that will drive investments globally (EU + RoW). The "Investment EU Emissions PBA" column records direct emissions in the European Union. The "EU_PBA Emissions" column records direct emissions from the industry in the European Union.

Figure 5.1. Historical and projected EU Residential Emissions (RES) under different scenarios (Kt CO_2e)

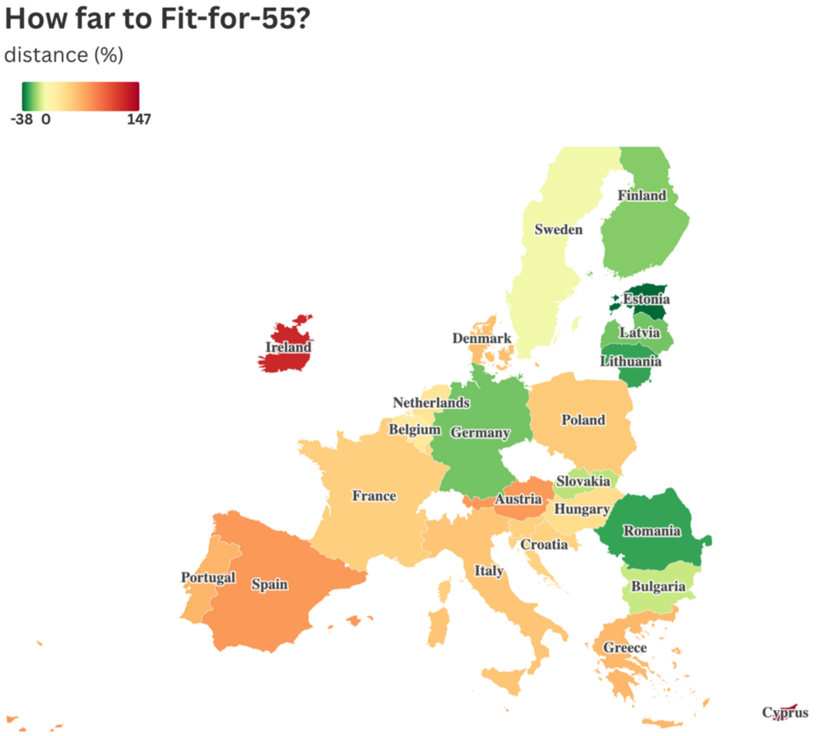


Source: Own elaboration

The simulations incorporated in our MRIO model include two scenarios with improvements in emission coefficients efficiency, according to emissions recorded in existing measures (WEM) and additional measures (WAM) projections of the EEA. These simulations suggest that the EU could approach fulfilling the 2030 target, from the perspective of residents' emissions (RES). Specifically, emissions in the WEM scenario are reduced by 27% and in the WAM scenario by 29%, which is 16% and 12% above the Fit for 55% target, respectively. In other words, the policies implemented significantly reduce the gap between the EU's residential emissions (RES) from 2023 and 2030.

The degree of compliance with the 55% reduction in RES emissions vary among different EU countries according to our simulations for 2030 (Figure 5.2). The leaders in emissions below the 55% target are Estonia (-38%), Romania (-28%), Germany (-21%) and Latvia (21%), while the worst performers with emissions above the 2030 targets are Cyprus (124%), Ireland (124%), Spain (68%) and Austria (68%), whose policies will allow them to reduce their emissions, but not enough to meet the targets set in the European Green Deal.

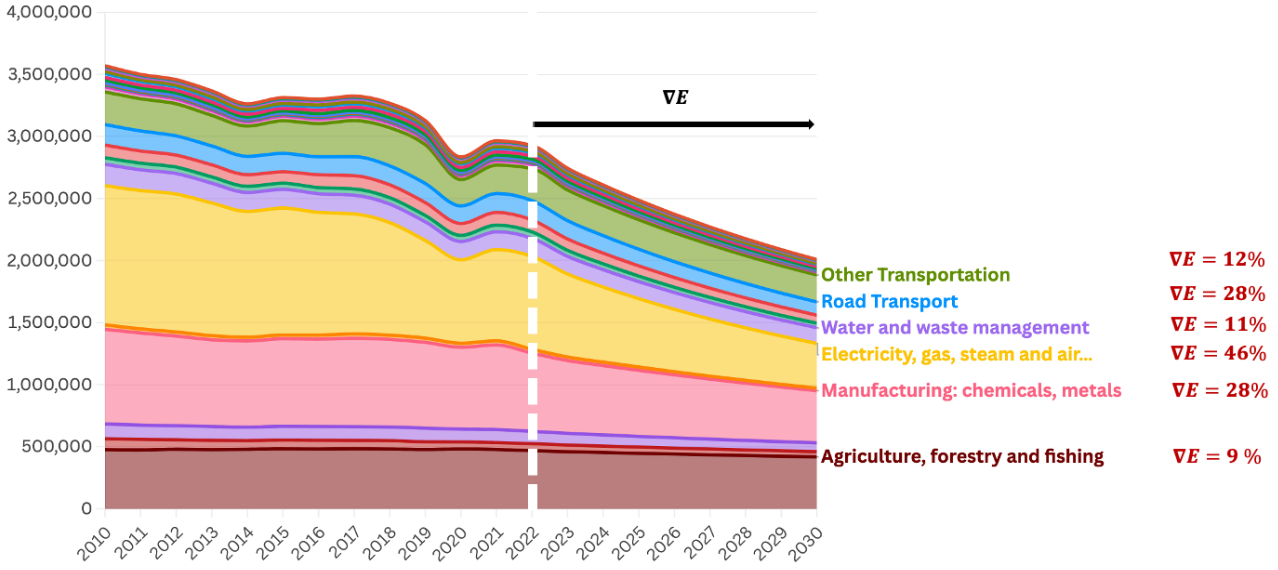
Figure 5.2. Discrepancy between residents' emissions (RES) under Fit 55% and WAM scenario to 2030



Source: Own elaboration

Analysing carbon emissions (PBA) by EU sectors, Figure 5.3 shows that 5 out of 23 sectors account for more than 82% of total emissions: Manufacturing of chemicals, metals (21%), Agriculture, forestry and fishing (21%), Electricity, gas, steam and air conditioning supply (18%), Other Transportation and storage (11%), Water and waste management (6%), and, Road Transport (5%). The electricity sector is the one showing the greatest reduction in emissions, with a reduction of 46% between 2022 and 2030, due to advanced low-carbon technologies which allow it to improve efficiency. Not only Electricity sector would reduce its impact, Manufacturing of chemicals, metals, and Road transport would also significantly reduce emissions by 28% to 2030. Lastly, it is relevant to mention that some sectors are lagging in decarbonisation. Emissions would be only reduced by 12% in Other transportation and storage, and just by 9% in Agriculture. Therefore, Electricity sector will notably reduce its weight (from 24% to 18% in 2030), meanwhile Agriculture and Other transportation will increase its contribution (from 17% to 21%, and from 9% to 11%, respectively).

Figure 5.3. Historical and projected EU emissions (PBA) by sectors under the WAM scenario (Kt CO2e)



Source: Own elaboration

Delving into the decarbonisation of countries and sectors, Table 5.2 shows all sectors which a reduction in emissions above 70% in the period 2022-2030 in WAM scenario. Our findings show that all the EU countries are on track of reducing the emissions from Electricity sector, at different levels. Germany, Finland and Denmark stand out as countries that would reduce their impact largely to 2030: Germany will reduce by 76%, corresponding to 169,815 ktCO2e less, Finland will reduce by 86%, which corresponds to 10,335 ktCO2e less, and Denmark will reduce its emissions by 100%, which corresponds to a reduction of 5,580 ktCO2e. There would be also a significant reduction in Hungary's emissions of Electricity and gas (-50%), although on the other hand, emissions from Other transportation would increase by 45%. It is interesting to highlight the case of the Baltic countries (Estonia, Latvia, and Lithuania), which would largely meet the 55% target. Lithuania and Latvia will reduce the mining sector by 74% and 66% by 2030, respectively, and Estonia will reduce emissions from Other transport by 67%. Other countries will need to make additional efforts to achieve decarbonisation in key sectors. This is the case of Spain, a country that would reduce its emissions in highly polluting sectors such as Electricity (60%), Manufacturing (overall by around 35%) and Road transport (46%), but would increase its carbon impact by 20% in

Agriculture and 10% in Other transport, which is a constraint on the fulfilment of the objectives, in contrast to the performance of other countries.

Table 5.2. Sector/country variations in emissions in WAM scenario 2022-2030

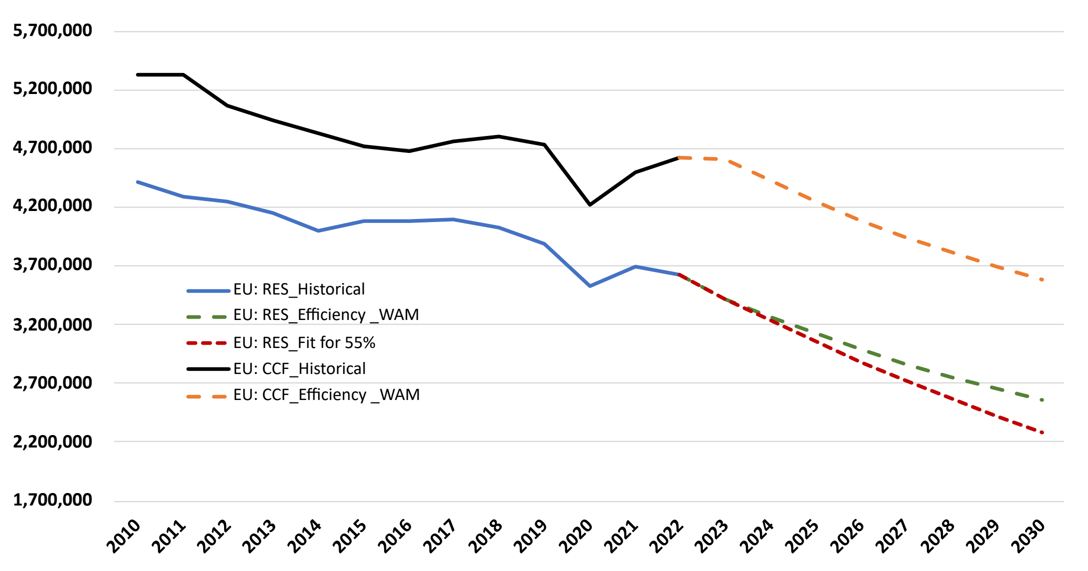
Country	Sector	Kilotonnes CO2e	%
Germany	'Electricity, gas, steam and air conditioning supply'	-169,815	-76%
Finland	'Electricity, gas, steam and air conditioning supply'	-10,335	-86%
France	'Wholesale and retail trade; repair of motor vehicles'	-8,237	-73%
France	'Administrative and support services'	-5,762	-73%
Denmark	'Electricity, gas, steam and air conditioning supply'	-5,580	-100%
Portugal	'Electricity, gas, steam and air conditioning supply'	-4,534	-73%
France	'Human health and social work activities'	-4,522	-72%
France	'Public administration and defence; compulsory social security'	-3,703	-72%
France	'Education'	-2,459	-73%
France	'Accommodation and food service activities'	-2,370	-73%
France	'Professional, scientific and technical activities'	-1,525	-73%
France	'Arts, entertainment and recreation'	-1,347	-73%
Denmark	'Construction'	-1,262	-78%
France	'Information and communication'	-933	-73%
France	'Financial and insurance activities'	-686	-73%
France	'Other service activities'	-600	-73%
France	'Real estate activities'	-328	-73%
Malta	'Mining and quarrying'	-36	-84%
France	'Activities of households'	-18	-72%
Lithuania	'Mining and quarrying'	-15	-74%
Slovakia	'Other Transportation and storage'	3	6%
Romania	'Other Transportation and storage'	23	5%
Belgium	'Other Transportation and storage'	81	2%
Poland	'Other Transportation and storage'	106	5%
Italy	'Mining and quarrying'	458	14%
Spain	'Other Transportation and storage'	1,419	10%
Hungary	'Other Transportation and storage'	2,025	45%
Ireland	'Agriculture, forestry and fishing'	4,188	18%
Spain	'Agriculture, forestry and fishing'	8,696	20%

Source: Own elaboration. Note: The table collects all the pairs sector-country with reductions above 70% (green) and all the sectors-country with increase in emissions (red)

If results are analysed under the consumption carbon footprint (CCF) approach, there is still a gap between Fit for 55 target and the EU consumption carbon footprint (consumption-based emissions extended with the direct household emissions). Figure 5.4 shows the historical and projected CCF to 2030, comparing it with RES under WAM and Fit for 55 scenarios. Our findings show that the weight of net emissions embedded in EU trade (i.e. imports minus exports) does not decrease, but rather increases, rising from 22% in 2022 to 29% in 2030. The consumption carbon footprint is reduced by only 22% between 2023 and 2030 in the WAM scenario, while the reduction in residents' emissions is 29%.

Therefore, the simulated efficiency improvements in the EU lead to significant reductions in emissions within the EU, but this is not enough if emissions embodied in imports from the rest of the global economy are considered. In other words, the simulation under the WAM scenario would allow the EU (as a whole) to approach the proposed carbon emission reduction targets within its territory (also known as the residents' emissions). However, environmental policies would need to be more ambitious to reduce the consumption carbon footprint because emissions generated by imported products are not considered in EU targets. Therefore, greater commitment is needed from the EU to reduce emissions embedded in imports and/or, at the same time, for the countries from which the EU imports to increase their emission reduction targets.

Figure 5.4. Historical and projected EU emissions of RES and CCF under different scenarios (KtCO2e)

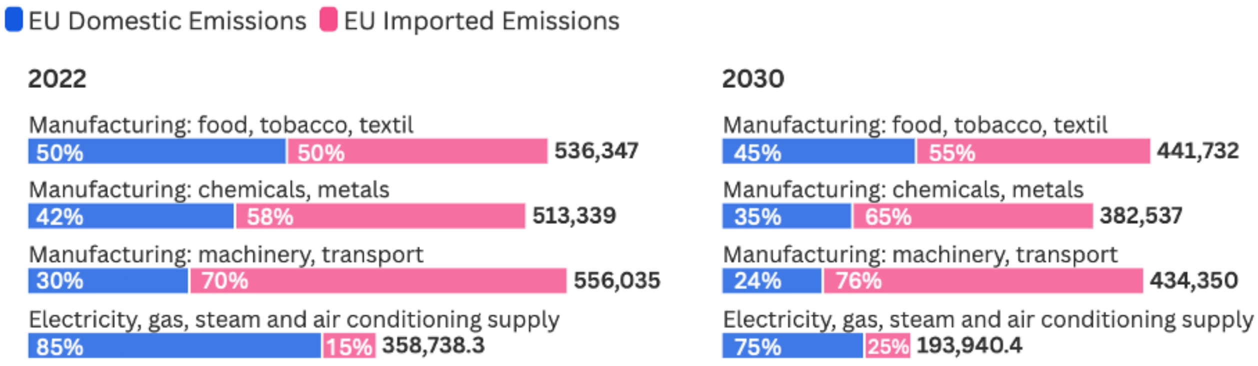


Source: Own elaboration

Delving into the sectoral distribution of CCF, it is obtained that 4 sectors out of the 23 account for 49% of total emissions (Figure 5.5). It is relevant to highlight that emissions embedded in imports of some sectors represent more than 50% of the total emissions. Specifically, in Manufacturing of food, tobacco, textile sector, imports account for 50% of the total CBA emissions in 2022; in Manufacturing of chemicals, metals (which includes the main products covered by the CBAM: cement, iron and steel, aluminium, and fertilizers, but not electricity and hydrogen), imports account for 58%; and in Manufacturing of machinery, transport, 70%.

The efficiency improvements simulated in the WAM scenario will lead to an increase in the share of imported emissions of the above-mentioned sectors (rising respectively to 55%, 65%, and 76% to 2030), since EU's mitigation policies are more ambitious than those applied by the countries from which they import.

Figure 5.5. Domestic and imported EU CBA emissions (KtCO2e) in 2022 and 2030 in WAM scenarios



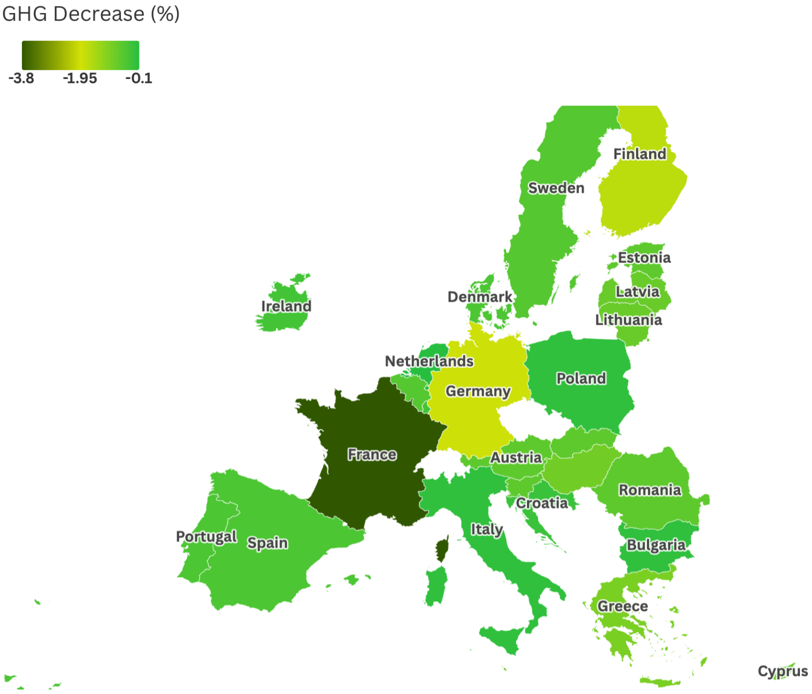
Source: Own elaboration

Trump trade war scenario

As mentioned above, one of the main issues in this chapter is to evaluate the imposition of high-intensity border tariffs by Trump administration with a reciprocal response simulated in (Reiter, 2025), using the same tariffs data of chapters 3 and 4 of this report. Our findings show a reduction of EU carbon emissions by 1.1%, as the trade war reduces EU production and exports (Table A 5.2). The total emission reduction is 28,242 KtCO2e and is concentrated in highly polluting industries. Specifically, the sectors that experience the most significant carbon reduction (in relative terms) are the following: Agriculture, forestry and fishing (3%), Wholesale, retail trade and repair of motor vehicles (2%) and Manufacturing of chemicals, metals (1%). However, the reductions in emissions are less significant in tertiary sectors as they are less involved in global production chains. Finally, the emissions increased slightly in Mining and quarrying and Activities of households.

A country-by-country analysis of the impact of the trade war shows how the relative change in emissions varies significantly between a reduction of 0.1% for Netherlands and a decrease of 3.8% for France (Figure 5.6 and Table A 5.3). This discrepancy is explained both by the different composition and volume of the reduction in exports by country and by the different pollution intensity of those countries. However, in absolute terms, the most considerable reductions occur in economies that jointly have a higher GDP and/or are more polluting: France, Germany and Spain.

Figure 5.6. Changes in EU PBA carbon emissions due to US tariffs in 2025, (Kt CO2e)



Source: Own elaboration

Results show some interesting aspects. First of all, although the RRF implies an increase in EU CO_2 emissions in the short-term, it does not significantly compromise the reduction commitment targets outlined in the EU Green Deal of 55% by 2030 compared to 1990 (European Commission, 2019). Second, in the medium-term, we conclude that policies are on the right track, but still insufficient to reduce resident's emissions to reach Fit for 55%, with a gap of 16% in scenario WEM and 12% in scenario WAM above the target. In the period 2022-2030, the highest carbon reductions are found in the Electricity, gas, steam and air conditioning supply sector (46%), although there has also been a notable decrease in other sectors such as Manufacturing of chemicals, metals (28%) and Road transport (28%).

Secondly, the phase of increasing globalization has caused EU emissions according to the consumption-based criterion to grow more significantly than those according to the production-based criterion (Wilting & in 't Veld, 2025). Additionally, the emissions embedded in imports are becoming increasingly important for the EU's carbon footprint (Wood et al., 2020). However, the narrowing gap in developed and developing country emission intensities (Meng et al., 2023) and the increasing disruptions in international trade (Liu et al., 2020) have led to a reduction in global trade's carbon leakage. In this context, simulations show that the greater ambition of the mitigation policies implemented by the EU is insufficient to meet the Fit for 55% target for emissions by residents (production-based approach plus households' emissions), and they do not allow for a significant approximation to the consumption carbon footprint (CCF). The results show that until 2030, there continues to be a gap between the committed resident's emission targets and the EU's carbon footprint, as the weight of carbon emissions embedded in EU imports does not decrease (rising from 22% in 2022 to 29% in 2030).

Thirdly, it is clear that US trade war affects the global trade configuration, and thus the resident's emissions generated by countries. In particular, a total reduction of 1.1% of EU emissions is estimated, which differs by country depending on the composition and volume of production and its sectoral carbon intensity. This scenario highlights the trade-off between economic and environmental objectives: these tariffs could have highly negative effects for European economies, although it would improve the EU carbon emissions.

Conclusions and policy implications

In 2020, COVID-19 paralyzed the world and severely affected EU economies. The adoption of the European Union's Recovery and Resilience Facility (RRF) as part of Next Generation package enabled the EU to deploy fiscal stimulus to mitigate the adverse effects of the crisis. Our understanding of the impacts of the green stimulus in response to COVID-19 focuses on the effects in terms of greenhouse gas emissions, and this study has shed light on the magnitude, by country and sectoral distribution, of the funds. We conclude that the carbon emissions generated by the funds in the short term are relatively insignificant compared to the emissions savings achieved through efficiency improvements in the medium term because of the measures planned by the EU countries in their national energy and climate plans.

Additionally, the chapter contains an evaluation of whether these efficiency improvements will be sufficient to meet the EU's targets, as the Fit for 55 initiative requires the EU to reduce greenhouse gas emissions by at least 55% by 2030 above the baseline year of 1990. Our results show that existing (WEM) and additional (WAM) efforts announced by countries are insufficient to reach the 55% target by 2030. Specifically, there is an 16% gap in the WEM scenario and a 12% gap in the WAM scenario compared to the target. These findings align with the outcome data and reports of the International Energy Agency (IEA, 2023) and the European Environment Agency (EEA, 2025) regarding the potential for achieving EU targets through improvements in efficiency. However, in this report, the emissions are analysed not only by the direct emissions of EU residents (RES) but also by the consumption carbon footprint (CCF) which includes both direct and indirect emissions associated with the country's final demand. Therefore, EU efforts to reduce emissions should go beyond borders, including the responsibility of imported goods from carbon-intensive countries. In this context, our work concludes that greater commitment is needed to reduce emissions embedded in EU imports and, at the same time, for the countries from which the EU imports to increase their emission reduction targets.

It is a fact that countries' efforts towards decarbonisation are unequal and heterogeneous, both in magnitude and in the sectors involved. In this context, the European Commission aims to enhance the use of Important Projects of Common European Interest (IPCEIs) to make a significant contribution to economic growth, job creation, the green and digital transitions, and competitiveness for the Union's industry and economy (European Commission, 2021b). In detail, the fourth hydrogen IPCEI, launched by the EU until 28 May 2024, is expected to boost the supply of renewable and low-carbon hydrogen, thereby reducing dependency on natural gas supplies in the industrial sector and facilitating the development of mobility and transport applications (road, maritime, and aviation) based on hydrogen. In road transport, the several initiatives launched by the EU and its member countries to promote electric vehicles should be intensified, thereby reducing greenhouse gas emissions from both private transport services and households, since this process reduces the consumption of solid fuels and carbon products and is accompanied by an improvement in the emissions coefficients in the electric sector. More concretely to get this greater efficiency in the electricity sector, REPowerEU focus on developing renewable energy sources, primarily wind and solar photovoltaic, as well as conserving energy and diversifying energy sources. Besides, according to Directive EU 2024/1275 (European & Council of the European, 2024), there must be a reduction in emissions in housing energy consumption through improvements in efficiency in buildings (European Commission, 2022). We consider these strategies to be adequate; however, given our findings, the policies should be more targeted to achieve the stated commitments.

After calculating the consumption carbon footprint for 2030, we conclude that a more significant commitment is needed to reduce the emissions embedded in EU imports. Given that the relevance of domestic emissions has been reduced, the Carbon Border Adjustment Mechanism (CBAM) established by EU (European Commission, 2021a) should not only incorporate more products (not only cement, iron and steel, aluminium and fertilizers and electricity) but also include Scope 3 emissions that are currently not being considered. Additionally, the EU Corporate Sustainability Reporting Directive (CSRD) (European Commission, 2023) and the Corporate Sustainability Due Diligence Directive (European Parliament, 2020) are adequate to ensure that businesses address negative environmental and human rights impacts on their operations, subsidiaries, and value chains, both within and outside the EU (European Parliament, 2020). However, the Omnibus package, proposes to simplify EU rules, boost competitiveness, and unlock additional investment capacity, representing a step back in the fight against emissions leakage due to international trade (European Commission, 2025). Specifically, the Omnibus package proposes simplifying the CBAM for a fairer trade, making sustainability reporting more accessible and efficient and simplifying due diligence to support responsible business practices. In this context, an alternative approach could be to source from lower-carbon suppliers, foster trade alliances with these suppliers, or replace the purchase of carbon-intensive intermediates with domestically produced circular inputs, as targeted in the EU’s Circular Economy Action Plan (European Commission, 2020).

Amid the trade war with the US, we simulate the impact that current tariffs war may have on EU carbon emissions in 2025 (under PBA approach), including a sectoral and regional analysis. Specifically, we model the 'high intensity' scenario considering that the US has imposed tariffs on strategic sectors globally (Canada, México, and the EU27); and, in response to this situation, some affected countries have announced retaliation tariffs. Despite the negative impacts of tariffs on countries' trade and GDP, our results show that tariffs could have a positive environmental impact, allowing for a reduction in EU emissions. Specifically, a total reduction of 1.14% of EU emissions is estimated, which differs by country depending on the composition and volume of production and its sectoral carbon intensity. This tariff war occurs in a context where current trade policy creates a global implicit subsidy to CO2 emissions in internationally traded goods and contributes to climate change. This is because import tariffs and non-tariff barriers are substantially lower on carbon-intensive industries than on clean industries (Shapiro, 2020). Therefore, to the extent that the new tariffs focus more significantly on carbon-intensive products, such as steel and aluminium, it can also be an opportunity to apply similar trade policies to clean and dirty goods, thereby reducing carbon emissions without causing significant income reductions.

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Technical Appendices

Appendix methods

The Environmentally Extended Multiregional Input-Output models (EEMRIO) are useful for evaluating total country carbon emissions for different allocation criteria (Miller & Blair, 2022). The basic equation to compute the total emissions is:

$$\boldsymbol{E^T} = \boldsymbol{E} + \boldsymbol{h}' = \hat{\boldsymbol{e}}(\boldsymbol{I} - \boldsymbol{A})^{-1}\bar{\bar{\boldsymbol{y}}} + \boldsymbol{h}' \qquad (1)$$

where E is a matrix that measures the cumulative carbon emissions from industrial activity by country and h' is the transposed vector of direct household carbon emissions for each country. $\hat{\boldsymbol{e}}$ is a diagonalized vector that contains the direct CO2 emission coefficients for every industry and country, I is the identity matrix, A the matrix of technical coefficients, $(I - A)^{-1}$ is the inverse Leontief matrix and $\bar{\bar{y}}$ is the total final demand diagonalized by blocks (differentiating between domestic final demand and exports per country). Following (Davis & Caldeira, 2010; Peters, 2008) when we add up all the E matrix' elements for country r by rows, we obtain the production-based accounting (PBA) criteria of responsibility or direct carbon emissions made in that country by residential industries. However, when we add by columns all the elements of the matrix E for country r, we obtain the consumption-based accounting criteria (CBA) that quantifies the total emissions, direct and indirect, associated with the final demand made by this country. Finally, we define the consumption carbon footprint (CCF) of a country r as the consumption-based emissions extended with the direct emissions household emissions. When we incorporate the households' emissions, we define residents emissions (RES) by country r as the sum of production-based emissions plus direct household emissions (Wilting & in 't Veld, 2025).

For the short-term analysis, we calculate the carbon emissions of EU investment plans carried out by the 27 EU countries for 2021-2026. To do so, based on the fiscal stimuli carried out by the countries relying on BRUEGEL database (Darvas, 2023) we construct the sectoral investment functions for each country $\boldsymbol{I^{bg}}$ -differentiating between domestic and imported investment. Introducing these investments into the multi-regional input-output model allows us to obtain both producer-based (PBA) and consumer-based (CBA) EU emissions linked to these investments (Monsalve et al., 2016):

$$\Delta\boldsymbol{E} = \hat{\boldsymbol{e}} \cdot (\boldsymbol{I} - \boldsymbol{A})^{-1} \cdot \boldsymbol{I^{bg}} \qquad (2)$$

For the medium-term analysis, we calculate annually the emissions of the 27 EU countries for the period 2022-2030 (E^T)., both for the consumption carbon footprint as well as the residential emissions (see equation 1).

To validate the model, we conducted out a Montecarlo analysis whose results (Table A 5.1) confirm its robustness. By running 10,000 iterations with perturbations of 25% of emission coefficients the total emissions range between [-6,8% - 7,5%] in WAM scenario and [-6,3% - 6,2%] in WEM scenario.

Table A 5.1. Description of scenarios

Scenario	WaM	WeM
iteration	10000	10000
perturbation	25%	25%
Max	7.511906076	6.277866655
Min	-6.8412954	-6.33712903
Mean	-0.00450518	-0.00944673
Std Dev	1.788543508	1.826780559

Appendix: scenarios

In the BAU scenario, we simulate a growth of domestic final demand for each country according to its GDP growth provided by the IMF (International Monetary Fund, 2025), while imports of final goods grow according to the GDP growth of the demanding countries. We also generate two new scenarios based on information provided by the European Environment Agency database (EEA, 2025) on efficiency improvements associated with EU existing mitigation measures (WEM scenario) and EU additional measures (WAM scenario) announced by countries. In these scenarios, in addition to growth in EU demand, improvements in emissions coefficients ($\hat{e}^s$) and household emissions (h'^s) are introduced for the 27 EU countries up to 2030. Finally, for the rest of the world, we consider that the different sectors improve their environmental efficiency, but with the EU country that will improve its efficiency the least.

Lastly, based on data provided by (Reiter, 2025), we include a scenario of the environmental impact of the trade war started by the US administration, led by Donald Trump, from the beginning of 2025. Specifically, this scenario is based on reciprocal tariffs and corresponds to "Scenario 3: High intensity" with retaliation tariffs on countries such as Canada, Mexico and China and including VAT in this 'new' tariff for European countries.

Table A 5.2. Description of scenarios

Scenarios	Assumptions
BAU (2010-2030)	INDUSTRY EMISSIONS - Actual data: 2010 - 2022: FIGARO Database - Projections: 2022 - 2030: FIGARO 2022 technical structure + Final demand projections according to FMI GDP estimates.
	HOUSEHOLD EMISSIONS - Actual data: 2010 - 2023: EUROSTAT HH direct emissions - Projections: 2024 - 2030: EEA WAM
WEM (2023-2030)	- Improved emissions coefficients, according to EXISTING policies and measures that have already been implemented (or approved and imminent) - FIGARO 2022 technical structure
WAM (2023-2030)	- Improved emissions coefficients, according to ADDITIONAL policies and measures - FIGARO 2022 technical structure
TRADE WAR (2025)	- High Intensity War

Table A 5.3. Change in EU PBA carbon emissions due to US tariffs by sectors (2025)

Sectors	WAR - BAU	%
Agriculture, forestry and fishing	-14,332.2	-3.2%
Mining and quarrying	328.5	0.7%
Manufacturing: food, tobacco, textile	-468.7	-0.5%
Manufacturing: chemicals, metals	-6,205.3	-1.2%
Manufacturing: machinery, transport	-11.5	0.0%
Electricity, gas, steam and air conditioning supply	-2,248.6	-0.4%
Water supply; sewerage, waste management and remediation activities	-873.8	-0.6%
Construction	-8.0	0.0%
Wholesale and retail trade; repair of motor vehicles	-1,713.9	-2.1%
Road Transport	-23.6	0.0%
Other Transportation and storage	-1,654.7	-0.7%
Accommodation and food service activities	-129.3	-0.5%
Information and communication	-65.3	-0.5%
Financial and insurance activities	-27.5	-0.5%
Real estate activities	-17.7	-0.3%
Professional, scientific and technical activities	-59.2	-0.4%
Administrative and support services	-73.6	-0.4%
Public administration and defence; compulsory social security	-444.7	-1.9%
Education	-84.8	-0.8%
Human health and social work activities	-70.3	-0.3%
Arts, entertainment and recreation	-38.4	-0.4%
Other service activities	-22.9	-0.4%
Activities of households	3.8	1.8%
Total	**-28,241.7**	**-1.1%**

Table A 5.4. Change in EU PBA carbon emissions due to US tariffs by countries (2025)

Country	Emissions Reduction	Change
Austria	- 338.0	-0.7%
Belgium	- 466.8	-0.6%
Bulgaria	- 99.2	-0.2%
Croatia	- 46.5	-0.3%
Cyprus	- 49.4	-0.8%
Czechia	- 720.0	-0.9%
Denmark	- 271.4	-0.5%
Estonia	- 88.4	-0.7%
Finland	- 555.5	-1.7%
France	- 11,213.4	-3.8%
Germany	- 9,124.7	-1.9%
Greece	- 728.9	-1.0%
Hungary	- 398.9	-0.9%
Ireland	- 210.9	-0.4%
Italy	- 583.1	-0.2%
Lithuania	- 137.7	-0.8%
Luxembourg	- 29.6	-0.4%
Latvia	- 67.6	-0.8%
Malta	- 15.1	-0.8%
Poland	- 676.6	-0.2%
Portugal	- 224.3	-0.5%
Romania	- 561.1	-0.7%
Slovakia	- 184.0	-0.7%
Slovenia	- 79.2	-0.7%
Spain	- 978.2	-0.5%
Sweden	- 215.3	-0.6%
Netherlands	- 177.8	-0.1%
TOTAL	- 28,241.7	-1.14%

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6 Giving substance to the EU's Open Strategic Autonomy: Scenarios for the implementation of a Carbon Border Adjustment Mechanism

Contextual background and research objectives

Climate change represents the most pressing challenge for current and future generations. Immediate and decisive action is required to mitigate any environmental damage caused by greenhouse gas (GHG) and other emissions. Overcoming the severe consequences associated with climate change will require a transition in industrial, trade and environmental policies with a strong emphasis on sustainability under the umbrella of an ideally strong global cooperation. The European Union (EU) has taken the lead in this effort by pioneering the European Green Deal (EGD), a policy measure aiming to reduce carbon emissions by 55% compared to 1990 levels by 2030, with the goal being to make Europe the first climate-neutral continent by 2050.

The full implementation of the CBAM, set for 2026, will require importers of specific carbon-intensive goods to pay for the emissions embedded in their products (Boning et al., 2023). The CBAM targets carbon-intensive goods (e.g. aluminium, cement, iron and steel, fertilizers and electricity) due to their significant GHG emission intensity and vulnerability to carbon leakage. This climate measure imposes a carbon price on these goods, which is expected to significantly affect their competitiveness within the EU market via prices while reducing carbon leakage at the same time.[2]

This chapter examines the economic implications of the Carbon Border Adjustment Mechanism (CBAM) while recognising that the European Commission has already decided how these revenues will be allocated. Specifically, it looks at how the implementation of the CBAM affects trade flows, welfare and CO2 emissions across countries and industries. By using a state-of-the-art trade model combined with novel data, this study provides new insights into the general equilibrium (GE) effects of the CBAM and highlights the mechanism's potential to contribute to the environmental and economic objectives, such as "Green Own Resources", where CBAM and ETS revenues could strengthen the budget for climate action, reinforcing Europe's commitment to sustainability and innovation, see Stöllinger (2020).

Previous studies have shown the effects of CBAM using an extended structural gravity model with embedded CO2 emissions: CBAM is expected to affect EU's export competitiveness via prices while mitigating climate change (Korpar et al. 2023) and support global carbon reduction efforts while complying within WTO rules (Böhringer et al. 2022).

[2] The CBAM is introduced to prevent carbon leakage by imposing tariffs on carbon-intensive imports, ensuring EU industries face a level playing field with foreign competitors (Böning et al. 2023).

In addressing these issues, this chapter contributes to the literature on trade policy and environmental economics. The interactions among trade policies, economic impacts and environmental outcomes present significant challenges in the context of climate change. Issues that may be driven by free trade agreements (e.g. increased emissions from international trade and transportation as well as deforestation) highlight the complexity of aligning trade and environmental policies. However, trade and trade policies could also help to mitigate these environmental concerns. Felbermayr et al. (2024) provide a comprehensive overview of the economic literature and recent developments on the linkages between trade policies and environmental outcomes. Their survey sheds light on the crucial role of input-output analysis and new quantitative trade models – such as computable general equilibrium (CGE) and structural gravity models – in exploring these linkages. These models serve as powerful tools for determining the environmental impacts embedded in trade and for assessing the effectiveness of various policy measures, thereby offering novel insights that can guide policy makers towards more sustainable practices.

In general, research studies have shown the role of quantitative trade models as well as the interaction between trade policies and climate outcomes, see Beaufilis, Wanner and Wenz, (2024) and Mahlkow and Wanner (2023) and Felbermayr, et al. (2024). Moreover, there has been interest in quantifying the effects of CBAM, see Alessia et al., (2024), Korpar et al. (2023), Sogalla (2023) and Clausing and Wolfram (2023).

This study relies on Flórez Mendoza et al. (2024) where we evaluate the EU CBAM's impact on trade, welfare and CO2 emissions by employing a general equilibrium analysis following the framework of Caliendo and Parro (2015). This chapter contributes to the literature of trade policy and environmental economics by providing sector-specific insights into how CBAM affects different industries and helps identify the winners and losers of this climate policy by offering policy recommendations on the EU's climate goals and economic performance.

Methods of analysis and data

We use data from the OECD Inter-Country Input-Output (ICIO) tables (OECD, 2023). The ICIO covers 76 economies plus a "rest-of-the-world" aggregate and 45 industries for 1995-2020, providing precisely the sectoral granularity required to track carbon-intensive upstream activities under the EU CBAM scenario. Using this detailed data basis, effects of trade policy on supply chains (which can span multiple countries and industries) can effectively be traced.

Furthermore, we include data on CO2 emissions, which are provided by Yamano and Guilhoto (2020), to additionally be able to compute the effect of changing trade policy on CO2 emissions. So, this model allows us to capture the role of input-output linkages on CO2 emissions.

Trade elasticities for manufacturing come from gravity-consistent estimates in Fontagné et al. (2022) and Eppinger et al. (2021). For market services elasticities, we adopt the aggregate elasticity from Freeman et al. (2021).

Baseline ad valorem tariffs are taken from the World Bank's World Integrated Trade Solution (WITS) database (World Bank, 2023), supplemented by the OECD-ICIO-mapped industry classification kindly compiled and cleaned by Cieslik and Ghodsi (2024) to ensure complete sectoral coverage. Emissions data come from OECD Greenhouse gas footprint indicators. Carbon tariffs equivalent was computed following the methodology proposed by Korpar et al. (2023), and the main source is the European Environment Agency (EEA). Our baseline scenario assumes an EU internal CO2 price of €100/tCO2.[3]

To assess the effect of CBAM, we add the carbon tariff equivalent to the latest tariff data for the 27 member of the EU and the three European Free Trade Association (EFTA) Iceland, Norway and Switzerland (because of their alignment within the ETS). The difference in tariff levels (with and without CBAM) constitutes the trade policy change of interest. Since the model is solved in changes, we obtain the reported change in welfare and real wages capturing the change in trade policy.

Findings and discussion

The main findings suggest that introducing a €100/t-CO_2 CBAM leads to modest yet positive welfare effects for the 27 EU member states and EFTA countries, where welfare rises thanks to improvements in Terms-of-Trade (ToT) by 0.016% and 0.013% respectively.[4] In contrast, non-EU countries experience small welfare losses as their terms of trade worsen by 0.005 %. Figure 6.1 gives a detailed depiction of the welfare changes (and how they are composed of terms-of-trade and trade volume effects) for all countries in our data sample.
At the global level, trade volume declines slightly (0.001 %) and real wages fall across all regions, with the largest drop present mostly in the EU and EFTA countries (0.025 %), as shown in Table 6.1.

[3] For scenario results on different CO2 prices, see Flórez Mendoza et al. (2024).
[4] One has to keep in mind, however, that the model assumes that tariff revenues (thus also the additional revenues from the CBAM tariffs) are directly forwarded to the households and form a part of their income.

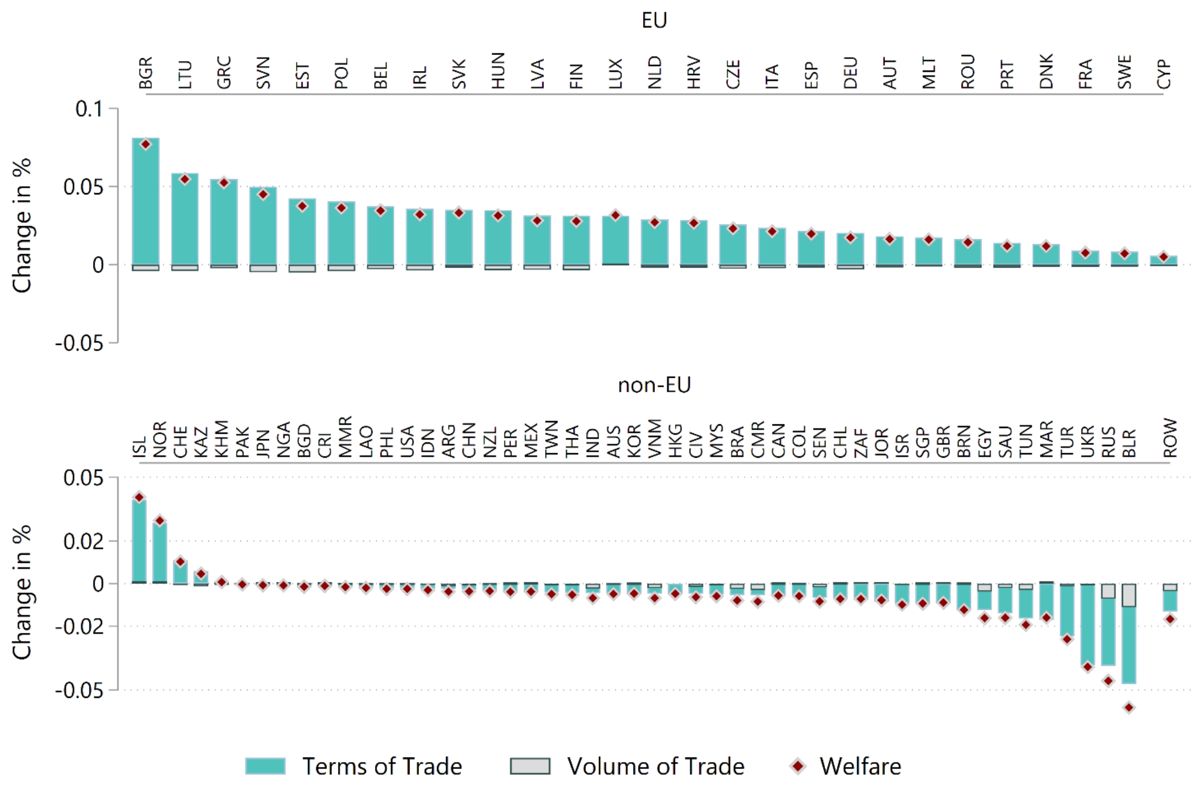
Table 6.1. Changes in selected variables due to the introduction of the CBAM by the EU

Region / outcome	Terms of trade %	Welfare %	Real wage %	Trade volume %	CO_2 %
EU27	0.0216	0.0160	-0.0248	-0.0056	0.7190
EFTA	0.0163	0.0129	-0.0250	-0.0034	0.6657
NonEU	-0.0050	-0.0054	-0.0052	-0.0005	-0.1434
World	—	-0.0014	-0.0089	-0.0014	-0.0794

Source: own calculations.

Note: Welfare is measured as the combination of terms of trade (ToT) and volume of trade (VoT) (see Caliendo and Parro, 2015). Moreover, labour is the only factor of production, and hence welfare includes the income from CO2 taxation, which in the model is then disbursed to households.

Figure 6.1. General-equilibrium effects of a €100/t-CO_2 CBAM (baseline)

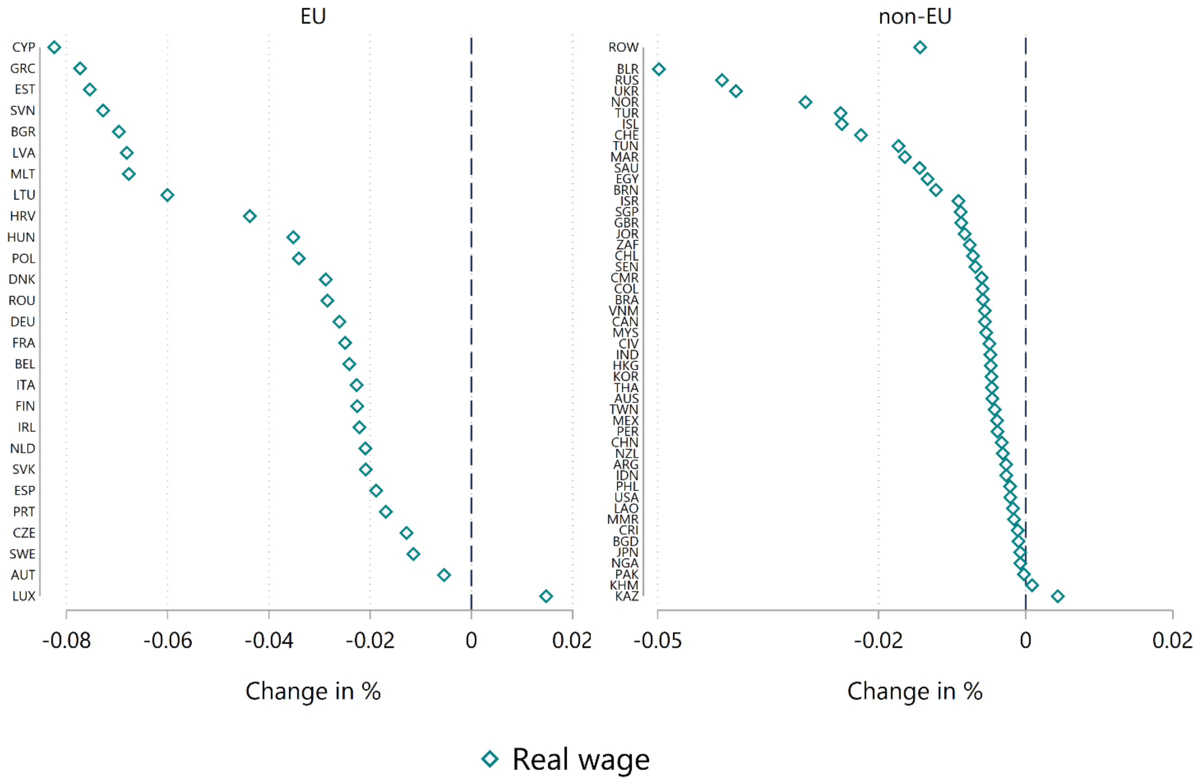


Source: Author's elaboration.

Figure 6.2 shows the changes in real wages. For the EU and EFTA countries, these negative changes are driven by price increases due to the higher tariffs. Firms and households using or consuming carbon-intensive products imported from abroad will face higher costs.

Real wages in non-EU countries decline because of decreased competitiveness and reliance on exports of carbon-intensive goods (especially Belarus, Russia and Ukraine).

Figure 6.2. Changes in real wage from EU CBAM (baseline)



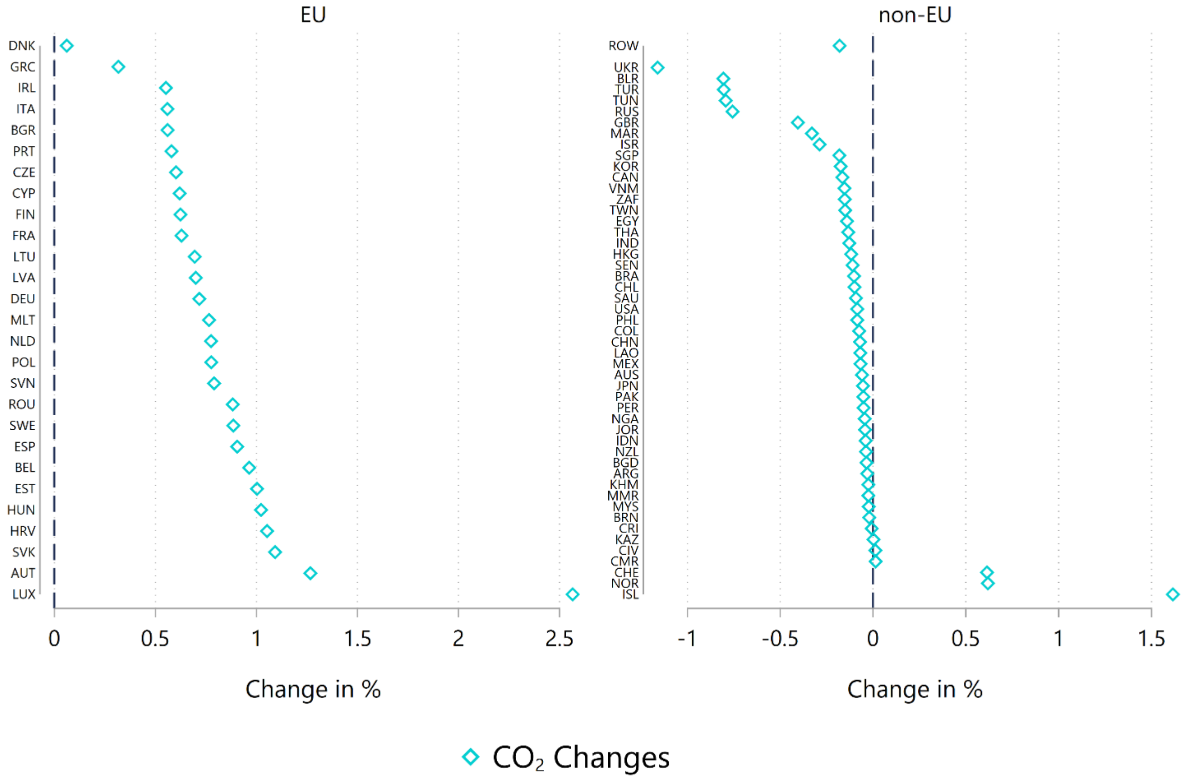
Source: Author's elaboration.

Consistent with the EU Green Deal targets, CBAM implies an overall reduction of CO_2 emissions worldwide of 0.080 %. This mechanism prices the carbon embedded in imports and shifts demand toward the EU’s comparatively cleaner producers, channelling tariff revenue that can finance further mitigation initiatives within the EU. Emissions in Non-EU countries fall by 0.14 % (especially in countries whose exports are very carbon intensive such as Ukraine, Belarus and Turkey, see Figure 6.3 below), leading the overall decline in carbon emissions.

In line with OECD evidence by Dechezleprêtre et al. (2025) who found that CBAM can tackle carbon leakage, leading to a global reduction in emissions of 0.39% and suggesting that without CBAM every tonne abated inside the EU would trigger 0.19 tonnes of additional emissions abroad. However, with CBAM, leakage not only disappears but is reversed, increasing the global reduction to 0.54%.

As an effective measure, CBAM can therefore reduce leakage and increase global mitigation, but its ultimate effectiveness will depend on its design, industry coverage, careful verification of embedded emissions, treatment of downstream sectors, and ongoing monitoring of the policy's impact along the ripple effects in GVCs.

Figure 6.3. Changes in CO_2 emissions from EU CBAM (baseline)



Source: Author's elaboration.

Conclusions and policy implications

The effects of the EU CBAM are relatively small in magnitude, consistent with previous studies such as Korpar et al. (2023). Nevertheless, the tariffs shift specialisation toward energy-intensive sectors, so EU emissions rise even though global CO_2 emissions decline. Overall, the findings suggest that EU CBAM helps reduce global CO_2 emissions. However, aggregate effects look tiny, suggesting that the design of the policy matters for achieving impactful policies in line with the European Green Deal. Furthermore, as there are plans to extend CBAM to a wider set of industries, our obtained results from the model simulations give a clear indication in which direction such extensions would go.

The EU must balance its strategic choice between climate goals and its industry viability, ensuring global competitiveness while reducing emissions. Moreover, policy makers should consider integrating incentives for clean technologies to achieve both environmental and economic objectives. Policy makers should also consider policy reactions (including retaliatory measures such as own tariff increases) with which trading partners might respond to the EU's CBAM and that would affect the outcome. EU's policy regarding the final implementation of this policy (which is currently in a trial phase) might well adjust to these expected reactions and might get modified in the context of further trade policy negotiations.

As for future research, we stress the importance of researching firm-level responses to such a trade policy change: whether (and under what conditions) it leads firms to effectively reduce CO2 emissions by adopting of clean technologies.

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Technical Appendices

For further details concerning the methodology, please consult Flórez Mendoza et al. (2024).

PART B. Integrated Scenarios

In this part, we present the results of the second Task of WP6, namely the results of the integrated scenarios, by constructing the New Trade Policy Scenario and its effects on the EU competitiveness.

The new trade policy conceived by the EU represents a reaction to these events (European Commission, 2021). Official EU documents reflect a completely new perspective on trade compared to the past, setting new goals, and moving from years of liberal attitudes towards global trade to an increasing need for strategic protectionism (Schmitz & Seidl, 2023). Despite being radically different from prior attitudes, the main new idea driving the EU's new trade policy is also simple: trade policy should move from managing interdependencies to managing dependency (Eliasson & Garcia-Duran, 2023), leading Europe towards the creation of a more self-sustained economy, in particular avoiding depending on imports of strategic goods and critical materials. Shortages of fundamental supplies, especially healthcare goods, during the pandemic, caused by the disruptions in the international supply chains due to the nearly global lockdowns, are to be avoided. As a reaction, the EU launched a New Normal Trade policy as a way to shelter itself from the fragility of the international division of production through Global Value Chains (henceforth, GVCs), without losing the advantages of an integrated world economy.

Borrowed from the military jargon, the notion of Open, Sustainable and Assertive Trade Policy - often referred to as Open Strategic Autonomy - has become a central concept in the European Union's external action from 2020 onward (European Commission, 2021). New geopolitical conflicts in Europe and Middle East reinforced the need for the new trade policy perspective, forcing the EU to interpret strategic autonomy from a long-term goal as it was perceived after the pandemic, to an urgent need (Fabry, 2022). This changing perspective is also due to the emergence of a global tendency towards the weaponization of trade (Farrell & Newman, 2019), which has helped blur the line between trade and foreign policy. In fact, the New Normal Trade policy aims at achieving geopolitical and geoeconomic objectives through strategic trade agreements and policy measures (Hoekman & Puccio, 2019).

Chapter 7 deals with the effects on EU GDP growth of the new trade policy scenario. For the EU, the concept of OSA encompasses two major elements. On the one hand, it emphasizes the importance to act strategically on the international scene, by playing an active role among trade partners, and contributing to assertively shaping its trade relations. On the other hand, it also requires the EU to foster relative independence from international partnerships, thereby ensuring the Union's capacity to act as a self-standing global actor (Beaucillon, 2023). These two aspects are translated into qualitative assumptions, and inserted as target variables (in a quantitative manner) into a regional forecasting growth model. The richness of the model is to be able to produce GDP growth rates for Europe as a whole, as well as for Countries and regions in Europe.

Chapters 8 and 9 present the last efforts of WP6. It has the aim to highlight the challenges of EU trade and investment in this New Normal context and explores how existing and new policy responses will change the incentive structure and likely geography of several key GVCs. In so doing, it also illustrates how this new policy context is shifting, once again, the role of the state in GVCs, underlining the urgent need for detailed work on the effects on international linkages of policy responses to crises.

7 New normal trade policy scenario: results from the MASST5 model

Contextual background and research objectives

The EU's main idea is to develop a trade scenario to continue reaping the benefits of international trade, and at the same time to assertively defend its interests, protecting the EU economy from unfair trade practices, and ensuring a level playing field (Eliasson & Garcia-Duran, 2023). This chapter has the aim to build a "New Normal Trade Policy" scenario based on official EU documents and identify the growth trajectories obtained at regional level. Indeed, the new trade policy largely misses an explicit spatial dimension; however, it is also expected to trigger likely spatial consequences. The EU is aware of this issue, but when the sub-national level is introduced in official documents (European Commission, 2021), contrasting goals at regional level are mentioned. In fact, while claiming that reindustrialization should follow exclusively criteria like scale economies and pre-existing capacities of territories, inevitably in favor of more advanced and industrialized regions, the EU also underlines that elements like balanced and equitable regional development should be pursued, in order to guarantee economic, social and territorial convergence.

The reasons for a change in the trade policy perspective are very clear. The way in which major trade actors operate has changed. China is eager to internalize all parts of the supply chain in green and advanced technologies and secures the access to the required critical materials and resources, expanding production capacity in many sectors and threatening the future of many European industries, from automotive to high-tech. President Trump's US first policy and his aggressive protectionist tariff policy with China – only partially revisited by President Joe Biden, who endorsed decoupling as a strategy to rebalance economic interdependence with China and to limit Chinese economic dynamism (Fabry, 2022) – are used by the US Government to deploy its geopolitical power to re-orient and secure supply chains.

Decoupling strategies between US and China, US industrial policies, and new geo-political conflicts like Russian's invasion of Ukraine force the EU to look for a new level playing field. This requires to protect EU's trade participation and decrease EU's dependence from the rest of the world claiming that "the days of unchecked offshoring and blind reliance on imports are over" (Spanish Presidency of the Council of the European Union, 2023, p. 26).

However, according to the EU, responding to protectionism abroad with protectionism at home is not the right answer, although tariffs were for some specific products maintained, in order to protect European industries from unfair competition. For instance, this is the case of the 26 per cent to 48 per cent (depending on the brand) tariffs imposed on electric vehicles imported from China, decided in June 2024. The EU looked for a different action than protectionism for creating a fair level playing field, claiming that it has to act in the field of economic security, protecting its vulnerabilities and strengthening its position as a global actor. In other words, it has to move towards an open strategic autonomy.

If this is the case, a New Normal Trade policy scenario can be envisaged, characterized by different features, summarized in Table 7.1. First of all, it is a scenario that assumes an industrial policy oriented at the reinforcement of the strategic core European industries, identified as those with an already competitive edge and potential to be frontrunner. These industries will be reinforced through boosting EU's technological global leadership by promoting the development of key competitive advantage, through stimulating competition, keeping State aid based on competition and open markets with effective rules that level the playing field. Given that the interest is Europe-wide, the industrial policy will be developed from an EU perspective rather than a national one. This means that reindustrialization will follow exclusively criteria like economies of scale, pre-existing capacities of territories, and relaunching industrial vocations that suffered from offshoring strategies.

Back-shoring and reindustrialization will therefore happen in those regions in Europe that have a historic industrial specialization in strategic core industries manufacturing the products that the EU considers as critical. The reindustrialization of Europe will not be space invariant. New manufacturing activities, benefitting from significant technological progress and from the related productivity growth typical of urban areas, will be attracted by well-developed regional locations. In addition to the major metropolitan regions, and the regions specialized in core strategic industries, second-tier cities and metropolitan areas will also benefit, except for some in Central and Eastern Europe that suffer from low accessibility.

The support of the strategic core European industries will also come from the strengthening of the Single market that provides a genuine level playing field for promoting European value chains, favored by lower administrative and organizational barriers among European member states. There will be therefore incentives for a restructuring of GVCs in line with a nearshoring strategy, especially when previous trade relations involved risky partners like Russia and China. In general, back- and near-shoring towards European countries endowed of specific production capacity will be advocated. Even if on aggregate, the EU27's capacity utilization in manufacturing industry has declined over the past two years by roughly 5 percentage points, official EUROSTAT statistics indeed suggest that roughly one quarter of the spare capacity in manufacturing plants in the EU14 + UK is not used as of Q4/2024. These data suggest that the idea of an expansion of production capacity in Europe is not a so far-fetched vision. Innovation will be boosted in key areas, guaranteeing support to the competitiveness of strategic sectors, for the efficient production of critical products and raw materials. Table 7.1 summarises the qualitative assumptions of the New Trade Policy scenario.

Table 7.1. Qualitative assumptions of the New Normal Trade policy scenario

#	Statement	National assumption	Regional assumption	Urban assumption
1	The New Normal Trade policy scenario envisages an industrial policy oriented at the reinforcement of the strategic core European industries, identified as those with an already competitive edge and potential to be frontrunner.		Expansion of European industries with competitive advantage: Increase in production in industries with an already competitive edge and potential to be frontrunner.[5]	
2	These industries will be reinforced through boosting EU's technological global leadership by promoting the development of key competitive advantage		Share of 4.0 patents, Robot density in technology manufacturing, Specialization in technology manufacturing; all strengthened centripetally.	
3	President Trump's "US first" policy and his aggressive protectionist tariff policy with China, only partially revisited by President Joe Biden, who endorsed decoupling as a strategy to rebalance economic interdependence with China and to limit Chinese economic dynamism (Fabry, 2022), are used by the US Government to deploy its geopolitical power to re-orient and secure supply chains. This shift is leading to a decreased trade dependence of the EU on global markets.	Country-level indicators of backward participation and reliance on foreign final demand are reconstructed[6] due to the polarization between US and China and the EU's new geopolitical approach (thus, we refer more to domestic internal demand).		
4	Increased investment in security axis	Higher deficit; possibly modifying Country fixed effects in public	Modest reduction in Framework Programs (urbanization	

[5] EU core industries, considered critical under the New Normal Trade policy scenario, are defined by their competitive advantage and potential to lead globally. In the MASST5 simulations, these industries are identified using UNCTAD's 2024 Revealed Comparative Advantage (RCA) Index.

[6] See Table A 7.2 in the Technical Appendix for additional details.

#	Statement	National assumption	Regional assumption	Urban assumption
		expenditure specification, in favor of Countries bordering Russia.	economies, equilibrium urban population)	
5	The EU looked for a different action than protectionism for creating a fair level playing field, claiming that it has to act in the field of economic security, protecting its vulnerabilities and strengthening its position as a global actor. In other words, it has to move towards an open strategic autonomy		Participation (lower) and upstreamness (lower) of sector C; assumptions targeting EU regions specialized in EU core industries (with a more intense decline).	
6	Related productivity growth typical of urban areas			Constant urban rent; high-level functions in cities
7	While claiming that reindustrialization should follow exclusively criteria like economies of scale and pre-existing capacities of territories, inevitably in favor of more advanced and industrialized regions In addition to the major metropolitan regions, and the regions specialized in core strategic industries, second-tier cities and metropolitan areas will also benefit, except for some in Central and Eastern Europe that suffer from low accessibility		Higher specialization of ISCO 7 in manufacturing employment growth; higher in regions specialized in core strategic industries, and in agglom./urban areas.	
8	Lower administrative and organizational barriers among European member states		Coefficients of the trade and geographical matrices in calculating GDP and employment spillovers	

#	Statement	National assumption	Regional assumption	Urban assumption
9	Innovation will be boosted in key areas, guaranteeing support to the competitiveness of strategic sectors, for the efficient production of critical products and raw materials.		Product or process innovation in increasing everywhere, but more in core strategic industries; Specialization in high-level professions; Rank-size rule; Share of college graduates	
10	Private investments will be mainly incentivized towards projects with common European interests	Higher investment constant		
11	Like energy saving projects (solar panels), green and digital transition and circular economy projects		Energy consumption, Online sales in carrier services, Specialization in carrier services, in regional targets; more in cities.	
12	Inflation will inevitably increase	Inflation in national targets		
13	The influence of workers' bargaining power	Higher ULC in national targets		
14	General stagnation in innovation adoption rates		Robot density in induced manufacturing, Specialization in induced manufacturing; keep constant or slightly decrease.	
15	The production of renewable energy will find its natural location in rural areas (e.g. wind energy technologies) and will favor urban areas the most, with the consequent widening of the sense of inequality between rural and urban areas.		Largest urban population in regional targets	
16	Slowdown in China's GDP growth	Lower BRICs growth		

Source: Authors' elaboration

Methods of analysis and data

Scenario modelling: The MASST model

Building scenario through the MASST model requires a two-stage procedure. Firstly, structural relations in various national and regional equations are econometrically estimated on the basis of the specifications derived from the standard approaches in the extant literature. Next, the estimations thus obtained are used to simulate likely future growth rates (usually, over a 15-20 years' horizon), and given an internally coherent set of assumptions forming regional growth scenarios. Scenarios comprise a set of logical relations depicting a possible (however not necessarily more likely) future development trajectory of European regions, to which the system converges by means of national and regional targets. In this scenario, the assumptions in Table 7.1 are translated into quantitative levers as targets.

The target mechanism works as follows. All variables exogenous to the model are levers in the hand of the modeler and allow her to set qualitative future values depending on the way scenarios are implemented. In Eq. (1.), x is the variable modeled with the target mechanism, indices t and t-1 indicate two consecutive time periods, T is the value of the target at the end of the simulation period, and, finally, s is the speed of adjustment:

$$x_t = x_{t-1} + s(T - x_{t-1}) \quad (1.)$$

For higher *s*, adjustment to the target is faster; in fact, for *s=1* the adjustment to the target value takes place instantaneously (i.e. in the first simulation year).

In the most recent version of the model, presented in Capello and Caragliu (2020), for the first time targets are dual for all variables. The modeler is allowed to set two targets for each variable, with a switch year left as a decision lever to model and incorporate regime switches, if any. While in the absence of conceivable breakthrough events such as a major crisis this mechanism is not needed, and can be left dormant, in the present situation this improvement appears particularly promising, in that the short run values of many exogenous levers will likely suffer from short-run decreases or contractions due to the lockdowns enacted in Spring 2020, only to resume their long run tendencies once the slump is over.

The model merges national and regional features factors by explaining regional growth (ΔY_r) as the sum of national growth rates (ΔY_N) and the regional differential shift (s) as in Eq. 2 (in Appendix A1 the structure of the model is presented. See also Capello et al., 2024):

$$\Delta Y_N = \Delta Y_N + \text{s};\ r \in N \quad (2.)$$

The national sub-model is based on a Keynesian quasi-identity, modeling GDP growth (ΔY_N) as a function of consumption, investment, public expenditure, export and import growth rates. This first part of the model captures macroeconomic determinants of regional growth according to a partial equilibrium setting, focusing on macroeconomic policies and trends in interest rates, in public expenditure, in inflation rates, in investment rates that can differ rather substantially among European Countries. Major dichotomies characterize in particular Eastern and Western Countries, and Northern and Southern ones. Lastly, the national sub-model also captures idiosyncratic differences between individual Countries through Country fixed effects.

The second component in Eq. (2.) is the regional differential shift (s) that is explained by regional competitiveness, measured as the efficient use of local resources, increases in the quality and quantity of production factors, including human capital, infrastructure, energy efficiency, European Structural funds, and interregional spatial linkages, capturing growth and productivity interdependence as suggested in Ertur and Koch (2007).

While a full-fledged description of the specific functional forms of the equations in the model cannot be presented here for reasons of space limitations, at this stage it is worth mentioning the major advances of the model's fourth generation. These mostly characterize the regional sub-model, and build upon major structural breaks in the behavior of regional economies as evidenced by the econometric analyses presented in Capello et al. (2024).

Regional inequalities

Regional inequalities are accounted for by the Theil Index (Theil, 1967), which allows to decompose overall disparities into their within and between components (Camagni, Capello, Cerisola, & Fratesi, 2020). More specifically, the aggregate Theil index is calculated as (Eq. 3):

$$T = \sum_{r} \frac{Y_r}{Y_{EU}} ln\left(\frac{Y_r/P_r}{Y_{EU}/P_{EU}}\right) \quad (3.)$$

where Y stands for regional GDP, P for regional population levels, and indices EU and r stand for the EU and for region r, respectively.

In turn, overall disparities can be decomposed into between and within disparities (Eq. 4):

$$T = \sum_{C} \frac{Y_C}{Y_{EU}} ln\left(\frac{Y_C/P_C}{Y_{EU}/P_{EU}}\right) + \sum_{C} \frac{Y_C}{Y_{EU}} \sum_{r\epsilon C} \frac{Y_r}{Y_{EU}} ln\left(\frac{Y_r/P_r}{Y_{EU}/P_{EU}}\right) \quad (4.)$$

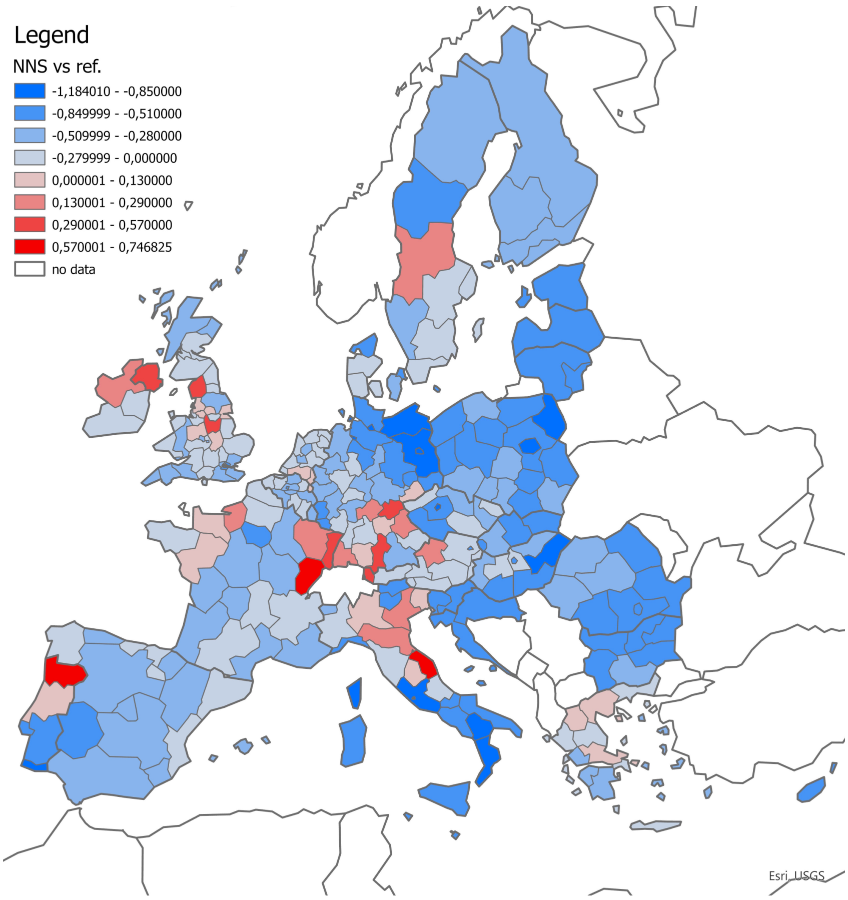
where, along with indices discussed in Eq. (2), C stands for countries.

Findings and discussion

Results on GDP growth

Regional results for the average annual real GDP growth rate over the simulation period in the NNT scenario are illustrated in Figure 7.1. Positive growth rates, relative to the reference scenario, are shown in progressively darker shades of red, while negative (or less positive) growth rates are depicted with increasingly darker shades of blue. Clear growth advantages can be identified for specific groups of regions. Figure 7.1 suggests that the main beneficiaries of a New Normal Trade policy scenario would be located in core areas, attracting control functions and already hosting major manufacturing hotspots: this is the case of the South of Germany, West of Austria, Italy's North-West, North of Portugal, and Attiki.

Figure 7.1: Average annual real GDP growth rate over the simulation period in the New Normal Trade policy scenario

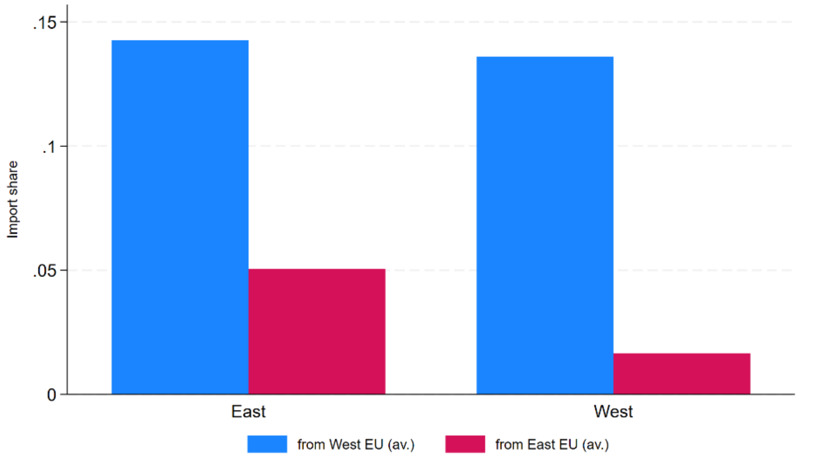


Source: Authors' elaboration

Regions in the EU14 + UK grow faster than regions in CEECs. Due to the trade-centric nature of this scenario, this result can be explained with the current trade relationships that the two blocs of countries have. Trade integration among Western and Eastern EU blocks (Figure

7.2)[7] suggests that both Eastern and Western EU countries import similar shares from Western regions. In contrast, Eastern countries import more significantly from within the Eastern bloc, while Western regions rely less on imports from the East. Hence, the reallocation of international trade from decoupling countries goes at the advantage of Western countries.

Figure 7.2: Import shares across major EU blocks



Furthermore, another important category of regions getting advantages from the New Normal Trade policy refers to the urban areas. This is a phenomenon mostly for second and third-tier city regions rather than capital ones, probably because of the geographical distribution of manufacturing headquarters that, at least for what concerns Western countries, in favor of second-tier cities (e.g. Turin, Munch, Toulouse, Lyon, just to mention a few of them).

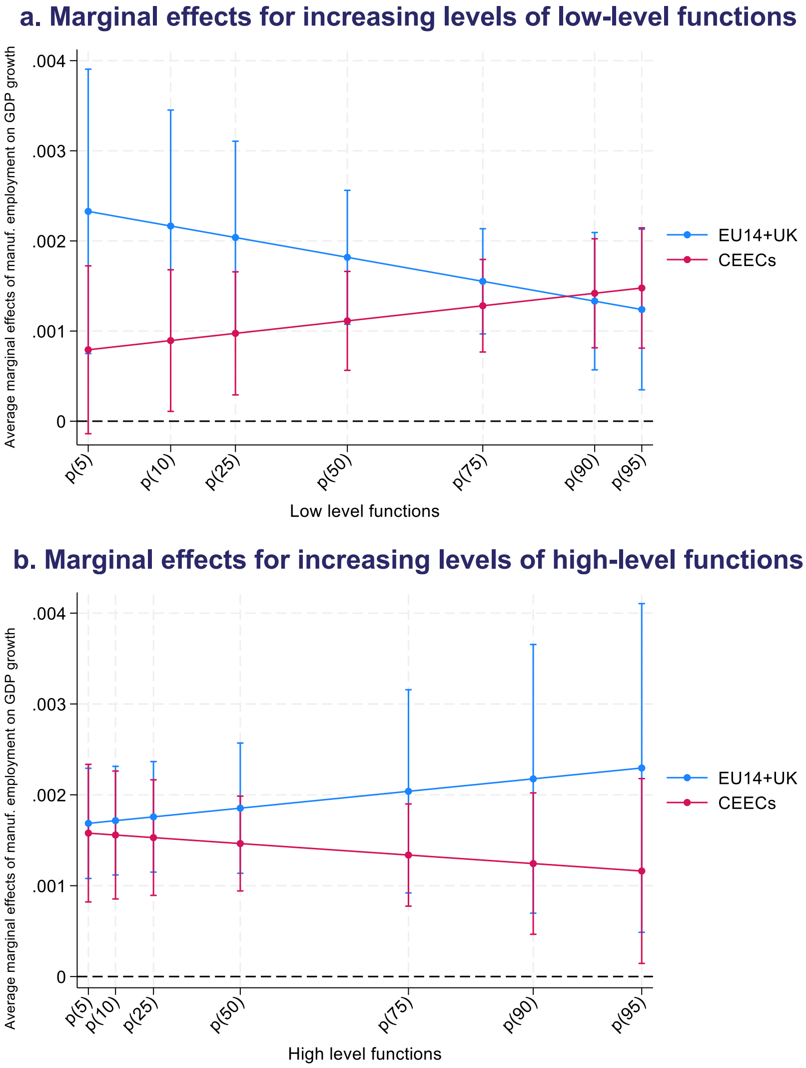
Beyond Western regions compared to Eastern ones, and aside from urban, non-capital areas, the geography of the New Normal Trade Policy scenario also includes other, not necessarily urban, regions that benefit from a defensive trade approach. These are naturally regions with a large manufacturing workforce that tend to be associated with a better future performance than those specialized in tertiary activities, in that manufacturing regions gain from hosting reshored activities. This phenomenon is particularly intense in Western Europe, where these regions are destined to outpace manufacturing regions in CEECs.

Not all manufacturing regions gain with the same intensity: production-specialized regions, where lower level functions are spatially concentrated, gain decisively more than others. The advantage increases with the increase in low-level functions, and this is true for Eastern countries (Figure 7.3.a). Instead, in Western countries, manufacturing regions gaining the

[7] This graph excludes intra-county trade and RoW for easier comparability. Information on these dimensions are available upon request

most are those specialized in high-level functions; the higher the presence of headquarters in a Western region the higher the gains (Figure 7.3.b).

Figure 7.3. Marginal effects of manufacturing employment on average annual GDP growth for increasing levels of low- and high-level functions



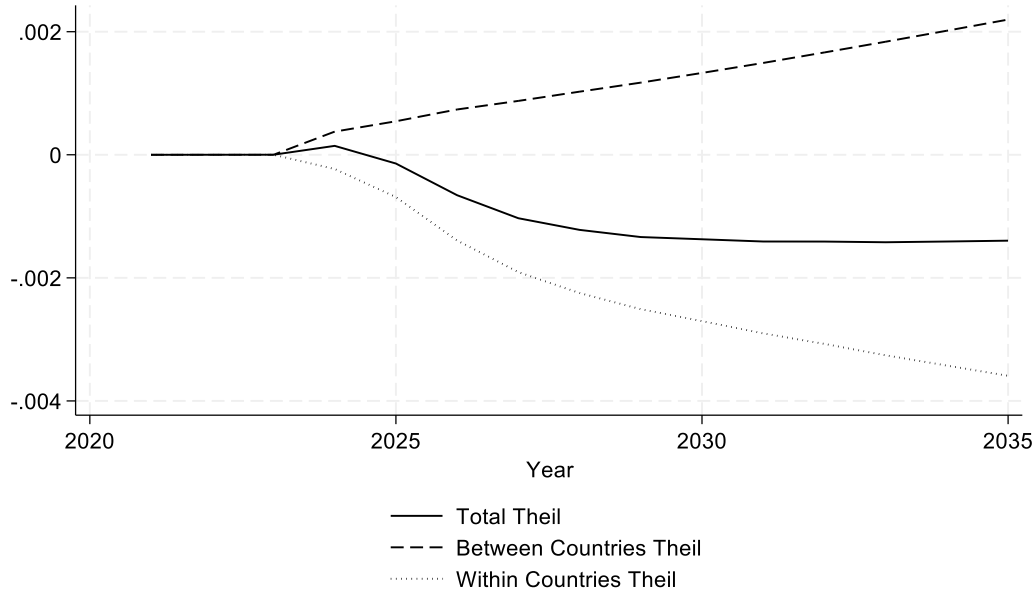
Taken together, these two sets of results suggest that the two blocks of Europe are still strongly specialized in different manufacturing activities, with control functions still located in the Western part of the EU, and production largely concentrated in CEECs. the difference in this specialization depends on their capacity to gain in a New Normal Trade policy scenario.

Results on regional disparities

Results of the evolution of the total (solid line), between (dashed line) and within (dotted line) for the simulation period are shown in Figure 7.4, again as a difference with the reference scenario.

Figure 7.4 confirms that the New Normal Trade policy scenario is not spatially blind. It impacts differently groups of regions, with substantial effects on regional disparities. In particular, reshoring of manufacturing activities would favor Western countries with respect to Eastern ones, explaining the higher between country disparity trends in Figure 7.4.

Figure 7.4. Total, Within, and Between Theil indices for the New Normal Trade Policy scenario



Source: Authors' elaboration

Moreover, within-country disparities tend to decrease with respect to the reference scenario. This result is explained by the fact that the New Normal Trade Policy scenario goes at the advantage of manufacturing regions, manufacturing productive Eastern regions, second-tier city regions, while penalizing capital cities. This trend is so strong that it offsets the between-country effect, triggering a decrease in total disparities.

Conclusions and policy implications

After major global shocks such as supply-side bottlenecks during the COVID-19 pandemic, and strains induced by geopolitical conflicts, the EU finds itself at a crossroads, thorn between the need to react to an unfair level-playing field in global trade, and the imperative to preserve European consumers gains due to trade openness. These challenges pave the way for a New Normal Trade Policy, meant to deal with these structural challenges. However, while the New Normal Trade policy may be potentially stimulating aggregate economic performance, although under tight legal and economic conditions (Mariotti, 2024), the spatial distribution of its effects is difficult to foresee. In this paper we quantified the regional distributive effects of a New Normal Trade policy; results of this simulation exercise may help shaping appropriate mitigating policies.

At this stage, a New Normal Trade policy scenario is still, at least partially, a black box. On the one hand, its implementation follows shocks that occur repeatedly, continuously changing the landscape. On the other hand, some of the defining tracts of this policy still remain to be studied.

A first issue is related to the aggregate gross costs of this policy. Despite the EU's commitment to supporting reshoring efforts for over a decade, evidence from past experiences suggests that these costs may be substantial, as economic forces often resist policy interventions. As consequence, only minimal manufacturing may have been actually reshored from GVCs towards North America and Europe, and this, only under dire technological constraints that make reshoring viable and profitable only for firms in specific industries (Vanchan, Mulhall, & Bryson, 2018).

The second issue is a logical consequence of the first: what would the net impact of a New Normal Trade policy be? The debate revolves around a pessimistic view, based on an international trade perspective, that sees reshoring as a cause of reductions in product variety, missed comparative advantage, and lower returns to scale; and the political science angle, that celebrates the EU's capacity to gain independence from risky, or unreliable, trade partners. However, our findings suggest that the two angles are not mutually incompatible, while both are based on a set of crucial preconditions for a negative, or positive, impact, to prevail.

A third issue to be further analyzed, and that policy documents tend to underestimate, is related to potential price increases associated with a New Normal Trade policy scenario. Inflation in both retail prices and wages is a logical consequence one would expect from a major process of reshoring manufacturing activities. Over the past decade, a symmetric argument has been presented in favor of the net gains that may have been accruing to the US following China's entry into the WTO. While substantial job losses have been triggered by increased competition from Chinese manufacturers (Caragliu & Gerritse, 2022), these may have been offset by aggregate price reductions (Caliendo, Dvorkin, & Parro, 2019). Whether CPI increases would more than offset expected job creation remains an open question, and one that MASST5, not being based on general equilibrium, cannot address.

A fourth issue is related to what has so far been insufficiently discussed in the European literature on reshoring: how much of manufacturing reshoring would effectively translate into job creation within the EU? As forces driving location decisions are mostly economic, reshoring may happen largely through job automation, with the logical consequence that little of the expected positive impacts of a New Normal Trade policy would take place, leaving room for costs to prevail (Capello, Lopes Afonso, & Perucca, 2024; Krenz, Prettner, & Strulik, 2021).

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Technical Appendices

Structure of the MASST5 model

The MASST5 model is the fifth version of a macroeconometric regional growth model built to simulate regional growth in the medium and long-run. The acronym contains the different dimensions (Macroeconomic, Sectoral, Social and Territorial) on which the model is built. While the first version of the model is presented in detail in Capello (2007), the model has undergone several substantial improvements over the past 15 years (Capello and Fratesi, 2012; Capello et al., 2017; Capello and Caragliu, 2021a), and has been applied to simulate the effects of several complex scenarios, as well as the impacts of multiple exogenous shocks.

MASST belongs to the macro class of regional macroeconometric growth models. In this sense, it is a pretty traditional model, in that model parameters are econometrically estimated, following in the footsteps of the Cowles commission approach to identification. More specifically, in the MASST model, regional growth is explained by a combination of national (macroeconomic) and regional (structural) factors.

The national sub-model is based on Keynesian quasi-identities explaining the growth of aggregate income, consumption, public expenditure, exports, and imports, thereby modeling aggregate demand. With the aim to explain the differential growth rate of a region with respect to its nation, the regional sub-model, instead, captures the supply side, depicting the sectoral, social and territorial aspects characterizing the region by:

- quantifying tangible and intangible elements, i.e. different assets of territorial capital (Camagni, 2019), especially those with an intangible nature, linked to actors' perceptions, relational elements, and cooperation attitudes;
- analytically formulating territorial complexity, i.e. the set of context specificities and synergies that characterize regional growth.

The model runs across two stages:

- in the estimation stage, structural relations between explanatory and dependent variables in various national and regional equations are estimated over a long run time span through a set of equations included in the model;
- in the simulation stage, estimated coefficients are employed for simulating likely future growth patterns (usually, over a 15-20 years' horizon), and given an internally coherent sets of assumptions forming regional growth scenarios.

The model merges national and regional growth-enhancing factors by explaining regional growth (ΔY_r) as a decomposition between a national growth rate (ΔY_N) and a regional differential shift (s) (Capello, 2007):

$$\Delta Y_r = \Delta Y_N + s;\ r \in N \qquad (1.)$$

The shift s in Eq. (1.), is represented at the core of Figure A 7.1, depicting the logical structure of the model. In Figure A 7.1, individual model equations are represented with shaded grey areas. Within each equation, Figure A 7.1 shows two types of shapes:

- octagons, representing variables exogenous to the model. For these variables, the model does not produce forecasts, and their value is used by the modeler as a long-run target to which initial values of each variable tend;
- rounded-angled shapes, that represent instead variables endogenous to the model. These dependent variables are simulated by the model, and may enter the specification of other endogenous variables, or instead represent final outcomes of the simulation exercise.

In Figure A 7.1, the left-hand side represents the national sub-model, while the right-hand side encompasses regional sub-model equations.

The logical structure of the model foresees creating a comprehensive set of assumptions on all exogenous variables of the model. This combination is the quantitative translation of a scenario – a blend of hypotheses on mega-trends in all sectors of national and regional economies that need to be based on solid and internally coherent thinking about likely developments in the macro and local spheres.

Translated into quantitative variables, assumptions are included in the model as targets (*T*) to which an independent variable (*x*) tends over the period $t - 1$ and t with a speed of adjustment (s):

$$x_t = x_{t-1} + s(T - x_{t-1}) + s \qquad (2.)$$

where s denotes the speed of adjustment. As *s* approaches 1, the exogenous variable approaches the target value faster (so that, hypothetically, when $s=1$ the speed of adjustment is instantaneous). In MASST5, targets can be set also differently for different combinations of Countries or typologies or regions.

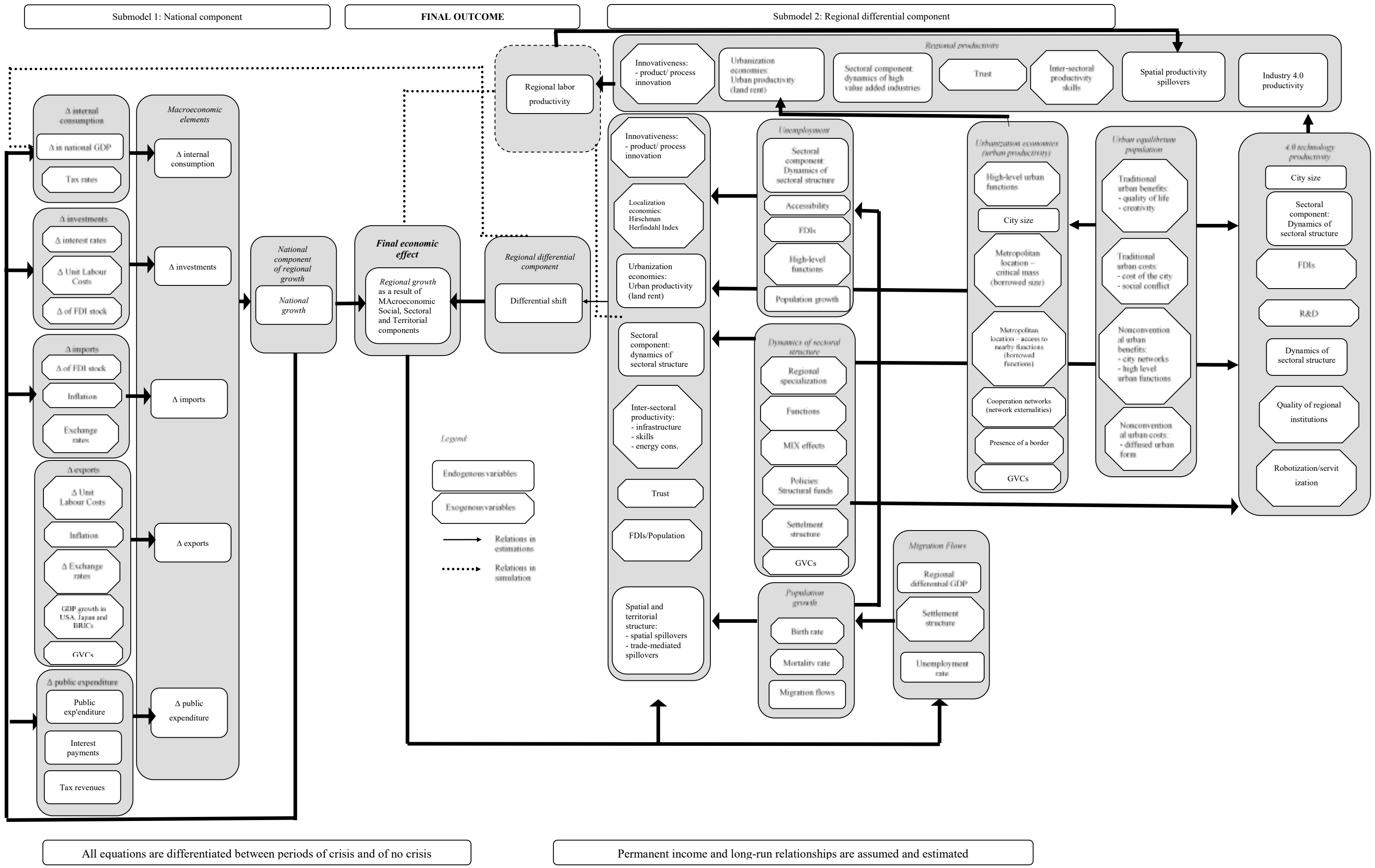
One last word relates to the outcomes of the model. MASST5 predicts the following results for all NUTS2 regions in Europe, with a major effort for the fifth generation of the model to readjust the NUTS classification to its more recent 2016 version, leading to the inclusion of all 281 administrative units, including overseas territories (Table A 7.1).

Outcomes of simulation exercises must be interpreted differently from the results of SGCE simulations. While MASST5 does produce point forecasts about all variables, including regional GDP growth rates, their magnitude is to be compared across regions, rather than being interpreted as precise assessments; in this sense, quantitative foresights strike a balance between long-run qualitative foresights, whose diffusion has been relatively slowed down by a "paucity of grounded hypotheses about scenario planning and still insufficient empirical field data to test its core premises" (Schoemaker, 2021, p. 1), and quantitative forecasts.

Table A 7.1. MASST5 simulated outcomes (endogenous variables)

Block of the model	MASST5 simulation outcomes
National	GDP growth Consumption growth Public expenditure growth Investment growth Export growth Import growth
Regional/Urban	Regional GDP growth Manufacturing employment growth Service employment growth Unemployment rates Migration rates Urban land rent (dynamic agglomeration economies) Equilibrium urban population Regional labor productivity Labor productivity growth in 4.0 sectors Regional population

Figure A 7.1. Structure of the MASST5 model



Source: Capello et al., 2024

Trade flows restructuring

The restructuring of the trade flows is based on four groups of countries, identified based on their behaviour in key United Nations votes (Table A 7.2).[8] Although other geopolitical factors—such as trade agreements—may also shape these groupings, they are excluded from this classification because of their more temporary nature, as such agreements can be quickly suspended due to sanctions, political changes, or regulatory triggers.

Table A 7.2. Geopolitical blocks of extra-EU countries

Block 1 Decoupling countries	**Block 2 Trade-friendly countries**	**Block 3 Neutral countries**	**Block 4 Antagonistic countries**
China Russia	Australia Canada Japan Norway South Korea Switzerland Türkiye	Argentina Brazil Mexico South Africa United States Rest of the World	India Indonesia Saudi Arabia

Key indicators such as backward participation and dependence on foreign final demand are recalculated based on adjusted Input-Output flows through a four-step process:

1. European countries reduce imports from Block 1 nations.
2. To keep overall trade volume and structure unchanged, the missing imports are redistributed across other partners (excluding Blocks 1 and 4) based on prior trade shares.
3. Block 1 countries (notably China and Russia) respond by cutting imports from Europe.
4. These lost imports are then reallocated across other partners (excluding Europe and Block 2), again proportionally to existing trade shares.

[8] UN voting similarity is based on correlations between the voting patterns of the main trade partners included in the IO tables and those of the EU, China, and Russia from 2001 (the year China joined the WTO) to 2019. A cluster analysis reveals distinct groupings among these countries.

8 Balancing 'Openness': the effects of post-COVID geo-political shifts on EU trade and investment relationships with its near abroad and rising powers

Contextual background and research objectives

We are moving into a new trade paradigm. Traditional certainties about what types of policies are acceptable and the links between trade and other policy objectives no longer hold. In this very fluid context, there are great challenges, but also potential for innovation. In this context, this chapter seeks to provide some insights for researchers and policy makers.

This chapter takes up this challenge and explores how Covid-19, the subsequent geopolitical shifts and emerging crises facing the EU (sometimes termed the Polycrisis) are changing its trade and investment policy. In the post-Covid 'New Normal', growing political tensions both with countries that have long represented strategic challenges – like Russia – and former allies – like the US, require the EU to reassess its integration with Global Production Networks (GPNs) and reorient its dependencies. This type of 'geopolitical' decoupling is not new (Blazek and Lypianin, 2024), but the current context has been particularly challenging in terms of the rapid speed of deterioration of relations, first with Russia and now with the US. Traditional and novel policy responses are needed. We explore these changes in the global environment, the EU's existing and proposed policy responses, and highlight how key aspects of these shifts will likely reshape GPNs, encouraging new forms of decoupling and recoupling.

The TWIN SEEDS project has undertaken extensive research over the past three years on the evolution of EU-facing GPNs and how different aspects of EU policy impact on these shifts. This chapter seeks to build on this work, highlighting how it can inform EU policymaking in the emerging, very turbulent, context. Indeed, the current context is unprecedented in modern economic and diplomatic history. It requires extensive analysis and a scientific approach. This paper will seek to provide insights from existing scholarship and the TWIN SEEDS project.

More in detail, the objective of the chapter is to highlight the challenges to EU trade and investment in this New Normal context and explore how existing and new policy responses will change the incentive structure and likely geography of several key GPNs. Building on work in WP1, which looked at long-term geopolitical trends (Curran, 2023) and WP2, that looked at the Covid pandemic (Curran, 2024), we focus on two other key aspects of the 'polycrisis'. Firstly, the emergence of major disruptions in international relations and the resurgence of trade conflicts – especially the weaponization of trade linkages by the US and, to a lesser extent, China. Secondly, the EU's attempts to address the climate crisis (and other negative externalities of trade) through its sustainable trade agenda. We highlight the likely impacts on GPNs – both intended and unintended – of these developments and provide some policy proposals for going forward.

The chapter underlines how the work which has been undertaken in WP6 addresses policy contexts which are very novel and/or emerging. In providing data and analyses on optimum reactions to both the geopolitical crises that the EU faces and its efforts to address the climate crisis, the research can provide up-to-date information to support policymakers. It can also highlight some underexplored aspects of the current context – such as how differences in the way GPNs are covered by the various measures within the sustainable trade agenda may affect outcomes, or how decoupling from China (or the US) could create opportunities for some EU regions, while harming others.

Methods of analysis and data

The work draws on literature on GPNs and the role of the state in coupling and decoupling within these networks. Methodologically, it draws on policy documents, as well as academic and 'grey' literature. In the context of emerging trade agreements, we mobilise the revised OEP framework. In relation to due diligence, it draws on 31 interviews with policymakers, trade associations and civil society (Table A 8.1 in annex). In terms of new normal tariff scenarios, the work focuses on tariffs in manufactured goods and assumes that the outcome of FTA negotiations with key partners would mirror recent agreements with similar countries.

The methodologies of the work we build on from other TWIN SEEDS partners are explained in the various deliverables.

Findings and discussion

In terms of **international relations and trade conflicts,** these are evolving rapidly, and it is difficult to know at this juncture where the current tensions will lead. What is clear is that the existing international trade architecture has reached its limits, and the US is determined to restructure it. This will mean that the EU needs to rethink its trade and investment policy and build new (and renewed) alliances. It will also need to prepare for a world where the World Trade Organisation (WTO) and its norms no longer provide the certainty that states and businesses have become used to.

In relation to its key bilateral relationships, the war in Ukraine makes any re-engagement with **Russia** a distant prospect, while continued Russian aggression may encourage the EU to expand membership to countries in its neighbourhood that are seeking stronger economic ties - not only Ukraine, but Moldova, Georgia and the

Balkans. It will also, of course, fuel increased EU defence spending, changing the industrial fabric of some regions and states.

In relation to **the US**, the tumultuous start to the Trump II administration has shattered previous conceptions of the bilateral relationship. A key issue is the potential loss of US defence guarantees, which will further fuel the above-mentioned increase in defence spending and encourage autonomous EU production networks. More broadly, faced with new tariffs on steel, aluminium and cars, as well as the prospect of 'reciprocal' tariffs of 20% (or more) the EU has had to significantly revise its approach to bilateral trade relations.

A riposte from the EU to the increased US protectionism seems inevitable. The bloc agreed on a list of products for retaliation against the US metal and car tariffs on 9 April 2025. Key products included soybeans, plastic and almonds (Gijs and Coi, 2025). Analysis by researchers in the TWIN SEEDS project explored which products would be optimum for EU retaliation, in terms of minimising the effect on EU welfare and maximising the negative impact on the US (Landesmann et al., 2025). This work suggests that, in the initial round of retaliation, the EU should focus on transport equipment, pharmaceuticals, chemicals and electronics. The work also indicated that agricultural products like soya and almonds were not optimal targets. However, some products included on the EU's list, like cosmetics, polyethylene, plastics and electric motors, are coherent with the findings of their work. As negotiations continue, it would be useful to focus threatened or actual retaliation more on these kinds of products.

In terms of relations with the **rest of the world**, the EU needs to carefully balance its priorities. Strategic autonomy is not possible in all sectors, and if the union loses their previously reliable partnership with the US, there will be a need for new partnerships to secure access to resources, markets and technologies. In the course of this Commission, the EU's trade policy is more likely to be pragmatic than ideological. What that means is that negotiations on trade agreements with key potential partners may need to compromise on previously vital EU priorities like sustainable development in the interests of securing progress (Letta, 2024). This issue will be particularly pertinent in relation to Mercosur (where the agreement is completed, but transposition will be highly contested) and India (where negotiations seem to be reviving after many years in limbo). Existing frameworks for analysing potential trade agreements can be useful, but may need adjustments to the emerging context (Curran et al. 2020). While a trade deal with China looks unlikely, sector-specific agreements could have potential, especially in relation to green technologies and the need to transition to a low-carbon future. Various scenarios are possible and potential tariff structures following certain key trade agreements are proposed by the researchers.

TWIN SEEDS researchers have explored **the impact of changing trade alliances**, looking especially at the potential impacts within the EU. They find that a restructuring of trade through decoupling from Russia and China and recoupling with more ‘friendly’ countries would have differential effects across the EU, with core regions and second tier cities benefitting most.

Regarding **the sustainable trade agenda** and the EU’s efforts to address the negative externalities of trade through new measures like the Carbon Border Adjustment Mechanism (CBAM) (CEC, 2023a), the EU Deforestation Regulation (EUDR) (CEC, 2023b) and the Corporate Sustainability Due Diligence Directive (CS3D) (CEC, 2024), these seem likely to have important, but varied, effects on trade.

Work within the TWIN SEEDS project sheds light on the likely impacts of CBAM. Researchers have modelled the effect of CBAM on trade, welfare and CO2 emissions. They find small increases in welfare for the EU, small losses for the rest of the world, and minor reductions in CO2 emissions (under -0.1% globally) (Florez Mendoza et al., 2025). The study also finds that, as carbon-intensive production relocates to the EU, the CO2 emissions of the EU and EFTA would increase by 0.72% and 0.7% respectively. This confirms the earlier TWIN SEEDS work reported in Cadarso (2024), which highlighted that, although CBAM has the potential to reduce the carbon emissions linked to EU consumption, in the absence of extensive decarbonization of EU production, it is likely to increase the EU’s own emissions. Furthermore, restructuring the EU ’s trade to favour the low-carbon producers won’t, on its own, significantly reduce global carbon emissions. Unless CBAM has the desired impact of encouraging trade partners to increase the cost of carbon domestically and adopt low carbon technologies, there is a risk that the impact on climate change will be minimal.

CBAM will, however, restructure trade by increasing the cost of CBAM products imported from more carbon-intensive sources. This will sometimes favour EU production, but in other cases, demand will be reoriented towards low-carbon production in other countries. However, along GPNs within Europe, CBAM will also have effects. CBAM costs increase with the cost of carbon-intensive goods in the EU and so affected products, like steel, will become more expensive. There is a risk that such products, as well as those that use CBAM inputs, will lose competitiveness both within the EU and outside. Again, our research suggests that there is a risk of restructuring of GPNs to reorient low-carbon goods to the EU while reorienting high-carbon goods to other less demanding markets – so called ‘resource shuffling’. This could result in minimal CO2 reductions. Cadarso (2024) even suggest it could increase global emissions.

In relation to EUDR, similar risks exist. Although the TWIN SEEDS project did not model the potential impact of the regulation on trade or welfare, it is clear that there is also a

risk of resource shuffling in this case. Specifically, exporters of EUDR goods like coffee or palm oil to the EU could favour sources which have low risk of deforestation, while continuing to source from deforested lands for other markets. There is also a risk that EU industries which depend on inputs covered by EUDR could face unfair competition from suppliers that use inputs from deforested land to produce derivative products.
However, our research highlights that the manner in which these two regulations cover value chains varies, and their impacts are also likely to differ. Specifically, imports of goods where CBAM products are important inputs – like airplanes or cereals – are not subject to charges for embedded carbon. This fact means that there is a risk that EU producers of such goods may be incentivized to offshore production to jurisdictions where carbon costs are lower.

In the case of EUDR, the regulation goes much further down the supply chain – the need for due diligence and the potential ban applies to wood, but also derivative products, like furniture and paper. However, the extent of value chain reach varies across sectors. For palm oil, derivative products like food and cosmetics are not subject to the Regulation. Even in wood, some derivative products, like viscose, are not covered. The varied application of these two sustainable trade measures (bans versus effective tariffs) and differences in how they apply along the value chains, means that their impacts will likely be very heterogeneous across sectors. In the case of both EUDR and CBAM, the Commission will need to carefully monitor trade flows, not just in the affected products, but along the value chain, in order to assess whether the overall objectives are being reached and whether trade is being diverted to avoid the Regulations.

Finally, the **Corporate Sustainability Due Diligence Directive (CS3D)** is another novel policy measure which, although it doesn't seek to directly reorient trade, nevertheless has the potential to impact GPNs. The Directive was intensely debated in the legislative process and is still under discussion in the context of the Omnibus (CEC, 2025). There are many issues of contestation in this case, but a key one, from the point of view of TWIN SEEDS research, is the definition of the value chain. In the initial Directive, it was proposed that companies should be responsible for due diligence along their downstream value chain (CEC, 2024). The Omnibus proposes to restrict that to tier 1 suppliers (CEC, 2025). In our interviews, most actors considered that going beyond tier 1 was vital to effectively addressing potential abuses in GPNs. The decisions on where to place responsibilities along the chain and what tiers should be covered will be vital to both the effectiveness of the proposal and its impact on production structures going forward.

Conclusions and policy implications

The analysis outlined in chap. 8 seeks to build on the key outcomes of WP6 research, as well as work in earlier WPs to contribute to policymaking on EU trade and investment. The EU is facing a very uncertain global environment and future research will certainly be required to support efforts to create optimal trading partnerships and monitor (and sometimes revise) the new emerging policy measures.

Our analysis highlights how these pressures are driving selective decoupling from traditional partners and reshaping GPNs. The EU's capacity to anticipate and adapt to emerging challenges—while ensuring fairness across regions and sectors—will determine the resilience and sustainability of its future trade relations.

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Figure A 8.1. The revised Open Economy Politics Framework (Curran et al. 2021).

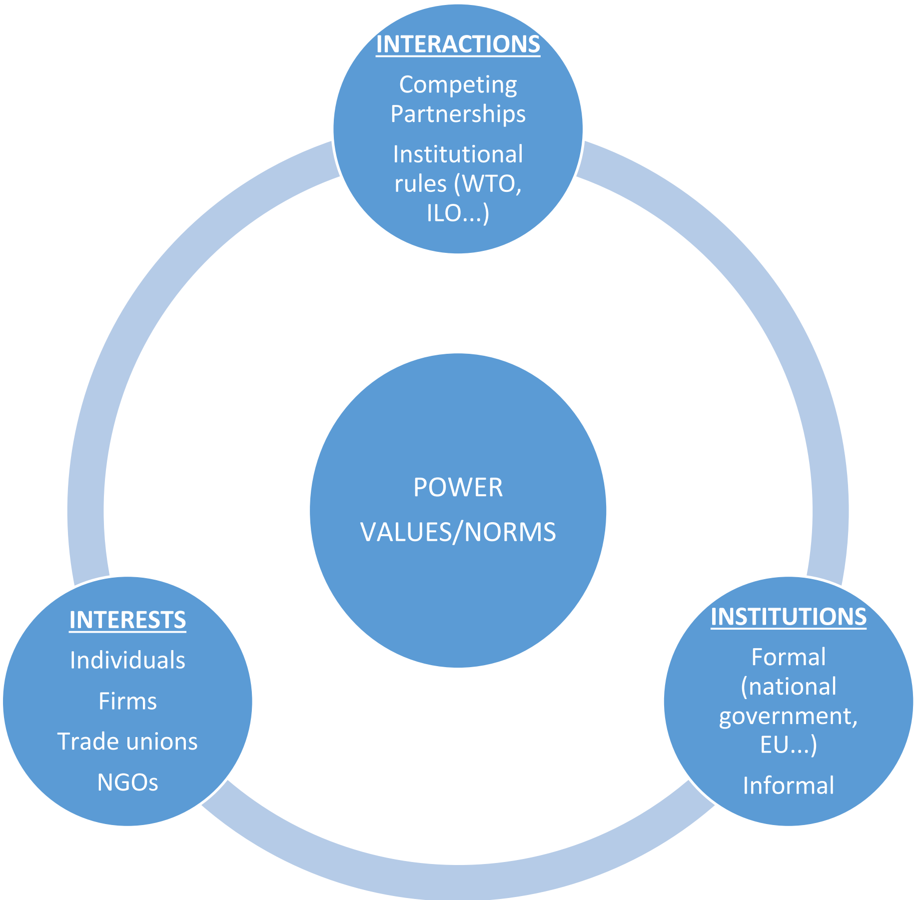

Table A 8.1. Interviews for the project

Institution	Code	Position	Interview date	Format
EP	EP1	EP staff	Dec 12th 2023	zoom
	EP2	EP staff	1st february 2024	zoom
	EP3	EP Staff	March 18th 2024	zoom
	MEP1	MEP's assistant	April 24th 2023; 5th M	FtF/phone
	MEP2	MEP's assistant	April 24th 2023	FtF
	MEP3	MEP's assistant	October 9th 2018	phone
	MEP4	MEP's assistant	March 19th 2024	zoom
Commission	COM1	Commission official	June 19th 2023	Webex
	COM2	Commission official	22nd March 2024	zoom
	COM3	Commission official	29th April 2024	Webex
	COM4	Commission official	24th May 2024	Teams
EESC	EESC	Business representative	16th April 2024	zoom
NGOs	NGO1	Researcher	September 29th 2023	zoom
	NGO2	Researcher	October 20th 2023	zoom
	NGO3	Advocacy	17th January 2024	teams
	NGO4	Advocacy	26th January 2024	zoom
	NGO5	Advocacy	February 5th	zoom
	NGO6	Advocacy	8th February	teams
	NGO7	Advocacy	18th March	zoom
	NGO8	Advocacy	22nd March	Zoom
Business	B1	EU Trade Assocation	29th january 2024	zoom
	B2	Nordic Trade Association	3rd and 15th April 202	zoom
	B3	German Trade Association	3rd May 2024	zoom
	B4	EU Trade Assocation	7th May 2024	zoom
Trade Union	TU	EU Trade Union	2nd May	zoom
Other	O1	Legal actor	February 16th 2024	zoom
	O2	Responsible business support	22nd March	zoom
	O3	Think Tank	30th April 2024	zoom

We conducted 31 interviews over the period April 2023-May 2024. Details of the informants, dates of the interviews and other key information are provided in Table A 8.1. Interviews were all undertaken in English and followed a semi-structured format. They were mainly conducted online over video conference, although some were face-to-face. In general, interviews lasted between 60-90 minutes. We transcribed them and coded the issues highlighted by our informants in terms of the key actors, the key issues of debate, their perception of the outcomes in our core aspects of interest and the explanatory factors behind them. Appropriate ethical protocols were followed with informed consent and anonymity assured for all primary respondents.

9 Conclusions and policy lessons

The rich and novel research developed in WP6 and presented in this report leads to lessons that are here summarized:

- The **risks associated with the disruption of GVCs driven by the protectionist trade and investment policies launched by the US administration** on productivity growth's opportunities for Europe are real. Because of their adverse effects on EU regions' relatedness to the technological frontier of the value chain, re-shoring strategies pursued by American companies should be monitored carefully and complemented by internal policies able to stimulate technological and knowledge advances of EU companies or by promoting foreign investments by countries with at least the same technological level of the USA. Moreover, place-based policies able to sustain productivity growth dynamics are needed. Again, a mix of place-based innovation and educational policies, as well as incentive to capital accumulation may be considered.
- **A tariff war between the EU27 and the US** – where each trading partner tries to inflict maximum damage to the 'welfare' of the other while minimising the impact on its own welfare – in a non-cooperative setting could, firstly, significantly drive-up tariff rates further. Secondly, for the EU's perspective it would be important to include in such a situation important services industries (where the US has a comparative advantage) in the calculation of retaliatory tariffs.
- **In a scenario where US-China trade collapses due to prohibitive tariff walls between these two economies**, what would be specifically relevant for the EU are trade diversion effects (i.e. significant trade flows from China being diverted from the US to other markets). This is an important policy issue in the relationship between China and the EU: on the one hand, both these two entities would like to maintain a relatively liberalised international trading system, but, on the other hand, a significant redirection of trade flows from China to EU markets can generate serious challenges for EU producers, especially in particular sectors. Hence a quantitative assessment with a model such as the one presented here of such trade diversion effects are important for negotiations with China about a reasonable reaction to the Trump 'disruption' of the international trading system. A possible outcome of such negotiations could be so-called "voluntary export restrictions" (VER's) which were negotiated by the US vis-à-vis Japanese car producers in the 1980s and could set a precedent for such negotiations between the EU and China.

- **Recent events like the Ukraine war or the COVID-19 pandemic** have demonstrated two key insights for what concerns their effects on energy household consumption: (1) changes in household final demand can have a substantial impact on emissions, and (2) even under extreme circumstances, such reductions tend to be short-lived. This underscores the need for more assertive and sustained policy action. Reductions in household emissions should not be taken for granted—even in the presence of current incentives. Stronger, more targeted interventions are required to induce lasting behavioral and structural shifts in consumption patterns. For example, time-limited stimulus measures during Covid-19 temporarily altered spending habits, but emissions quickly rebounded once restrictions were lifted. Emerging uncertainties - such as shifts in global trade patterns, geopolitical tensions, and climate-related disruptions - may introduce new shocks to household demand and emissions. While the projected impacts of such shocks have so far been modest, they highlight the need for flexible, adaptive policy frameworks capable of responding quickly to both risks and opportunities.
- **The adoption of the European Union's Recovery and Resilience Facility (RRF) as part of Next Generation package** generates insignificant increases of carbon emission in the short term compared to the emission savings achieved through efficiency improvements in the medium term because of the measures planned by the EU countries in their national energy and climate plans. These efficiency improvements will however not be sufficient to meet the EU's targets, as the Fit for 55 initiative requires the EU to reduce greenhouse gas emissions by at least 55% by 2030 above the baseline year of 1990. Specifically, there is a 16% gap in the WEM scenario and a 12% gap in the WAM scenario compared to the target. These findings align with the outcome data and reports of the International Energy Agency (IEA, 2023) and the European Environment Agency (EEA, 2025) regarding the potential for achieving EU targets through improvements in efficiency, enlarging the previous analyses to the consumption carbon footprint (CCF) which includes both direct and indirect emissions associated with the country's final demand. Therefore, EU efforts to reduce emissions should go beyond borders, including the responsibility of imported goods from carbon-intensive countries. In this context, our work concludes that greater commitment is needed to reduce emissions embedded in EU imports and, at the same time, for the countries from which the EU imports to increase their emission reduction targets.
- **Despite the negative impacts of tariffs on countries' trade and GDP due to the US imposed tariffs on strategic sectors globally** (Canada, México, and the EU27), and, in response to this situation, some affected countries have announced

retaliation tariffs, simulation results show that tariffs could have a positive environmental impact, allowing for a reduction in EU emissions. Specifically, a total reduction of 1.14% of EU emissions is estimated, which differs by country depending on the composition and volume of production and its sectoral carbon intensity. This tariff war occurs in a context where current trade policy creates a global implicit subsidy to CO2 emissions in internationally traded goods and contributes to climate change. This is because import tariffs and non-tariff barriers are substantially lower on carbon-intensive industries than on clean industries. Therefore, to the extent that the new tariffs focus more significantly on carbon-intensive products, such as steel and aluminium, it can also be an opportunity to apply similar trade policies to clean and dirty goods, thereby reducing carbon emissions without causing significant income reductions.

- With respect to the **EU's Carbon Border Adjustment Mechanism (CBAM), a climate policy which is part of the European Green Deal's (EGD) "Fit-for-55" package** aiming to reduce 55% of carbon emissions compared to 1990 by 2030 and make Europe the first climate-neutral continent by 2050, its overall effects of CBAM on trade and emissions seem minimal, consistent with previous studies. All 27 EU member states experience welfare gains from the CBAM implementation, as it enhances economic competitiveness while effectively mitigating carbon leakage. Furthermore, the design of CBAM and CO_2 prices might affect the impact of this climate policy to achieve climate neutrality within the EU. Moreover, the EU must balance its strategic choice between climate goals and its industry viability, ensuring global competitiveness while reducing emissions. Policy makers should consider integrating incentives for clean technologies (carrots) to achieve both environmental and economic objectives.
- **The new normal trade policy scenario** triggered by recent geopolitical conflicts in Europe and the Middle East, and coupled with a geopoliticization of trade, moving away from managing interdependencies to managing dependency through Open Strategic Autonomy. While a New Normal trade policy may be fundamental in restoring the European level playing field in international trade, it will not be exempt from costs that will affect regions differently, as geoeconomic fragmentation may significantly hurt low-income regions, negatively affecting living standards. Estimated gains are spatially heterogeneous. Regions growing fastest include non-capital urban areas, Western European regions, manufacturing regions, and regions with strong institutions. Growth drivers differ, with high-level functions boosting Western regions, while Eastern regions focus on production-related ones. Between-country disparities increase, yet within-country inequalities tend to grow less

due to the advantages of non-manufacturing areas in Western countries; overall these trends would lead to a slowdown in territorial inequalities.

- The analysis of the very uncertain global environment EU is facing highlights how these pressures are driving selective decoupling from traditional partners and reshaping GPNs. The EU's capacity to anticipate and adapt to emerging challenges - while ensuring fairness across regions and sectors - will determine the resilience and sustainability of its future trade relations. **Three possible scenarios lie ahead**:

  - **a proactive strategic realignment** emphasizing green and secure partnerships; the EU deepens its commitment to 'open strategic autonomy,' focusing on enhancing resilience, and fostering industrial ecosystems which are less vulnerable to geopolitical blackmail or environmental degradation. This would imply strengthening trade ties with its regional allies and the near-abroad, building green trade alliances, and recalibrating value chains to favour sustainability and proximity.
  - **a passive approach** which is likely to increase internal and external tensions. In this case, regulatory uncertainty and policy fragmentation could exacerbate asymmetries across EU regions and sectors, slowing progress towards EU goals on both decarbonisation and resilience.
  - **a hybrid model balancing strategic autonomy with selective engagement**. The EU could pursue selective decoupling while maintaining pragmatic cooperation in critical areas such as green tech, raw materials, and industrial standards, especially with key partners like China and the US. In this scenario, trade and investment policy would become an even more complex balancing act, demanding agility, strategic foresight, and robust mechanisms for policy coordination and impact monitoring.