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Distributional impacts of EU tariffs on Chinese electric vehicles across European markets

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In July 2024, the European Union (EU) introduced additional tariffs on battery electric vehicles imported from China. How these trade measures affect the pace and distribution of vehicle electrification depends on automakers' response strategies. Here we combine model-level cost data with a market adoption framework to quantify how tariff-induced cost shocks propagate through total cost of ownership and reshape electric vehicle adoption across 20 EU countries and 10 vehicle classes. We find that, depending on automaker responses, the EU-wide electric vehicle share in 2035 ranges from 56.4% (market withdrawal) to 68.9% (low-cost onshoring), compared with 64.4% under a business-as-usual projection. Adoption losses are concentrated in price-sensitive classes and lower-income countries that rely heavily on affordable China-produced battery electric vehicles, while onshoring production can partially offset tariff impacts and accelerate electrification. Our findings highlight the distributional consequences of uniform trade interventions and underscore the importance of aligning trade and industrial policy to support a resilient and inclusive transition.

The automotive sector is a cornerstone of the European Union (EU) economy, supporting 13.8 million jobs and contributing over 7% of the EU's gross domestic product[1]. Before 2020, EU automakers occupied over 75% of traditional domestic auto market[2]. As road transport represents a major source of carbon emissions, vehicle electrification has become a central pillar of the EU's low-carbon transition strategy, accompanied by ambitious electrification targets in the road transport sector. Up to 2022, the share of electric vehicles (EVs) in new car registrations increased rapidly, reaching 21% across the EU[3]. However, this momentum has weakened in recent years, with EV growth adoption slowing noticeably. A growing body of evidence suggests that the rollback of purchase subsidies and fiscal incentives has undermined the EV affordability, leaving them less competitive with internal combustion EVs in many markets. In Germany, for example, only one-quarter of battery electric vehicle (BEV) sales were priced below their internal combustion EV equivalents in 2024[3].

By contrast, the EV industry has expanded rapidly in China, with China-made BEVs gaining a growing foothold in the EU market. In the first half of 2024 (2024H1), 24% of BEV sales in the EU were imported from China, up from almost zero before 2020[4,5]. To protect the domestic automotive industry while continuing to promote electrification, the EU has introduced a range of policies and regulations in the EV sector, including import tariffs on China-made BEVs. In October 2023, the EU initiated an antisubsidy investigation on BEV imports from China

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and subsequently imposed additional tariffs[6]. Specifically, based on the investigation of subsidy rate by brand, the EU set tariff rates of 17.0% on BYD, 18.8% on Geely, 35.3% on SAIC, 7.8% on Tesla and 20.7–35.3% on other automakers (details in Supplementary Note 1). This tariff policy was formalized following the publication of the investigation results in July 2024. As automakers may respond to trade policy intervention through a wide range of pricing, production and market strategies, whether such tariffs can ultimately achieve their intended objectives remains an open empirical question[7].

Despite the broad relevance and attentions of the EU's tariff intervention, existing discussions have so far remained dominated by qualitative analyses and institutional reports[5,8–10], which primarily focused on trade disputes, industrial competitiveness or short-term price effects. Existing quantitative assessments have typically focused on price changes for selected vehicle segments or representative models, rather than examining how such trade measures may translate into changes in the pace and distribution of vehicle electrification. Moreover, these analyses fail to account for the diversity of automaker responses to this tariff policy shocks, such as differences in price pass through, production relocation or market withdrawal, even though these strategic responses are likely to be decisive in shaping market outcomes. While trade policies in other sectors, including renewable energy equipment, have been evaluated in terms of their impacts on market diffusion, comparable framework-based assessments remain scarce for passenger vehicle markets[11–14]. The pronounced heterogeneity across countries, vehicle classes and powertrain technologies further complicates such evaluations, limiting the ability of current approaches to link trade policy interventions with long-term electrification trajectories.

To address these gaps, we examine how the EU's import tariffs on China-made BEVs may affect vehicle electrification under multiple automaker response scenarios. We integrate detailed model-level cost information with a market adoption framework to assess how tariff-induced changes in total costs of ownership (TCOs) propagate through market structure and shape electrification outcomes. Specifically, the analysis covers all available 168 BEV models and 125 plug-in hybrid electric vehicle (PHEV) models across 200 segments spanning 20 EU countries and 10 vehicle classes. Rather than assuming a single adjustment mechanism, we explicitly consider heterogeneous firm responses, including price adjustments, production relocation and market withdrawal, and evaluate how these responses condition the direction and magnitude of tariff impacts on electrification trajectories and distributional outcomes. We find that, depending on automakers' responses, the EU-wide EV share in 2035 ranges from 8.0% lower (market withdrawal scenario) to 4.5% higher (low-cost onshoring scenario) than the business-as-usual (BAU) projection of 64.4%. At the segment level, between one-third and two-thirds of segments experience a decline in EV share regardless of how Chinese brands respond, with the most extreme case reaching a 69.4% decline for compact SUVs (S2) in Romania under a withdrawal scenario. These effects are most pronounced in lower-income countries and medium-to-small vehicle classes, where heightened consumer sensitivity to ownership costs exacerbates the impact.

Market penetration of China-produced BEVs before tariff

In 2024H1, while the antisubsidy investigation was ongoing and the tariff policy had not yet been implemented, 684,621 BEVs were sold in the EU (Fig. 1a), of which 24% were imported from China (Fig. 1b and Supplementary Fig. 13). Tesla, Geely, SAIC and BYD were the leading automakers driving these imports, although Volvo and MG primarily produce vehicles marketed as 'European' brands (Fig. 1c). The market penetration of China-produced BEVs varies considerably across EU member states. In Romania, 56% of BEVs sold in 2024H1 were imported from China, reflecting strong consumer preference. Dacia Spring, produced by Renault's Chinese partner Dongfeng, is Romania's best-selling BEV, accounting for nearly 40% of total BEV sales. Similarly, in Spain and Portugal, the strong sales of Tesla Model 3 have driven the market share of China-produced BEVs to over 40%. Conversely, Slovakia exhibits the lowest penetration rate of 12%. In the EU's largest markets, China-produced BEVs account for 20% of total BEV sales in Germany and 17% in France. Pronounced heterogeneity is also observed across vehicle classes. While 79% of large car (C4) BEV are imported from China, China-produced BEVs account for almost zero penetration in the mini car (C1) and multipurpose vehicle (MPV) classes. China's flagship BEV models face intense competition from European counterparts, such as MG 4 versus Volkswagen ID.3, Volvo EX30 versus Mercedes-Benz EQA (Fig. 1d). Among the ten analysed vehicle classes, the best-selling BEV models in three classes are produced in China (Tesla Model 3, Dacia Spring and Volvo EX30).

Following the implementation of tariffs, short-term price rigidity and limited immediate adjustment by Chinese automakers were accompanied by a decline in the market share of China-produced BEVs in most countries. The overall penetration rate fell from 24% in 2024H1 to 22% in the second half of 2024 (2024H2) and further to 20% in the first half of 2025 (2025H1)[4]. To provide a longer pre- and post-policy context, the evolution of market shares before and after tariff implementation is shown in Supplementary Fig. 14. Given that automakers responses to the additional import duties are expected to evolve over time, we do not treat these short-run shifts as the main focus of inference. Instead, we use the 2024H1 market structure as the baseline for subsequent analysis and construct multiple scenarios and cases to examine potential market trajectories.

Automaker response strategies to EU import tariffs

Understanding automaker responses to the tariff shocks is the key to assessing the policy's market and transition impacts[15]. As an exogenous trade intervention, the EU's import tariffs directly increase the export-related variable costs for China-produced BEVs, thereby altering automakers' profit conditions in the EU market. While a temporary pricing hold has been observed following the implementation of tariffs, automakers are likely to reassess their pricing, production and market strategy over a longer horizon. In this context, we identify three representative response strategies that capture the range of strategic adjustments available to automakers. We formalize these strategies as three automaker response scenarios (Table 1) and quantify the vehicle model-level price changes under each scenario (Fig. 2).

ADA scenario

The adapting to tariff (ADA) scenario represents a price-adjustment strategy, under which automakers continue exporting BEVs from China and respond to the tariff shock primarily through pricing adjustments. As the EU import tariffs raise the export-related component of variable costs, automakers face a trade-off between preserving market competitiveness and maintaining profitability. While automakers may accept short-term losses to preserve market presence, sustained participation in the EU market over a longer horizon requires that prices at least cover variable production and export costs, even if profits are compressed[15,16]. Three cases (low, mid and high) are further developed to represent the extent to which the automakers adjust retail prices (details in the Methods). Under this scenario, among the 56 China-produced models, price increases are observed for 8 (the low case), 25 (the mid case) and 56 (the high case) BEV models, respectively. MINI Cooper consistently exhibits the largest price increase, followed by BMW iX3 and MG Cyberster. By contrast, BEV models produced by automakers with strong cost competitiveness such as BYD show greater resilience to the tariffs.

ONS scenario

The onshoring BEV production (ONS) scenario represents a production relocation strategy, under which automakers respond to the tariff shock

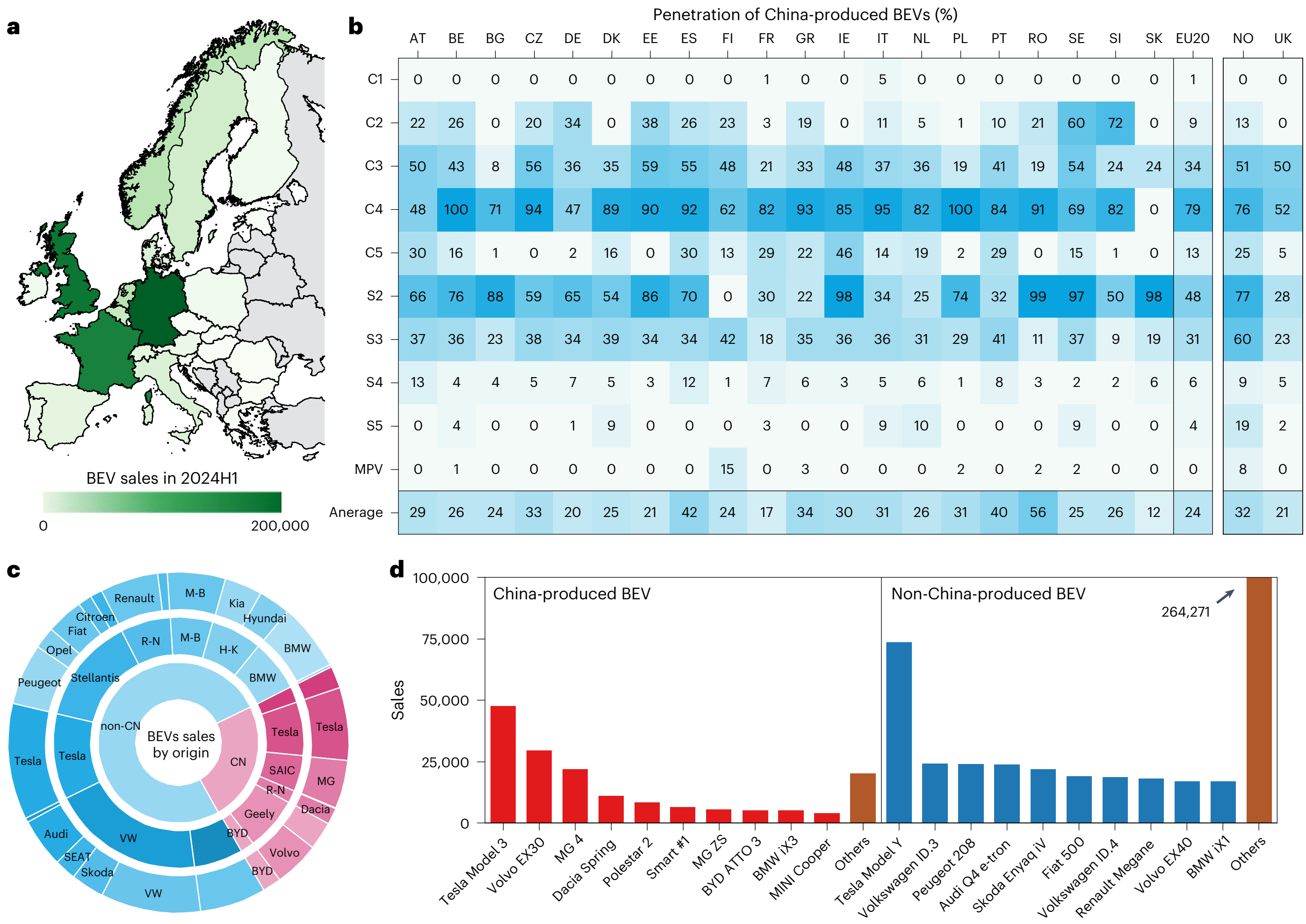

Fig. 1 | Overview of the EU BEV market in 2024H1. **a**, BEV sales across European countries, with colour intensity representing BEV sales volume; grey indicates data unavailable for those countries. **b**, Penetration rates of China-produced BEVs. Penetration rates are presented for 20 EU countries (horizontal) and 10 vehicle classes (vertical), indicated by both the numbers on and the colour depth of the cells. Data for Norway and the UK are also included. **c**, EU BEV market breakdown by production origin. Automakers are categorized by production location, brand and group from the centre to the outer layers. Automakers with less than 9,000 BEV sales are not labelled. **d**, Top ten best-selling China-produced and non-China-produced BEV models in the EU20. C1–C5, mini, compact, mid-size, large and executive car, respectively; CN, China-produced; H-K, Hyundai Kia; M-B, Mercedes-Benz; non-CN, non-China-produced; R-N, Renault–Nissan Alliance; VW, Volkswagen; S2–S5, compact, mid-size, large and executive SUV, respectively; SUV, sport utility vehicle. Country names are described using International Standard Organization (ISO) alpha-2 codes, as detailed in Supplementary Table 4. Basemap data in **a** from Eurostat[54] under a Creative Commons license CC BY 4.0.

by onshoring BEV production to the EU to bypass export-related costs, including tariffs and long-distance transportation[17,18]. While onshoring eliminates these export-related expenses, it also exposes automakers to higher factor costs (for example, labour, land and energy) and more stringent compliance costs with regulations (for example, environmental and carbon-related regulations). To parameterize the cost implications, we compare prices of 18 BEV models sold by domestic manufacturing in both the Chinese and EU markets, using the observed price discrepancies as a proxy for production cost variation[19,20]. This comparison yields an average price difference of 20% under the mid case (Supplementary Table 7), with assumed differences of 10% and 30% for the low and high cases, respectively. Under this scenario, 46 BEV models exhibit price decreases related to pre-tariff levels under the mid case, with Omoda 5, Leapmotor C10 and DR 1.0 showing the largest reductions. The number of models with price reductions rise to 51 under the low case and falls to 33 under the high case.

WIT scenario

The withdrawing from the EU (WIT) scenario is designed as a bounding case to examine how EU electrification outcomes would change if China-produced BEVs become less available in the EU market under a more restrictive external environment. Rather than representing a prediction of near-term firm exit under current tariff levels, the WIT scenario captures the potential consequences of broader market disruption arising from non-economic factors, including geopolitical tensions, regulatory uncertainty, investment retrenchment and strategic supply-chain reallocation. The three WIT cases represent progressively more severe reductions in market availability: in the low case, only China domestic brands (36 models) are assumed to become unavailable; in the mid case, this extends to brands partially or fully acquired by Chinese companies (13 models); and in the high case, all China-produced BEVs are assumed to become unavailable in the EU market. These cases are intended to reflect different levels of disruption severity, rather than calibrated probabilities of firm withdrawal.

Heterogeneous TCO impacts across vehicle segments

To translate model-level price adjustments into consumer-relevant cost implications, we convert price variations into TCO based on 2024H1

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Table 1 | Scenarios and cases design on automaker response scenarios

Scenario	Description	Case	Description
ADA	Automakers continue exporting BEVs from China to the EU and respond to the tariff shock through pricing adjustments.	Low	Prices constrained by variable cost (zero-profit continuation).
		Mid	Partial tariff pass through (intermediate adjustment).
		High	Full tariff pass through to consumers.
ONS	Automakers shift BEV manufacturing from China to the EU to bypass export-related costs.	Low	Onshoring raises retail price by 10%.
		Mid	Onshoring raises retail price by 20%.
		High	Onshoring raises retail price by 30%.
WIT	Automakers withdraw China-produced BEVs from the EU market.	Low	Exit of purely domestic Chinese brands.
		Mid	Exit of domestic Chinese brands and Chinese-acquired brands.
		High	Exit of all China-produced BEVs, including foreign brands manufactured in China.

market conditions, incorporating expenditures on depreciation, energy, maintenance, taxation and insurance[21,22].

At the EU20 level (the 20 EU countries covered in this study), tariff-induced TCO impacts are moderate on average but highly uneven across countries and vehicle classes, with the strongest effects concentrated in price-sensitive segments and lower-income markets (Fig. 3). This heterogeneity becomes more apparent when examined across all country–segment combinations (Fig. 3a,e). Under the ADA and ONS scenarios, C2 in Slovakia consistently emerge as the most affected segment, with TCO increases of 25.2% under the ADA (high case) and 27.5% under the ONS (high case). Under the WIT scenario, C5 in Ireland, France and Spain exhibit the largest increases in the low and mid cases, with TCO rises of 19.1%, 16.1% and 14.1%, respectively. The impacts become more extreme under the high case, where S2 in Romania experience a TCO increase of 69.4%, followed by Bulgaria (+61.2%) and Estonia (+51.3%). This pattern is driven by the exit of the best-selling Dacia Spring, a low-cost model that is strongly preferred by local consumers.

When aggregated to broader dimensions, the magnitude of TCO impacts becomes more balanced across vehicle classes (Fig. 3b) and countries (Fig. 3c). At the EU20 level (Fig. 3d), the average TCO changes range from −2.4% under the ONS scenario (low case) and +4.4% under the WIT scenario (high case), indicating that aggregate impacts are modest relative to the substantial variation observed at the segment level. TCO increases of over 60% are observed for compact SUVs (S2) in Romania and Bulgaria under the WIT scenario (high case).

To further illustrate the underlying price-to-TCO transmission mechanism at the model level, we take Germany, the EU's largest EV market, as an illustrative case (Fig. 4). For example, in the mid-size car (C3) class (Fig. 4c), which accounts for 16% of total BEV sales in Germany (Fig. 4k), we list the TCO of the three best-selling non-China-produced BEV models (Volkswagen ID.3, Renault Megane and Opel Astra) alongside the three top-selling China-produced models (MG 4, Polestar 2 and GWM Ora 03). The sales-weighted average pre-tariff TCOs for non-China-produced and China-produced BEVs in this class are estimated at €59,767 and €50,292, respectively.

Under the ADA scenario (mid case), GWM Ora 03 is projected to maintain its price, while MG 4 and Polestar 2 experience price increases of 3% and 9%, respectively. As a result, the sales-weighted average TCO of China-produced BEVs rises by 3.0% to €51,950. Under the ONS scenario (mid case), Polestar 2's price increases by 14%, whereas MG 4 and GWM Ora 03 benefit from price reductions of 23% and 34%, respectively, leading to a 14.4% decline in the average TCO. By contrast, under the WIT scenario (low case), where China-produced BEVs from Chinese domestic brands exit, the average TCO increases by 1.2%. This smaller change reflects the fact that the WIT low case removes only a subset of China-produced BEV offerings, whereas the ONS scenario modifies the prices of the remaining models directly. Consequently, average TCO changes are shaped by model composition and sales-weighted exposure, rather than by the nominal severity of the scenario alone. Across the nine cases, the ADA (high case) yields the largest TCO increase in this segment, whereas the ONS (low case) delivers the greatest TCO reduction.

This price-to-TCO transmission mechanism generalizes across vehicle classes in Germany (Fig. 4a–j), but the magnitude and direction of TCO changes vary substantially by segment and automaker response strategies. The largest TCO increase and decrease occur at compact car (C2, +39.0%) under the ONS scenario (high case) and mid-size car (C3, −20.4%) under the ONS scenario (low case), respectively. While China-produced BEVs often remain cheaper than comparable non-China-produced models, tariffs reduce this price advantage to varying degrees, and the resulting impact on EV adoption depends on how automakers adjust prices, production or market presence under different scenarios.

Electrification trajectories under multiple scenarios

To examine how EU import tariffs on China-made BEVs may reshape the electrification pathway under multiple automaker response strategies, we further project EV adoption across EU countries and vehicle classes through 2035 by employing the New Energy and Oil Consumption Credit (NEOCC) model (Methods). The NEOCC model is a transportation market dynamics quantification framework originally developed by Oak Ridge National Laboratory, which has been utilized to project the market shares of vehicle types, classes and technologies under policy constraints[23–25]. The NEOCC-based projections in this study do not impose EU fleet CO_2 compliance constraints, but the model allows to calculate annual fleet-wide CO_2 emissions and assess the gap between model outcomes and policy targets (details in Supplementary Note 3).

Under the BAU scenario, EV adoption accelerates steadily from 2025 onwards, reaching 46% by 2030 and 64% by 2035 at the EU20 level (Fig. 5a). Relative to this baseline trajectory, multiple automaker responses to the tariff induce pronounced divergences in electrification outcomes (Fig. 5b). Under the ADA scenario, EV adoption slows modestly, with the EU20 EV share projected to be 0.7% (low case), 1.2% (mid case) and 3.8% (high case) lower than BAU in 2035. By contrast, onshoring BEV production accelerates electrification, making the EV share by −0.1% (high case), +2.1% (mid case) and +4.5% (low case). These contrasting outcomes indicate that changes in EV adoption are not driven by the tariff in isolation, but by how automakers respond to the tariff shock. Tariffs combined with price pass through tend to increase BEV prices and weaken EV competitiveness, thereby reducing adoption. By comparison, tariffs combined with production relocation remove tariff- and transport-related costs; for some models, these savings more than offset the assumed increase in production costs, leading to lower projected prices and TCOs and, in turn, higher EV uptake in certain markets. The WIT scenario generates more heterogeneous outcomes. If only foreign-brand models produced in China (for example, Dacia Spring and Tesla Model 3) remain available, EV adoption increases by 3.2%. However, if all China-produced BEVs withdraw from the EU market, electrification is substantially hindered, with the EV share falling by 8.0%.

At the national level, electrification trajectories remain highly divergent (Fig. 5c). Denmark, Sweden, Finland and the Netherlands

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Fig. 2 | Projected price changes of China-produced BEVs under different scenarios. a, Additional tariff rates, the share of variable costs and type of brand for BEVs from different brands. **b**, Prices of each model in the EU and Chinese markets, along with projected price changes under the ADA and ONS scenarios. The red and blue dots represent prices in the Chinese and EU markets, respectively. The orange and green squares indicate the projected prices under the ADA and ONS scenarios, respectively. For each scenario, the square represents the projected price in the mid case, with the left and right ends of the error bar indicating the low and high cases, respectively. AC, brand partially or fully acquired by Chinese brand; CN, China domestic brand; non-CN, non-China domestic brand.

have already reached EV shares of over 50% and are projected to exceed 80% by 2035, whereas six countries are expected to remain below 50% by 2035. These trajectories are further reshaped under multiple automaker response scenarios (Fig. 5d). Under the ADA scenario, Greece and Romania are the most affected markets, with EV shares in 2035 falling by 6.4% and 6.3%, respectively, under the high case. Under the ONS scenario, electrification accelerates most strongly in Romania (+5.0%), Greece (+3.5%) and Ireland (+3.5%) under the mid case. The WIT scenario generates the most polarized outcomes. Under the mid case, EV adoption rises sharply in Greece (+9.3%), Italy (+6.0%) and Romania (+5.3%). By contrast, when all China-produced BEVs exit, these same countries experience the largest declines, led by Greece (−16.8%) and Romania (−14.9%).

At the class level, electrification progresses most rapidly in larger vehicle segments, with C4, C5, S4 and S5 projected to reach around 80% EV share by 2035 (Fig. 5f). However, adoption trajectories diverge under multiple automaker response scenarios. Under the ADA scenario (mid case), EV shares decline in six of the ten classes. By contrast, the

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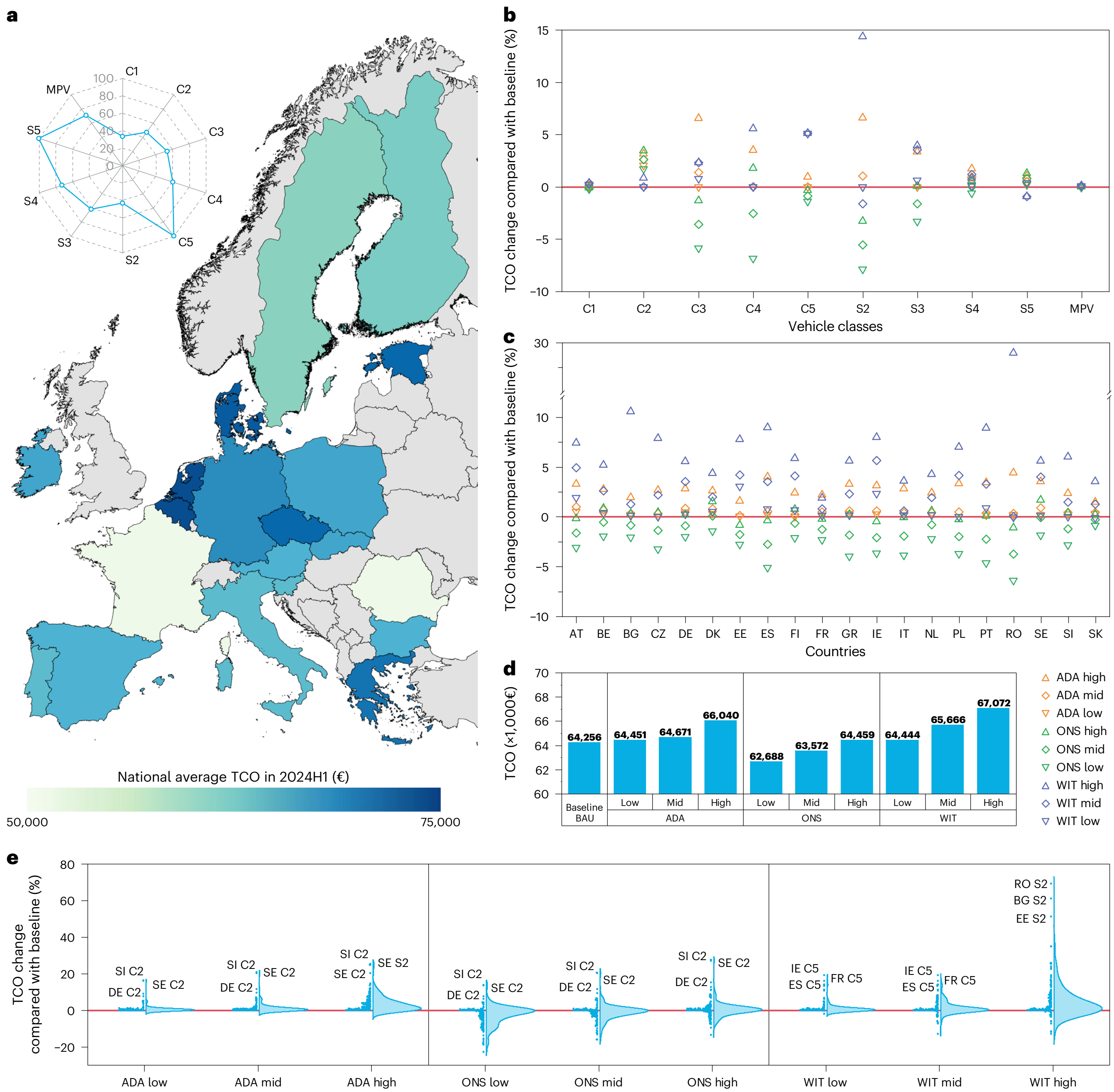

Fig. 3 | TCO estimates for BEVs in 20 EU countries across 10 vehicle classes. **a**, Average TCO in 2024H1 at national and vehicle class levels under baseline. The colour shading across countries represents the national average TCO. The radar chart displays the average TCO by vehicle class. **b**, TCO differences by vehicle class compared with baseline under various scenarios and cases. The symbols of different shapes represent TCO changes under various scenarios and cases. **c**, TCO differences by country compared with baseline under various scenarios and cases. The symbols of different shapes represent TCO changes under various scenarios and cases. **d**, The average TCO at the EU20 level under various scenarios and cases. **e**, The distribution of TCO change compared with baseline across various scenarios and cases. Several extreme segments are labelled. More details are shown in Supplementary Figs. 15–43. Country names are described using ISO alpha-2 code, as detailed in Supplementary Table 4. Basemap data in **a** from Eurostat[54] under a Creative Commons license CC BY 4.0.

ONS scenario (mid case) accelerates adoption in five classes, with particularly strong gains in S2 (+5.7%), C5 (+5.1%) and MPV (+4.1%). Under the WIT scenario (low case), sharp declines already emerge in C5 (−14.1%), S5 (−5.1%) and MPV (−4.9%). These effects intensify under the mid case, where six classes exhibit EV share changes exceeding 5%, including strong contractions in C5 (−15.9%) and S5 (−11.4%), alongside expansions in S2 (+12.9%). Under the high case, EV shares decline across all classes, with the largest reductions observed in C1 (−17.2%).

Although average impacts on EV adoption remain moderate, large disparities emerge across individual market segments (Fig. 5g). Under the ADA scenario (high case), several segments experience strong reductions, including S2 in Romania (−9.7%), C5 in Italy (−8.1%) and C3 in Greece (−8.0%). The ONS scenario exhibits a more dispersed distribution of outcomes, particularly under the low case. The largest declines occur in the MPV segment in Belgium (−18.0%), Austria (−17.0%) and Germany (−15.4%), while the strongest gains appear in S4 in Poland

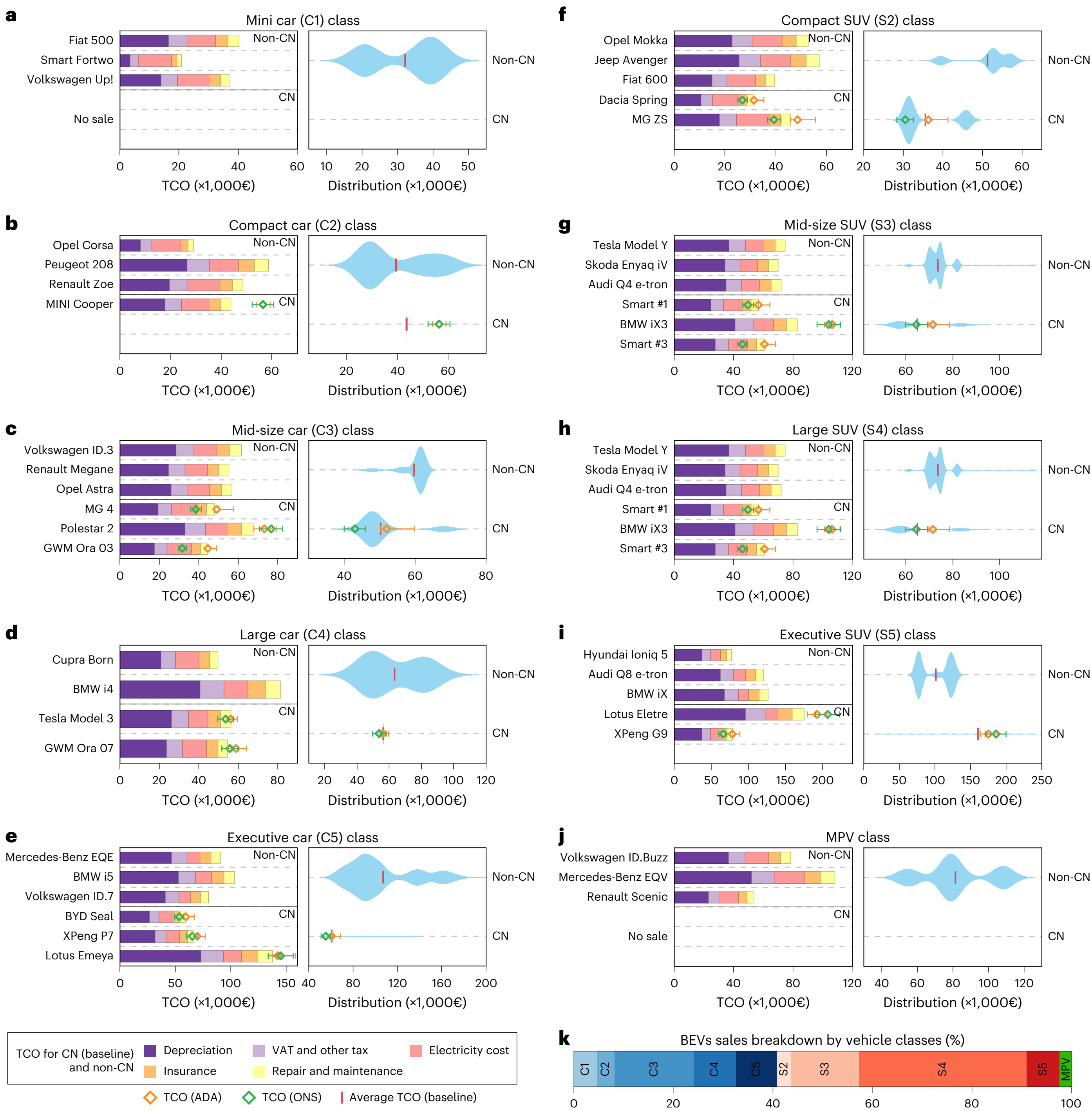

Fig. 4 | TCO estimations for BEVs in Germany. a–j, TCO estimations for different vehicle classes: C1 (**a**), C2 (**b**), C3 (**c**), C4 (**d**), C5 (**e**), S2 (**f**), S3 (**g**), S4 (**h**), S5 (**i**) and MPV (**j**). Left: the TCO breakdown for the three best-selling non-China-produced and China-produced BEV models under baseline (listed in Supplementary Table 8). Right: the blue shades indicate the sales-weighted TCO distribution and the red lines indicate the average TCO under baseline. Orange and green squares indicate the projected TCO under the ADA and ONS scenarios, respectively. For each scenario, the square represents the projected price in the mid case, with the left and right ends of the error bar indicating the low and high cases, respectively. **k**, BEV sales breakdown by vehicle classes. Cases in other 19 countries are provided in Supplementary Figs. 44–62.

(+19.5%), C5 in Italy (+19.0%) and C1 in the Netherlands (+19.0%). The WIT scenario generates the most extreme outcomes. Under the low case, nine segments experience EV share reductions exceeding 10%, led by C5 in Italy (−32.8%), Spain (−27.4%) and France (−27.2%). Moreover, the high case produces widespread contraction, with 50 out of 200 segments experiencing declines greater than 10%, including extreme losses in S2 in Romania (−69.4%), C3 in Greece (−50.0%) and C4 in Belgium (−46.3%).

Recognition of vulnerable segments

Together, these results show that although the average impact of EU import tariffs on EV adoption is moderate at the aggregate level, tariff-induced shocks generate highly uneven electrification outcomes across countries and vehicle classes. Adoption losses are concentrated in price-sensitive markets and segments that rely heavily on affordable China-produced BEVs, reflecting how tariff-induced cost increases

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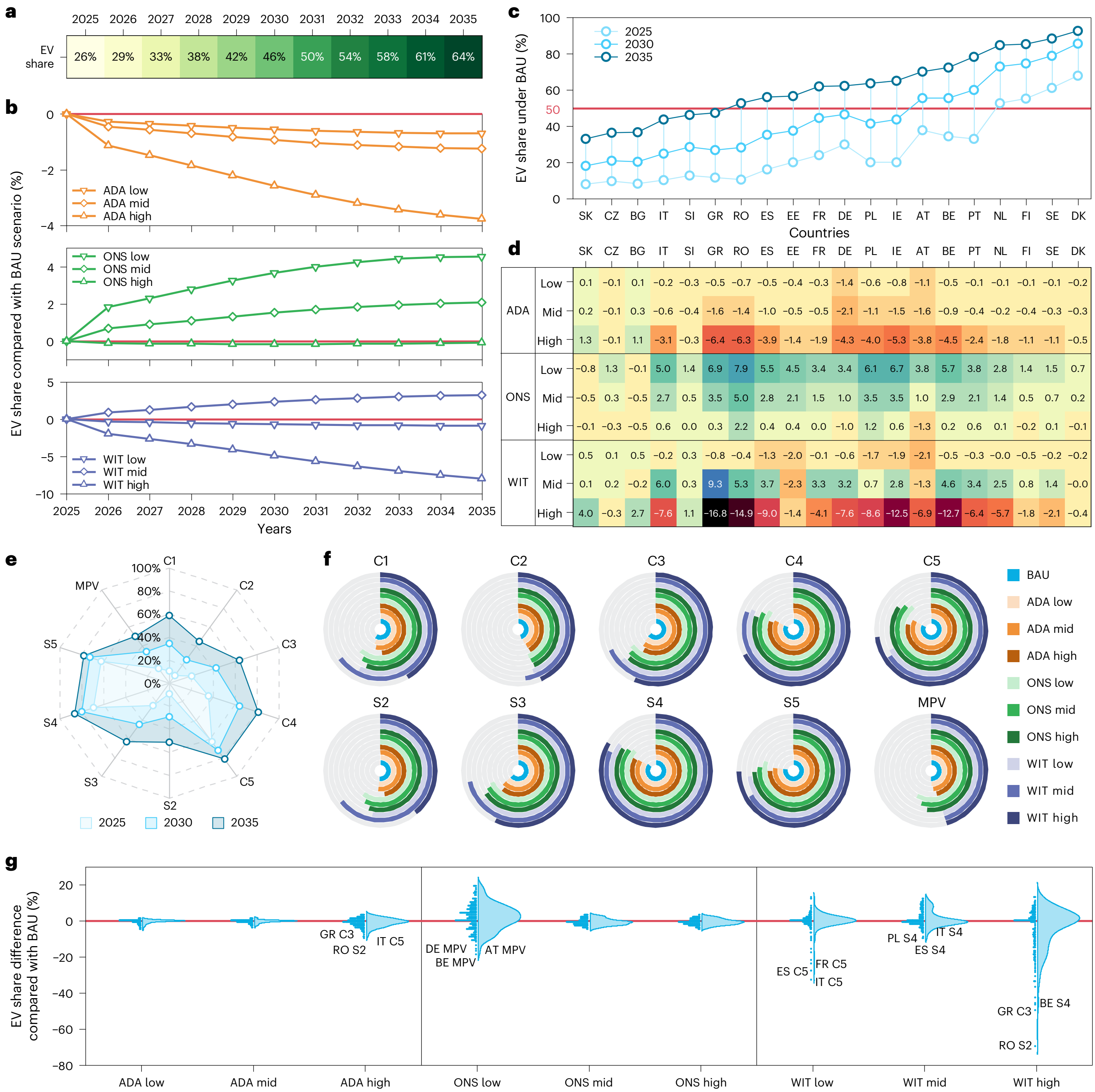

Fig. 5 | EV share projections in 20 EU countries across 10 vehicle classes. **a**, Annual EV share projections from 2025 to 2035 under the BAU scenario. **b**, Annual EV share differences compared with the BAU scenario across multiple scenarios and cases. **c**, EV share projections across 20 EU countries in 2025, 2030 and 2035 under the BAU scenario. **d**, EV share differences compared with the BAU scenario across 20 countries under different scenarios and cases. **e**, EV share projections across vehicle classes in 2025, 2030 and 2035 under the BAU scenario. **f**, Projected EV share across vehicle classes in 2035 under various scenarios and cases. **g**, The distribution of EV share difference compared with BAU in 2035 across various scenarios and cases. Several extreme segments are labelled. More details are shown in Supplementary Figs. 63–96. Country names are described using ISO alpha-2 code, as detailed in Supplementary Table 4.

interact with heterogeneous model portfolios and consumer price sensitivity to reshape market structure.

This distributional dimension becomes particularly clear when electrification outcomes are examined alongside structural vulnerability indicators (Fig. 6). Small-to-medium vehicle classes (C1–C3 and S2–S3) and lower-income member states cluster in the low-adoption, high-affordability-constraint region and experience larger relative adoption losses under multiple scenarios. Consumers of mini cars (C1) are the most cost sensitive, with the lowest TCO at €33,514 among all vehicle classes. However, EV adoption in this class remains relatively weak, reaching only 58.9% by 2035, making it particularly vulnerable. The negative impact is more pronounced under policy stress: the EV share drops by 10.0% under the high case of the ADA scenario and by 17.2% under the high case of the WIT scenario. Similarly, Romania is identified as a vulnerable national market, where consumers have the second-lowest median income (€6,568) and an EV adoption rate of just

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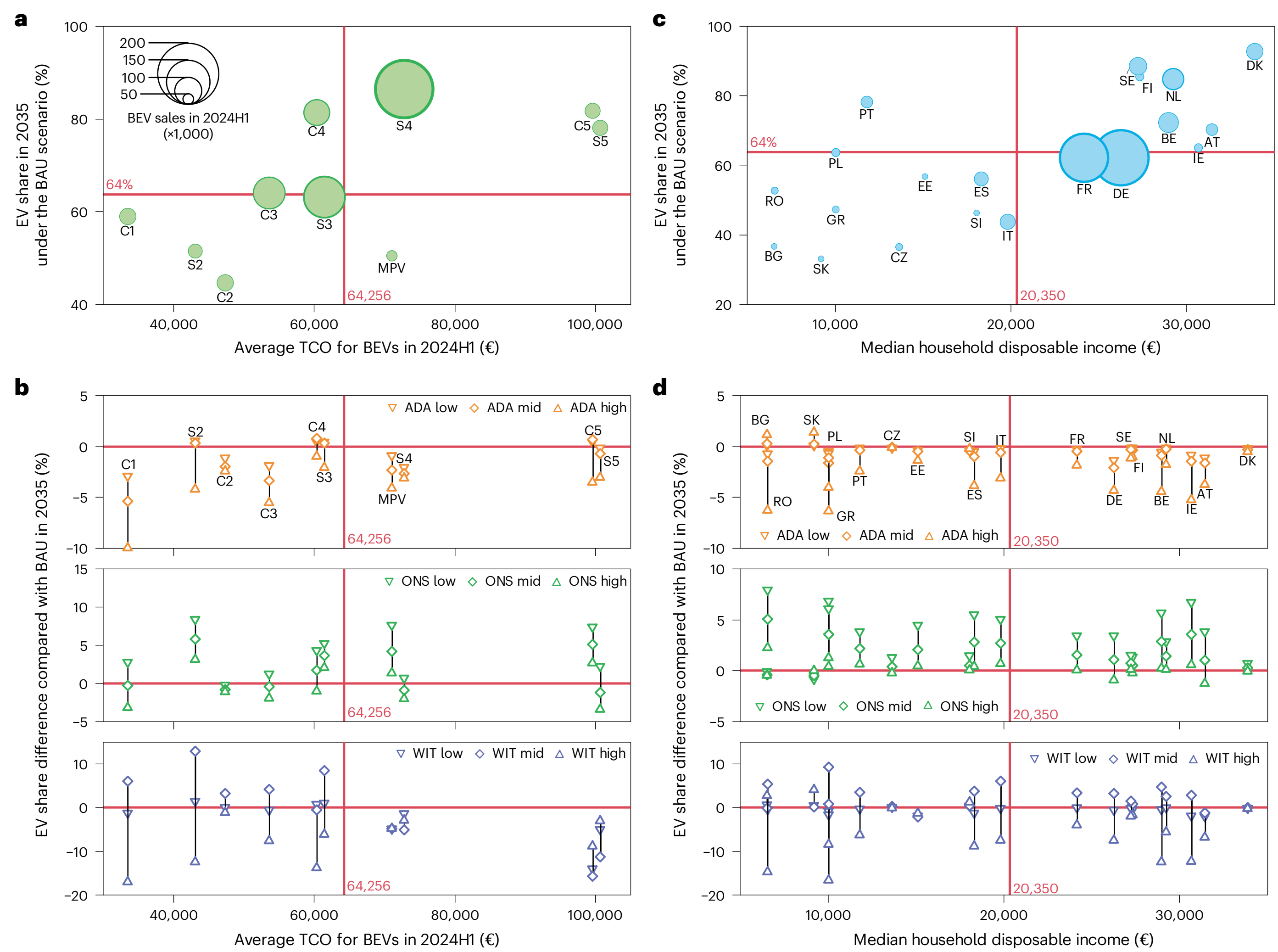

Fig. 6 | EV penetration against vulnerability indicators across countries and vehicle classes under various scenarios and cases. a, Projected EV penetration in 2035 versus TCO in 2024H1 at the vehicle class level under the BAU scenario. The red lines represent the sales-weighted average values of all countries and vehicle classes. **b**, Projected EV share difference compared with BAU in 2035 versus TCO in 2024H1 at the vehicle class level under the ADA, ONS and WIT scenarios. **c**, Projected EV penetration in 2035 versus median household disposable income in 2024H1 at the national level under the BAU scenario. The red lines represent the sales-weighted average values of all countries and vehicle classes. **d**, Projected EV share difference compared with BAU in 2035 versus median household disposable income in 2024H1 at the national level under the ADA, ONS and WIT scenarios. Country names are described using ISO alpha-2 code, as detailed in Supplementary Table 4.

52.6% in 2035. These vulnerabilities are exacerbated under ADA and WIT responses. However, Romania stands to benefit substantially if automakers opt to onshore their EV production. These patterns highlight a potential tension between uniform trade interventions and the objective of an inclusive electrification transition.

Discussion

Recognizing these vulnerable markets, tariff policy may be embedded with a broader policy framework that reconciles industrial objectives with distributional considerations. In small-to-medium classes, China-produced BEVs retain a cost advantage, in part due to their extensive use of low-cost lithium iron phosphate batteries, a technology in which EU automakers lag[26]. In the absence of complementary measures, uniform tariff application in these markets risks weakening affordability. Mitigation strategies could focus on strengthening the competitiveness of the EU-based supply chain, including accelerated onshoring of lithium iron phosphate battery production and the strategic use of tariff revenues to support incentives for consumers in vulnerable countries and classes purchasing EU-produced BEVs. The EU's consideration of a recycling tariff income into EV subsidies points in this direction[27,28], but a more explicitly distribution-aware design could be essential to ensure that trade policy and electrification objectives remain mutually reinforcing.

The responses of automakers are shaped not only by tariff policy but also by the broader regulatory and industrial environment. Our results indicate that onshoring BEV production represents the most cost-effective strategy, with the potential to lower transition costs while supporting the EU's manufacturing base. However, the current EU policy environment does not yet appear fully aligned with this objective. For example, Farasis Energy, a leading battery manufacturer in China, has proposed a 10-GWh battery production facility in Saxony-Anhalt, Germany, serving an expansion of local production capacity[29]. Yet regulatory hurdles, including land-use approval delays and concerns over supply chain security, have stalled the project for over 3 years[30]. While not all onshoring initiatives face similar barriers, for instance, the investments and construction projects by BYD and CATL in Hungary are progressing successfully, such frictions illustrate how regulatory uncertainty and permitting constraints can weaken

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investment incentives in strategically important segments of the EV value chain. Given the projected electrification gains from onshoring, closer alignment between trade policy and industrial policy could play a critical role in realizing cost-effective electrification while strengthening EU's domestic EV supply base.

The WIT scenario, in which China-produced BEVs become less available in the EU market under a more restrictive external environment, is intended as a stress-test of market disruption rather than a prediction of near-term firm exit. Since the introduction of the additional tariffs, limited progress in EU–China negotiations and retaliatory trade measures have increased political and commercial uncertainty[31,32]. In this context, several automakers and battery suppliers have begun to reassess their European investment strategies[33,34]. From a transition perspective, such dynamics may raise concerns about the resilience of Europe's electrification pathway. Our results indicate that China-produced BEVs play an important role in several price-sensitive and lower-income markets, where affordable models are essential for sustaining adoption momentum. If broader trade, regulatory or geopolitical disruptions were to reduce the availability of these models, the resulting supply contraction could not only reshape market structure, but also slow electrification precisely where progress is already fragile. These findings highlight the importance of confidence-building measures that preserve investment incentives and supply-chain continuity during the transition. Potential approaches include joint ventures between global and EU automakers to strengthen local value chains, clearer regulatory guidance for overseas manufacturers and more structured dialogue between industry and EU institutions to reduce policy uncertainty[35]. More broadly, maintaining a predictable and cooperative trade environment may be an important condition for ensuring that electrification proceed in a stable and resilient manner.

In addition, price undertaking arrangements have recently been introduced as an alternative to tariff-based measures in the EU–China EV trade context, reflecting a broader evolution in trade policy instruments[36]. While such arrangements are conceptually distinct from the automaker response strategies, their potential implications for electrification outcomes are assessed in the Supplementary Note 5. The EU's Fit for 55 packages also requires manufacturers to meet fleet-wide emission targets by 2035. As the 2035 target of 90% reduction on fleet emissions is not reached under any scenario, additional policies and incentives that support EV adoption in the EU will also be necessary to advance electrification (Supplementary Note 3).

This study is subject to several limitations. First, our analysis adopts a scenario-based framework to explore plausible automaker response strategies rather than to predict firm-level decisions, which will ultimately depend on evolving market, regulatory and geopolitical conditions. Second, while our adoption projections capture dynamic interactions between ownership costs and consumer choice, future policy adjustments, such as changes in purchase incentives or CO_2 standards, could alter electrification trajectories beyond the scope of this study. Third, the market diffusion analysis focuses on new passenger vehicle sales and does not explicitly account for secondhand vehicle markets, which may moderate observed EV penetration in some countries[37] (Supplementary Note 6). Finally, our focus is on consumer affordability and adoption outcomes, rather than on the full system-wide implications of trade policy for lifecycle emissions and supply-chain transformation. These limitations could be addressed in future studies.

Methods

Tariff scope and applicability

According to the EU tariff regulation, the product concerned is new BEVs, principally designed for the transport of nine or fewer persons, propelled solely by one or more electric motors[38]. Therefore, the analysis focuses on vehicles classified in the M1 category, aligning with the scope of the EU's antisubsidy investigation[38,39].

Determining vehicle production origin

The additional tariff is applied to BEVs produced in China. We determine the production locations of BEV models by collecting automakers' production information via the MarkLines database[4]. Given the complexity of the global supply chain, there are BEV models that have multiple production sites. For these models, we examine their production capacity via official website and make the following assumptions: (1) for models with production capacity in both China and the EU (for example, BMW i5), the EU-sold vehicles are assumed to be primarily produced in the EU and free from the tariff; (2) for models with production capacity in both China and other countries beyond the EU (for example, Tesla Model 3), we trace the actual supply chain relationship to determine their subjection to the tariff. The list of models subject to the additional tariff is provided in Supplementary Table 10.

Vehicle segmentation and classification

In this study, passenger vehicles are divided into three main types (cars, SUVs and MPVs). Cars and SUVs are further divided into five classes according to vehicle wheelbase, that is, mini (less than 2,450 mm), compact (2,450–2,600 mm), mid-size (2,600–2,750 mm), large (2,750–2,900 mm) and executive (more than 2,900 mm). Owing to the negligible sales, mini SUVs are not covered in the analysis. MPVs are not further divided owing to the largely consistent size within this vehicle type. Above all, we categorize passenger vehicles into ten vehicle classes (five for cars, four for SUVs and one for MPVs), as detailed in Supplementary Table 11. The vehicle models covered in the vehicle classes are presented in Supplementary Table 12.

Vehicle sales

Vehicle sales are obtained from the MarkLines database[4], which provides country-level, monthly vehicle sales records. Out of the 27 EU countries, data are available for 23 countries, with data for Cyprus, Malta, Latvia and Lithuania unavailable. In addition, for Croatia, Luxembourg and Hungary, the database only reports EV sales for Tesla and unknown brands, which is insufficient to support the analysis. Thus, these seven countries are excluded from the analysis. For reasons discussed in the main text, we retrieve sales data for 2024H1 as the baseline for analysis.

Vehicle retail price

The manufacturer's suggested retail prices of vehicle models are sourced from Chinese[20] and EU[19,40] online databases. For one BEV model, there are typically multiple trims with varying performances (such as, range capacity, horsepower, hardware and software configurations) and prices. For comparability, we consistently use the medium-performance trims retail price as the basis for analysis. In addition, the exchange rates are based on the average value during 2024H1, listed in Supplementary Table 13.

TCO-related data

We compile a wide range of data sources to support the TCO estimation. The details are introduced in the 'TCO' section.

ADA scenario

In this context, we characterize a feasible price-adjustment space bounded by two economic constraints[41]. The lower bound corresponds to a zero-profit continuation condition, under which automakers price their vehicles at variable cost to remain in the market under intense competitive pressure. The upper bound corresponds to full tariff pass through, whereby the entire tariff burden is shifted to consumers. Between these bounds, intermediate adjustment paths reflect partial pass through under heterogeneous demand and competitive conditions. We therefore construct three cases to span this response space. In the low case, prices are adjusted only when the post-tariff variable cost exceeds the current price. In the high case, prices increase by the full amount of the tariff-induced cost increment. In the mid case, prices adjust to the average of the variable-cost threshold and the full pass-through price whenever this exceeds the current price. Variable costs are proxied using automaker-level operating cost shares derived from financial statements, providing a conservative benchmark for long-run pricing constraints.

Price adjustments are driven by the interaction between tariff-induced cost increases and model-specific variable cost structures. We construct three cases that span the feasible price-adjustment space under competitive and cost constraints. Detailed parameter values and data sources ranges are reported in Supplementary Note 2.

In the low case, prices are bounded by a zero-profit continuation condition, under which automakers adjust prices only when the post-tariff variable cost exceeds the current EU retail price. The projected price is determined by equation (1)

$$P_{\mathrm{ADA,low}} = \max\left(P_{\mathrm{EU}}, P_{\mathrm{VC}}\right), \tag{1}$$

where $P_{\mathrm{ADA,low}}$ is the projected retail price under the ADA low case (€), P_{EU} is the pre-tariff retail price in EU market (€) and P_{VC} is the post-tariff variable-cost threshold price in the EU market (€).

The post-tariff variable-cost threshold price is calculated in equation (2)

$$P_{\mathrm{VC}} = P_{\mathrm{CN}} \times \omega_{\mathrm{VC}} + C_{\mathrm{Ins}} + C_{\mathrm{Fre}} + C_{\mathrm{Tar}}, \tag{2}$$

where P_{CN} is the Chinese-market retail price (€), ω_{VC} is the variable cost share inferred from automaker financial statements (%), C_{Ins} is the insurance cost (€), C_{Fre} is the freight cost (€) and C_{Tar} is the tariff amount (€).

The tariff amount is calculated in equation (3)

$$C_{\mathrm{Tar}} = \left(P_{\mathrm{CN}} + C_{\mathrm{Ins}} + C_{Fre}\right) \times q_{\mathrm{TT}}, \tag{3}$$

where q_{TT} is the total tariff rate, including 10% basic tariff and additional tariff (%).

In the high case, tariffs are assumed to be fully passed through to consumers. The projected price is determined by equation (4)

$$P_{\mathrm{ADA,high}} = P_{\mathrm{EU}} + \left(P_{\mathrm{CN}} + C_{\mathrm{Ins}} + C_{\mathrm{Fre}}\right) \times q_{\mathrm{AT}}, \tag{4}$$

where $P_{\mathrm{ADA,high}}$ is the projected price under the ADA high case (€) and q_{AT} is the additional tariff rate (%).

In the mid case, prices follow an intermediate adjustment path between the zero-profit floor and full pass-through ceiling. The projected price is shown in equation (5)

$$P_{\mathrm{ADA,mid}} = \max\left(P_{\mathrm{EU}}, \frac{P_{\mathrm{VC}} + P_{\mathrm{ADA,\,high}}}{2}\right), \tag{5}$$

where $P_{\mathrm{ADA,mid}}$ is the projected price under ADA mid case (€).

ONS scenario

To parameterize the cost implications of production relocation, we draw on both industry estimates and observed cross-market price differentials. According to an investigation by United Bank of Switzerland, relocating BEV production from China to the EU is expected to increase production costs by 25% (refs. 42,43). Consistent with this assessment, we compare prices of 18 BEV models sold by domestic manufacturing in both the Chinese and EU markets, using the observed price discrepancies as a proxy for production cost variation[19,20]. This comparison yields an average price difference of 20% (Supplementary Table 7), aligning closely with the United Bank of Switzerland estimation.

Based on these benchmarks, we define three cases to reflect uncertainty around the magnitude of onshoring cost increases. In the mid case, onshoring raises production costs and hence prices to 120% of their Chinese-market prices. The low and high cases assume price increases of 10% and 30%, respectively, capturing a plausible range of outcomes around the central estimate. We parameterize the resulting price change using observed cross-market price differentials as a proxy for production cost differences. The projected EU retail price under onshoring is given by equation (6)

$$P_{\mathrm{ONS,case}} = P_{\mathrm{CN}} \times \left(1 + \alpha_{\mathrm{case}}\right), \tag{6}$$

where $P_{\mathrm{ONS,case}}$ is the projected price under the ONS scenario (€) and α_{case} is the assumed production cost differential, set to 10%, 20% and 30% for the low, mid and high cases, respectively.

WIT scenario

Rather than representing a prediction of firm-level market exit, the WIT scenario is designed as a stress-test to examine how electrification outcomes would change if the availability of China-produced BEVs in the EU market is reduced under a more restrictive external environment. Given the heterogeneity in ownership structures, production networks and strategic positioning across automakers, we also construct three cases to capture progressively more restrictive levels of market availability. In the low case, only purely domestic Chinese brands (for example, BYD and GWM) are assumed to become unavailable in the EU market. In the mid case, withdrawal extends to brands that have been partially or fully acquired by Chinese firms (for example, MG and Volvo). In the high case, market exit further encompasses foreign automakers whose BEVs are primarily manufactured in China for export to the EU, such as Tesla and BMW.

TCO. The TCO is defined as the discounted lifetime costs incurred by a vehicle owner over the service life of the vehicle[21,22]. In this study, TCO is estimated for both BEVs and PHEVs, capturing their respective cost structures over the ownership period. Typically, TCO comprises depreciation, taxes, energy, insurance and repair and maintenance costs. Depreciation reflects the loss of value over the operational lifetime. Taxes include one-off purchase taxes (for example, value-added tax (VAT), registration and license fees) and recurring ownership-related taxes (for example, road tax and inspection tax). Energy costs capture the cost of electricity consumption for BEVs and the cost of both electricity and fuels for PHEVs. Insurance is compulsorily required and typically determined by vehicle retail price. Repair and maintenance cost represents the cost of repairing and replacing components over a vehicle's lifetime. The TCO calculation is shown in equation (7)

$$\mathrm{TCO} = C_{\mathrm{DP}} + C_{\mathrm{TO}} + C_{\mathrm{IS}} + C_{\mathrm{RM}} + \sum_{t=0}^{\mathrm{LS}} \frac{C_{\mathrm{Tt}} + C_{\mathrm{EC}}}{\left(1 + \mathrm{DR}\right)^{t}}, \tag{7}$$

where C_{DP} is the depreciation cost (€), C_{TO} is the one-off purchase tax (€), C_{IS} is the insurance cost (€), C_{RM} is the repair and maintenance cost (€), C_{Tt} is the annual recurring tax (€ yr^{-1}), C_{EC} is the annual energy cost (€ yr^{-1}), LS is the assumed vehicle lifespan (yr) and DR is the discount rate (%).

Depreciation cost is estimated as the difference between the purchase price and the end-of-life residual value, based on the AFLEET model[44]. Taxes are calculated according to ACEA's Tax Guide, which provides country-specific vehicle taxation and incentive schemes across the EU[45,46]. Insurance and repair and maintenance costs are estimated by referring to the Car Cost Index report by LeasePlan in 2018, which provides TCO estimations across EU countries with a detailed cost breakdown[47]. The discount rate is determined by 5% under the baseline, based on the existing TCO assessment targeting Europe. See Supplementary Tables 14–16 for detailed information.

Energy cost is calculated based on vehicle use intensity and the energy consumption under the Worldwide Harmonized Light Vehicle

Test Procedure (WLTP) cycle, which is the standard fuel and electricity consumption testing protocol in the EU. Electricity and fuel prices are distinguished by country and the charging location (household or public). The calculation is shown in equation (8)

$$C_{\mathrm{EC}} = D \times \left(\mathrm{EC} \times \frac{(p_{\mathrm{el,hh}} \times \tau_{\mathrm{hh}} + p_{\mathrm{el,pb}} \times (1 - \tau_{\mathrm{hh}}))}{\eta_{\mathrm{ch}}} + \mathrm{FC} \times p_{\mathrm{fuel}} \right), \quad (8)$$

where D is the annual vehicle use intensity (km yr^{-1}), EC is the electricity consumption rate under the WLTP cycle (kWh km^{-1}), $p_{\mathrm{el,hh}}$ is the household electricity price (€ kWh^{-1}), $p_{\mathrm{el,pb}}$ is the public charging electricity price (€ kWh^{-1}), τ_{hh} is the share of household charging (%), η_{ch} is the charging efficiency (%), FC is the fuel consumption rate under WLTP cycle (l km^{-1}) and p_{fuel} is the fuel price (€ l^{-1}).

The electricity and fuel consumption rate are sourced from an online database and the fuel consumption for BEVs is set at zero[48]. The vehicle use intensity is from carVertical[49] (Supplementary Table 17). The country- and year-specific electricity and fuel prices are sourced from the EU Commission[50] (Supplementary Tables 18 and 19). The ratio of charging in households is assumed to be 80% following previous empirical studies[51]. The charging efficiency is assumed to be 90% (ref. 52).

EV share projection. To translate tariff-induced changes TCO into market adoption dynamics, we employ the NEOCC model, a transportation market dynamics quantification framework originally developed by Oak Ridge National Laboratory.

The NEOCC model integrates the discrete choice method with the genetic algorithm to quantify and project the market share of vehicle types, classes and technologies under policy constraints, while accounting for the dynamics interactions among refuelling infrastructure development, technological evolution and consumer preferences. In this study, we implement NEOCC as a three-level nested logit model, in which consumers choose sequentially across vehicle type, powertrain and vehicle class. Within this framework, changes in TCO enter the utility function directly and are translated into changes in market share through the nested choice structure. In addition to TCO, we calibrate an 'other cost' term to capture implicit and hard-to-quantify factors affecting vehicle choice. The calibration aims to minimize the discrepancy between simulated and observed market shares, and the resulting root mean square errors are below 0.002 across all calibrated years.

In this study, the NEOCC model is adapted to the EU passenger vehicle market and calibrated using country-level sales data and TCO estimates for BEVs and PHEVs from 2019 to 2025. Based on the assumed automaker response scenarios from 2026 onwards, the model is then used to simulate market dynamics through 2035 under multiple scenarios. Market structure and technology shares in 2023–2025 are used to initialize the baseline conditions. The projected EV shares therefore refer to new passenger vehicle market shares, rather than the full vehicle stock or all car acquisition channels in each country. Detailed model structure, calibrated sensitivity parameters and projection inputs are provided in Supplementary Note 4.

Data availability

The data that support the findings of this study are available within the Analysis and its Supplementary Information. Source data are provided with this paper.

Code availability

The code used for TCO modelling, together with the processed vehicle cost datasets, is available via figshare at https://doi.org/10.6084/m9.figshare.32146813 (ref. 53). The code used for EV adoption modelling and scenario analysis is available via GitHub at https://github.com/Translab-SCUT/Electrification-projection-in-European-Union-under-tariff-impact-scenarios-to-2035.

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Author contributions

Conceptualization by H.D., H.H., M.L., J.G., B.L., L.M. and X.S. Data curation by H.D., S.J. and L.M. Formal analysis by H.D. and S.J. Funding acquisition by H.H., B.L., Z.L. and F.Z. Investigation by H.D., S.J., M.L. and L.M. Methodology by H.D., S.J., M.L. and L.M. Software by H.D., S.J. and S.S.O. Supervision by S.S.O., H.H., X.Q., Y.G., K.H., F.M., D.R., Z.W. and J.T. Validation by S.S.O., H.H., X.Q., Y.G., K.H., F.M., D.R., Z.W., J.T., Y.W. and C.L. Writing—original draft by H.D., H.H. and X.S. Writing—review and editing by H.D., H.H., K.H., F.M., D.R., Z.W., J.T. and X.S.

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Competing interests

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Additional information

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