From Trade War to Green Transition: Optimal Electric Vehicle Tariffs with Revenue-Funded Subsidies [*]

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Abstract

We study the optimal design of trade and industrial policy when governments pursue environmental objectives alongside traditional national welfare. Motivated by the global transition to electric vehicles (EVs) and growing concerns about competitiveness, resilience, and the environment, we develop a framework in which policymakers choose tariffs and domestic production subsidies to maximize national welfare, defined as the sum of consumer surplus, domestic profits, environmental benefits, and tariff revenue net of subsidies. We combine a theoretical model of differentiated-product oligopoly with a structural demand model estimated using vehicle-level data from 13 countries during 2004-2023 that together account for the vast majority of global EV sales. Our central finding is that the optimal policy combines a moderate tariff on imported EVs with a subsidy to domestic EV production financed through tariff revenue. This policy substantially outperforms both outright protectionism and laissez-faire. Relative to current policies, it preserves consumer access to affordable EVs, accelerates fleet electrification, supports domestic producers, and remains budget-neutral. For the United States, the optimal policy more than doubles EV market share, generates over $45 billion in annual welfare gains, and avoids approximately 95 million tons of lifetime CO_2 emissions. A key mechanism underlying these results is the pass-through of tariffs and subsidies to prices, which depends critically on demand curvature, product substitution, and market structure. More broadly, our results suggest that effective industrial policy requires careful attention to market structure and country-specific conditions, balancing consumer, producer, fiscal, and environmental objectives rather than adhering to ideological prescriptions.

Keywords: Industrial policy, trade policy, tariffs, subsidies, energy transition, electric vehicles

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1 Introduction

Recent years have witnessed a resurgence of subsidies and other forms of industrial policy in countries that had largely refrained from their use in the past three decades, most notably the US (Juhász, Lane, and Rodrik, 2024; Juhász et al., 2025; Evenett et al., 2024). Although economists have traditionally been skeptical of industrial policy, several features distinguish the current wave. First, many interventions target genuine market failures and externalities, particularly in the context of energy transition and green growth, with a focus on sectors such as electric vehicles (EVs) and solar panels. Second, national security and resilience to geopolitical risk have become central policy objectives. Third, industrial policy has increasingly relied on (or been implemented in conjunction with) traditional trade policy instruments, such as tariffs and export restrictions, as illustrated by policies targeting the EV, semiconductor, and solar panel sectors. Fourth, the use of industrial policies and trade protectionism by the world's two largest economies, the US and China, has placed other countries in a difficult position, forcing them to balance competing objectives in their responses. In many cases, this has led to recommendations that depart sharply from past practice.[1]

A central dilemma for policymakers is whether to prioritize consumers or domestic producers and workers. A consumer-oriented approach implies abstaining from tariffs and a passive, if not welcoming, stance toward most foreign subsidies, as these reduce prices for domestic consumers. As international economists have often noted, if a country subsidizes its production and/or exports, the right response for an importing country is to "write a thank-you note" (Suranovic, 2010). This argument is even stronger in the presence of externalities, for example when subsidized imports of green technologies help reduce emissions. However, such imports may undermine domestic industries and adversely affect workers. The recent backlash against free trade and multilateralism underscores the importance of taking political economy, and in particular producer and worker responses, into account when setting policy. Furthermore, concerns about resilience, especially to geopolitical risks, have strengthened the case for domestic production rather than dependence on imports, irrespective of employment or profit considerations.

These tradeoffs are particularly salient in the EV sector. The global shift from internal combustion engine (ICE) vehicles to EVs represents the most significant transformation in passenger transportation in over a century. Since their mass-market introduction in 2011, EV sales have

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[1] For example, the Draghi report on European competitiveness (Draghi, 2024) explicitly advocates policies long resisted in Europe, including subsidies and tariffs. Similarly, a recent World Bank report on industrial policy (Fernandes and Reed, 2026) adopts a more nuanced stance relative to the past, acknowledging that sectoral targeting may at times be warranted.

reached 20.7 million units, accounting for nearly one-quarter of global new vehicle sales by 2025.[2] Adoption, however, varies widely across countries: EVs account for 97% of new vehicle sales in Norway, 69% in Denmark, 54% in China, 29% in Germany, and only 9% in the US (Figure 1). Countries seeking to reduce emissions have a strong interest in promoting EV adoption, including through imports from China. Although the rising global sales of Chinese EVs may be beneficial to consumers seeking affordable EVs, and desirable from an environmental perspective, they pose a significant challenge to domestic EV industries in the US and parts of Europe. Policy responses have included trade protection (prohibitive tariffs and import restrictions in the US, more moderate tariffs elsewhere), domestic subsidies, and growing calls for stronger government intervention to preserve domestic production capacity in support of both employment and resilience in an increasingly fragmented geopolitical environment.

Motivated by these developments, we develop a framework to jointly analyze trade and industrial policy when governments pursue environmental objectives along with traditional national welfare, as is the case in the EV sector. Policymakers maximize welfare, defined as the sum of consumer surplus, domestic firm profits, environmental externalities, and tariff revenue net of subsidies, using two instruments: tariffs and subsidies. We also consider alternative welfare formulations, including one in which the value of domestic jobs explicitly enters the welfare function.

Our analysis proceeds in two steps. We first develop a simple theoretical model in which domestic automakers compete with imported EVs in a differentiated-product oligopoly, yielding analytical insights on how optimal tariffs and subsidies depend on demand curvature, market structure, and the substitutability between domestic and imported products. We then estimate a flexible random-coefficients demand model of the global vehicle market (Berry, Levinsohn, and Pakes, 1995) using comprehensive data on vehicle sales and attributes from 13 countries over the 2004–2023 period. Together, these countries accounted for 85% of global ICE sales and 95% of EV sales during the sample period. The richness of our data allows us to estimate a highly flexible empirical specification. Consistent with prior work on cost pass-through, this flexible demand specification is crucial for understanding tariff and subsidy pass-through and therefore for optimal policy design. We validate this demand system out of sample using the October 2024 EU countervailing duty: empirical estimates from 2024–2025 data closely match the model's predicted effect on Chinese-brand EV sales.

A core result from our analyses is that the optimal policy package combines a modest tariff with a subsidy to domestic EV production, financed through tariff revenue (i.e., tariff revenue recycling). This policy balances the relevant tradeoffs: it preserves consumer access to affordable imported

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[2] EVs include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

EVs, supports the domestic industry through protection and subsidization, remains budget-neutral, and promotes EV adoption, thereby reducing emissions and generating environmental benefits. More broadly, our analysis suggests that effective policy requires embracing nuance rather than ideology: moderate tariffs combined with revenue-funded subsidies dominate both extreme protectionism and pure laissez-faire.

To illustrate this insight, we conduct a series of counterfactual analyses. We begin by evaluating the welfare effects of the trade and industrial policies recently adopted in the United States and the European Union: the US de facto ban on Chinese EVs and the EU's countervailing-duty regime introduced in late 2024. Two findings emerge. First, outright bans on Chinese EVs impose substantial welfare losses, largely by foreclosing consumer access to affordable EVs and slowing fleet electrification. Second, allowing Chinese EV entry under a combination of moderate tariffs and domestic EV subsidies markedly improves welfare relative to banning: the policy package yields substantial consumer and environmental gains from accelerated EV adoption while keeping losses in domestic profits and manufacturing employment moderate, thereby sustaining a domestic industry consistent with resilience goals. Across both the US and the EU, policies that permit entry under moderate tariffs, especially when revenue is recycled into domestic EV subsidies, dominate outright bans.

These findings raise a natural question: among policies that permit entry, what is the welfare-maximizing combination of tariffs and subsidies? We compare four policy regimes: tariff-only, subsidy-only, unconstrained joint use of tariffs and subsidies, and revenue-recycled joint use where tariff revenue funds domestic EV subsidies under a balanced budget. The recycling policy shifts the welfare frontier upward, outperforming trade-only or subsidy-only approaches, and closely approximates the unconstrained optimum while remaining budget-neutral. For the US, the welfare-maximizing package combines an approximately 25% tariff with a recycling subsidy of nearly $7,500 per domestically produced vehicle. Relative to the status quo, this policy more than doubles the EV market share, generates over $45 billion in annual social welfare gains, avoids approximately 95 million tons of lifetime CO_2 emissions, and limits the implied decline in US auto manufacturing employment to roughly 52,000 jobs, the most favorable combination of outcomes among the alternative scenarios we consider.[3] These results are robust to explicitly accounting for the value of jobs in the welfare formulation. As expected, the optimal tariff and subsidy levels both increase with the value attached to domestic employment, but the increase is very small relative to the benchmark case (for instance, setting the value of a job in auto manufacturing at ca. $70,000 yields an optimal tariff of 30% and an optimal subsidy of $7,800 per domestically

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[3] These conclusions are robust to a wide range of alternative assumptions on the quality and cost of the Chinese models introduced into the US market.

produced vehicle).

The advantage of the tariff-recycling design rests on a pass-through asymmetry that we do not impose a priori, but recover directly from the data. On the one hand, the pass-through of the ad valorem tariff is less than one: each additional dollar of tariff revenue raises the US consumer price of Chinese EVs by less than one dollar, as Chinese exporters absorb part of the burden by compressing markups.[4] On the other hand, the pass-through of the domestic subsidy is greater than one: a one-dollar per-vehicle subsidy to US producers lowers domestic EV prices by more than one dollar, because the subsidy induces domestic firms to compress their own pre-existing markups while attracting consumers from a more price-sensitive region of demand, partially correcting market-power distortions in the domestic EV segment.[5] Together, these two channels generate a "double dividend" that no single instrument can replicate: rents transferred from foreign exporters finance consumer-facing relief on domestic EVs.

We conclude with a cross-country comparison of the US, Germany, the UK, and Spain, ranging from a broad domestic EV sector to no domestically headquartered EV producer, and present two main results. First, the qualitative prescription is robust across all four markets: the optimal tariff is positive, but moderate (in the range of 12.5% to 37.5%), everywhere, as Chinese exporters absorb part of the burden through markup compression even where no domestic producer exists, and the budget-balanced tariff-recycling subsidy closely approximates the unconstrained joint optimum. Second, two monotonic patterns emerge: the optimal tariff rises with the size of the domestic EV portfolio, while the optimal subsidy rises with the average domestic EV markup, reflecting its role in shifting profits and correcting domestic market power.

The optimality of a moderate tariff across a range of country settings stems from its rent-extraction role under imperfect competition and incomplete tariff pass-through. When foreign producers absorb part of the tariff burden through lower markups, a tariff transfers rents from foreign firms to the domestic economy. This rationale would be less compelling in the presence of foreign retaliation. In the context of the EV sector, however, retaliation is largely beside the point, as the relevant benchmark already features substantial trade barriers—most notably in the United States, where Chinese EV imports are effectively excluded from the market. More broadly, while tariffs and subsidies may not constitute first-best policies in a world of international cooperation aimed at maximizing global efficiency, they can be welfare-improving when governments pursue unilateral objectives. Our analysis is intended to speak to this latter environment, which more

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[4] Note that our analysis focuses on consumer prices. A recent literature documents incomplete pass-through of the 2018-19 and 2025 US tariffs, but most of this literature focuses on the prices facing exporters, not consumers.

[5] Allcott et al. (2026) also find more than complete pass-through of the $7,500 IRA subsidy, which is consistent with a model of demand with flexible curvature.

closely reflects current policy realities.

Our study is related to several literature strands. First, we contribute to the literature on the role of industrial policies, particularly in the context of the green transition and EV adoption (Gerarden, 2023; Bollinger et al., 2024; Banares-Sanchez et al., 2025; Barwick et al., 2025; Sabal, 2025; Allcott et al., 2026; Head et al., 2026). This literature shows that industrial policies can accelerate innovation, reshape supply chains, and influence production locations, but may also create important tradeoffs involving market power, fiscal costs, and international spillovers. Recent work on EVs and batteries further highlights the importance of learning-by-doing, domestic content requirements, and multi-stage supply-chain linkages in determining who captures the gains from clean industrial policy. A striking feature of recent industrial policies, not only in the EV industry but also in other sectors (e.g., solar panels, semiconductors), is that they frequently employ tools of trade policy, such as tariffs and export restrictions (Gerarden et al., 2025; Goldberg et al., 2024). Our paper connects trade policy, industrial policy, and environmental objectives within a unified quantitative framework that allows these interactions to be evaluated jointly and advances the literature by characterizing the optimal policy mix in a specific, highly policy-relevant context.

Second, our paper contributes to the analysis of trade policies under imperfect competition. While the foundational strategic trade policy literature established that governments could shift rents and improve welfare through export subsidies and tariffs (Spencer and Brander, 1983; Dixit, 1984; Brander and Spencer, 1985), early critiques highlighted that these results were highly sensitive to assumptions regarding market structure and retaliation (Eaton and Grossman, 1986; Bagwell and Staiger, 2002). Rather than examining the robustness of the results to alternative assumptions, we exploit institutional knowledge to inform relevant assumptions and estimate model parameters based on rich micro data. Specifically, we empirically estimate a flexible differentiated-product equilibrium model of the global automobile market, in which demand curvature, substitution patterns, and pass-through are disciplined by comprehensive data.

Third, we contribute to the growing literature on the adoption of EVs (Li et al., 2017; Li, 2023; Springel, 2021; Muehlegger and Rapson, 2022). This literature shows that EV adoption is shaped by strong indirect network effects between charging infrastructure and vehicle demand, and that consumer subsidies can meaningfully increase EV uptake, although their effects depend on market structure, product availability, and policy design. More recent work also emphasizes that firms respond strategically to EV policies through pricing, product offerings, and other supply-side adjustments, implying that the welfare effects of subsidies extend beyond their direct impact on consumer demand (Kiso, 2022; Barwick, Kwon, and Li, 2024; Kwon, 2025; Remmy, 2025; Wang and Xing, 2025). Our analysis adds to this literature by examining how a joint design of trade and industrial policy can affect EV diffusion in a global market. In doing so, it highlights how substitution patterns, pass-through, and market power mediate the effects of tariffs and domestic EV subsidies on market outcomes and welfare.

Our paper is perhaps most similar in spirit to Berry, Levinsohn, and Pakes (1999) and Goldberg (1995), which used differentiated-product oligopoly frameworks to analyze the impacts of an early strategic trade policy, namely voluntary export restraints (VERs) on Japanese vehicle exports to the US in the 1980s, as well as exchange rate pass-through.[6] While these papers focused on quantity-based trade restrictions and exchange rates, we examine a modern policy package of ad valorem tariffs coupled with revenue-funded subsidies in a setting where trade policy, industrial policy, and environmental objectives interact. We demonstrate that this integrated approach can generate significant welfare gains relative to isolated policies for the adopting country while simultaneously accelerating the domestic energy transition.

The remainder of the paper is organized as follows. Section 2 presents the theoretical model to build intuition. Sections 3 and 4 describe the data and estimation. Section 5 introduces the counterfactual framework and specific welfare metric used in the empirical analysis. Section 6 evaluates recent US and EU trade and industrial policies on Chinese EVs, motivating our optimal policy analysis. Section 7 characterizes the optimal policy design, demonstrates the welfare dominance of tariff-recycling subsidies, and explores the underlying mechanisms, distributional consequences, and cross-country comparisons. Section 8 concludes.

2 Theoretical Model

Consider $j = 1, \ldots, J$ heterogeneous products with marginal cost C_j and demand $Q_j(\tilde{\mathbf{P}})$, where we suppress its dependence on non-price characteristics $\mathbf{X}$ that enter consumer utility. Let J_f and J_d denote the sets of foreign and domestic products, respectively. The consumer price $\tilde{P}_j$ reflects the policy instruments: an ad valorem tariff τ on imports, so $\tilde{P}_j = (1+\tau)P_j$ for $j \in J_f$, and a unit subsidy b on domestic goods, so $\tilde{P}_j = P_j - b_j$ for $j \in J_d$. Given policies (τ, b), firm ℓ solves the following profit maximization problem:

$$\max_{\{P_j\}_{j \in J_\ell}} \sum_{j \in J_\ell} (P_j - C_j) Q_j(\tilde{\mathbf{P}})$$

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[6] There are striking historical parallels between the 1980s VERs on Japanese cars and today's prohibitive tariffs on Chinese EVs; in both cases, the US government leveraged trade barriers to protect the same domestic incumbents from a foreign challenger. Similarly, there are many parallels between exchange rate and tariff pass-through as they both depend on market structure, the nature of competition, and demand curvature.

$$[P_j]: \qquad F_j = P_j - C_j - \Delta_j = 0, \qquad \forall j = 1, ..., J, \tag{1}$$

where Δ_j is the model-implied markup for product j. Stacking the first-order conditions F_j from Equation (1) into a vector **F**, the Implicit Function Theorem implies the pass-through of tariffs and subsidies:

$$\frac{\partial \tilde{\mathbf{P}}}{\partial \gamma} = -\left(\frac{\partial \mathbf{F}}{\partial \mathbf{P}}\right)^{-1} \frac{\partial \mathbf{F}}{\partial \gamma}, \tag{2}$$

for policies $\gamma = (\tau, b)$. Firms pass through tariffs and subsidies to final consumer prices. The pass-through matrix depends on conduct through $\frac{\partial \mathbf{F}}{\partial \mathbf{P}}$ and on the curvature of demand through the Jacobian terms.

The social planner maximizes the sum of consumer surplus, domestic producer surplus, government revenue, and externalities:

$$\begin{aligned} W(\tau, b) = & \underbrace{\sum_{j \in J} \int_0^{Q_j(\tilde{P})} (Q_j^{-1}(s, \tilde{P}_{-j}) - \tilde{P}_j) ds}_{\text{Consumer surplus}} + \underbrace{\sum_{j \in J_d} (P_j - C_j) Q_j(\tilde{P})}_{\text{Domestic profits}} \\ & + \underbrace{\sum_{j \in J} \phi_j Q_j(\tilde{P})}_{\text{Externalities}} + \underbrace{\sum_{j \in J_f} \tau P_j Q_j(\tilde{P}) - \sum_{j \in J_d} b Q_j(\tilde{P})}_{\text{Government revenue net of expenditures}}, \end{aligned} \tag{3}$$

where ϕ_j measures externalities induced by good j. The social planner chooses policies $\gamma = (\tau, b)$ to maximize this objective function. We analyze the unconstrained optimum in Section 2.1 before introducing a government budget constraint in Section 2.2.

2.1 No Budget Constraint

In this baseline case, the social planner sets policies freely without a budget balance constraint. The first-order conditions of Equation (3) are:

$$
\begin{aligned}
\frac{dW}{d\gamma} = & -\sum_{j\in J}\left[\frac{\partial \tilde{P}_j}{\partial \gamma} Q_j\right] && \text{(Consumer surplus)}\\
& + \sum_{j\in J_d}\left[(P_j - C_j)\sum_{k\in J}\frac{\partial Q_j}{\partial \tilde{P}_k}\frac{\partial \tilde{P}_k}{\partial \gamma} + \frac{\partial P_j}{\partial \gamma} Q_j\right] && \text{(Domestic profits)}\\
& + \sum_{j\in J}\phi_j \sum_{k\in J}\frac{\partial Q_j}{\partial \tilde{P}_k}\frac{\partial \tilde{P}_k}{\partial \gamma} && \text{(Externalities)}\\
& + \sum_{j\in J_f}\frac{d(\tau P_j Q_j)}{d\gamma} - \sum_{j\in J_d}\frac{d(bQ_j)}{d\gamma}. && \text{(Government revenue)}
\end{aligned}
$$

The first-order conditions have four pieces:

1. *Changes in consumer surplus*: Consumer surplus loss (gain) due to pass-through of tariffs (subsidies). Pass-through behavior may be incomplete or more than complete, depending on the curvature of demand.

2. *Changes in domestic profits*: Domestic firms gain through the direct channel of diversion from imports to domestic products, holding prices fixed, and through the indirect channel of pass-through of rival tariffs.

3. *Changes in externalities*: The impact on externalities may be positive or negative, depending on the quantity distortions and the relative sizes of externalities for each product.

4. *Fiscal effects*: The social planner gains revenue from tariffs, accounting for diversion away from imports, and loses from subsidy expenditures.

Prices P and $\frac{dQ}{d\gamma} = \sum_k \frac{\partial Q_j}{\partial \tilde{P}_k}\frac{\partial \tilde{P}_k}{\partial \gamma}$ account for pass-through behavior of firms as determined in Equation (2). Three forces jointly determine the optimal policies. First, prices are strategic complements: an import tariff raises prices of foreign products and triggers domestic price increases, with the strength of complementarity shaped by the degree of product and cost differentiation. Second, market structure governs the extent of trade diversion: with more domestic products, demand diverted by a tariff is spread across a larger base, leading to a more moderate price response, while more imports yield a larger base from which the planner can generate revenue. Third, demand curvature attenuates or amplifies pass-through, shifting the optimal policy mix. These forces interact, making the optimal policies sensitive to market conditions and motivating the quantitative analysis that follows.

2.2 Balanced Government Budget

In many situations, governments face binding fiscal constraints. We now impose a balanced budget requirement, recycling tariff revenue into unit subsidies on domestic goods. The planner's first-order conditions are identical to those of the unconstrained planner, except that the fiscal terms (tariff revenue and subsidy expenditure) are now scaled by λ, the Lagrangian multiplier on the budget constraint that captures the shadow value of public funds. When $\lambda = 1$, the budget constraint is not distortionary, and the optimal policies coincide exactly. Outside this knife-edge case, when $\lambda \neq 1$, the constrained solution is second-best: the planner effectively over- or under-weights the revenue and expenditure components of the objective function, distorting policy away from the unconstrained solution.

The detailed theoretical results on the optimal design of trade and industrial policy in oligopolistic markets with differentiated products are presented in Appendix A. These results extend the canonical work in Brander and Spencer (1985) to a richer setting with simultaneous tariff and subsidy instruments and endogenous revenue. We provide a brief summary here.

Proposition 1 in Appendix A recovers the optimal tariff and describes the conditions under which the optimal tariff is positive. Broadly, positive tariffs are warranted when domestic profit gains and fiscal revenue outweigh the consumer cost of higher prices. This intuition can break down when sufficiently convex demand generates more-than-complete pass-through. This echoes the results in Goldberg (1995), Goldberg and Hellerstein (2013), and Miravete, Seim, and Thurk (2023), which show that the curvature of demand is essential in determining optimal tariff rates. Appendix B.3 illustrates this: with a finite number of Nash-Bertrand competitors, CES and logit demand generate incomplete pass-through (consistent with a positive optimal tariff), while overshifting emerges only under consumer heterogeneity in price sensitivity.

Proposition 2 delivers a parallel result: subsidies are positive when pass-through generates sufficient gains in consumer surplus and domestic profit to justify the fiscal cost of volume expansion. Corollary 1 shows that revenue recycling, i.e., funding subsidies from tariff revenue, can raise or lower the optimal tariff depending on the shadow value of public funds and the pass-through regime. The direction depends on the sign of the unconstrained budget, as detailed in Lemma 1. Proposition 3 then establishes that the welfare cost of the budget constraint is second-order, so revenue recycling achieves near first-best welfare when the unconstrained optimum is close to budget-balanced. The global EV market, marked by substantial differentiation, cost asymmetries, and layered policy interventions, provides an ideal setting in which to take these predictions to the data.

3 Background and Data

3.1 Chinese EVs Around the World: Penetration and Entry Barriers

Chinese automakers are playing an increasingly important role in the global EV market, supplying models with relatively high quality at low prices.[7] Yet their global reach differs sharply across markets, driven by wide variation in policy barriers. The US is the most restrictive: Section 301 tariffs were raised to a total of 102.5% in 2024, and the Commerce Department's Connected Vehicle Rule effectively bans most Chinese EV imports. Canada has been similarly restrictive, with a 100% surtax through 2025, although a late-2025 quota arrangement points toward partial reopening. The EU has been substantially more moderate, applying combined import tariffs ranging from 17.8% to 45.3% on Chinese-manufactured BEVs.[8] Australia is the most open of the four, with no Chinese-EV-specific tariffs. Chinese EV penetration tracks this policy gradient closely (Figure 1): it is essentially zero in the US throughout the sample, rises steadily in the EU after 2020, and exceeds 30% in Australia by 2024. Appendix C.1 provides detailed policy descriptions for each market.

These barriers are also reflected in EV prices. Appendix Table F.1 shows that EV MSRPs were substantially lower in China relative to ICE models; after accounting for government subsidies, consumer prices of EVs in China were already on par with, or even below, those of ICE models. In contrast, EV prices in North America and the EU remained approximately 27 percent higher than comparable ICE models even after subsidies.

3.2 Data

We draw on several comprehensive datasets covering the global automobile industry.

Global Automobile Sales and Attributes. We assemble automobile sales and attribute data for 13 countries spanning major markets from 2004 to 2023, encompassing the critical period of the global EV transition.[9] Nine of these are European: six EU member states (Austria, France, Germany, the Netherlands, Spain, and Sweden) and three non-EU countries (Norway, Switzerland, and the United Kingdom). Throughout the paper, "EU" refers to these six member states and "Europe" (or "European countries") to all nine. Sales data come from the MarkLines database, which

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[7] In 2023, BYD became the world's largest EV producer with 3.02 million sales (BEV + PHEV combined).

[8] 10% most-favored-nation (MFN) tariff plus brand-specific countervailing duties of 7.8%–35.3% (the 7.8% floor applies to Tesla's Shanghai-built models; our counterfactual covers Chinese-brand EVs, with duties of 17%–35.3%).

[9] The 13 countries are Austria, Canada, China, France, Germany, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the United Kingdom, and the United States.

reports annual sales by fuel type for all major markets since 2004.[10] Vehicle attributes come from the Teoalida Car Database, supplemented by IHS Markit, Ward's Automotive for the US, and EV Volumes; attributes for fringe Chinese models were collected manually from automobile forums. Together, these 13 countries account for 85% of global ICE sales and 95% of global EV sales over the sample period.

EV Battery Suppliers and Government Policies. EV battery supplier data come from the Battery Cell/Module module of the MarkLines database, which identifies the battery supplier (e.g., CATL) and battery attributes for each EV model. We extend the worldwide EV incentive data from Barwick et al. (2023) by manually collecting and coding a large set of policy documents covering both financial incentives (e.g., tax credits, subsidies) and non-financial incentives (e.g., green plates, parking benefits, HOV lane access). The resulting dataset records total monetary incentives for EV consumers at the country, year, and model levels, as well as dummy variables for non-financial incentives.

Tariffs and Industrial Policies. We construct a comprehensive dataset on trade barriers and industrial policies. Bilateral automobile tariffs are manually collected for the sample countries from government policy documents, WTO tariff schedules, and news reports. Industrial policy data come from Barwick et al. (2024).

Auxiliary Data. We draw on several auxiliary sources. Income distributions for demand estimation come from the World Inequality Database (WID).[11] To construct micro-moments for demand estimation, we combine household survey data on new vehicle buyers from China (2018–2020) and the US (2018) (Leard, Linn, and Springel, 2024; Barwick et al., 2025). Finally, to document the rise in protectionism, we manually collect historical tariff data and non-tariff policy barriers across major countries.

4 Empirical Model

We develop an empirical model of demand and supply for the global automobile industry, in which heterogeneous consumers choose among differentiated vehicles, and firms set prices for their existing models.

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[10] Data on China come from the China Automotive Technology and Research Center (CATARC) for 2012 to 2018, MarkLines's China monthly registrations for 2020 to 2023, and IHS Markit data as used in Barwick et al. (2025).

[11] WID can be accessed at `https://wid.world/`.

4.1 Demand

Consumer i in market m (country) chooses a vehicle j from the product set $\mathscr{J}_{mt} = \{0, 1, ..., J_{mt}\}$, which includes both EVs and ICEs. The outside option $j = 0$ represents not buying a new vehicle. The utility of consumer i from purchasing vehicle model $j \neq 0$ in market m and year t is:

$$u_{ijmt} = -\alpha_{im}\left(\tilde{P}_{jmt} - b_{jmt}\right) + \mathbf{X}_{jmt}\beta_{im} + \eta_{jmt} + \gamma_{ijmb} + \xi_{jmt} + \varepsilon_{ijmt}. \tag{4}$$

The utility of the outside option is normalized to $u_{i0mt} = \varepsilon_{i0mt}$ for all i, m, t. The consumer price $\tilde{P}_{jmt}$ incorporates taxes and tariffs, and b_{jmt} denotes the government subsidy for EVs, so consumers pay the net-of-subsidies price.[12] The vector $\mathbf{X}_{jmt}$ contains product characteristics, η_{jmt} is a rich set of fixed effects, and γ_{ijmb} captures brand loyalty (discussed below). The term ξ_{jmt} denotes unobserved vehicle quality or demand shocks, and ε_{ijmt} is an idiosyncratic preference shock with a Type I extreme value distribution.

The price coefficient is specified as $\alpha_{im} = \bar{\alpha} + \alpha_m / y_{im} + \sigma^p v_{im}^p$, where $\bar{\alpha}$ is the average price sensitivity across markets and y_{im} is household income in country m. We allow the coefficient on income to vary across countries, grouping them into four tiers by median income: $\{\alpha_1, \alpha_2, \alpha_3, \text{ and } \alpha_4\}$.[13] The α_m / y_{im} component expresses the income-varying part of price sensitivity in real terms, which is important for cross-country estimation: without it, nominal exchange-rate movements (e.g., the 2014 USD appreciation) would contaminate demand estimates, whereas our specification absorbs them through the real ratio $(\tilde{P}_{jmt} - b_{jmt})/y_{im}$. The term v_{im}^p follows a log-normal distribution and σ^p captures heterogeneity in price sensitivity.

The parameters $\beta_{im} = \{\beta_{imk}\}_{k=1}^{K}$ represent heterogeneous preferences for K vehicle attributes, with $\beta_{imk} = \bar{\beta}_k + \sigma_m^k v_{im}^k$, where $\bar{\beta}_k$ is the mean preference for attribute k, v_{im}^k follows a standard normal distribution, and σ_m^k captures market-level heterogeneity in preferences.

We extend the Berry, Levinsohn, and Pakes (1995) framework by incorporating consumer-specific brand preferences γ_{ijmb} as a component of random utility, specified as a random coefficient on the market-brand fixed effect $\gamma_{ijmb} = \sigma_m^b v_{ibm}$. We assume v_{ibm} follows a standard normal distribution and restrict it to be constant across all models j of the same brand b for a given consumer i. This random coefficient captures heterogeneity in within- and cross-brand substitution: a larger σ_m^b indicates stronger within-brand loyalty and weaker cross-brand substitution, so consumers are

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[12] As in Barwick, Kwon, and Li (2024), the consumer price is constructed as $\tilde{P} = MSRP \times \frac{1+t^{\text{ValueAdded}}+t^{\text{Sales}}}{1+t^{\text{ValueAdded}}}$ and the producer price is constructed as $P = MSRP \times \frac{1-t^{\text{Consumption}}}{1+t^{\text{ValueAdded}}}$.

[13] Groups follow ascending median income: Group 1 = China, Group 2 = Japan, Spain, France, and Germany, Group 3 = United Kingdom, Netherlands, Austria, and Sweden, and Group 4 = Canada, Norway, United States, and Switzerland.

more likely to substitute within a firm's lineup, such as from its ICE models to newly introduced EV models. We allow σ_m^b to vary across markets but restrict it to be common across brands within a market.

Following standard practice, we decompose utility in Equation (4) into a mean component $\delta_{jmt} = \mathbf{X}_{jmt}\bar{\beta} + \eta_{jmt} + \xi_{jmt}$ and an individual-specific component $\mu_{ijmt} = -\alpha_{im}\left(\tilde{P}_{jmt} - b_{jmt}\right) + \sum_k \sigma_m^k x_{jkt} \nu_{im}^k + \sigma_m^b \nu_{ibm}$. Under the Type I Extreme Value assumption on ε_{ijmt}, quantities sold for product j in market m at time t are:

$$q_{jmt} = M_{mt} \int \frac{\exp(\delta_{jmt} + \mu_{ijmt})}{1 + \sum_{j'=1}^{J_{mt}} \exp(\delta_{j'mt} + \mu_{ij'mt})} dF(\mu_{ijmt}), \tag{5}$$

where M_{mt} is the market size of country m at time t and the integral aggregates individual choice probabilities over the distribution of consumer heterogeneity.

4.2 Supply

Automakers set prices for all models in each country to maximize profits.[14] Firm f chooses post-tax/tariff prices to maximize profit in country m at time t:

$$\pi_{fmt}(\mathscr{J}_{mt}) = \max_{\{p_{jmt}; j \in \mathscr{J}_{fmt}\}} \sum_{j \in \mathscr{J}_{fmt}} (p_{jmt} - mc_{jmt}) \cdot q_{jmt}(p_{jmt}, \mathbf{p}_{-j,mt}) \qquad \forall m \in 1, \ldots, M, \tag{6}$$

where $\mathbf{p}_{-j,mt}$ is the post-tax/tariff price vector for all products except j, and mc_{jmt} is the marginal cost. Assuming a pure-strategy equilibrium exists, the first-order condition for product j of firm f is (suppressing mt subscripts for notational simplicity):

$$q_j + \sum_{k \in \mathscr{J}_f} (p_k - mc_k) \frac{\partial q_k}{\partial p_j} = 0,$$

where multi-product firms internalize cross-price effects (cannibalization) among their own products. Stacking these conditions, let Δ be the $J \times J$ ownership and substitution matrix with its (j,k)-th element defined as:

$$\Delta_{jk} = \begin{cases} -\frac{\partial q_k}{\partial p_j} & \text{if products } j \text{ and } k \text{ are produced by the same firm} \\ 0 & \text{otherwise} \end{cases}$$

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[14] We assume Bertrand competition, which is standard in the automobile market literature and better reflects short-run price flexibility in a highly differentiated product market than Cournot. Firms have complete information about product attributes, rival pricing strategies, demand and cost shocks, and account for government policies such as EV subsidies and bilateral tariffs.

Inverting Δ yields the equilibrium pricing equation:

$$\mathbf{p}^* = \mathbf{mc} + \Delta^{-1}\mathbf{q} \tag{7}$$

where $\Delta^{-1}\mathbf{q}$ is the vector of equilibrium markups. Given estimated demand parameters, we use Equation (7) to recover marginal costs for each vehicle model in each market.

4.3 Estimation and Identification

Aggregate Moments and Instruments. We use three sets of instruments to address price endogeneity. The first follows Berry, Levinsohn, and Pakes (1995) and includes the number of rival brands, the count of own- and rival-brand models, the count of own-brand models in other markets, and average own- and rival-product attributes. The second consists of "differentiation IVs" from Gandhi and Houde (2019), using the "local distance" suggested by Conlon and Gortmaker (2020), which counts products within one standard deviation of a given attribute within a predefined market scope.[15] The third, following Barwick, Kwon, and Li (2024), interacts battery capacity with battery supplier dummies for each EV model to capture exogenous upstream supply shocks. Denoting instruments as $\mathbf{Z}_{jmt}$ and exogenous product attributes as $\mathbf{X}_{jmt}$, the aggregate moment conditions are:

$$\mathbb{E}\left[\xi_{jmt} \mid \mathbf{Z}_{jmt}, \mathbf{X}_{jmt}\right] = 0.$$

Micro-Moments. We include two sets of micro-moments to aid identification of preference parameters. The first matches the average household income of vehicle buyers predicted by the model to observed averages from household surveys in China and the US, covering 45 popular EV and ICE models in China (2018–2020) and 79 in the US (2018), yielding 124 micro-moments. The second targets EV buyers specifically, matching the model-predicted share of EV buyers within income brackets to observed shares from survey data in Canada (2013), Germany (2013), Norway (2014), Japan (2015), Sweden (2015), and the Netherlands (2019).[16] We estimate via two-stage GMM, following Conlon and Gortmaker (2025) for the construction of the variance-covariance matrix and gradients of the aggregate- and micro-moments.

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[15] We define the scope of competition as the same country, year, segment, and fuel type. The set of attributes includes: displacement, horsepower, footprint, driving range, and battery capacity.

[16] These data are collected from the literature. There are five income groups in Canada, four in Germany, six in Norway, five in Japan, three in Sweden, and four in the Netherlands. Since groups are mutually exclusive, we drop one per country, yielding 21 micro-moments.

4.4 Estimation Results

Table 1 reports parameter estimates for global automobile demand, based on 65,574 observations across 13 countries from 2004 to 2023. Column (1) shows the OLS multinomial logit without instruments. Column (2) adds price instruments described above: the price coefficient becomes substantially more negative, reflecting the positive correlation between prices and unobserved product quality. The remaining coefficients have intuitive signs (consumers prefer home brands, more horsepower, larger vehicles, and longer EV driving ranges) and are all precisely estimated.

Columns (3) and (4) introduce random coefficients to capture preference heterogeneity; Column (4) additionally includes country-by-year-by-EV and brand-by-EV fixed effects and is the specification used in the counterfactual analysis. We therefore interpret the estimates from Column (4). Signs are consistent with Column (2). The large random coefficient on the EV indicator reflects substantial heterogeneity in EV preferences. All income coefficients are positive, confirming that higher-income households are less price-sensitive. The dispersion parameters on income-price interactions vary across country groups: the parameter is largest for Japan/Spain/France/Germany, followed by China, with UK/Netherlands/Austria/Sweden and Canada/Norway/US/Switzerland considerably smaller. The brand-loyalty random coefficients are largest for the US and Canada, consistent with the strong brand loyalty associated with the Big Three dominating the US market and implying strong within-brand substitution. Coefficients for China and larger European countries are smaller, reflecting greater market fragmentation and weaker brand attachment.

The estimated average own-price elasticity is -2.62, consistent with the literature on combined EV and ICE demand (Grieco, Murry, and Yurukoglu, 2024) and with prior estimates of global EV demand elasticity in the range -2 to -4 (Barwick et al., 2025; Li et al., 2017). EV buyers tend to have higher incomes and thus lower price sensitivity. Price semi-elasticities (the percentage change in sales for a \$1,000 decrease in a vehicle model's consumer-facing price) are larger in magnitude for less expensive vehicles, consistent with buyers of cheaper vehicles typically having lower incomes and greater price sensitivity. Panel (a) of Appendix Figure E.1 reports the histogram of own-price elasticities for the US market; Panel (b) plots own-price semi-elasticities against consumer prices.

Finally, we evaluate the model's out-of-sample performance. The EU countervailing duties (CVD) on Chinese EVs took effect in the second half of 2024, after the end of our 2004–2023 estimation sample; Section 6.2 and Table 3 report the effects of the CVD simulated from the estimated model. We then compare this prediction with the realized effect, which we estimate separately from 2024–2025 registration data using the synthetic control method: post-duty sales of incumbent Chinese-brand EVs in our six EU sample countries are benchmarked against a weighted combination of non-Chinese brands chosen to match their pre-duty sales path. The model-predicted contraction in Chinese-brand sales lies within 1.4 percentage points of the synthetic control estimate (Appendix D.1).

5 Counterfactual Framework

5.1 Welfare Measures

We adopt the same welfare objective as in the theoretical framework (Equation (3) in Section 2), evaluating each policy regime relative to a benchmark (such as the 2023 status quo):

$$\Delta\text{Welfare} = \Delta CS + \Delta\Pi^{\text{dom}} + \Delta\text{GovRevenue} + \Delta\text{EnvBenefits}, \tag{8}$$

where ΔCS is the change in consumer surplus, $\Delta\Pi^{\text{dom}}$ the change in domestic firm profits, $\Delta\text{GovRevenue}$ the net change in government revenue (tariff collections minus subsidy expenditures), and $\Delta\text{EnvBenefits}$ the change in environmental benefits. We also consider two extensions: a marginal cost of public funds (MCPF) adjustment that penalizes net fiscal deficits, and an augmented measure that monetizes the value of domestic jobs. The MCPF adjustment is described in detail in Appendix C.5, and the value of jobs is described below.

Dropping subscripts (m,t) for simplicity, consumer surplus is computed via $CS = M\int \frac{1}{\alpha_i}\log\Big(1 + \sum_{j\in\mathscr{J}}\exp(\delta_j + \mu_{ij})\Big)\,dF(\mu_{ij})$ + constant, where M is the market size, α_i is the individual-specific marginal utility of a dollar, δ_j is mean utility, and μ_{ij} captures heterogeneous tastes. The additive Euler constant cancels in differences and plays no role in ΔCS. Domestic producer surplus is $\Pi^{\text{dom}} = \sum_{j\in J^d}(P_j^{\text{CF}} - C_j)Q_j(\tilde{\mathbf{P}}^{\text{CF}})$, where $\tilde{\mathbf{P}}^{\text{CF}}$ is the vector of consumer-facing prices inclusive of tariffs and subsidies and J^d is the set of domestic products. Government revenue net of subsidy expenditures is:

$$G = \sum_{j\in J^f}\tau P_j Q_j(\tilde{\mathbf{P}}^{\text{CF}}) - \sum_{j\in J^d} b Q_j(\tilde{\mathbf{P}}^{\text{CF}}), \tag{9}$$

where J^f is the set of imports subject to the ad valorem tariff τ and J^d is the set of domestic goods subject to the unit subsidy b.

Environmental benefits arise from policy-induced reductions in ICE sales, where each avoided ICE sale reduces lifetime external damages from CO_2 emissions and local air pollution:

$$\Delta\text{EnvBenefits} = -\Delta Q^{\text{ICE}}\cdot\big(\text{UnitCarbCost} + \text{UnitHealthCost}\big), \tag{10}$$

where UnitCarbCost and UnitHealthCost are per-vehicle lifetime external costs calibrated from

Funke et al. (2023). Details and the physical-unit CO_2 conversion are in Appendix C.3.

The job-augmented welfare measure adds a monetized employment term, $\Delta\text{Welfare}^{\text{Job}}(w) = \Delta\text{Welfare} + w \cdot \Delta\text{Jobs}$, where ΔJobs maps equilibrium domestic sales into US manufacturing jobs and w is the annualized social value per job. Jobs-per-vehicle calibrations and per-job-year benchmarks (with bounds from Slattery, 2025 and BLS NAICS 336) are in Appendix C.4.

5.2 Counterfactual Implementation

The policy instruments we consider are ad valorem tariffs on Chinese EVs and per-unit subsidies on domestically produced EVs. Our counterfactuals focus specifically on Chinese EVs because China has emerged as the dominant force in global EV production (accounting for 60% of global EV sales by 2025), yet Chinese EVs remain absent from the US and have low penetration in Europe, not for lack of competitiveness, but because of deliberate policy barriers. This makes Chinese EV entry the natural counterfactual for evaluating current tariff and subsidy regimes.

For each policy regime, we re-solve the Nash-Bertrand pricing equilibrium under the specified policy using the algorithm of Morrow and Skerlos (2011) and compute the welfare changes defined above. In the EU trade remedy evaluation (Section 6.2), Chinese EVs are already present, so we directly use the estimated mean utilities and marginal costs of the observed Chinese EV models. For the US entry counterfactuals (Section 6.1) and the optimal-policy analysis across the US, Germany, the UK, and Spain (Section 7.4), we exogenously introduce the top 10 China-manufactured EV models ranked by 2023 Chinese market shares.[17] These are mainstream, high-volume models from established automakers (e.g., BYD, SAIC, GAC), several of which already compete in European markets, providing cross-market data to construct their mean utilities and marginal costs (Appendix C.2).[18] We focus on these models rather than niche models from smaller startups, which face greater reputational uncertainty and higher exit rates (Wang and Xing, 2025). As such, they represent both the most credible entry candidates and likely a conservative lower bound on the competitive threat from Chinese EVs. Results are robust to using the top 10 China-manufactured EV models currently sold in Europe, and qualitatively similar across the top 5 to 20 most popular Chinese EVs.

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[17] Appendix Table F.2 lists these models, which together account for 34.3% of the Chinese EV market in 2023. Appendix Figure E.2 shows the full market-share distribution of the top 50 models.

[18] Appendix D.2 shows that results are unchanged when constructed quality and marginal cost are jointly varied by up to ±$5,000 per vehicle.

6 Welfare Effects of Recent US and EU Policies

This section evaluates recent US and EU policies targeting Chinese EVs. In the US, prohibitive tariffs and the Connected Vehicle Rule amount to a de facto ban; in the EU, countervailing duties were introduced in late 2024 alongside negotiations over minimum price commitments. We evaluate both EU instruments: Section 6.2 models the minimum price commitment as the price-side analog of a voluntary export restraint, which replicates the duty-inclusive equilibrium but reallocates the tariff wedge from EU government revenue to Chinese exporters' rents.

6.1 US Tariff and Subsidies

Policy Scenarios. We examine a range of alternative US–China tariff rates and US domestic subsidy schemes in addition to the recent policy, which is a de facto ban. Column (1) in Table 2 reports the 2023 status quo (no Chinese EV entry, no domestic EV policy) as a reference baseline. Column (2) maintains the Chinese EV ban while providing a $7,500 EV incentive to US-manufactured EVs, mimicking the domestic-content requirement under the Inflation Reduction Act. The remaining columns (3) to (6) lift the ban and exogenously introduce the top 10 most popular Chinese EV models into the US market under different combinations of trade and subsidy policies. Column (3) imposes no additional tariffs beyond the standard 2.5% rate. Column (4) adds a 25% tariff, and Column (5) a 100% tariff.[19] Column (6) considers a more protectionist industrial policy scenario in which tariff revenues collected on Chinese EVs are fully recycled as additional subsidies for US domestic EV manufacturers (GM, Ford, Tesla, etc.), reflecting the "tariffs-as-revenue" philosophy associated with the second Trump administration.[20] Finally, Column (7) introduces Chinese EVs with no tariff while US-manufactured EVs receive a $7,500 subsidy, aligning with an industrial policy aimed at fostering the domestic EV industry under free trade.

Results. Table 2 reports the results. Panel (a) shows effects on market outcomes, including prices and EV adoption. Panel (b) reports changes in each welfare component.

Chinese EV entry reshapes US adoption, prices, and welfare. First, it substantially increases EV adoption and lowers prices. The EV's share of all new vehicle sales rises from 9% in the status quo to 18.9% under the minimum-tariff scenario (Column 3), then declines gradually to 11.6% (Column 5) as tariffs increase. The tariff-recycling scenario (Column 6) falls between these extremes, while the free-trade scenario with domestic subsidies (Column 7) delivers the highest

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[19] These rates correspond to the Section 301 tariff levels imposed under the first Trump administration (25%) and the early Biden administration (100%).

[20] For a given tariff rate, we implement the revenue-recycling scenario by solving for the implied subsidy under a balanced-budget constraint, searching over a subsidy grid and selecting the value that exhausts tariff revenue.

EV share overall. The lower prices are driven by Chinese EVs: incumbent non-Chinese EVs are priced approximately $9,500 above comparable ICE vehicles in the status quo (helping explain the low US EV adoption rate), while, under low tariffs, the introduced Chinese models are priced well below both incumbent EVs and ICE vehicles owing to substantially lower (estimated) marginal costs.

Second, the effects on domestic production and employment provide a clear rationale for imposing tariffs. Under the low-tariff scenario (Column 3), Chinese EVs capture nearly 70% of the US EV market and generate roughly $28 billion in profits, with sizable losses for domestic producers and a decline of approximately 87,000 manufacturing jobs relative to the status quo.[21,22] As tariffs rise, Chinese EVs lose share but remain competitive: even at 102.5%, they still account for about 30.6% of the US EV market. This suggests that tariffs alone would not fully prevent Chinese EV entry and that non-tariff barriers contribute to the lack of their presence observed in the data. When tariff revenues are recycled as domestic subsidies (Column 6), the Chinese EV share falls below 20%, indicating that revenue-recycled industrial policy can more effectively limit foreign penetration than tariffs alone.

Third, Chinese EV entry increases social welfare by more than $30 billion across all scenarios, driven primarily by consumer surplus gains. The main losers are US domestic automakers, whose revenues decline as Chinese entrants capture market share. Among all scenarios, the largest welfare gain arises under the combined open-trade and domestic-subsidy scenario (Column 7), though this comes at the cost of steep ICE-segment declines as domestic ICE models face competition from both Chinese entrants and subsidized domestic EVs.

Restricting attention to trade policy (Columns 3–6), welfare is highest under the moderate 27.5% tariff (Column 4) and lowest under the punitive 102.5% tariff (Column 5). Recycling revenues from the punitive tariff as domestic EV subsidies raises welfare by about 12% relative to the tariff-only case (Column 6 vs. Column 5). Under tariffs alone, domestic automakers lose profits in both EV and ICE segments. Revenue recycling reverses this: domestic EV producers gain substantially, though domestic ICE firms suffer from competition from both imported and domestically subsidized EVs. On net, domestic automaker profits turn positive, and the implied manufacturing job loss narrows to roughly 11,000, compared with a range of 87,000 (at 2.5%) to 23,000 (at 102.5%) under tariffs alone. Under recycling, the primary losers shift to non-US

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[21] The job measure aggregates jobs attributed to domestic production by US firms and incumbent transplants, that is, foreign-headquartered automakers producing in US assembly plants (e.g., Toyota, Honda, BMW). Job changes are reported relative to the 2023 status quo; Appendix C.4 details the construction.

[22] While these employment effects supply the strongest rationale for protection, we show in Section 7.2 that they do not justify protection at prohibitive levels: even when each manufacturing job is valued at the full industry-average wage, the welfare-maximizing tariff remains moderate.

incumbent automakers (European, Korean, and Japanese firms): the policy simultaneously admits low-priced Chinese EVs and subsidizes US-manufactured ones, so foreign incumbents, who benefit from neither, cede market share on both fronts.

The qualitative findings are robust along three dimensions. Replacing the entrant set with the top ten China-manufactured EVs currently sold in Europe preserves the qualitative patterns, with magnitudes roughly half as large (Appendix Table F.3). Varying the construction of fixed effects and ξ components leaves the simulated US EV market share stable across policy scenarios (Appendix Figure E.3). Extending the analysis to 2014–2023 illustrates how allowing Chinese EV entry would have shifted the historical US EV adoption trajectory (Appendix Figure E.4).

6.2 European Union Trade Remedy

Policy Scenarios. In 2023, Chinese EVs are already present in the EU market under the existing 10% MFN tariff, embedded in observed 2023 prices.[23] Column (1) is the status quo. Column (2) applies the EU's October 2024 brand-specific countervailing duties (CVD) from 17% to 35% on top of the 10% MFN tariff.[24] Column (3) retains the same CVD structure but recycles the resulting revenue as a uniform per-vehicle subsidy to EU-member-manufactured EVs; consistent with treating the EU as a single policymaker, one subsidy rate applies in all six member states and is set so that aggregate subsidy outlays equal aggregate CVD revenue, balancing the budget for the bloc as a whole rather than country by country. Column (4) models a Minimum Price Commitment (MPC), the price analog of a voluntary export restraint, in which Chinese exporters commit to a minimum export price.[25] We set the price floor at the CVD-inclusive equilibrium price, the natural benchmark since MPC arrangements are designed as substitutes for the duties. At this level, the MPC and CVD generate identical consumer prices, quantities, and EV adoption rates; they differ only in the disposition of the tariff wedge: retained by the EU government as revenue under CVD, but captured by Chinese exporters as rents under MPC. Column (5) is a counterfactual ban removing all Chinese EV models from the EU market.

Results. Table 3 reports the results. Three findings are worth highlighting, with emphasis on insights that complement the US analysis.

First, the October 2024 CVD (Column 2) substantially reduces Chinese EV competition (the Chinese share of EU EV sales falls by more than half) but generates only a modest net welfare loss,

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[23] All scenarios in Table 3 operate on existing Chinese EV models; no additional entrants are introduced.

[24] +17% for BYD, +18.8% for Geely-group brands, and +35.3% for all other Chinese brands.

[25] In early 2026, the EU and China reached a bilateral framework under which several major Chinese automakers, including BYD and SAIC, agreed to minimum export price commitments as an alternative to the October 2024 CVD.

as tariff revenue and domestic profit gains partially offset the consumer surplus decline. Recycling the CVD revenue as a per-vehicle subsidy to EU-member EVs (Column 3) reverses this welfare loss and yields the best outcome among the policy columns. This mirrors the central result from the US analysis: revenue recycling dominates the tariff-only alternative by converting fiscal rents into consumer-facing price relief on domestic EVs.

Second, and most distinctively, the MPC (Column 4) generates identical consumer prices, quantities, and EV adoption as the CVD, yet produces a large welfare loss. The entire gap reflects the disposition of the tariff wedge: under CVD, it flows to the EU Treasury; under MPC, it is retained by Chinese exporters as export rents. The contrast, a policy equivalent in market outcomes yet sharply inferior in welfare, mirrors the classic finding of Berry, Levinsohn, and Pakes (1999) on voluntary export restraints and illustrates a concrete cost of the price-commitment approach currently under negotiation.

Third, an outright ban (Column 5) is by far the most costly scenario, generating a consumer surplus loss more than twice that of the CVD. Unlike the US setting, where Chinese EVs are not yet present, Chinese EVs in the EU are already embedded in the competitive landscape: their removal not only eliminates affordable options but also relaxes competitive pressure on non-Chinese EV makers, whose prices rise as a result. These findings underscore a key policy implication: once Chinese EVs have entered a market, the costs of reversing that entry are substantially higher than the costs of moderating it through tariffs.

We test the model's counterfactual predictions in Column (2) out of sample. Using the 2024–2025 vehicle sales data, the synthetic control estimate of the realized contraction in incumbent Chinese-brand EV sales post the CVD is 57.4%, closely matching the model-predicted decline of 56.0% (Appendix Figure E.5; design details in Appendix D.1).

7 Optimal Policy Design

The US and EU exercises highlight a robust welfare pattern: prohibitive tariffs impose substantial welfare losses, as the consumer surplus forgone from restricting competitively priced imports dominates the producer-surplus gains from protection. These results raise a natural question: what combination of tariffs and subsidies is welfare-maximizing, and how closely can a budget-balanced tariff-recycling subsidy approximate that optimum?

This section provides a systematic analysis across markets. Focusing first on the US, Sections 7.1 and 7.2 compare optimal policy designs without and with revenue recycling, while Section 7.3 elucidates the mechanisms driving those results. Section 7.4 then extends the analysis to Germany, the UK, and Spain, ranging from a country with a broad domestic EV sector to one with no domestically headquartered producer.

7.1 Policy Comparisons

We characterize the optimal policy design over four regimes: subsidy-only, tariff-only, an unconstrained joint policy combining both instruments, and the tariff-recycling subsidy policy under which tariff revenues are rebated to domestic EV producers.

Table 4 compares these regimes for the benchmark of ten Chinese EV models. The unconstrained optimum is attained at a tariff of 22.5% and a subsidy of $8.4 thousand, dominating the subsidy-only regime (which requires a larger subsidy of $9.6 thousand) and the tariff-only regime (which requires a higher tariff of 27.5%). The optimal recycling policy sets a 25.0% tariff and a subsidy of $7.47 thousand, delivering $45.33 billion in welfare gains — nearly identical to the unconstrained optimum of $45.45 billion — while remaining budget-neutral.[26] Relative to the tariff-only regime, recycling raises EV adoption from 16.06% to 19.60%, increases environmental benefits from $3.66 billion to $5.47 billion, and reduces the decline in US firm profits from $8.70 billion to $3.24 billion. Recycling is also more politically feasible than the subsidy-only or unconstrained regimes, which require large government outlays ($14.77 billion and $3.01 billion, respectively).

The bottom rows of Table 4 report employment and emissions impacts. Tariff recycling avoids 95.44 million tons of lifetime CO_2 emissions, and its manufacturing employment loss, approximately 52,000 jobs, is essentially tied with the unconstrained optimum for the smallest among the four regimes. Downstream market expansion partially offsets this: the roughly 508,000 additional vehicle sales under recycling support about 20,300 net new service jobs, offsetting approximately 39% of the manufacturing loss.[27]

Distributional Considerations. Table 5 reports welfare changes by consumer income quartile. Subsidy-based regimes (Columns 3 and 4) concentrate gains among higher-income households, since incumbent EVs sit at the upper end of the price distribution. Introducing Chinese EVs generates more equitable gains, concentrated in the middle of the income distribution (Q3 in particular), as the Chinese models are priced closer to mainstream ICE vehicles and expand the EV choice set for households currently priced out of incumbent EVs.

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[26] The unconstrained optimum carries a fiscal deficit. Appendix Figure E.6 extends these comparisons across alternative regimes and Chinese EV counts; the recycling policy consistently lies close to the unconstrained optimum and dominates the single-instrument alternatives.

[27] The optimal-policy conclusions are robust to jointly varying the constructed quality and cost of the introduced Chinese models: the welfare gain of the optimal recycling policy remains positive, compared to the status quo with the current policy interventions and without Chinese EVs, and revenue recycling continues to dominate single-instrument designs across a wide neighborhood of the baseline construction (Appendix D.2).

Winning and Losing Firms. Figure 2 plots changes in EV profits against ICE profits under the four optimal policy scenarios. Under tariff-only (top left), Chinese entry harms all incumbents across both segments, with Tesla the largest loser given its EV exposure. Under the tariff-funded subsidy, Tesla becomes the largest winner (over $2 billion in EV profits) and GM and Ford shift into positive EV-profit territory, with several firms ending up net positive overall. The subsidy-only scenario, by contrast, allows more aggressive Chinese EV competition, generating ICE losses that more than offset EV-profit gains for most firms. Across scenarios, subsidy-inclusive regimes disproportionately benefit firms with larger EV footprints, while non-US incumbents (European, Japanese, and Korean firms) experience profit declines across both segments.

Domestic Product Entry. The baseline holds domestic automakers' portfolios fixed. In practice, firms may expand their EV lineups in response to Chinese competition. We conduct a robustness exercise adding one or three domestic EV models by reassigning major third-country EVs to Tesla and Volkswagen; Table F.4 reports results for the US and Germany. The main policy conclusions are robust: the tariff-funded subsidy remains close to the unconstrained optimum regardless of domestic product entry, and welfare increases further with each additional domestic model (from $45.60 billion with no entry to $51.78 billion with three models under recycling). Details on optimal policy adjustments and the mechanisms driving welfare changes are in Appendix D.3.

7.2 Welfare Implications

Figure 3 plots the welfare components against the tariff rate under the top-10 Chinese EV entry scenario, comparing the no-recycling and revenue-recycling regimes. The decomposition clarifies why recycling dominates tariff-only policy. Social welfare is hump-shaped in the tariff under both regimes, and recycling shifts the welfare frontier upward across nearly the entire tariff range while lowering the welfare-maximizing tariff (25.0% versus 27.5%, consistent with Table 4): less aggressive protection is needed once tariff revenues are returned as domestic EV subsidies. At any given tariff rate, recycling also sustains a markedly higher EV market share, preserving consumer surplus and environmental benefits while improving US producer profits. Recycling thus relaxes the central tradeoff of tariff-only policy, under which protecting domestic producers comes at the expense of consumers and the environment.

Figure 4 reports market outcomes and welfare effects under the optimal tariff-recycling policy for different numbers of Chinese EV entrants. In the benchmark top-10 case with a 25% tariff paired with a $7.5 thousand recycling subsidy (Table 4), EV adoption rises by 117.7% and the average EV price falls by 25.4% relative to the status quo. Panel (b) shows that the welfare gains are driven primarily by a $43.10 billion increase in consumer surplus, reflecting both a broader

EV choice set and access to more affordable models, while the decline in domestic firm profits remains modest because the recycling subsidy partly offsets the losses induced by Chinese entry. This expansion in EV adoption underlies the 95 million tons of avoided lifetime CO_2 emissions reported in Section 7.1, underscoring the climate benefits of admitting lower-cost Chinese EVs.

Welfare Measures Incorporating Value of Jobs. A central rationale for trade and industrial protection is preserving domestic manufacturing employment. We therefore augment the baseline welfare measure with a monetized job-value term.[28]

Appendix Table F.5 re-evaluates the welfare of the baseline optimal policies under each benchmark. At the lower bound ($10,700 per job-year; Slattery, 2025), the findings are essentially unchanged: the recycling policy's welfare gain falls modestly to $44.78 billion and the ranking of policy regimes is preserved. At the upper bound ($70,000, the BLS NAICS 336 average wage), the recycling policy's welfare gain drops to $41.70 billion and remains close to the unconstrained optimum. Even at the $169,000 per-job fiscal cost that Allcott et al. (2026) estimate for the IRA's EV credits, optimal recycling still delivers a $36.55 billion welfare gain.[29]

Appendix Figure E.7 shows how the optimal policy itself shifts as the per-job-year valuation w rises: the optimum moves toward higher tariffs and larger recycling subsidies, since broader Chinese entry at lower tariffs amplifies job displacement. Quantitatively, however, the shift is modest: even at the upper-bound valuation of $70,000 per job-year, the optimal tariff rises only from 25% to 30% and the recycling subsidy from $7.5 to $7.8 thousand per vehicle, far below the prohibitive levels currently in place. Even a planner who values each manufacturing job at the full industry wage would therefore not choose policies resembling the de facto ban: concern for workers rationalizes moderate protection, not exclusion.

Welfare with MCPF. A second extension incorporates the marginal cost of public funds (MCPF): raising revenue through distortionary taxation is socially costly, so we penalize net fiscal deficits at a multiplier χ (Ballard, Shoven, and Whalley, 1985; Dahlby, 2008; Goulder and Williams, 2003).[30] The adjustment matters only for regimes that run deficits (*Subsidy Only* and the unconstrained *Both*), while *Tariff Only* (which generates a surplus) and *Recycling* (budget-balanced by construction) are unaffected. As the lower panel of Appendix Table F.5 shows, *Recycling* dominates across all reported values of χ and overtakes the unconstrained optimum as soon as the

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[28] We map equilibrium domestic sales into US auto-manufacturing employment using jobs-per-vehicle coefficients differentiated by ICE versus EV, and multiply the implied employment change by a per-job-year social value. Appendix C.4 provides the formulas and the five benchmarks we consider.

[29] Allcott et al. (2026) evaluate the welfare consequences of the IRA's EV credits using transaction-level data on US new vehicle sales and registrations.

[30] A one-dollar net deficit carries a social cost of χ dollars; surpluses are returned lump-sum at par. Appendix C.5 details the construction and motivates the range $\chi \in \{1.1, 1.3, 1.5\}$.

MCPF penalty binds, already exceeding it at $\chi = 1.1$. Once the cost of raising public funds is taken into account, the case for stand-alone subsidies weakens and the case for the self-financing tariff-recycling policy strengthens.

7.3 Mechanisms: Pass-through and Markups

The welfare results above hinge on how tariffs and subsidies transmit to consumer prices, a first-order determinant of aggregate outcomes in counterfactual trade-policy experiments (Head and Mayer, 2026). We therefore compute pass-through rates for both instruments. Because the tariff is ad valorem, we measure tariff pass-through as the change in consumer prices relative to the change in realized tariff payments per vehicle, dP/dT, and subsidy pass-through analogously as the reduction in consumer prices per dollar of per-vehicle subsidy; Appendix B.2 provides details.[31]

Figure 5 reveals a clear asymmetry. Chinese EVs exhibit incomplete tariff pass-through: they absorb part of the tariff burden by compressing their tax-exclusive markups rather than passing the full cost to consumers. The ad valorem structure of the tariff is central to this result, since under imperfect competition ad valorem taxes are more likely than specific taxes to be incompletely passed through (Delipalla and Keen, 1992; Anderson, De Palma, and Kreider, 2001).[32] By contrast, US-branded EVs receiving the recycling subsidy display persistent over-shifting: their prices fall by more than the per-vehicle subsidy, consistent with evidence that pass-through under rich consumer heterogeneity can exceed one (Goldberg, 1995; Goldberg and Hellerstein, 2013; Miravete, Seim, and Thurk, 2023).[33] This asymmetry, taxing foreign producers at less than full pass-through while delivering subsidies to domestic producers at more than full pass-through, is what gives the tariff-recycling policy its dual advantage.

The asymmetry, in turn, reflects where the two groups sit on the demand curve, both before and after policy intervention (Appendix Figure E.8). Under the no-policy benchmark, Chinese entrants combine high local market power (high Lerner indices) with relatively flat demand curvature in the low-price, high-market-share region of the demand curve (Appendix Figure E.9): they have both the ability (high markups) and the incentive (stable elasticities) to absorb part of the tariff shock. US incumbent EVs sit in the opposite region, near the "elbow" where curvature is high: a sub-

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[31] In the standard additive-cost case, pass-through is defined as Δprice$/\Delta$marginal cost; see Weyl and Fabinger (2013) and Miravete, Seim, and Thurk (2023).

[32] Under an ad valorem tariff, $P = (1+\tau)x$ and per-vehicle tariff payments are $T = \tau x$, so if firms optimally reduce the tax-exclusive price x as τ rises, dP/dT falls below one, a standard result under variable-markup oligopoly (Atkeson and Burstein, 2008), confirmed empirically in the US–China trade war by Fan et al. (2025). Our framework adds a second channel, heterogeneity in price sensitivity across income groups, which can generate over-shifting (Anderson, De Palma, and Kreider, 2001; Miravete, Seim, and Thurk, 2023). Appendix B.2 formalizes both channels.

[33] Allcott et al. (2026) similarly find more-than-complete pass-through of the IRA EV consumer credit, driven by the same consumer-heterogeneity mechanism.

sidy that lowers their effective price draws additional middle-income consumers into the market, making demand more elastic and amplifying pass-through above one. The tariff-recycling policy moves the two groups in opposite directions along the demand curve: the tariff pushes Chinese entrants toward lower markups, lower Lerner indices, and higher curvature, while the subsidy pushes US incumbents deeper into the region of above-one pass-through. As a result, Chinese EV prices rise and US EV prices fall, so consumer prices converge. Pricing power, however, shifts in favor of US incumbents: the policy compresses Chinese markups while strengthening the competitive position of US EVs.

7.4 Cross-Country Comparisons

We extend the analysis to three additional countries that, together with the US, span the spectrum of domestic EV industry structure: Germany (a broad domestic EV base across multiple price tiers), the United Kingdom (ultra-premium domestic EV production only), and Spain (no domestically headquartered EV producer). Table 6 reports the optimal policies for all four markets side by side, with the detailed US decomposition in Table 4. The comparison serves two purposes. It tests whether the central US findings generalize to markets with very different structures, and it isolates how distinct features of market structure (the breadth of the domestic EV portfolio and the level of domestic markups) each shape the optimal policy mix.

Germany versus the United States. Figure 6 compares the welfare contours and optimal policy combinations for the US and Germany. The two markets differ sharply in the role of the domestic subsidy: the welfare-maximizing subsidy in the unconstrained optimum is \$10.60k per vehicle for Germany versus \$8.40k for the US. The difference reflects the higher markups and prices of German domestic EVs, not the size of the portfolio. German domestic EVs are substantially more expensive than their US counterparts (sales-weighted average prices of \$75k vs. \$50k under the status quo) and carry higher markups, so the market-power distortion the subsidy corrects is larger and the price gap relative to Chinese entrants is wider, both calling for a larger per-unit subsidy. That portfolio size is not the driver is clear from the UK, which has only 8 domestic EV models, half as many as the US, yet the highest optimal subsidy of all four markets, owing to its ultra-premium, high-markup producers.

The optimal tariff is also higher in Germany, for two reasons. First, tariff pass-through is lower in Germany, so foreign exporters absorb a larger share of the tariff burden through the markup-compression channel documented in Section 7.3, making higher tariffs more attractive. Second, the broader domestic portfolio strengthens the profit-shifting rationale: Germany hosts 61 domestic EV models (Volkswagen, BMW, Mercedes, Audi, Porsche, and others) versus 16 in the US (dominated by Tesla, GM, Ford, Rivian, and Lucid), so more domestic products are available to absorb demand diverted away from Chinese imports.

While the optimal tariff and subsidy levels are thus context-specific, the central findings from Sections 7.1 to 7.3 carry over: in both markets, the tariff-funded subsidy is closely aligned with the unconstrained optimum. The reason is that the two motives are roughly self-balancing: the tariff revenue generated by the profit-shifting motive approximately covers the subsidy expenditure called for by the market-power-correction motive, so the unconstrained optimum is nearly self-financing regardless of market structure. This also echoes the EU-wide result in Section 6, where the CVD-with-recycling scenario delivers the highest welfare among the EU policy alternatives.

The United Kingdom and Spain. Table 6 extends the comparison to the United Kingdom and Spain. Spain provides a clean limiting case: with no domestically headquartered EV producer, the optimal subsidy is zero in every regime and the policy problem reduces to choosing the tariff. Strikingly, the optimal tariff remains strictly positive (17.5%) even though there is no domestic industry to protect. With incomplete pass-through, part of the tariff is paid by Chinese exporters out of their markups, so a moderate tariff extracts foreign rents at limited costs to domestic consumers. Spain's 17.5% can thus be read as pure rent-extraction, with the increments above it for the UK, the US, and Germany measuring the additional protection motive that domestic production justifies.

Comparing the four markets in the unconstrained optimum reveals two monotone patterns, and an instructive divergence between them. The optimal tariff rises with the number of domestic EV models (17.5% for Spain with 0 models, 20.0% for the UK with 8, 22.5% for the US with 16, and 37.5% for Germany with 61), because a broader domestic portfolio amplifies the demand-diversion and profit-shifting gains from protection. The optimal subsidy instead rises with the average markup of domestic EVs (zero for Spain, \$8.40k for the US, \$10.60k for Germany, and \$12.80k for the UK), as correcting the market-power distortion created by high domestic markups is among the subsidy's main rationales. The two rankings do not coincide: the UK has the second-lowest optimal tariff but the highest optimal subsidy, since its small domestic portfolio limits the gains from protection while the ultra-premium positioning of its producers maximizes the value of corrective subsidies. The optimal policy mix is therefore genuinely two-dimensional (tariffs respond to how many products the domestic industry offers, subsidies to how those products are priced), so countries cannot be ranked along a single protectionist scale. Finally, even in the most protection-friendly environment we consider (Germany), the optimal tariff of 37.5% remains far below the prohibitive duties currently imposed by the US, reinforcing the message of Section 6: the case for moderate, revenue-recycled protection is robust across market structures, while the case for exclusion is not.

8 Conclusion

The resurgence of industrial policy has reignited a longstanding debate about the appropriate role of government intervention in markets. In the context of the global transition to electric vehicles, policymakers face a particularly challenging set of tradeoffs. On the one hand, access to affordable imported EVs promotes consumer welfare and accelerates decarbonization. On the other hand, concerns about competitiveness, domestic production, employment, and economic resilience have led many governments to adopt tariffs, subsidies, and other forms of intervention. This paper develops a framework for evaluating these tradeoffs jointly and for designing policies that balance environmental, consumer, producer, and fiscal objectives.

Combining a theoretical model of differentiated-product oligopoly with a structural model estimated using data from 13 countries, we characterize the optimal use of tariffs and domestic production subsidies. Our results show that the effects of these policies depend critically on market structure, competitive conditions, demand responses, and the size of the domestic sector. Consequently, the precise welfare-maximizing policy differs across countries. While optimal tariffs are generally positive, reflecting the ability of governments to capture part of foreign producers' rents, the optimal subsidy varies with the strength and competitiveness of the domestic EV sector.

At the same time, our analysis delivers a robust and broader lesson. Across a wide range of market environments, policy packages that combine instruments outperform policies that rely on a single tool. In particular, the joint use of tariffs and domestic EV subsidies, financed through tariff revenues, consistently generates outcomes that are close to the unconstrained optimum while remaining fiscally sustainable. Relative to tariff-only policies, revenue recycling preserves consumer access to affordable EVs and supports faster electrification. Relative to subsidy-only policies, it avoids high fiscal costs while maintaining support for domestic producers.

More broadly, our findings suggest that effective industrial policy requires careful attention to market structure and country-specific conditions rather than adherence to universal prescriptions. Yet recognizing the importance of context does not imply the absence of general lessons. If anything, our results point to a common principle: when governments pursue multiple objectives simultaneously, coordinated policy packages that combine complementary instruments and recycle revenues productively are likely to outperform simpler interventions. As countries increasingly turn to industrial policy to address climate, competitiveness, and security concerns, understanding these interactions will be essential for designing policies that achieve multiple objectives without sacrificing economic welfare.

We conclude with thoughts for future research. Our analysis takes product portfolios and production locations as given and should be interpreted as capturing the short- to medium-run effects of trade and industrial policy. Understanding the long-run consequences of these policies requires endogenizing firms' product-entry and location decisions, allowing domestic automakers to expand EV offerings in response to intensified competition. More broadly, trade barriers may reshape the geography of production and global supply chains. Just as the voluntary export restraints of the 1980s contributed to the expansion of Japanese transplant manufacturing in the US, today's tariffs may encourage Chinese automakers to establish production facilities in North America and other destination markets. How firms adapt along these margins in response to trade and industrial policies remains an important question for future research and for understanding the next phase of the global energy transition.

References

Allcott, Hunt, Reigner Kane, Maximilian S. Maydanchik, Joseph S. Shapiro, and Felix Tintelnot. 2026. "The Effects of "Buy American": Electric Vehicles and the Inflation Reduction Act." NBER Working Paper 33032, revised March 2026.

Anderson, Simon P, Andre De Palma, and Brent Kreider. 2001. "Tax incidence in differentiated product oligopoly." *Journal of Public Economics* 81 (2):173–192.

Atkeson, Andrew and Ariel Burstein. 2008. "Pricing-to-Market, Trade Costs, and International Relative Prices." *American Economic Review* 98 (5):1998–2031.

Bagwell, Kyle and Robert W. Staiger. 2002. *The Economics of the World Trading System*. MIT Press.

Ballard, Charles L., John B. Shoven, and John Whalley. 1985. "General Equilibrium Computations of the Marginal Welfare Costs of Taxes in the United States." *American Economic Review* 75 (1):128–138.

Banares-Sanchez, Ignacio, Robin Burgess, David Laszlo, Pol Simpson, John Van Reenen, and Yifan Wang. 2025. "Chinese Innovation, Green Industrial Policy and the Rise of Solar Energy." NBER Working Paper.

Barwick, Panle Jia, Hyuk-soo Kwon, and Shanjun Li. 2024. "Attribute-Based Subsidies and Market Power: An Application to Electric Vehicles." Working paper, National Bureau of Economic Research.

Barwick, Panle Jia, Hyuk-Soo Kwon, Shanjun Li, Yucheng Wang, and Nahim B Zahur. 2024. "Industrial policies and innovation: evidence from the global automobile industry." *National Bureau of Economic Research* .

Barwick, Panle Jia, Hyuk-soo Kwon, Shanjun Li, and Nahim Bin Zahur. 2025. "Drive Down the Cost: Learning by Doing and Government Policies in the Global EV Battery Industry." Working paper.

Barwick, Panle Jia, Hyuk-soo Kwon, Binglin Wang, and Nahim Bin Zahur. 2023. "Pass-through of electric vehicle subsidies: A global analysis." In *AEA Papers and Proceedings*, vol. 113. American Economic Association 2014 Broadway, Suite 305, Nashville, TN 37203, 323–328.

Berry, Steven, James Levinsohn, and Ariel Pakes. 1995. "Automobile prices in market equilibrium." *Econometrica* :841–890.

———. 1999. "Voluntary Export Restraints on Automobiles: Evaluating a Trade Policy." *American Economic Review* 89 (3):400–430.

Bollinger, Bryan, Todd Gerarden, Kenneth Gillingham, Drew Vollmer, and Daniel Yi Xu. 2024. "Strategic Avoidance and the Welfare Impacts of Solar Panel Tariffs." NBER Working Paper.

Brander, James A. and Barbara J. Spencer. 1985. "Export Subsidies and International Market Share Rivalry." *Journal of International Economics* 18 (1-2):83–100.

Conlon, Christopher and Jeff Gortmaker. 2020. "Best practices for differentiated products demand estimation with pyblp." *The RAND Journal of Economics* 51 (4):1108–1161.

———. 2025. "Incorporating micro data into differentiated products demand estimation with PyBLP." *Journal of Econometrics* :105926.

Dahlby, Bev. 2008. *The Marginal Cost of Public Funds: Theory and Applications*. Cambridge, MA: MIT Press.

Delipalla, Sofia and Michael Keen. 1992. "The comparison between ad valorem and specific taxation under imperfect competition." *Journal of Public Economics* 49 (3):351–367.

Dixit, Avinash K. 1984. "International Trade Policy for Oligopolistic Industries." *Economic Journal* 94:1–16.

Draghi, Mario. 2024. "The Future of European Competitiveness: A Competitiveness Strategy for Europe." Tech. rep., European Commission. URL `https://commission.europa.eu/document/`

97e481fd-2dc3-412d-be4c-f152a8232961_en. Report prepared for the European Commission.

Eaton, Jonathan and Gene M. Grossman. 1986. “Optimal Trade and Industrial Policy under Oligopoly.” *Quarterly Journal of Economics* 101 (2):383–406.

Evenett, Simon, Adam Jakubik, Fernando Martín, and Michele Ruta. 2024. “The Return of Industrial Policy in Data.” *The World Economy* 47 (7):2762–2788.

Fan, Haichao, Lixin Tang, Wei Tian, Caiyun Wu, and Miaojie Yu. 2025. “Tariff Pass-through in the Trade War: A Firm-Heterogeneity Perspective.” SSRN Working Paper.

Fernandes, Ana Margarida and Tristan Reed. 2026. *Industrial Policy for Development: Approaches in the 21st Century*. Policy Research Reports. Washington, DC: World Bank.

Funke, Christoph, Joshua Linn, Sally Robson, Ethan Russell, Daniel Shawhan, and Steven Witkin. 2023. “What Are the Climate, Air Pollution, and Health Benefits of Electric Vehicles.” *RFF Working Paper* .

Gandhi, Amit and Jean-François Houde. 2019. “Measuring substitution patterns in differentiated-products industries.” *NBER Working paper* (w26375).

Gerarden, Todd D. 2023. “Demanding innovation: The impact of consumer subsidies on solar panel production costs.” *Management Science* 69 (12):7799–7820.

Gerarden, Todd D., Bryan K. Bollinger, Kenneth Gillingham, and Daniel Yi Xu. 2025. “Strategic Avoidance and the Welfare Impacts of U.S. Solar Panel Tariffs.” NBER Working Paper 34401, National Bureau of Economic Research.

Goldberg, Pinelopi and Rebecca Hellerstein. 2013. “A structural approach to identifying the sources of local currency price stability.” *Review of Economic Studies* 80 (1):175–210.

Goldberg, Pinelopi K, Réka Juhász, Nathan J Lane, Giulia Lo Forte, and Jeff Thurk. 2024. “Industrial policy in the global semiconductor sector.” *National Bureau of Economic Research* .

Goldberg, Pinelopi Koujianou. 1995. “Product Differentiation and Oligopoly in International Markets: The Case of the U.S. Automobile Industry.” *Econometrica* 63 (4):891–951.

Goulder, Lawrence H. and III Williams, Roberton C. 2003. “The Substantial Bias from Ignoring General Equilibrium Effects in Estimating Excess Burden, and a Practical Solution.” *Journal of Political Economy* 111 (4):898–927.

Grieco, Paul LE, Charles Murry, and Ali Yurukoglu. 2024. “The evolution of market power in the us automobile industry.” *The Quarterly Journal of Economics* 139 (2):1201–1253.

Head, Keith and Thierry Mayer. 2026. “Poor Substitutes? Counterfactual Methods in Industrial Organization and Trade Compared.” *Review of Economics and Statistics* 108 (1):241–256.

Head, Keith, Thierry Mayer, Marc Melitz, and Chenying Yang. 2026. “Industrial policies for multi-stage production: The battle for battery-powered vehicles.” *Working Paper* .

Juhász, Réka, Nathan Lane, and Dani Rodrik. 2024. “The New Economics of Industrial Policy.” *Annual Review of Economics* 16 (1):213–242.

Juhász, Réka, Nathaniel Lane, Emily Oehlsen, and Veronica Perez. 2025. “Measuring Industrial Policy: A Text-Based Approach.” NBER Working Paper 33895, National Bureau of Economic Research.

Kiso, Takahiko. 2022. “A Subsidy That Is Inversely Related to the Product Price.” *Economic Journal* 132 (646):2173–2206.

Kwon, Hyuk-soo. 2025. “Subsidies versus Tradable Credits for Electric Vehicles: The Role of Market Power in the Credit Market.” Working Paper.

Leard, Benjamin, Joshua Linn, and Katalin Springel. 2024. “Vehicle Attribute Tradeoffs and the Distributional Effects of US Fuel Economy and Greenhouse Gas Emissions Standards.” Working Paper.

Li, Jing. 2023. “Compatibility and Investment in the US Electric Vehicle Market.” *Working Paper* .

Li, Shanjun, Lang Tong, Jianwei Xing, and Yiyi Zhou. 2017. “The market for electric vehicles: indirect network effects and policy design.” *Journal of the Association of Environmental and Resource Economists* 4 (1):89–133.

Miravete, Eugenio, Katja Seim, and Jeff Thurk. 2023. “Elasticity and Curvature of Discrete Choice Demand Models.” Working Paper.

Morrow, W Ross and Steven J Skerlos. 2011. “Fixed-Point Approaches to Computing Bertrand-Nash Equilibrium Prices Under Mixed-Logit Demand.” *Operations Research* 59 (2):328–345.

Muehlegger, Erich and David S Rapson. 2022. “Subsidizing low-and middle-income adoption of electric vehicles: Quasi-experimental evidence from California.” *Journal of Public Economics* 216:104752.

Remmy, Kevin. 2025. “Adjustable Product Attributes, Indirect Network Effects, and Subsidy Design: The Case of Electric Vehicles.” Working Paper.

Sabal, Alejandro. 2025. “Product Entry in the Global Automobile Industry.” *Working Paper* .

Slattery, Cailin. 2025. “Bidding for Firms: Subsidy Competition in the United States.” *Journal of Political Economy* 133 (8):2563–2614.

Spencer, Barbara J. and James A. Brander. 1983. “International R&D Rivalry and Industrial Strategy.” *Review of Economic Studies* 50 (4):707–722.

Springel, Katalin. 2021. “Network externality and subsidy structure in two-sided markets: Evidence from electric vehicle incentives.” *American Economic Journal: Economic Policy* 13 (4):393–432.

Suranovic, Steve. 2010. “International Trade: Theory and Policy.” *Book* .

Wang, Jingyuan and Jianwei Xing. 2025. “Subsidizing Industry Growth in a Market with Lemons: Evidence from the Chinese Electric Vehicle Market.” Working Paper.

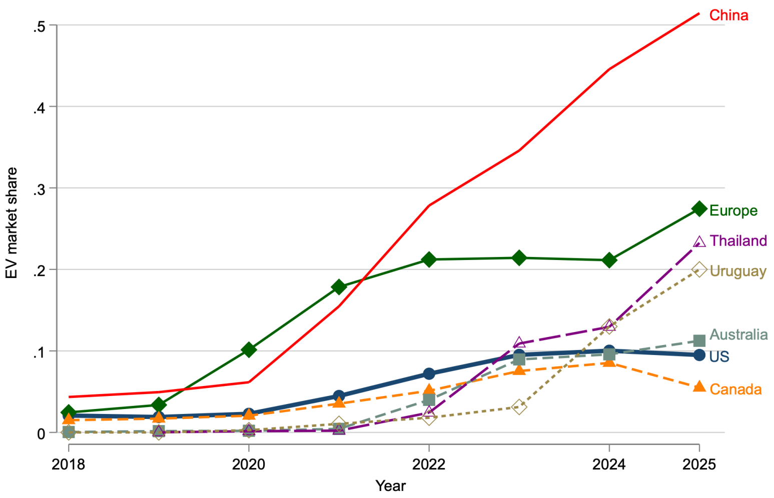
Weng, Andrew, Omar Y Ahmed, Gabriel Ehrlich, and Anna Stefanopoulou. 2024. “Higher labor intensity in US automotive assembly plants after transitioning to electric vehicles.” *Nature communications* 15 (1):8088.

Weyl, E. Glen and Michal Fabinger. 2013. “Pass-through as an economic tool: Principles of incidence under imperfect competition.” *Journal of Political Economy* .

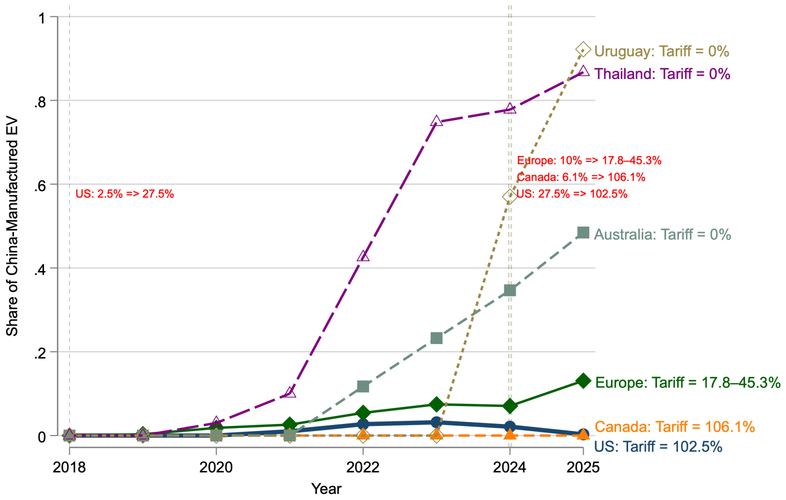
Figures & Tables

Figure 1: Global Electric Vehicle Adoption and the Rise of Chinese-Brand EVs

(a) EV adoption across markets

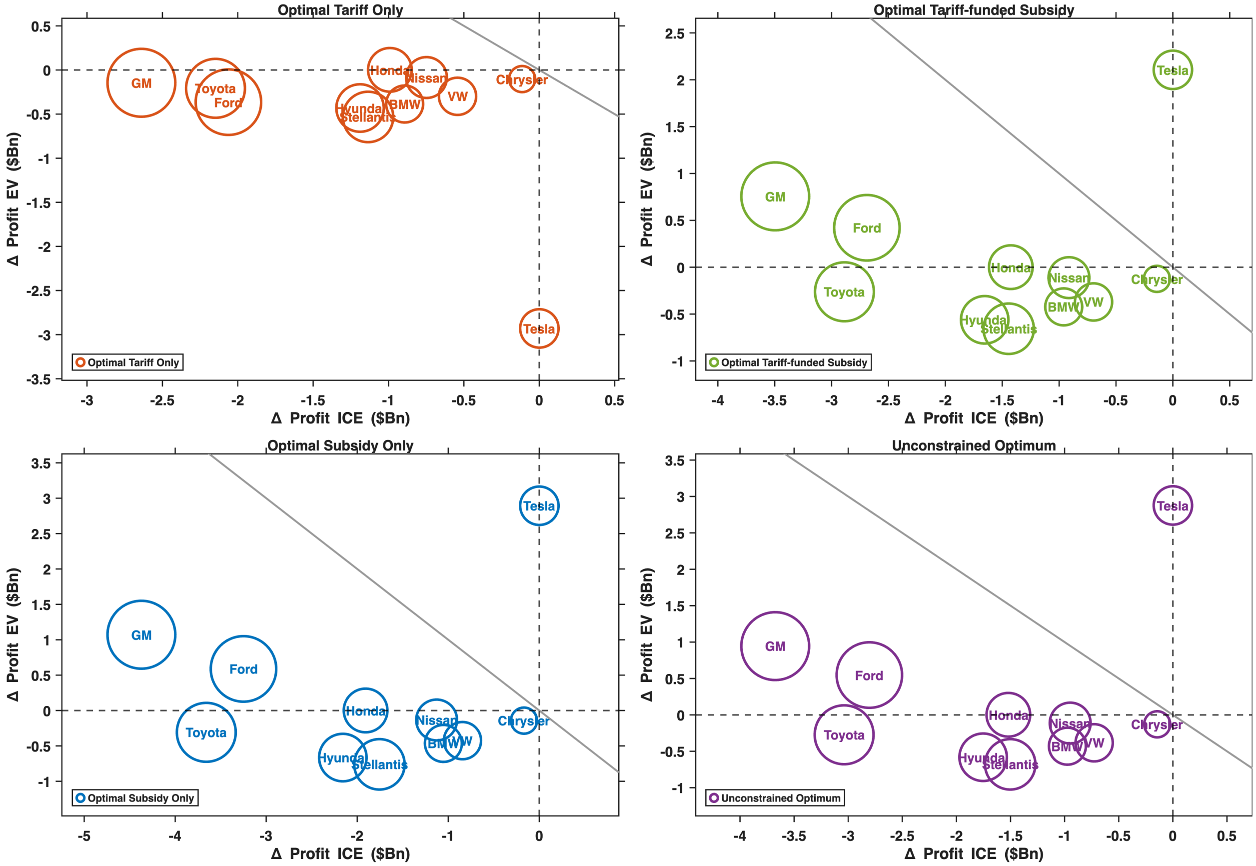


(b) Share of Chinese-brand EVs in total EV sales



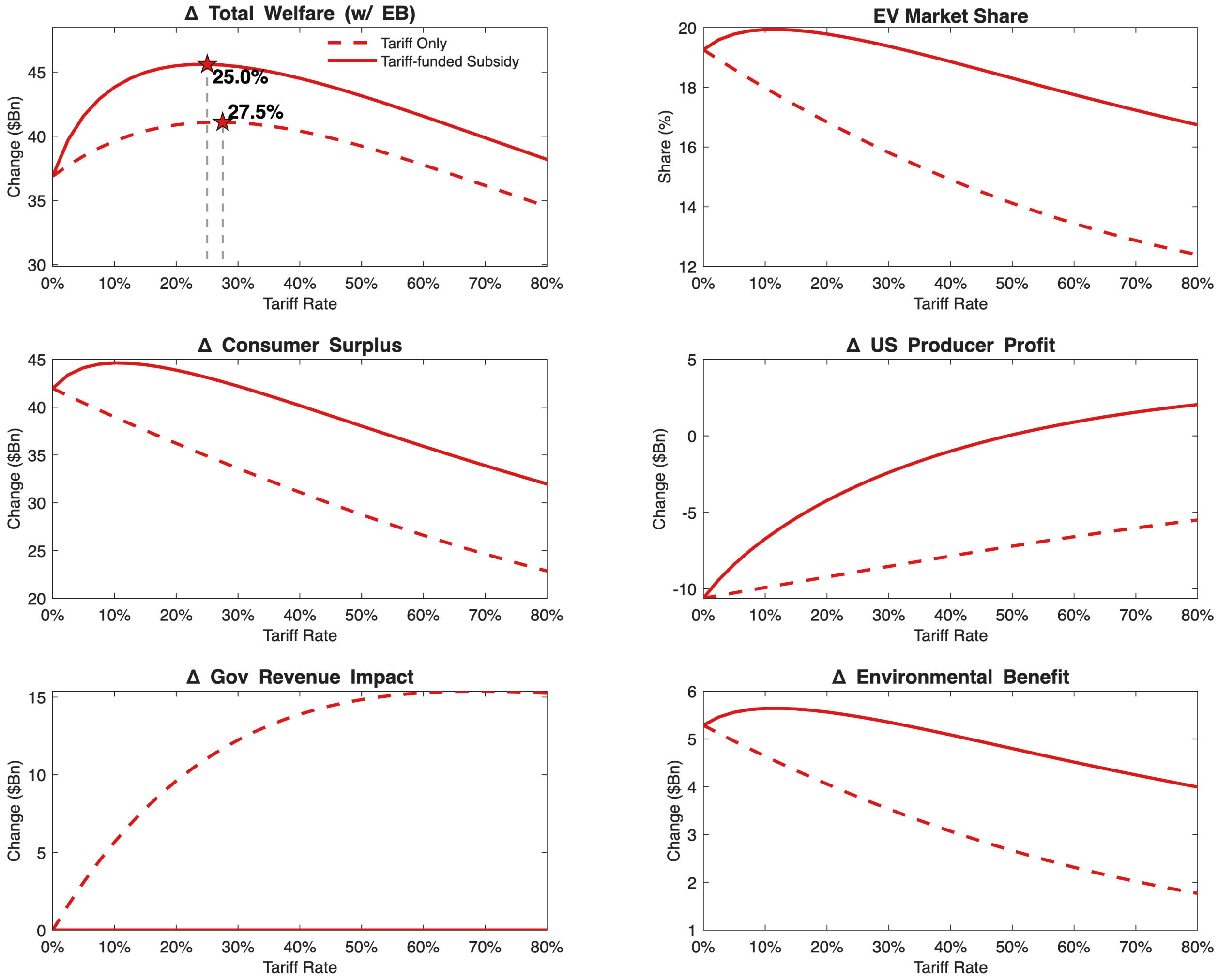
Notes: This figure shows the trends in EV adoption and the market penetration of Chinese-brand EVs across major global markets from 2018 to 2025. Panel (a) displays the EV adoption rate, defined as the share of new EV registrations in total passenger vehicle sales. The lines represent different markets (countries or groups of countries). Panel (b) shows the share of Chinese-brand EVs out of total new EV sales in each destination market. In Panel (b), the legend next to each line reports the total import tariff rate on Chinese EVs effective at the end of 2024, and the vertical dashed lines mark the two major tariff changes, with the rates before and after each change annotated: the 2018 US Section 301 action (2.5% to 27.5%) and the 2024 round (US: 27.5% to 102.5%; Canada: 6.1% to 106.1%; EU: 10% to 17.8%–45.3%, reflecting brand-specific countervailing duties on top of the 10% MFN). Import tariffs on Chinese EVs are zero in Australia, Thailand, and Uruguay.

Figure 2: Changes in US Firm Profits after Chinese EV Entry under Alternative Policy Scenarios



Notes: This figure illustrates US auto firms' profit changes with the entry of **top 10** Chinese EV models under four optimal policy scenarios relative to the 2023 status quo: *Optimal Tariff Only* (top left), *Optimal Tariff-funded Subsidy* (top right), *Optimal Subsidy Only* (bottom left), and *Unconstrained Optimum* (bottom right). The horizontal axis denotes the profit change from ICE vehicles, while the vertical axis denotes the profit change from EVs, in $billions. Bubble sizes are proportional to each model's total profit in the baseline scenario. In each panel, the gray negative 45-degree solid line represents the zero-sum boundary for total profit; points located above this line represent a net increase in total profits. Under *Optimal Tariff Only*, all firms lie below this boundary.

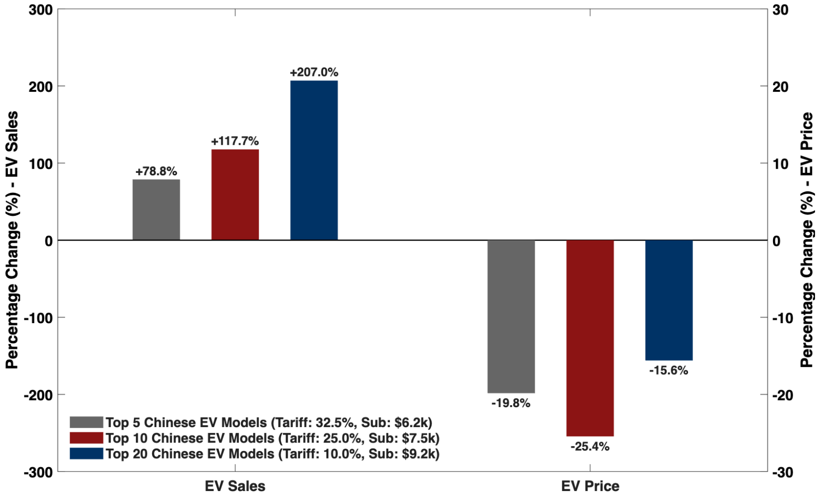
Figure 3: Welfare Components and Relationship with Tariff Rates



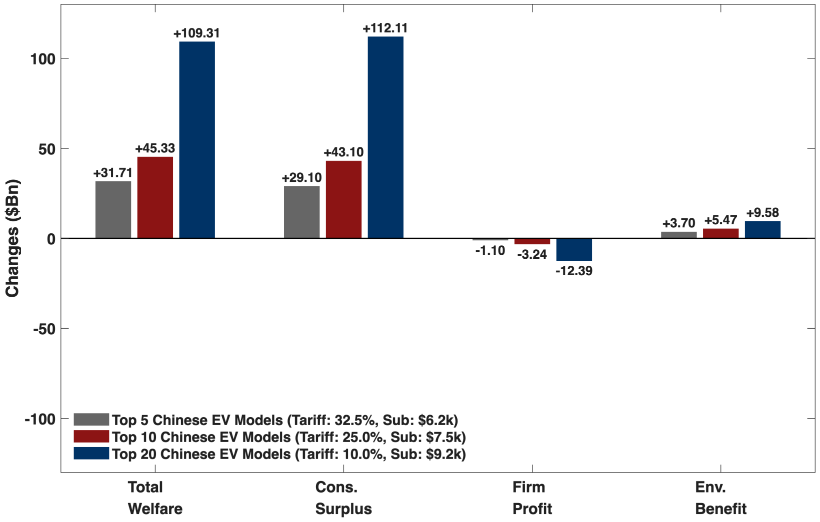
Notes: This figure illustrates the simulated changes in welfare components and market outcomes relative to the 2023 status quo across different tariff rates, following the introduction of the **top 10** Chinese-manufactured EV models into the US market. The red solid lines represent the scenario with tariff revenue recycling into domestic EV subsidies, while the red dashed lines represent the scenario without such recycling. The stars in the "Total Welfare" panel (top-left) indicate the optimal tariff rates that maximize social welfare under the two policy regimes. All monetary values are measured in $billions.

Figure 4: Market Outcomes and Welfare Effects under Optimal Tariff-Funded Subsidies

(a) EV Adoption and EV Price



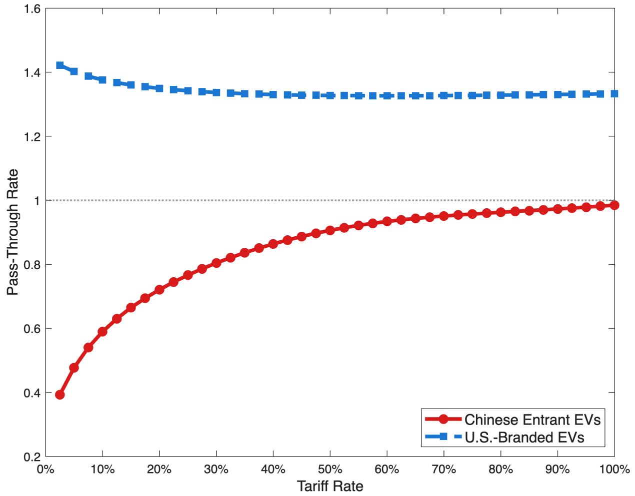
(b) Welfare



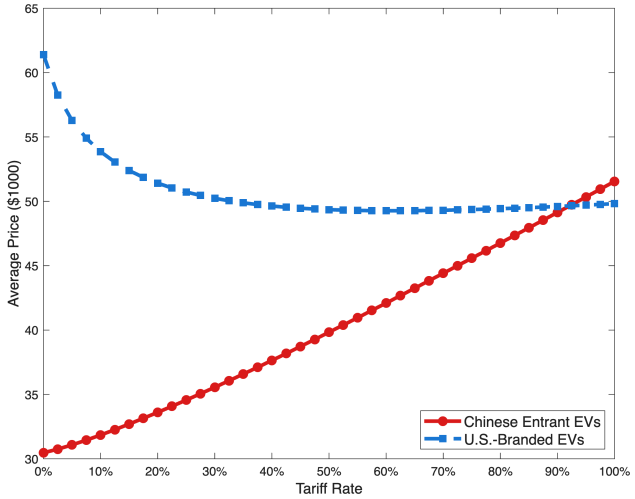
Notes: This figure shows market outcomes and welfare effects under the optimal tariff-recycling subsidy policies, relative to the 2023 status quo. Panel (a) plots percentage changes in EV sales (left axis) and the sales-weighted average EV price (right axis). Panel (b) plots changes in welfare components in $billions: total welfare, consumer surplus, firm profits, and environmental benefits, in that order. Government revenue is omitted because the recycling design balances tariff revenue and subsidy expenditure by construction. Bar colors correspond to the three entry cases in the legend (introducing the top 5, top 10, or top 20 Chinese EV models), which entail manufacturing job losses of 30.9k, 52.0k, and 107.6k, respectively (not shown).

Figure 5: Aggregated Pass-Through Rates and EV Price Against Tariff Rates

(a) Pass-Through Rates



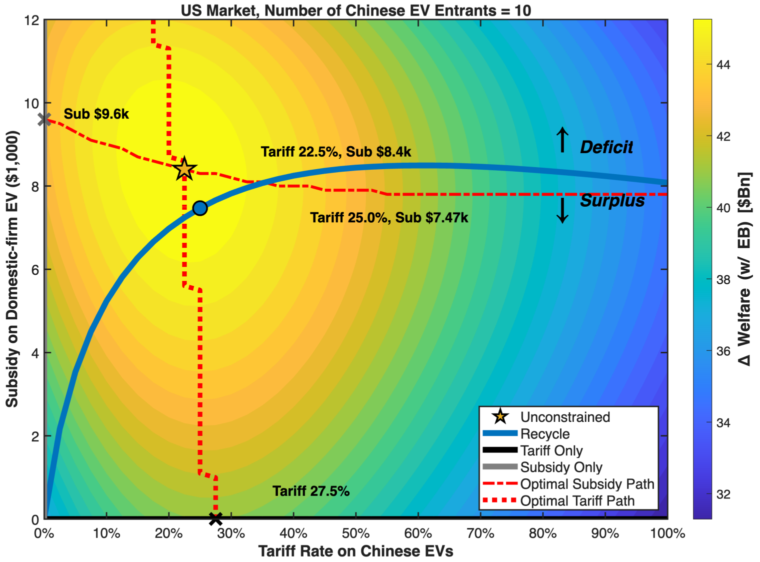
(b) Average EV Price



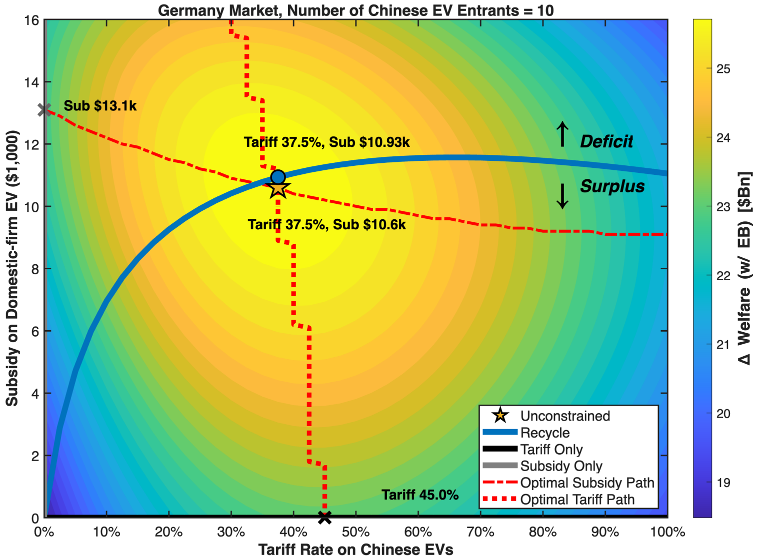
Notes: This figure shows simulated market responses under the joint policy of tariffs on the top 10 Chinese EVs and a recycling-based subsidy for US domestic EVs, with 2023 as the status quo. Panel (a) plots pass-through rates across tariff levels. For Chinese entrant EVs (red solid line with circles), tariff pass-through is ($\Delta p/\Delta T$), where (ΔT) is the change in per-vehicle tariff payments rather than the tariff rate, since the tariff is ad valorem. For US-branded EVs (blue dashed line with squares), subsidy pass-through is defined symmetrically as (-$\Delta p/\Delta S$), where (ΔS) is the change in the per-vehicle subsidy; because the subsidy is per-unit, this coincides with the standard per-dollar pass-through measure. The horizontal dotted line marks a pass-through of unity. Panel (b) plots the corresponding changes in average EV prices ($1,000) for the two groups as the tariff rate rises.

Figure 6: The Optimal Policy Mix and Welfare Contour

(a) US Market



(b) Germany Market



Notes: This figure plots simulated changes in social welfare ($\Delta Welfare$, in $billions) relative to the 2023 status quo over the two-dimensional policy space, after the top 10 Chinese-manufactured EV models are introduced into the US and German markets. The horizontal axis is the tariff rate on Chinese EVs; the vertical axis is the per-unit subsidy to domestically produced EVs; colors of the heatmap indicate the magnitude of the welfare gain (color bar). The gold star marks the unconstrained optimum. The blue solid line traces the tariff-recycling path, along which subsidy outlays exactly exhaust tariff revenues; the blue circle marks the optimal policy on this path. Points above the line entail a fiscal deficit, and points below a surplus. The gray ‘x’ markers denote the single-instrument optima: tariff-only on the horizontal axis and subsidy-only on the vertical axis. The red dashed line traces the optimal subsidy for each given tariff, and the red dotted line the optimal tariff for each given subsidy. Neither the red best-response curves nor the single-instrument and unconstrained optima impose budget balance; only the blue recycling path does.

Table 1: Demand Estimation Results

	(1) OLS		(2) IV		(3) RC		(4) RC	
Parameter	Coef	SE	Coef	SE	Coef	SE	Coef	SE
Panel A: Linear parameters								
Price ($\bar{\alpha}$)	-0.013	0.001	-0.093	0.004	-0.033	0.004	0.009	0.005
1(Home brand)	0.224	0.025	0.169	0.029	0.041	0.034	0.111	0.034
log(Horsepower)	-0.123	0.037	2.589	0.125	2.584	0.153	0.993	0.210
Fuel economy	-0.055	0.003	0.009	0.004	0.020	0.006	0.013	0.012
log(Driving Range) × EV	1.352	0.051	1.172	0.059	2.450	0.039	2.112	0.191
log(Footprint)	0.277	0.023	0.755	0.033	0.893	0.046	0.485	0.054
Panel B: Non-linear parameters								
σ, Constant					0.336	0.128	0.747	0.128
σ, EV					2.490	0.094	2.485	0.109
σ, log(Footprint)					0.186	0.010	0.233	0.012
σ, Brand, CHN					0.228	0.444	0.252	0.438
σ, Brand, US+CA					1.349	0.117	1.568	0.126
σ, Brand, EU: larger markets					0.233	1.022	0.304	0.741
σ, Brand, EU: smaller markets					1.709	0.265	0.387	0.089
α_1, CHN					1.849	0.095	1.992	0.120
α_1, JP/SP/FR/DE					2.405	0.268	2.911	0.333
α_1, UK/NL/AT/SE					0.800	0.061	0.998	0.066
α_1, CA/NO/US/CH					0.728	0.052	1.107	0.074
σ, Price					0.084	0.005	0.103	0.006
Country-Year FE	Yes		Yes		Yes		Yes	
Body Type FE	Yes		Yes		Yes		Yes	
Segment FE	Yes		Yes		Yes		Yes	
Fuel Type FE	Yes		Yes		Yes		Yes	
Brand FE	Yes		Yes		Yes		Yes	
Country-Year-EV FE	No		No		No		Yes	
Brand-EV FE	No		No		No		Yes	

Notes: Demand is estimated using annual vehicle-model-by-country sales in 13 major EV markets from 2004 to 2023. The number of observations is 65,574 . All regressions include country, year, body type, segment, fuel type, and brand fixed effects. Column (1) reports results for the OLS logit regressions; Column (2) reports 2SLS IV estimation. The first set of instruments includes the number of rival brands, the count of models of the own brand and rival brands, the count of models of the own brand in other markets, and the average model characteristics of the own and rival brands. The second set of instruments includes battery-supplier dummies interacted with battery capacity, as well as three IVs based on vehicle attributes. The third set of instruments includes the number of products in the same predefined market scope that are within one standard deviation of an attribute. Column (3) is a random coefficient multinomial logit model and is estimated using simulated GMM with IVs and micro-moments. Column (4) is a random coefficient model with two additional fixed effects: country-by-year-by-EV and brand-by-EV fixed effects. The price coefficient α_i is specified as $\bar{\alpha} + \alpha_{1,M}/y_{i,M} + \sigma_p \nu_{i,p}$, where $y_{i,M}$ is consumer income and $\nu_{i,p}$ is the unobserved preference shock (i.i.d. log-normal draws). Price enters utility as $-\alpha_i(\tilde{P}_{jmt} - b_{jmt})$, so the row Price ($\bar{\alpha}$) reports the constant component $\bar{\alpha}$ of the price coefficient; the income interactions $\alpha_{1,M}$ enter with a positive sign, so higher-income consumers are less price-sensitive. The standard errors are clustered at the country-by-brand level.

Table 2: Impact of Chinese EV Entry under Alternative Policy Scenarios: United States

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Ban		**Add top 10 China manufactured EV**				
	Baseline	*Subsidy*	*Baseline Tariff*	*Moderate Tariff*	*Punitive Tariff*	*Tariff Recycle*	*Subsidy*
Subsidy/Tariff		\$7,500	2.5%	27.5%	102.5%	102.5%	\$7,500 / 0%
Panel (a) Effects on EV adoption							
Weighted Price: ICE (\$1,000)	42.62	42.85	42.72	42.51	42.39	42.68	42.93
Weighted Price: Non-Chinese EV (\$1,000)	53.18	43.14	53.59	52.44	51.79	40.81	41.53
Weighted Price: Chinese EV (\$1,000)	0.00	0.00	33.95	38.99	56.72	57.16	32.94
Total Sales (1,000)	15,327	15,508	15,798	15,646	15,435	15,639	15,993
Total EV Sales (1,000)	1,380	2,029	2,990	2,513	1,786	2,475	3,562
EV Share (%)	9.00	13.08	18.92	16.06	11.57	15.83	22.27
Chinese EV % of total EV	0.00	0.00	69.00	58.78	30.56	19.34	56.61
Profit, CHN EV (\$Bn)	0.00	0.00	27.92	17.01	5.49	4.94	26.91
Panel (b) Effects on US Welfare							
△ Welfare (\$Bn)		5.64	37.48	40.88	30.78	34.59	42.48
△ Consumer Surplus (\$Bn)		8.71	41.19	34.24	19.45	28.15	50.66
△ Government Revenue (\$Bn)		-11.82	1.61	11.69	14.48	0.00	-9.30
△ Profits, All US firms (\$Bn)		6.64	-10.44	-8.70	-4.49	2.92	-5.70
△ Profit, US EV		8.48	-4.66	-3.89	-1.93	7.22	1.59
△ Profit, US ICE		-1.84	-5.78	-4.82	-2.56	-4.30	-7.30
△ Env. Benefits (\$Bn)		2.10	5.12	3.66	1.34	3.52	6.82
△ Mfg Jobs (Thousands)		7.16	-86.91	-62.80	-22.68	-11.25	-76.66
△ CO_2 Reduction (Mn tons)		36.73	89.34	63.88	23.37	61.47	119.04

Notes: This table reports results when the top 10 Chinese EV models are introduced to the US market under a set of real-world and hypothetical policy environments. Column (1) reports the 2023 status quo (no Chinese EV entry, no domestic EV policy). Column (2) maintains the Chinese EV ban while providing a \$7,500 subsidy to domestically manufactured EVs, mimicking the domestic-content requirement under the Inflation Reduction Act. Columns (3)–(7) lift the ban and introduce the top 10 Chinese EV models. Column (3) applies the baseline 2.5% WTO most-favored-nation (MFN) tariff. Column (4) mimics the 2018 Trump administration's Section 301 action, which imposed an additional 25% tariff. Column (5) reflects the May 2024 Biden administration's Section 301 update, raising the total tariff to 102.5%. Column (6) considers a hypothetical policy in which revenue from the 102.5% tariff is earmarked to fund domestic EV subsidies; the implied budget-balancing subsidy is approximately \$8,139 per vehicle. Column (7) models a free-trade scenario with a 0% tariff on Chinese EVs, combined with a \$7,500 domestic EV subsidy under the Inflation Reduction Act. All monetary values are normalized to 2023 USD. The shipment cost is calibrated at \$2,750, and additional distribution and marketing costs are \$1,402. Distribution and marketing services are assumed to be provided at cost by US firms, so they generate no profits and affect welfare only through consumer prices. All average numbers are calculated as sales-weighted averages across models. △ CO_2 Reduction reports the lifetime CO_2 reduction (in million tons).

Table 3: Impact of Different Trade Policies on Chinese EVs: European Union

	(1)	(2)	(3)	(4)	(5)
	Chinese EVs Present				**No Chinese EVs**
Additional Policy	*Benchmark* 10% MFN (2023)	*EU CVD* Brand-specific	*CVD+Recycle* Revenue recycled	*MPC* Price undertaking	*Remove CHN EVs* Counterfactual ban
Panel (a) Effects on EV adoption					
Weighted Price: ICE ($1,000)	46.05	46.04	46.07	46.04	46.07
Weighted Price: Non-Chinese EV ($1,000)	62.30	62.25	61.36	62.25	62.58
Weighted Price: Chinese EV ($1,000)	54.72	71.55	71.64	71.55	—
Total Sales (1,000)	9,850	9,822	9,839	9,822	9,795
Total EV Sales (1,000)	2,345	2,270	2,336	2,270	2,208
EV Share (%)	23.81	23.11	23.74	23.11	22.54
Chinese EV % of total EV	9.89	4.50	4.28	4.50	—
Profit, CHN EV ($Bn)		1.68	1.65	3.10	—
Panel (b) Effects on EU Welfare (change vs. Benchmark)					
△ Welfare ($Bn)		-0.11	1.23	-1.52	-5.00
△ Consumer Surplus ($Bn)		-2.22	-0.68	-2.22	-5.64
△ Government Revenue ($Bn)		1.41	0.00	0.00	-1.15
△ Profits, EU domestic firms ($Bn)		1.15	1.89	1.15	2.57
△ Profit, EU EV		0.65	1.87	0.65	1.56
△ Profit, EU ICE		0.50	0.02	0.50	1.01
△ Env. Benefits ($Bn)		-0.45	0.01	-0.45	-0.79

Notes: This table reports the simulated effects of different EU import policies on Chinese EVs, given Chinese EV models present in the 2023 EU data. Results are aggregated across six EU member states: Austria, France, Germany, the Netherlands, Spain, and Sweden. Chinese-owned brands (including BYD, MG (SAIC), Aiways, and Geely-group brands such as Polestar and Lotus EVs) are classified as Chinese for all columns. Column (1) is the benchmark, reflecting the status quo in which Chinese EVs are present in the EU market under the existing 10% MFN tariff, embedded in 2023 observed prices. Column (2) applies the EU's October 2024 brand-specific countervailing duties (CVD) on top of the existing 10% MFN: BYD +17%, Geely group +18.8%, and all other Chinese brands +35.3%. Column (3) applies the same CVD tariffs as Column (2) and recycles the resulting revenue as a uniform per-vehicle subsidy to EU-member-manufactured EVs, with the budget-clearing subsidy solved jointly across all six member states. Column (4) models a Minimum Price Commitment (MPC), in which the price equilibrium is identical to Column (2) but the duty revenue accrues to the Chinese exporting firms rather than the EU government, consistent with a negotiated price floor arrangement. Column (5) is a counterfactual ban in which all existing Chinese EV models are removed from the EU market. Welfare is the sum of consumer surplus, profits of EU-headquartered automakers aggregated across the six member states, government revenue net of subsidy expenditure, and environmental benefits. All monetary values are in 2023 USD. All averages are sales-weighted.

Table 4: Welfare Effects under Optimal Policy Mixes: Adding Top 10 Chinese EVs to the US Market, Year = 2023

	(1)	(2)	(3)	(4)	(5)
	Ban	**Add top 10 China manufactured EV + Optimal designs**			
	Benchmark	*Tariff Only*	*Subsidy Only*	*Both*	*Recycling*
Tariff/Subsidy		27.5% / $0.00k	0.0% / $9.60k	22.5% / $8.40k	25.0% / $7.47k
Panel (a) Effects on EV adoption					
Weighted Price: ICE ($1,000)	42.62	42.51	43.05	42.81	42.74
Weighted Price: Non-Chinese EV ($1,000)	53.18	52.44	37.87	39.75	41.24
Weighted Price: Chinese EV ($1,000)	0.00	38.99	32.85	37.62	38.17
Total Sales (1,000)	15,327	15,646	16,079	15,882	15,834
Total EV Sales (1,000)	1,380	2,513	3,790	3,241	3,103
EV Share (%)	9.00	16.06	23.57	20.41	19.60
Chinese EV % of total EV	0.00	58.78	51.60	44.50	45.54
Profit, CHN EV ($Bn)	0.00	17.01	25.95	16.73	16.20
Panel (b) Effects on US Welfare					
△ Welfare ($Bn)		40.88	42.94	45.45	45.33
△ Consumer Surplus ($Bn)		34.24	53.67	45.01	43.11
△ Government Revenue ($Bn)		11.69	-14.77	-3.01	0.00
△ Profits, All US firms ($Bn)		-8.70	-3.41	-2.43	-3.24
△ Profit, US EV		-3.89	4.38	4.20	3.08
△ Profit, US ICE		-4.82	-7.79	-6.62	-6.32
△ Env. Benefits ($Bn)		3.66	7.46	5.87	5.47
△ Mfg Jobs (Thousands)		-62.80	-69.94	-51.52	-51.95
△ CO_2 Reduction (Mn tons)		63.88	130.14	102.54	95.44

Notes: This table reports the effects of introducing the top 10 Chinese EV models into the US market under optimal policy designs. Column (1) reports the status quo, in which Chinese EVs are banned from the US market. Column (2) reports the optimal tariff, and Column (3) reports the optimal subsidy. Column (4) reports the unconstrained optimum, allowing both tariffs and subsidies. Column (5) reports the optimal tariff-recycling subsidy, in which the tariff and subsidy are jointly chosen under a balanced-budget constraint. The counterfactual is based on the year 2023. All monetary values are normalized to 2023 USD. The shipment cost is calibrated at $2,750, and additional distribution and marketing costs are $1,402. Distribution and marketing services are assumed to be provided at cost by US firms, so they generate no profits and affect welfare only through consumer prices. All average numbers are calculated as sales-weighted averages across models. △ Mfg Jobs reports the change in manufacturing employment (in thousands), computed using industry input–output coefficients with a transplant-production ratio of 0.53. △ CO_2 Reduction reports the lifetime CO_2 reduction (in million tons), computed as the reduction in ICE vehicle sales multiplied by 78.5 tons of lifetime CO_2 per vehicle.

Table 5: Distributional Impacts of Chinese EV Entry into the US under Optimal Policy Mixes

	(1)	(2)	(3)	(4)	(5)
	Ban	**Add Top 10 China manufactured EV**			
	Benchmark	*Tariff Only*	*Subsidy Only*	*Both*	*Recycling*
Tariff/Subsidy		27.5% / $0.00k	0.0% / $9.60k	22.5% / $8.40k	25.0% / $7.47k
Panel (a) Effects on EV Share by Income Quantile					
EV Share (%) Q1	6.80	15.62	23.86	19.92	19.05
EV Share (%) Q2	7.56	12.41	19.98	16.93	16.04
EV Share (%) Q3	10.51	17.15	23.62	21.28	20.59
EV Share (%) Q4	11.15	19.06	26.82	23.51	22.71
Panel (b) Effects on Consumer Surplus by Income Quantile					
△ Consumer Surplus ($Bn) Q1		6.36	11.24	8.63	8.15
△ Consumer Surplus ($Bn) Q2		4.57	8.50	6.96	6.57
△ Consumer Surplus ($Bn) Q3		12.85	17.76	15.61	15.12
△ Consumer Surplus ($Bn) Q4		10.45	16.16	13.81	13.26

Notes: This table reports the distributional impact of introducing the top 10 Chinese EV models into the US market under optimal policy designs. Column (1) reports the status quo, in which Chinese EVs are banned from the US market. Column (2) reports the optimal tariff, and Column (3) reports the optimal subsidy. Column (4) reports the unconstrained optimum, allowing both tariffs and subsidies. Column (5) reports the optimal tariff-recycling subsidy, in which the tariff and subsidy are jointly chosen under a balanced-budget constraint. The counterfactual is based on the year 2023. All monetary values are normalized to 2023 USD. The shipment cost is calibrated at $2,750, and additional distribution and marketing costs are $1,402. Distribution and marketing services are assumed to be provided at cost by US firms, so they generate no profits and affect welfare only through consumer prices. All average numbers are calculated as sales-weighted averages across models. Q1 to Q4 are income quartiles, where Q4 represents the wealthiest consumers.

Table 6: Optimal Policy Across Countries: United States, Germany, United Kingdom, and Spain

Policy Scenario	**United States**	**Germany**	**United Kingdom**	**Spain**
Tariff Only				
Tariff Rate	27.5%	45.0%	20.0%	17.5%
Subsidy ($1,000)	0.00	0.00	0.00	0.00
ΔW^{EB} ($Bn)	40.88	23.16	9.80	8.23
Subsidy Only				
Tariff Rate	0.0%	0.0%	0.0%	0.0%
Subsidy ($1,000)	9.60	13.10	13.40	0.00
ΔW^{EB} ($Bn)	42.94	22.86	9.60	7.95
Unconstrained Optimum				
Tariff Rate	22.5%	37.5%	20.0%	17.5%
Subsidy ($1,000)	8.40	10.60	12.80	0.00
ΔW^{EB} ($Bn)	45.45	25.95	10.04	8.23
Tariff-funded Subsidy				
Tariff Rate	25.0%	37.5%	12.5%	17.5%
Subsidy ($1,000)	7.47	10.93	16.02	0.00
ΔW^{EB} ($Bn)	45.33	25.94	9.94	8.23
# Domestic EV Models	16	61	8	0
Avg Domestic EV Markup ($1,000)	16.65	23.67	30.11	—

Notes: This table reports the optimal policy parameters across four markets under a common entry scenario of $N = 10$ Chinese EV models. The four row panels correspond to distinct policy scenarios.*Tariff Only* fixes the subsidy at zero and optimizes over the tariff rate; *Subsidy Only* fixes the tariff at zero and optimizes over the subsidy; *Unconstrained Optimum* optimizes the two instruments jointly; *Tariff-funded Subsidy* restricts attention to the budget-balanced recycling path, along which tariff revenue collected on Chinese imports is rebated as a per-unit subsidy to domestic EVs. Within each panel, ΔW^{EB} denotes the change in total welfare inclusive of environmental benefits, measured in billions of US dollars relative to the status quo. The policy grid uses tariff increments of 2.5 percentage points and subsidy increments of $100. The last two rows report status-quo market characteristics: *# Domestic EV Models* is the count of EV models from domestically headquartered brands, and *Avg Domestic EV Markup* is their sales-weighted average markup (price less marginal cost, in thousands of US dollars). Spain hosts no domestically headquartered EV brand, so the optimal subsidy is zero across all policy regimes; the welfare gains from tariffs alone reflect pure rent extraction from foreign exporters.

Online Appendix

From Trade War to Green Transition: Optimal Electric Vehicle Tariffs with Revenue-Funded Subsidies

Panle Jia Barwick   Jack Collison   Penny Goldberg   Shanjun Li   Yucheng Wang

A Additional Theoretical Results

A.1 Propositions and Proofs

Proposition 1. *The optimal tariff τ is positive if the gains from diverting demand toward domestic goods at existing markups plus direct fiscal revenue exceed consumer surplus loss from higher prices. There are four scenarios that favor this condition:*

(i) High domestic markups $(P_j - C_j)$

(ii) Little differentiation between domestic and imported goods

(iii) Many domestic goods relative to imports, i.e., $|J_d|/|J_f|$ is large

(iv) Sufficiently incomplete tariff pass-through, i.e., demand that is not too convex

Proof. Set externalities $\phi = 0$ and fix b for simplicity. Rearranging the first-order condition for τ:

$$\tau = \frac{\sum_{j\in J} \overbrace{\left[-\frac{\partial \tilde{P}_j}{\partial \tau} Q_j\right]}^{(-)} + \sum_{j\in J_d} \overbrace{\left[(P_j - C_j)\frac{dQ_j}{d\tau} + \frac{\partial P_j}{\partial \tau} Q_j\right]}^{(+)} + \lambda \sum_{j\in J_f} \overbrace{\left[P_j Q_j\right]}^{(+)} - \lambda \sum_{j\in J_d} \overbrace{\left[b\frac{dQ_j}{d\tau}\right]}^{(+)}}{-\lambda \sum_{j\in J_f} \left[\underbrace{\frac{\partial P_j}{\partial \tau} Q_j}_{(\pm)} + \underbrace{P_j \frac{dQ_j}{d\tau}}_{(-)}\right]}$$

Numerator. The numerator balances: (a) consumer surplus loss from higher prices under tariffs; (b) domestic diversion gains from demand shifting toward domestic goods, which scale with product differentiation and grow wider when $|J_d|/|J_f|$ is large, i.e., the base over which diversion aggregates expands while the number of goods bearing the brunt of the consumer cost shrinks; and (c) tariff revenues from imports net of subsidy expenditures. Conditions (i)–(iv) enumerated in the proposition each strengthen channel (b) or weaken channel (a), and can make the numerator positive.

Denominator. The denominator is $-\lambda$ times the marginal change in aggregate pre-tariff import spending with respect to τ, i.e., the curvature of the Laffer curve. Its sign is governed by tariff pass-through, which hinges on the shape of demand. More-than-complete pass-through implies imports raise pre-tariff prices, whereas incomplete pass-through implies imports lower pre-tariff prices. Pass-through strongly depends on the curvature of demand and the relative numbers of imports to domestic goods in Equation (2). These can push pass-through toward or beyond unity.

Case 1: The denominator is positive, i.e., there is sufficiently low pass-through of tariffs by imports. The optimal tariff is positive if and only if the numerator is positive: diversion gains at existing markups plus government revenue exceed consumer welfare loss from higher prices. This is a natural case for the social planner to set positive tariffs.

Case 2: The denominator is negative, i.e., there is sufficiently more-than-complete pass-through by imports. The sign condition reverses. The optimal tariff is positive if and only if the numerator is negative. That is, consumer surplus losses exceed diversion and fiscal gains. In this case, the government can extract sufficiently high marginal revenue from imports by raising tariffs, even at the cost of lower consumer surplus, because import spending continues to rise with τ and the marginal gain in government revenue more than compensates for the consumer surplus loss. There must be limited diversion, e.g., inelastic demand and high product differentiation, which generates more-than-complete pass-through in the first place.

Discussion. There is also a case for import subsidies, i.e., $\tau < 0$. When the denominator is negative (sufficiently more-than-complete pass-through of tariffs) and consumer surplus losses are outweighed by the gains in domestic profits and fiscal benefits (positive numerator), the tariff may be negative. Finally, though omitted from the equation above, externalities shift the optimal tariff in the direction of Pigouvian correction. If imported goods generate negative externalities ($\phi_j < 0$ for imports), restricting imports carries additional social value, raising the optimal tariff. Conversely, positive externalities from imports, such as environmental externalities from electric vehicles, lower the optimal tariff. The net direction depends on whether the externality-weighted sum is negative or positive.

□

Proposition 2. *The optimal subsidy is positive when consumer surplus gains from lower domestic prices and increases in domestic profits outweigh the fiscal costs of reduced tariff revenues due to diversion away from imports and direct subsidy expenditures. The key tension is that product differentiation that amplifies consumer surplus gains also accelerates the erosion of tariff revenue.*

Proof. Set externalities $\phi = 0$ and fix τ for simplicity. Rearranging the first-order condition for b:

$$b = \frac{\sum_{j \in J} \overbrace{\left[-\frac{\partial \tilde{P}_j}{\partial b} Q_j \right]}^{(+)} + \sum_{j \in J_d} \overbrace{\left[(P_j - C_j) \frac{dQ_j}{db} + \frac{\partial P_j}{\partial b} Q_j \right]}^{(\pm)} + \lambda \sum_{j \in J_f} \overbrace{\left[\tau \frac{\partial P_j}{\partial b} Q_j + \tau P_j \frac{dQ_j}{db} \right]}^{(-)} - \lambda \sum_{j \in J_d} \overbrace{\left[Q_j \right]}^{(+)}}{\lambda \sum_{j \in J_d} \underbrace{\left[\frac{dQ_j}{db} \right]}_{(+)}}$$

Denominator. Because a subsidy reduces domestic marginal cost, it unambiguously expands domestic output ($dQ_j/db > 0$ for $j \in J_d$). The denominator is therefore unambiguously positive. This is different from the optimal tariff, where the shape of the Laffer curve determines the sign of the denominator. In the case of the subsidy, the optimal policy is entirely determined by the sign of the numerator.

Numerator. The numerator balances: (a) gains in consumer surplus due to lower prices (direct pass-through of own subsidies and through strategic complementarity), pushing b higher; (b) ambiguous domestic profit effects (volume expansion versus subsidy pass-through that lowers markups, depending on demand curvature); (c) tariff revenue erosion due to diversion away from imports toward domestic goods; and (d) increasing total government expenditures on subsidies through volume expansions. The optimal subsidy is positive if and only if the gains from (a) (and potentially from (b)) outweigh the losses from (c) and (d) (and potentially (b)).

Discussion. The same product differentiation channel that strengthens consumer surplus gains in channel (a) amplifies tariff revenue erosion in channel (c). When the government revenue channel is strong enough, the planner may even set $b < 0$ to restore revenue if the gains outweigh losses in consumer surplus. And, as above, externalities move the optimal subsidy in the direction of the Pigouvian correction.

□

Lemma 1. *Under a balanced budget constraint, we have sign*$(1 - \lambda) =$ *sign*(G^*)*, where* G^* *is the value of the government budget for the unconstrained planner. Equivalently,* $\lambda < 1$ *if* $G^* > 0$*,* $\lambda = 1$ *if* $G^* = 0$*, and* $\lambda > 1$ *if* $G^* < 0$*.*

Proof. Define $f(0) = W(\gamma_c^*)$, where γ_c^* are the constrained welfare-maximizing policies. Analogously, define $f(G^*) = W(\gamma^*)$ where G^* is the government budget under the unconstrained optimal policies γ^*. Notice that $f(0) \leq f(G^*)$ with equality if $G^* = 0$, meaning G^* maximizes f. Under regularity assumptions (smoothness, unique interior solution for the unconstrained planner), f is

C^1 with a unique interior maximum at G^*, meaning we have $f'(0) > 0$ for $G^* > 0$ and $f'(0) < 0$ for $G^* < 0$. By the envelope theorem, $1 - \lambda = f'(0)$. This implies that $\text{sign}(1-\lambda) = \text{sign}(G^*)$, completing the proof.

$\square$

Corollary 1. *Assume that optimal tariffs are positive. When tariff revenue is recycled into domestic subsidies, the revenue-constrained optimal tariff* τ^* *differs from its unconstrained counterpart* τ_u^* *in a manner that depends on the shadow value of public funds* λ *and the pass-through regime of Proposition 1:*

	Case 1	***Case 2***
$\lambda \in (0,1)$	$\tau^* > \tau_u^*$	$\tau^* < \tau_u^*$
$\lambda > 1$	$\tau^* < \tau_u^*$	$\tau^* > \tau_u^*$
$\lambda = 1$	$\tau^* = \tau_u^*$	$\tau^* = \tau_u^*$

Case 1 is sufficiently incomplete pass-through and Case 2 is sufficiently more-than-complete pass-through. In all four cases, the magnitude of the deviation from the unconstrained planner's solution scales with $|\lambda - 1|$.

Proof. Recall the expression for τ^* in Proposition 1. The revenue recycling constraint links b to tariff revenue, and the shadow value of public funds λ weights the fiscal terms in the denominator. When $\lambda = 1$, the shadow value of expanding the budget by one unit equals one unit of welfare, so the budget constraint is neither tight nor slack. The constrained and unconstrained optima are identical (third row of the table).

When $\lambda \in (0,1)$, the budget constraint is relatively slack, and the planner places a welfare premium on fiscal revenue of less than one. The fiscal terms in the denominator receive less weight, reducing the marginal fiscal cost of raising τ. The effect on τ^* depends on the sign of the denominator: in Case 1 (positive denominator, sufficiently incomplete pass-through), the reduced fiscal weight translates into a higher optimal tariff, because the planner can afford to use tariffs more aggressively without being constrained by revenue concerns. Furthermore, this connects with attenuated losses in consumer surplus due to incomplete pass-through. In Case 2 (negative denominator, sufficiently more-than-complete pass-through), the direction reverses, yielding a lower tariff, which is intuitive because consumer surplus losses are enhanced by high pass-through (first row of the table). From Lemma 1, this occurs when $G^* > 0$, i.e., the constrained planner is forced to a lower government surplus than they would like, distorting the optimal policies.

When $\lambda > 1$, the budget constraint is tight, and each dollar of fiscal revenue is valuable. The inflated weight on fiscal terms magnifies the marginal fiscal cost of raising the tariff, making the planner more cautious in raising tariffs. Thus, the optimal tariff is lower in Case 1 and higher in Case 2 (second row of the table). From Lemma 1, this occurs when $G^* < 0$, i.e., the constrained planner is forced to a higher government surplus than they would otherwise like, distorting the optimal policies.

The magnitude of this deviation scales with $|\lambda - 1|$, the distance of the shadow value of public funds from its non-distortionary level $\lambda = 1$; it vanishes at the knife-edge and grows as the budget constraint binds more tightly.

□

Corollary 1 shows that the constrained optimal policy deviates from the unconstrained benchmark by an amount that scales with $|\lambda - 1|$. The following result quantifies the resulting *welfare* loss and shows it is only second-order in this deviation: it vanishes at the knife-edge $\lambda = 1$ and grows quadratically as the constraint binds.

Let $f(\bar{G}) \equiv \max_\gamma \{W(\gamma) : G(\gamma) = \bar{G}\}$ be the constrained value function from the proof of Lemma 1, so that $\lambda(\bar{G}) = 1 - f'(\bar{G})$, the unconstrained welfare is $f(G^*)$, and the balanced-budget welfare is $f(0)$. Let $H_W \equiv \nabla^2 W$ and ∇G denote the Hessian of welfare and the gradient of the budget at the unconstrained optimum γ^*, and define the curvature of welfare in the budget direction,

$$\kappa \equiv -f''(G^*) = \frac{1}{\nabla G^\top (-H_W)^{-1} \nabla G} > 0. \tag{A.1}$$

Proposition 3. *Suppose W is C^2 with a unique interior unconstrained maximum at γ^*. Then $\lambda(G^*) = 1$, $\lambda'(G^*) = \kappa$, and the welfare loss from imposing the budget target $\bar{G}$ is*

$$\Delta W(\bar{G}) \equiv f(G^*) - f(\bar{G}) = \tfrac{1}{2}\kappa(\bar{G} - G^*)^2 + O\big((\bar{G} - G^*)^3\big). \tag{A.2}$$

In particular, the welfare cost of the balanced budget ($\bar{G} = 0$) is

$$\Delta W(0) \approx \tfrac{1}{2}\kappa(G^*)^2 = \frac{(1-\lambda)^2}{2\kappa}. \tag{A.3}$$

Proof. At $\bar{G} = G^*$ the constraint binds at the unconstrained optimum, so $\lambda(G^*) = 1$ and $f'(G^*) = 0$. Differentiating the planner's first-order condition $\nabla W = (1 - \lambda)\nabla G$ along the constraint and using $\nabla W(\gamma^*) = 0$ gives $\gamma'(G^*) = \lambda'(G^*)(-H_W)^{-1}\nabla G$; substituting into $\nabla G^\top \gamma'(\bar{G}) = 1$ yields $\lambda'(G^*) = 1/[\nabla G^\top (-H_W)^{-1} \nabla G] = \kappa$, which is positive because γ^* is a strict maximum ($H_W \prec 0$). For (A.2), expand around γ^* using $\nabla W(\gamma^*) = 0$: $W(\gamma^* + h) = f(G^*) + \frac{1}{2}h^\top H_W h + O(|h|^3)$ and $G(\gamma^* + h) =$

$G^* + \nabla G^\top h + O(|h|^2)$. To leading order the constrained problem is $\min_h \frac{1}{2} h^\top (-H_W) h$ subject to $\nabla G^\top h = \bar{G} - G^*$, with solution $h^* = \kappa(\bar{G} - G^*)(-H_W)^{-1} \nabla G$ and welfare loss $\frac{1}{2}(h^*)^\top (-H_W) h^* = \frac{1}{2}\kappa(\bar{G} - G^*)^2$. Setting $\bar{G} = 0$ and using $1 - \lambda(0) = f'(0) \approx \kappa G^*$ gives (A.3). $\square$

Proposition 3 makes the second-best logic precise. Lemma 1 and Corollary 1 establish that the constraint moves policy in a determinate direction by an amount of order $|\lambda - 1|$; Equation (A.3) shows the welfare cost is of order $(\lambda - 1)^2$, the familiar result that first-order policy distortions produce only second-order welfare losses near an optimum. The cost is governed by two primitives: the unconstrained fiscal imbalance G^* and the curvature κ. When the unconstrained optimum is near budget-balanced ($G^* \approx 0$, equivalently $\lambda \approx 1$), revenue recycling attains nearly first-best welfare. This is the theoretical basis for the finding, documented in the counterfactuals of Section 7 and the simulations below, that revenue recycling achieves welfare almost identical to the unconstrained optimum.

B Derivations and Formulas

B.1 Price Decision Rules for an Exporter under an Ad Valorem Tariff

The profit function for the exporter is

$$\pi_{fm}(s_{fmt}) = \max_{p_{jmt}} \sum_{j \in \mathscr{J}_{fmt}} \left(p_{jmt} - (mc_{jmt} + shipment)\right) q_{jmt}(\tilde{p}_{jmt}, \tilde{\mathbf{p}}_{-j,mt}) \qquad \forall m \in 1, ..., M \quad \text{(B.1)}$$

where

$$\tilde{p}_{jmt} = p_{jmt} \times (1+\tau) + otherCosts$$

$$\tilde{\mathbf{p}}_{-j,mt} = \mathbf{p}_{-j,mt} \times (1+\tau) + otherCosts$$

We drop the subscript mt for simplicity. The first-order condition of firm f with respect to p_j is

$$\sum_{h \in \mathscr{J}_f} [p_h - (mc_h + shipment)] \frac{\partial q_h}{\partial \tilde{p}_j}(1+\tau) + q_j = 0 \qquad \text{(B.2)}$$

The equilibrium price vector is defined in matrix notation as:

$$\boldsymbol{p}^* = (\boldsymbol{mc} + shipment) + (1+\tau)^{-1} \triangle^{-1} \boldsymbol{q} \qquad \text{(B.3)}$$

where the (j,h) element of $\triangle$ is $-\frac{\partial q_h}{\partial \tilde{p}_j}$ if products h and j are produced by the same firm and zero otherwise, with demand derivatives taken with respect to tariff-inclusive consumer prices. The $(1+\tau)^{-1}$ factor reflects that a one-unit increase in the producer price raises the consumer price by $(1+\tau)$, so, holding the markup term $\triangle^{-1}\boldsymbol{q}$ fixed, a higher tariff compresses the tax-exclusive markup; the full equilibrium response also depends on how $\triangle$ and $\boldsymbol{q}$ move with the tariff, as Appendices B.2 and B.3 make precise.

The final price that consumers face is

$$\boldsymbol{p}^{consumer} = [(\boldsymbol{mc} + shipment) + (1+\tau)^{-1} \triangle^{-1} \boldsymbol{q}](1+\tau) + otherCosts - subsidy \qquad \text{(B.4)}$$

The government revenue from each vehicle is

$$G^{Rev} = [(\boldsymbol{mc} + shipment) + (1+\tau)^{-1} \triangle^{-1} \boldsymbol{q}] \cdot \tau - subsidy \qquad \text{(B.5)}$$

The tariff τ and the subsidy are product-specific: τ applies to imported models and the subsidy to domestic EVs, so a given vehicle is subject to at most one of the two. Aggregate government revenue sums tariff receipts on imports net of subsidy outlays on domestic EVs.

B.2 Pass-through Formula in Differentiated Products Oligopoly

Additive Cost Shocks. We start from the Bertrand markup equation,

$$\mathbf{p} = \mathbf{mc} + \boldsymbol{\mu}(\mathbf{p}). \tag{B.6}$$

Since the markup vector depends on equilibrium prices, we have

$$d\boldsymbol{\mu} = D_{\mathbf{p}}\boldsymbol{\mu}\, d\mathbf{p}. \tag{B.7}$$

Rearranging gives that the pass-through matrix is

$$\frac{d\mathbf{p}}{d\mathbf{mc}'} = [I - D_{\mathbf{p}}\boldsymbol{\mu}]^{-1}. \tag{B.8}$$

Using $\boldsymbol{\mu}(\mathbf{p}) = \Delta^{-1}\mathbf{q}(\mathbf{p})$, we obtain

$$D_{\mathbf{p}}\boldsymbol{\mu} = \Delta^{-1}(J+H), \tag{B.9}$$

so that

$$\frac{d\mathbf{p}}{d\mathbf{mc}'} = \left[I - \Delta^{-1}(J+H)\right]^{-1} = (\Delta - J - H)^{-1}\Delta, \tag{B.10}$$

where

$$\Delta_{jk} = -\Omega_{jk}\frac{\partial s_k}{\partial p_j}, \tag{B.11}$$

$$J_{jl} = \frac{\partial s_j}{\partial p_l}, \tag{B.12}$$

$$H_{jl} = \sum_{k=1}^{J} \Omega_{jk}\mu_k \frac{\partial^2 s_k}{\partial p_j \partial p_l}. \tag{B.13}$$

Here, j indexes the product whose first-order condition is being considered, k indexes the product whose markup is internalized within that first-order condition, and l indexes the price dimension along which the demand system is differentiated. Δ is the ownership-adjusted matrix of first-order demand derivatives, J is the full Jacobian of demand, and H collects markup-weighted second-order demand derivatives. Ω_{jk} is the ownership matrix, $\mu_k = p_k - c_k$ is the markup of product k, and s_j denotes the market share of product j.

Ad Valorem Tariff. Let

$$M(\boldsymbol{\tau}) \equiv \mathrm{diag}(1+\tau_1,\dots,1+\tau_J), \qquad \mathbf{x} = M(\boldsymbol{\tau})^{-1}\mathbf{p},$$

where $\mathbf{x}$ is the *tax-exclusive price*, that is, the per-unit revenue the firm (exporter) receives net of the ad valorem tariff, as distinct from the consumer price $\mathbf{p} = M(\boldsymbol{\tau})\mathbf{x}$, which includes the tariff. The pricing equation can be written as

$$\mathbf{p} = M(\boldsymbol{\tau})\left[\mathbf{mc} + \boldsymbol{\mu}^x(\mathbf{p},\boldsymbol{\tau})\right], \tag{B.14}$$

where $\boldsymbol{\mu}^x$ is the markup vector in tax-exclusive prices. Define the realized per-vehicle tariff payment vector as

$$\mathbf{T} \equiv \mathrm{diag}(\boldsymbol{\tau})\mathbf{x}. \tag{B.15}$$

Let

$$A \equiv I - MD_{\mathbf{p}}\boldsymbol{\mu}^x, \qquad B \equiv \mathrm{diag}(\mathbf{x}) + MD_{\boldsymbol{\tau}}\boldsymbol{\mu}^x. \tag{B.16}$$

Then the pass-through matrix with respect to tariff payments is

$$\frac{d\mathbf{p}}{d\mathbf{T}'} = A^{-1}B\left[\mathrm{diag}\left(\frac{\mathbf{x}}{1+\boldsymbol{\tau}}\right) + \mathrm{diag}(\boldsymbol{\tau})M^{-1}A^{-1}B\right]^{-1}. \tag{B.17}$$

Link Between Two Pass-Throughs: A Single-Product Firm Example. We derive the relationship between ad valorem tariff pass-through and unit-specific tariff pass-through in the single-product case, where the mapping can be characterized analytically. Consider the consumer price under an ad valorem tariff τ:

$$p = (1+\tau)(\mu+c),$$

where c is marginal cost and $\mu = \mu(\tau)$ is the tax-exclusive markup, which may vary with the tariff rate τ. This price equation can be written in two equivalent ways. First, using the tariff-revenue decomposition,

$$p = (\mu+c) + \tau(\mu+c) = (\mu+c) + T, \qquad T \equiv \tau(\mu+c),$$

so that

$$\frac{dp}{dT} = \frac{\partial p/\partial\tau}{\partial T/\partial\tau} = \frac{(\mu+c)+(1+\tau)\mu'}{(\mu+c)+\tau\mu'},$$

where $\mu' \equiv d\mu/d\tau$. Second, using the effective-cost decomposition,

$$p = (1+\tau)\mu + (1+\tau)c = \underbrace{(1+\tau)\mu}_{\text{Effective Markup}} + \underbrace{(1+\tau)c}_{\text{Effective Marginal Cost}}.$$

Defining effective marginal cost as

$$\tilde{c} \equiv (1+\tau)c,$$

we obtain

$$\frac{dp}{d\tilde{c}} = \frac{\partial p/\partial \tau}{\partial \tilde{c}/\partial \tau} = \frac{(\mu+c)+(1+\tau)\mu'}{c}.$$

This second object provides the link to a unit-specific tariff. A unit-specific tariff enters the pricing problem as an additive wedge to marginal cost, so its pass-through is naturally measured by the response of prices to an additive increase in effective cost. In this sense, $dp/d\tilde{c}$ **is the analogue of unit-specific tariff pass-through, while** dp/dT **is the ad valorem tariff pass-through with respect to tariff payments**. The ratio between the two is therefore

$$\frac{dp/d\tilde{c}}{dp/dT} = \frac{\mu + c + \tau\mu'}{c}. \tag{B.18}$$

Equation (B.18) shows ad valorem and unit-specific tariffs need not generate the same pass-through, because tariff payments under an ad valorem tariff depend not only on marginal cost but also on the level and endogenous response of the markup.

For a single-product firm, distinguish between the effective-price markup $m(p)$ and the tax-exclusive markup μ. Since

$$p = (1+\tau)(\mu+c),$$

the effective-price markup is

$$m(p) \equiv p - (1+\tau)c = (1+\tau)\mu.$$

The firm's first-order condition implies

$$m(p) = -\frac{s(p)}{s_p(p)},$$

so that the pricing equation under an ad valorem tariff can be written as

$$p = (1+\tau)c + m(p).$$

Comparing this expression with

$$p = (1+\tau)(\mu + c)$$

implies that the tax-exclusive markup is

$$\mu = \frac{m(p)}{1+\tau}.$$

Differentiating $m(p)$ with respect to price gives

$$\frac{dm}{dp} = -1 + \frac{s s_{pp}}{(s_p)^2}.$$

Thus, defining demand curvature as

$$\rho \equiv \frac{s s_{pp}}{(s_p)^2},$$

we have

$$\frac{dm}{dp} = \rho - 1.$$

Along the tariff path,

$$\frac{dm}{d\tau} = \frac{dm}{dp}\frac{dp}{d\tau} = (\rho - 1)\frac{dp}{d\tau}.$$

Now differentiate the relationship $\mu = m/(1+\tau)$ with respect to τ:

$$\mu' \equiv \frac{d\mu}{d\tau} = \frac{1}{1+\tau}\frac{dm}{d\tau} - \frac{m}{(1+\tau)^2}.$$

Using $m = (1+\tau)\mu$, this becomes

$$\mu' = -\frac{\mu}{1+\tau} + \frac{\rho - 1}{1+\tau}\frac{dp}{d\tau}.$$

Substituting this expression into Equation (B.18) and rearranging yields

$$\frac{dp/d\tilde{c}}{dp/dT} = 1 + \frac{\mu}{(1+\tau)c} + \underbrace{\frac{\mu + c}{c}}_{\text{Markup rate}} \cdot \left(\underbrace{\rho}_{\text{Demand curvature}} - 1 \right) \cdot \varepsilon_{p,\tau} \tag{B.19}$$

where $\varepsilon_{p,\tau} \equiv \frac{dp}{d\tau}\frac{\tau}{p} > 0$ is the elasticity of consumer price with respect to the tariff rate.

B.3 Tariff Pass-Through under CES and Logit Demand

Appendix B.2 expresses single-product ad valorem pass-through as

$$\frac{dp}{dT} = \frac{(\mu + c) + (1+\tau)\mu'}{(\mu + c) + \tau\mu'}, \qquad \mu' \equiv \frac{d\mu}{d\tau},$$

where μ is the tax-exclusive markup and c the marginal cost. Because the numerator exceeds the denominator by exactly μ',

$$\frac{dp}{dT} \lesseqgtr 1 \quad \Longleftrightarrow \quad \mu' \lesseqgtr 0:$$

pass-through is complete, incomplete, or more than complete according to whether the firm holds, compresses, or expands its tax-exclusive markup as the tariff rises. That response is governed by demand curvature $\rho \equiv s\,s_{pp}/(s_p)^2$ (Appendix B.2). We evaluate it under three demand systems and position the random-coefficient logit specification used in the main text.

CES, atomistic monopolistic competition. With demand $q_j = A\,p_j^{-\sigma}$ and the demand shifter A treated as exogenous, profit maximization yields the constant-markup rule $x_j = \frac{\sigma}{\sigma-1}c_j$, independent of τ. Hence $\mu' = 0$ and pass-through is complete, $dp_j/dT_j = 1$. This is the textbook benchmark under which the optimal small-country tariff is zero.

CES, Nash-Bertrand. With $K < \infty$ firms, each internalizes its effect on the CES price index $P = \left(\sum_k p_k^{1-\sigma}\right)^{1/(1-\sigma)}$ through its share s_j. Using $\partial \ln P/\partial \ln p_j = s_j$, the perceived elasticity is $\varepsilon_j = \sigma - (\sigma-1)s_j < \sigma$ and the markup $x_j/c_j = \varepsilon_j/(\varepsilon_j - 1)$ rises with s_j. A tariff lowers s_j, so the firm compresses its markup, $\mu' < 0$:

$$\frac{dp_j}{dT_j} = \frac{[\sigma - (\sigma-1)s_j](1+\tau)}{\sigma + \tau[\sigma - (\sigma-1)s_j]} < 1, \qquad 1 + \varepsilon_x = \frac{\sigma - (\sigma-1)s_j}{\sigma} \in \left[\tfrac{1}{\sigma}, 1\right),$$

where $\varepsilon_x \equiv d\ln x_j/d\ln(1+\tau_j) = -(\sigma-1)s_j/\sigma$. Pass-through is strictly incomplete and decreasing in market share, consistent with the firm-level evidence in Fan et al. (2025); this share-dependent mechanism originates in Atkeson and Burstein (2008), of which the atomistic benchmark is the $s_j \to 0$ limit.

Simple logit, Nash-Bertrand. Replacing CES with simple logit preserves the result through a different markup structure. Logit markups are additive, $x_j - c_j = 1/[(1+\tau)\alpha(1-s_j)]$, and compress as the tariff rises, so $\mu' < 0$ and $dp_j/dT_j < 1$ strictly; unlike CES, however, logit admits no clean lower bound such as $1/\sigma$ (Anderson, De Palma, and Kreider, 2001). Both single-coefficient systems therefore deliver incomplete pass-through with no over-shifting.

Random-coefficient logit. Heterogeneity in price sensitivity across income groups raises demand curvature ρ in regions of the demand curve where the income-conditional elasticity rises in price. There $\mu' > 0$ becomes possible, generating over-shifting, $dp_j/dT_j > 1$ (Miravete, Seim, and Thurk, 2023). Over-shifting thus arises from the random coefficients, not from logit demand or Nash-Bertrand conduct per se. Table A1 summarizes the four cases. The specification used in the main text accordingly nests both the incomplete tariff pass-through we recover on Chinese entrants and the over-shifting on US incumbents that receive the recycling subsidy, the two margins that underpin the tariff-recycling result.

Table A1: Ad Valorem Tariff Pass-Through across Demand Systems

Model	$\varepsilon_x \equiv \frac{d\ln x}{d\ln(1+\tau)}$	**Level dp/dT**	**Elasticity $1+\varepsilon_x$**
CES + atomistic monopolistic competition	0	$=1$	$=1$
CES + Nash-Bertrand	$-\frac{(\sigma-1)s_j}{\sigma}$	<1, strict	$\frac{\sigma-(\sigma-1)s_j}{\sigma} \in \left[\frac{1}{\sigma},1\right)$
Simple logit + Nash-Bertrand	<0 (additive markup)	<1, strict	<1
Random-coefficient logit + Nash-Bertrand	varies with local demand curvature	$\lesseqgtr 1$	$\lesseqgtr 1$

Notes: This table summarizes ad valorem tariff pass-through under four nested demand and conduct assumptions. x is the tax-exclusive price, τ the ad valorem rate, s_j the market share, and σ the CES elasticity of substitution. The Nash-Bertrand rows assume a finite number of competing firms ($K < \infty$). Pass-through is reported in level form (dp/dT, the main-text convention) and elasticity form ($1+\varepsilon_x$). The last row is the specification used in the main text.

C Additional Details on Background, Data, and Variable Construction

C.1 Cross-Market Policy Stances on Chinese EVs

This appendix provides detailed policy descriptions of the four destination markets summarized in Section 3.

United States. The US is the most restrictive case. In 2024, it raised the Section 301 tariff on Chinese EVs from 25 percent to 100 percent, bringing the total tariff burden to 102.5 percent with the 2.5 percent MFN tariff included. The US policy has also expanded beyond tariffs toward non-tariff restrictions, especially through regulations on connected vehicles using Chinese software or hardware. The rule states that it is motivated by complex vehicle hardware and software that are not reviewed by the US, and are thus potential risks to US national security. In the public discourse and comments on the rule, major automakers (especially large US firms) supported the rule, but took steps, by commenting on the specific vehicle components subject to the rule, to ensure that their own supply chains would not be disrupted. In practice, these measures move US policy closer to a *de facto* ban. Consistent with this policy stance, Figure 1 shows that the share of Chinese-brand EVs in the US market remains essentially zero throughout the sample.

Canada. Canada adopted a similarly restrictive stance through the end of 2025. It imposed a 100 percent surtax on Chinese-made EVs, which, combined with the standard 6.1 percent MFN tariff, raised the total tariff burden to 106.1 percent. However, this policy stance shifted markedly in late 2025, when Canada and China reached a new arrangement allowing an annual quota of 49,000 Chinese EVs to enter at the regular 6.1 percent MFN tariff rate. This shift suggests a partial reversal of Canada's earlier restrictive stance and points to a more open policy direction going forward.

European Union. The EU has taken a more moderate approach. Rather than imposing a prohibitive uniform tariff, it introduced countervailing duties on EVs produced in China, with total tariff rates varying across firms and ranging from 17.8 percent to 45.3 percent. This leaves the EU more open than the US and Canada. Figure 1 shows that the share of Chinese-brand EVs in the EU rises steadily after 2020, though these vehicles still face substantial restrictions on market access.

Australia. Australia is the least restrictive market in our comparison. It has not imposed special punitive tariffs on Chinese EVs, and tariffs on passenger motor vehicles have already been phased down to zero. As a result, Chinese EV producers face few border-policy barriers in Australia relative to other major developed markets. Figure 1 shows that Australia has experienced by far the fastest growth in the share of Chinese-brand EVs, reaching more than 30 percent by 2024.

C.2 Construction of Mean Utility and Marginal Cost for Introduced Models

When we introduce a set of Chinese EV models into the US market in our counterfactual analysis, we need to take a stance on consumers' mean utility for those models and on their marginal cost of supplying the US market. This appendix subsection describes how we construct both objects.

Mean Utility. A key challenge in our counterfactual analysis is that Chinese-branded EV models are not observed in the US market in the estimation sample. Consequently, we must take a stance on the level of US consumers' mean utility for Chinese EVs. For each Chinese model j in the set $\mathscr{F}^{\text{CN}}$ of models produced by a Chinese automaker and introduced in our counterfactual, we specify the mean utility in the US market as

$$\delta_{j,\text{US}} = \mathbf{X}_{j,\text{US}}\,\bar{\beta} + \eta_{j,\text{US}} + \xi_{j,\text{US}}, \qquad j \in \mathscr{F}^{\text{CN}}, \tag{C.1}$$

where $\mathbf{X}_{j,\text{US}}$ is the observed product-characteristics vector, $\eta_{j,\text{US}}$ is a product fixed effect capturing persistent components of mean utility, and $\xi_{j,\text{US}}$ is the remaining demand unobservable. For the first component, we assume that the observable characteristics of a Chinese model are the same in the US as in its home market, $\mathbf{X}_{j,\text{US}} = \mathbf{X}_{j,\text{China}}$.

We then construct the fixed effect $\eta_{j,\text{US}}$ using information from models that are observed in both markets and are produced by non-Chinese automakers. Specifically, we assume that the US fixed effect for a Chinese model equals its China-market fixed effect plus an additive adjustment that captures the average cross-country difference in fixed effects for comparable products:

$$\eta_{j,\text{US}} = \eta_{j,\text{China}} + \psi_{g(j)}. \tag{C.2}$$

Here $g(j)$ indexes the aggregation level used to form the adjustment. In our baseline specification, $g(j)$ is the model's powertrain type (EV, ICE, HV, or PHEV), so the adjustment is common across all models within the same powertrain type. We estimate ψ_g from products observed in both countries that are produced by non-Chinese automakers. Let $\mathscr{J}^{\text{obs}}$ denote the set of models observed in both China and the US in our estimation sample. Then

$$\psi_g = \mathbb{E}\Big[\eta_{j',\text{US}} - \eta_{j',\text{China}} \mid g(j') = g,\ j' \in \mathscr{J}^{\text{obs}}\Big], \quad g \in \{\text{EV}, \text{ICE}, \text{HV}, \text{PHEV}\}. \tag{C.3}$$

This construction implies that the mean utility of an entering Chinese EV in the US inherits its relative positioning in the China market through $\eta_{j,\text{China}}$, while allowing for a systematic cross-country shift in valuation captured by ψ_g.[1]

For the third component, $\xi_{j,\text{US}}$, our baseline approach sets it equal to the corresponding unobservable estimated in the home market, $\xi_{j,\text{China}}$. As a robustness check, we instead draw ξ from the empirical distribution of estimated demand shocks in China and find that the resulting counterfactual outcomes are very similar. We also consider an alternative set of draws based on the empirical distribution of ξ among models sold in the US market.

Marginal Cost. We study automobile trade rather than foreign direct investment: we assume that Chinese EV models are produced in China and exported to the US market, as opposed to a scenario in which Chinese brands establish production facilities in the US.[2] Under this trade environment, imported Chinese EVs face ad valorem tariffs upon entry into the US. In our counterfactual simulations, we model these policies as (i) an ad valorem tariff applied to the consumer price of Chinese EVs and (ii) additional per-vehicle cost components that shift marginal cost, including international shipping and US-side distribution and marketing expenses.

Although we cannot directly estimate the marginal costs of Chinese EVs in the US market for models that are not yet sold there, we observe a set of Chinese EV makes and models that are sold in both China and the European countries in our sample. We use the estimated cross-country marginal-cost gap for these overlapping models (i.e., Chinese EVs sold in both China and Europe) to discipline the marginal-cost level of the counterfactually introduced Chinese models in the US market, accounting for tariffs and other per-vehicle trade costs. The assumption is that the observed cost wedge between serving Europe and China provides an empirical analogue for the additional cost wedge associated with serving the US market from China. We calibrate per-vehicle shipping costs at \$2,750 and additional US-side distribution and marketing costs at \$1,402, consistent with industry benchmarks and practitioner estimates of shipping and downstream selling costs in the global automobile market.

Robustness to the Constructed Quality and Cost of the Models Introduced into the US. Because both the mean utilities and the marginal costs of the Chinese EV models introduced into the US market are constructed from cross-market information rather than estimated in-sample, we assess how the optimal-policy conclusions in Section 7 respond to misspecification of these two

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[1] As a robustness check, we consider several alternative ways of constructing ψ, including using different aggregation levels for $g(\cdot)$. In addition, we implement an alternative approach that does not rely on a China-to-US shift: we use the distribution of estimated fixed effects in the observed US market to impute $\eta_{j,\text{US}}$ for entering Chinese EVs, assigning $\eta_{j,\text{US}}$ to the 25th or 75th percentile of the US fixed-effect distribution within the relevant product group. The resulting estimates and implied counterfactual outcomes are qualitatively similar across these alternatives.

[2] In comparison, Head et al. (2026) study endogenous global supply networks and production relocation in the EV battery industry.

objects. The exercise focuses on the US market, where this concern is most acute: no Chinese EV is sold in the US, so the primitives of the introduced models rely entirely on the cross-market construction, whereas Chinese EVs are already observed in the European markets. We jointly vary the perceived quality of all ten introduced models by a dollar-equivalent amount ranging from $-\$5{,}000$ to $+\$5{,}000$ per vehicle (implemented as a perceived-price wedge that no agent collects) and their marginal costs by an additive shift over the same range, on a 10×10 grid, and re-solve the full optimal-policy search at every grid point using the same tariff and subsidy grids as in the baseline. Appendix Figure E.10 reports the resulting optimal policies and welfare gains; Appendix D.2 discusses the findings.

C.3 Calibration of Environmental Benefits

Following Funke et al. (2023), we calibrate the per-vehicle lifetime external costs in equation (10) as $\text{UnitCarbCost} = \$3{,}810$ (climate damages from CO_2 emissions) and $\text{UnitHealthCost} = \$687$ (health damages from local air pollution) for the US. To also characterize the climate impact in physical units, we report the lifetime CO_2 reduction as $\Delta CO_2 = -\Delta Q^{\text{ICE}} \times 78.5$ tons, where 78.5 tons of lifetime CO_2 per vehicle is implied by UnitCarbCost evaluated at the social cost of carbon of approximately \$48.5 per ton.

C.4 Construction of Manufacturing Job Changes and Job Values

Step 1: Mapping Equilibrium Sales to Domestic Jobs. We construct an approximate measure of US auto manufacturing employment implied by each counterfactual by mapping equilibrium sales into domestically produced units and then into jobs. We classify domestic producers into (i) US-headquartered automakers and (ii) incumbent foreign-owned “transplant” automakers. For US firms, we assume 75% of US sales are produced domestically; for transplants, we assume 53% (Source: Alliance for Automotive Innovation). We then convert domestically produced units into jobs using a constant jobs-per-vehicle coefficient calibrated from aggregate data. We set the ICE coefficient to $\ell^{\text{ICE}} = 0.10$ jobs per vehicle, calculated as payroll employment in motor vehicles and parts (approximately 1 million jobs; FRED, CES3133600101) divided by US light-vehicle production in 2023 (approximately 10 million units; FRED, MVAAUTLTTS). We assume EV assembly to be less labor-intensive by scaling the ICE coefficient by 0.70, i.e., $\ell^{\text{EV}} = 0.70 \times \ell^{\text{ICE}}$, as suggested by Weng et al. (2024). The implied level of US manufacturing employment is

$$\text{Jobs} = \rho^{US}\left(\ell^{\text{ICE}} Q^{US,\text{ICE}} + \ell^{\text{EV}} Q^{US,\text{EV}}\right) + \rho^{TP}\left(\ell^{\text{ICE}} Q^{TP,\text{ICE}} + \ell^{\text{EV}} Q^{TP,\text{EV}}\right), \tag{C.4}$$

where $\rho^{US} = 0.75$ and $\rho^{TP} = 0.53$ are the domestic-production shares, and $Q^{g,v}$ denotes total US sales of powertrain type $v \in \{\text{ICE}, \text{EV}\}$ by producer group $g \in \{US, TP\}$. The counterfactual change in employment relative to the 2023 status quo is

$$\Delta\text{Jobs} \ = \ \text{Jobs}^{\text{CF}} - \text{Jobs}^{\text{SQ}}. \tag{C.5}$$

As an extension, we construct a back-of-the-envelope estimate of the net downstream US service-sector jobs created by Chinese EV entry. The key insight is that service-job creation depends on *total market expansion* (the increase in the number of consumers who purchase any vehicle) rather than on Chinese EV sales per se. A consumer who switches from a domestic vehicle to a Chinese EV simply reallocates dealership and service activity across manufacturers; the associated service jobs are neither created nor destroyed in net terms. Only buyers drawn from the outside option (those who would not have purchased a new vehicle absent Chinese EV entry) generate genuinely new downstream employment. We therefore apply the service-job coefficient to ΔQ^{total}, the simulation-implied increase in total new-vehicle sales relative to the ban scenario, rather than to Chinese EV sales.

The coefficient is calibrated from the 2024 NADA Annual Financial Profile of America's Franchised New-Car Dealerships, which reports 1.13 million franchised dealership employees supporting 15.9 million new light-vehicle sales, implying a raw coefficient of $1{,}130{,}000/15{,}900 \approx 71.1$ jobs per 1,000 vehicles sold. Since dealership employees serve new vehicle sales, used vehicle sales, and after-sales service simultaneously, we scale by the new-vehicle department's share of total dealership revenue (54.7%, per NADA 2024), yielding a coefficient of $71.1 \times 0.547 \approx 39$, which we round to 40 jobs per 1,000 new vehicles sold. This is internally consistent with the manufacturing-job coefficient ($\ell^{\text{EV}} = 0.07$ jobs per vehicle, i.e., 70 per 1,000), which is also derived from an aggregate employment-to-sales ratio and covers only NAICS 336 manufacturing, with no dealership employment included.

Step 2: Monetizing the Social Value of Jobs. Worker wages enter as costs in firm revenue and are already netted out of $\Delta\Pi^{US}$ in equation (8), so adding a job-value term does not double-count wage income. It instead captures the additional social value of manufacturing employment beyond what firm profits record: unemployment frictions, agglomeration spillovers, local fiscal effects, and workers' valuation of job stability. The generalized welfare measure under a per-job-year value w is

$$\Delta\text{Welfare}^{\text{Job}}(w) \ = \ \Delta\text{Welfare}^{\text{EB}} + w \cdot \Delta\text{Jobs}, \tag{C.6}$$

with $\Delta\text{Welfare}^{\text{EB}}$ defined in equations (8)–(10). The main text uses two anchors that span the empirically defensible range. The lower bound $w_{\text{LB}} = \$10{,}700$/job-year is the revealed-preference value implied by US state and local subsidy auctions (Slattery, 2025). The upper bound $w_{\text{UB}} = \$70{,}000$/job-year is the average BLS NAICS 336 auto-manufacturing wage; because wages are largely a transfer between workers and employers (Bartik, 2015), this treats the wage as if it were all social cost and is therefore a conservative cap. Appendix Table F.5 adds three intermediate benchmarks: the Bartik (2015) welfare-theoretic displacement cost of \$12,250/job-year (17.5% of annual earnings at average unemployment and a 7% discount rate); that same value scaled by the Moretti (2010) local-employment multiplier of $1 + 1.6 = 2.6$, yielding \$31,850/job-year and capturing local-services spillovers; and the Allcott et al. (2026) fiscal cost of \$169,000 per additional US auto-manufacturing job under the IRA EV credits, a cost-effectiveness ratio included as an upper-extreme stress test. The qualitative ranking of policies is preserved across all five benchmarks.

C.5 Construction of the MCPF-Adjusted Welfare Measure

The welfare aggregator in equation (8) treats fiscal flows symmetrically: tariff revenue is added at par and subsidy expenditure is subtracted at par. This abstracts from the deadweight cost of raising the marginal dollar of tax revenue used to finance a subsidy. To accommodate this concern we report a robustness measure that applies a marginal-cost-of-public-funds (MCPF) penalty to the net fiscal deficit only:

$$\Delta\text{Welfare}^{\text{MCPF}}(\chi) \;=\; \Delta\text{Welfare}^{\text{EB}} \;-\; (\chi - 1)\cdot \max\{\text{Gov. Deficit}, 0\}, \tag{C.7}$$

where $\chi \geq 1$ is the MCPF multiplier. The max operator retains only positive net deficits: a deficit-financed dollar of subsidy costs χ dollars of social welfare, while a fiscal surplus (tariff revenue in excess of subsidy outlays) is assumed to be rebated lump-sum at par and so generates no additional distortion.

Appendix Table F.5 reports MCPF welfare for three multipliers, $\chi \in \{1.1, 1.3, 1.5\}$. The central value $\chi = 1.3$ is the canonical estimate from Ballard, Shoven, and Whalley (1985), who use a computable general-equilibrium model of the US to compute the marginal welfare cost of raising an additional dollar of revenue through the US tax system. The wider range $\chi \in [1.1, 1.5]$ brackets the empirical literature surveyed in Dahlby (2008) and reflects the substantial gap between partial- and general-equilibrium estimates of the marginal excess burden documented in Goulder and Williams (2003) as well as the range of taxable-income-elasticity estimates summarized in Saez, Slemrod, and Giertz (2012). In our counterfactuals the MCPF penalty binds under regimes that run a positive fiscal deficit at the optimum: specifically, the *Subsidy Only* regime (which has zero tariff revenue) and the joint *Unconstrained Optimum* (“Both”), whose optimal subsidy exceeds the tariff revenue raised. It does not bind under *Tariff Only*, which runs a fiscal surplus, nor under *Recycling*, where the budget-balancing constraint forces $\max\{\text{Gov. Deficit}, 0\} \approx 0$ by construction, so the welfare ranking of the recycling policy is invariant to χ.

D Additional Analysis and Results

D.1 Empirical Estimates of the October 2024 EU Countervailing Duty

Our demand and supply parameters are estimated on data through 2023, whereas the EU's brand-specific countervailing duties (CVD) on China-manufactured electric vehicles took provisional effect on July 5, 2024 and were adopted definitively on October 29, 2024. The 2024–2025 post-policy period therefore provides an out-of-sample test of the counterfactual predictions in Table 3: no observation from 2024 or 2025 enters the estimation at any stage. This appendix compares those predictions with the realized data.

Design. We use monthly new-registration data from MarkLines for the six EU member states in our sample (Austria, France, Germany, the Netherlands, Spain, and Sweden), by brand and model, from 2023m1 through 2025m12, restricted to battery-electric and plug-in-hybrid vehicles. The treated unit is the aggregate monthly EU-6 sales of incumbent models (those with at least six months of positive 2023 sales) of the five large mature Chinese brands established in the EU by 2023: BYD, MG (SAIC), Polestar (Geely), NIO, and Lynk & Co (Geely). Restricting to incumbent models mirrors the static 2023 product set underlying the structural counterfactual (Section 5), and the outcome is the log of aggregate monthly sales. Following Abadie, Diamond, and Hainmueller (2010), the synthetic control is a convex combination of non-Chinese EU-6 EV+PHEV donor brands chosen to minimize the squared pre-period (2023m1–2024m6) deviation between treated and synthetic log-sales; the donor pool is screened to brands whose own placebo pre-period RMSPE does not exceed twice the treated unit's. The resulting pool contains 27 brands, the treated-unit pre-period log-RMSPE is 0.166, and the fitted weights concentrate on Volkswagen (70.3%), Fiat (24.0%), and BMW (5.7%).

Result. Appendix Figure E.5 reports the results. The pre-period gap is flat (log-RMSPE 0.166). After the provisional CVD takes effect, the treated-versus-synthetic gap drops sharply and stabilizes near the model's prediction; over the definitive-CVD window the mean gap is -0.853, a 57.4% reduction in the sales of these five brands. The model benchmark, the implied log change in Chinese-brand sales of $\log(102.2/231.9) = -0.820$ (-56.0%) computed from Columns 1 and 2 of Table 3, lies within 1.4 percentage points of the synthetic control estimate.[3] The estimated contraction thus closely matches the model-simulated estimate, indicating that the demand curvature and pass-through structure underlying our counterfactuals carry predictive content out of sample.

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[3] The model's predicted log change in *share* is $\log(4.50/9.89) = -0.787$; the sales benchmark is marginally lower because the model also predicts a 3.2% contraction in the total EU EV market. Averaging instead over all CVD-active months from July 2024 (including the three provisional months) gives -0.798 (-55.0%).

D.2 Sensitivity of the Optimal US Policies to the Quality and Cost of the Introduced Models

Appendix C.2 describes how the mean utilities and marginal costs of the ten Chinese EV models introduced into the US market are constructed from cross-market information, and the accompanying robustness exercise: we jointly vary the perceived quality and the marginal cost of all ten models by up to ±\$5,000 per vehicle and re-solve the full optimal-policy search of Section 7 at each point of a 10×10 grid. The exercise focuses on the US market, where no Chinese EV is sold and the quality and cost of the introduced models therefore rest entirely on the cross-market construction; this concern is weaker in the European markets, where Chinese EVs are already observed. Appendix Figure E.10 reports the results; this subsection discusses the findings.

The main conclusions are robust across the entire grid. The optimal tariff-recycling policy raises welfare relative to the 2023 status quo at every grid point, with gains between \$27.6 and \$78.6 billion (Panel (b)), and the optimal recycling tariff is strictly interior throughout, ranging from 17.5% to 32.5% (Panel (c)). Recycling also dominates the tariff-only design at every grid point and dominates the stand-alone subsidy throughout a wide neighborhood of the baseline construction (Panel (a)). The single qualification arises in the corner of the grid where the baseline simultaneously understates entrant costs and overstates entrant appeal. There, the introduced models sell in small volumes, so the tariff base is thin and the budget-balancing subsidy that tariff revenue can finance is correspondingly small; a stand-alone subsidy, unconstrained by the recycling budget, then delivers a larger welfare gain.

Panel (c) also displays an instructive comparative static: the optimal recycling tariff rises as entrant appeal falls. This matches the prediction of the stylized model in Appendix A: under a balanced-budget recycling rule, taxing less attractive imports forgoes little consumer surplus per dollar of revenue raised, while the revenue finances subsidies to domestic products that consumers value relatively more, so the planner optimally raises more revenue. As the entrants become more attractive, the consumer-surplus cost of the tariff grows and the planner recycles less. The budget-clearing subsidy (Panel (d)) tracks the size of the resulting revenue base.

D.3 Optimal Policies under Domestic Product Entry

This appendix details the domestic product entry exercise summarized in Section 7.1: one or three EV models are added to the domestic portfolio by reassigning major third-country EVs to Tesla and Volkswagen, holding product characteristics fixed, and the full optimal-policy search is repeated for each portfolio. Table F.4 reports the results for the US and Germany.

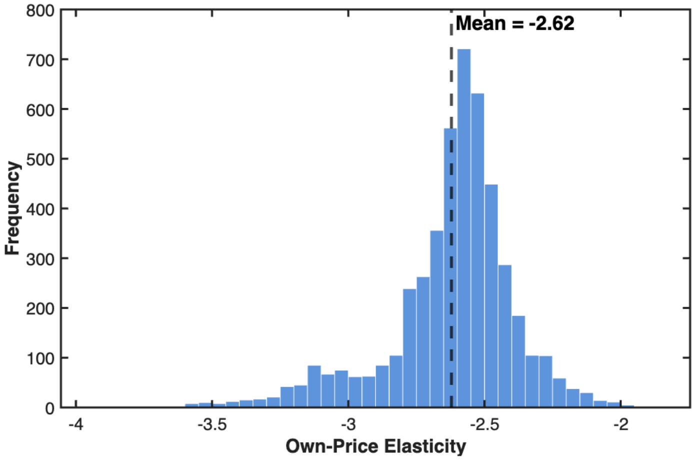
Expanding the domestic product line shifts both optimal instruments. In the US market, the per-unit subsidy rises in the *Subsidy Only* and *Unconstrained Optimum* regimes, as a broader set of eligible domestic models raises the producer-surplus and market-power-correction returns to the subsidy, but falls under the *Tariff-funded Subsidy*, where a roughly fixed pool of tariff revenue must cover a larger eligible base, so the budget-balancing subsidy per vehicle declines. The optimal US tariff rises in the *Tariff Only* and *Tariff-funded Subsidy* regimes, where additional domestic models strengthen the protection motive and require more revenue, while staying exactly flat at 21.5% in the *Unconstrained Optimum*: the unconstrained planner accommodates the broader portfolio through subsidies rather than additional tariffs, raising the optimal subsidy from \$8.50k to \$9.00k per vehicle. In Germany, where the domestic portfolio is already broad, the optimal subsidies in the *Unconstrained Optimum* and *Tariff-funded Subsidy* regimes decline modestly with additional models, while the *Subsidy Only* subsidy and the optimal tariffs remain roughly flat.

The welfare gains rise monotonically with the portfolio. Under the *Tariff-funded Subsidy*, adding one domestic EV model raises the welfare gain from \$45.60 billion to \$48.65 billion, and adding three models raises it further to \$51.78 billion, while the optimal tariff and subsidy remain close to their baseline values. This pattern suggests that if domestic automakers adjust their product portfolios endogenously in response to Chinese competition, the gains from combining product expansion with the optimal policy mix could be larger than in our static baseline.

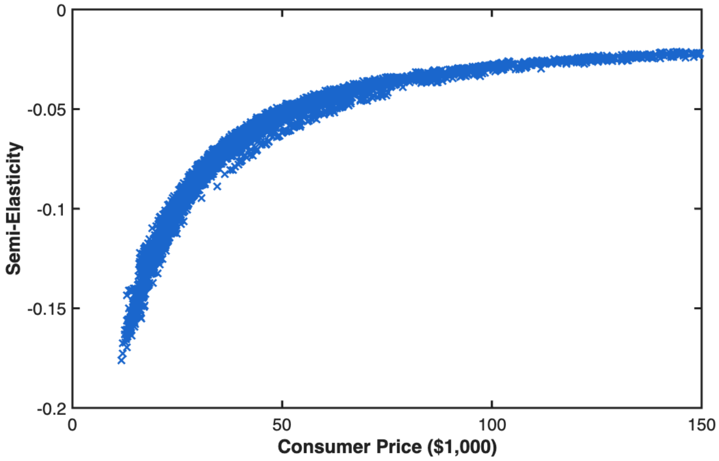
E Appendix Figures

Figure E.1: Estimated Own-Price Elasticities and Semi-Elasticities, United States

(a) Estimated Own-price Elasticity

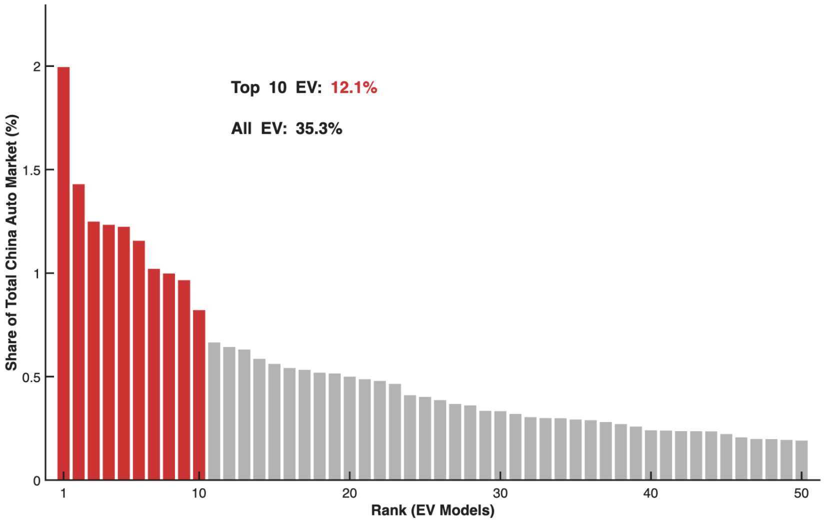


(b) Estimated Semi-Elasticity



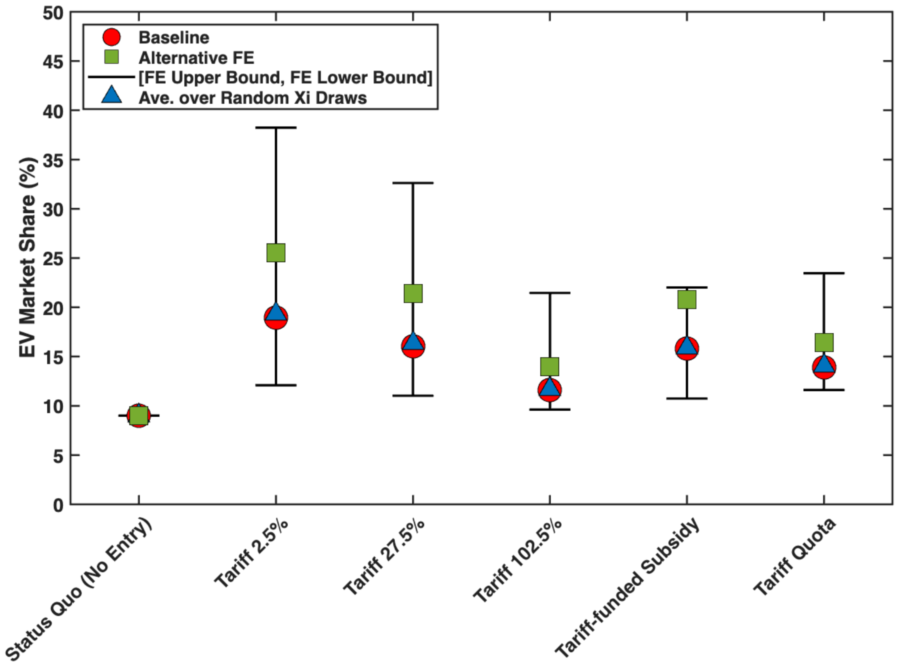
Notes: This figure displays the estimated demand elasticities for the US market. Panel (a) displays a histogram of the estimated own-price elasticities for all vehicle models sold in the US, where the vertical dashed line indicates a mean elasticity of -2.62. Panel (b) plots each vehicle model's own-price semi-elasticity against its consumer price (measured in \$1,000). The semi-elasticity measures the percentage change in a model's sales in response to a \$1,000 increase in its own consumer-facing price.

Figure E.2: Market Share Rank of Top Chinese EV Models in the Chinese Market



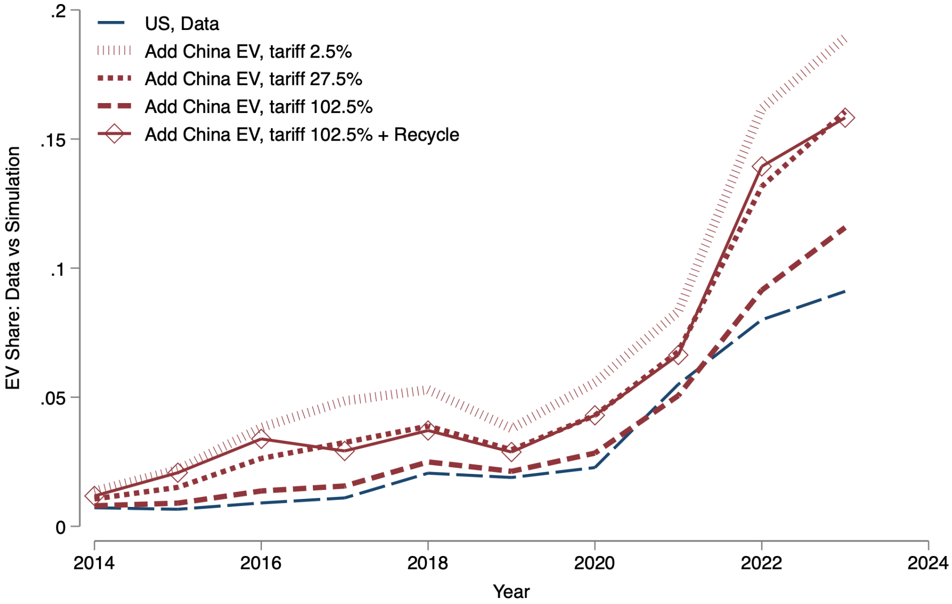
Notes: This figure illustrates the market share distribution of electric vehicle (EV) models in the Chinese domestic market based on 2023 data. The horizontal axis ranks individual EV models by their market share. The vertical axis represents each model's share of the total China auto market. The red bars highlight the **top 10** Chinese-manufactured EV models, which collectively account for 12.1% of the total automotive market. The gray bars represent the subsequent 40 models in the ranking. Collectively, all EV models in the sample represent 35.3% of the total Chinese auto market.

Figure E.3: Robustness Using Alternative Fixed Effects and ξ Draws, N = **10** Chinese EV Entrants



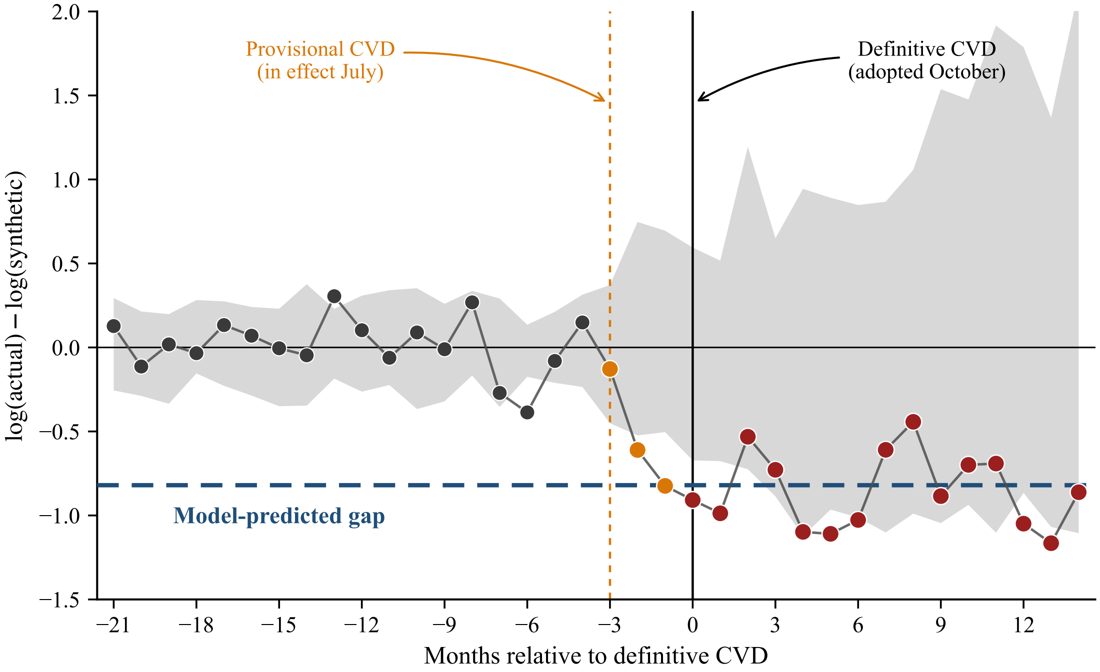
Notes: This figure presents a series of robustness checks for the simulated US EV market share in 2023 across various policy scenarios, serving as a sensitivity analysis for the results presented in Table 2. The simulation results are evaluated against two primary dimensions of uncertainty: the choice of product fixed effects and the unobserved quality (ξ) of the Chinese entrant models. The red circles represent the baseline specification used throughout the paper. The green squares denote the results using alternative fixed effect specifications, with the vertical error bars illustrating the upper and lower bounds of market outcomes constructed by assigning the 75th and 25th percentiles of the observed domestic fixed effects to the entrant models, respectively. The blue triangles show the mean market share calculated from 50 Monte Carlo simulations where the unobserved quality ξ for Chinese entrants is randomly drawn from the empirical distribution of existing models in the US market. The horizontal axis includes scenarios mirroring the policy configurations in the main text.

Figure E.4: Simulated EV Market Share in the US Over Time: Adding **Top 10** Chinese EVs



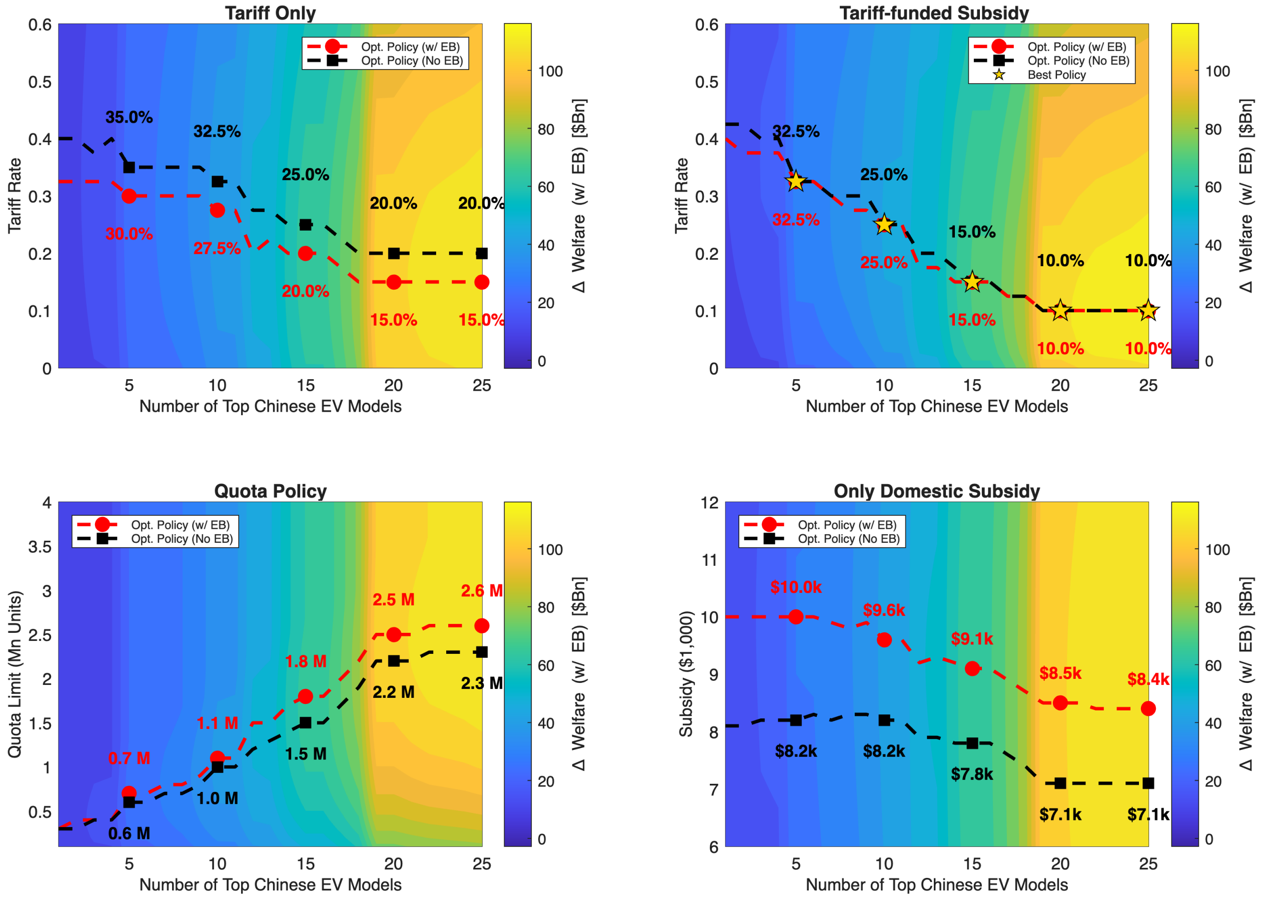
Notes: This figure shows the simulated trend of EV market share in the US market from 2014 to 2023. The blue dashed line represents the actual observed market share of EVs in the US during this period. The other curves illustrate simulated scenarios following the introduction of the **top 10** Chinese-manufactured EV models (ranked by their 2023 Chinese market share) under varying policy regimes: a tariff of 2.5% (thin red dotted line), a tariff of 27.5% (thick red dotted line), and a tariff of 102.5% (thick red dashed line). The solid red line represents the scenario with a 102.5% tariff combined with revenue recycling into domestic EV subsidies.

Figure E.5: Synthetic Control Estimates of the Effect of the October 2024 EU CVD on Incumbent Chinese-Brand EV Sales



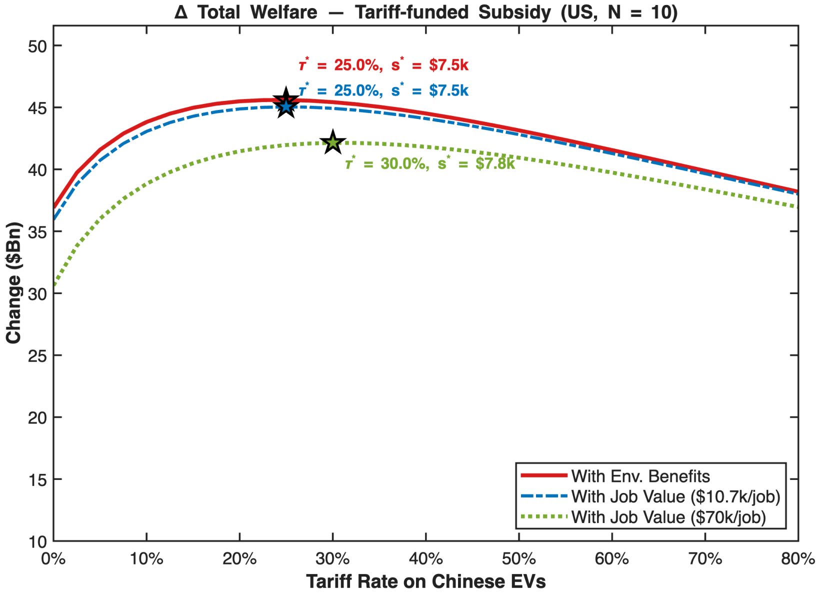
Notes: The plotted series is the log difference between actual and synthetic incumbent Chinese-brand EV+PHEV sales in EU-6 (Austria, France, Germany, the Netherlands, Spain, and Sweden), at monthly frequency from 2023m1 to 2025m12. The treated unit aggregates incumbent models (those with at least six months of positive 2023 sales) of five mature Chinese brands established in the EU by 2023: BYD, MG (SAIC), Polestar (Geely), NIO, and Lynk & Co (Geely). Gray circles denote pre-policy months, orange circles the three provisional-CVD months (July–September 2024), and red circles the definitive-CVD months (from October 2024). The shaded band is the 5th–95th percentile of placebo gaps obtained by running the same synthetic-control procedure with each donor brand as a fake-treated unit. The bold dashed line is the model-implied log change in Chinese-brand sales, $\log(102.2/231.9) = -0.820$ (-56.0% in levels), computed from Table 3 (Column 1 baseline: $0.0989 \times 2{,}345 = 231.9$ thousand; Column 2 post-CVD: $0.0450 \times 2{,}270 = 102.2$ thousand). The mean treated gap over the definitive window ($k \geq 0$) is -0.853 (-57.4% in levels). Data: MarkLines monthly sales.

Figure E.6: Optimal Policy Design by Alternative Policy Regimes and Number of Entrants



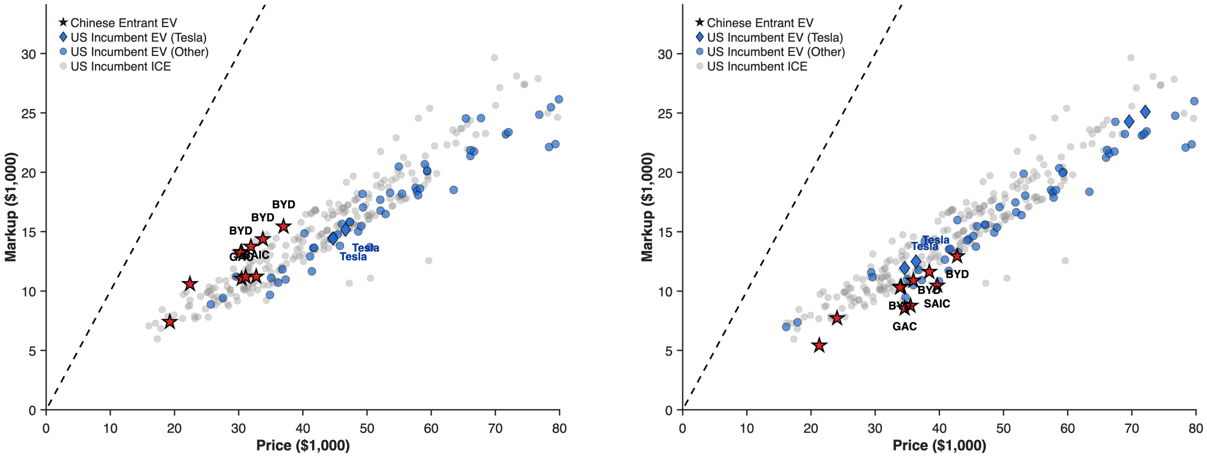
Notes: This figure illustrates the simulated optimal trade policies under varying numbers of Chinese EV entrants (x-axis) across four scenarios: tariff with no revenue recycling (top left), tariff with revenue recycled as domestic subsidies (top right), quota policy (bottom left), and domestic subsidy only (bottom right). The base year is 2023. The y-axis represents the policy value: tariff rate (top panels), quota in million units (bottom left), or subsidy in $1,000 (bottom right). The heatmap indicates the change in total welfare (including environmental benefits) in $billions, relative to the status quo. The red dashed lines trace the optimal policy, while the black dashed lines show the optimal policy with an alternative welfare measure that excludes environmental benefits. The percentage shown beside each line represents the equilibrium EV market share under the corresponding optimal policy. The yellow stars denote the "Global Optimal Frontier," marking the specific policy choice across all four scenarios that yields the highest absolute total welfare for a given number of entrants.

Figure E.7: Optimal Tariff-funded Subsidy Policy under Alternative Welfare Definitions, United States



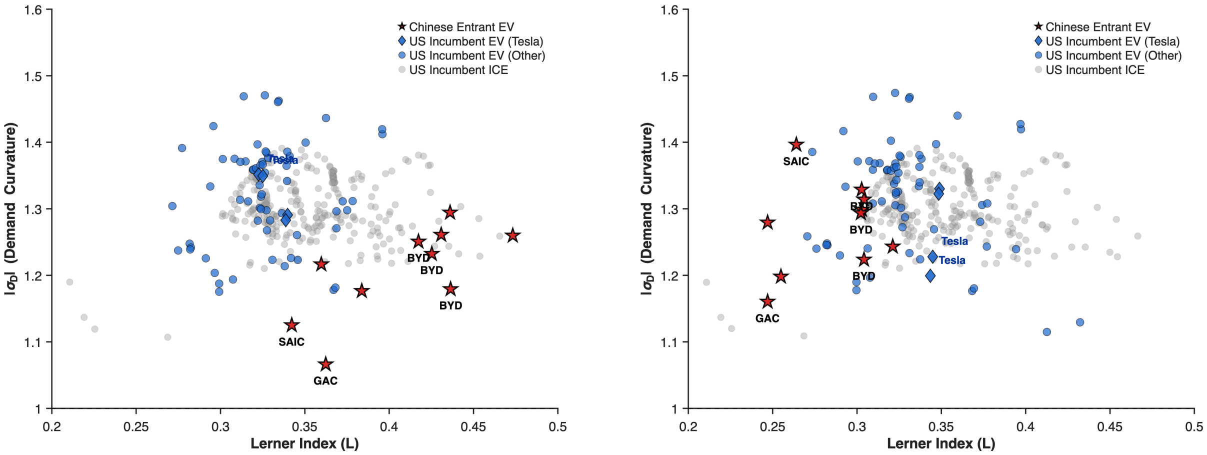
Notes: This figure plots the change in total welfare along the tariff-funded subsidy path for the United States, holding the number of Chinese EV entrants fixed at $N = 10$. Along this path, tariff revenue collected on Chinese EV imports is fully recycled as a per-unit subsidy to domestic EV buyers, so government revenue is balanced by construction. The horizontal axis shows the tariff rate on Chinese EVs; for each tariff level, the equilibrium subsidy is determined by the budget-clearing condition. The figure displays three welfare measures: welfare inclusive of environmental benefits only (red solid); welfare additionally incorporating a lower-bound estimate of the social value of manufacturing employment (blue dash-dot, valued at $10,700 per job-year following Slattery, 2025); and welfare incorporating an upper-bound estimate (green dotted, valued at the BLS NAICS 336 average auto manufacturing wage of $70,000 per job-year). Stars mark the optimal tariff rate and corresponding equilibrium subsidy for each welfare measure.

Figure E.8: Impacts of Policy on Pricing, Markup, Curvature, and Market Power



(a) Markup and Price: *No Policies*

(b) Markup and Price: *Tariff-funded Subsidy*

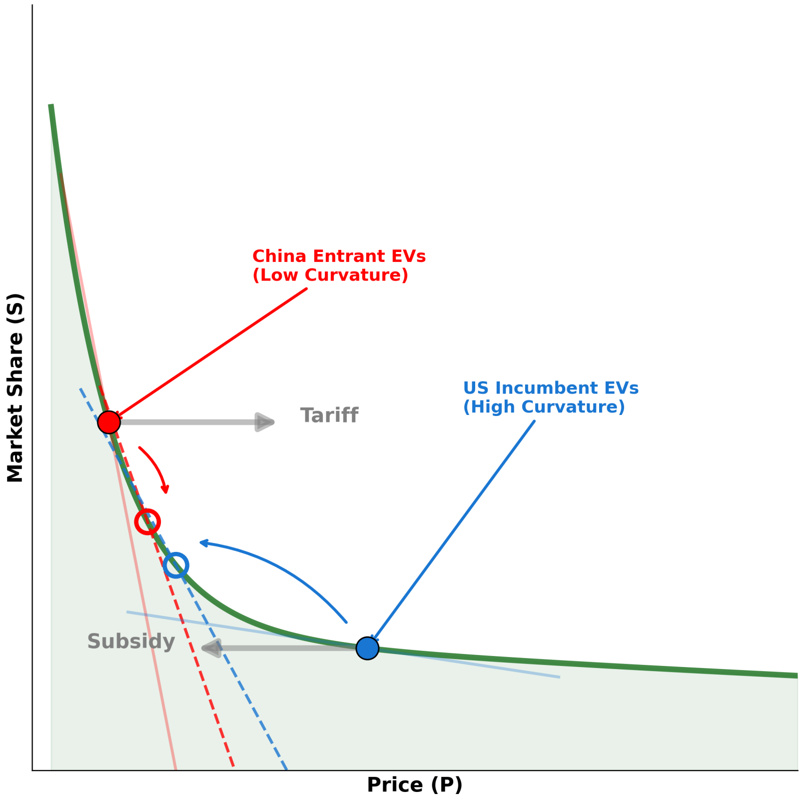


(c) Curvature and Market Power: *No Policies*

(d) Curvature and Market Power: *Tariff-funded Subsidy*

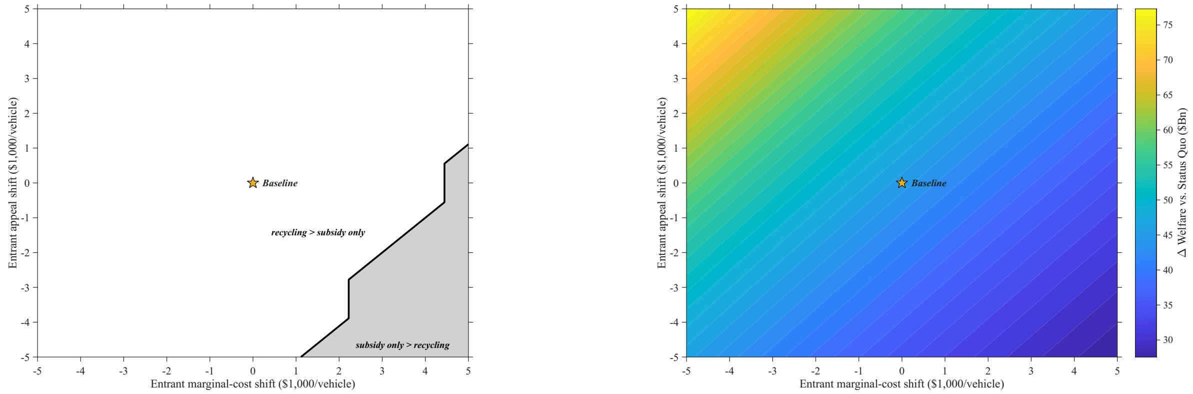
Notes: This figure illustrates the relationship between pricing strategies and demand characteristics for various vehicle models under two scenarios, No Policies (Panels a and c) and the Tariff-recycling Subsidy policy (Panels b and d), using 2023 as the baseline year with the **top 10** Chinese-manufactured EV models introduced as entrants. Each point in the scatter plots represents a specific vehicle model, categorized as Chinese entrant EV (red stars), US incumbent EV - Tesla (dark blue diamonds), US incumbent EV - Other (light blue circles), and US incumbent ICE (gray circles). Panels (a) and (b) plot the markup ($1,000) against the price ($1,000). Panels (c) and (d) plot the demand curvature ($|\sigma_d|$) against the Lerner index (L). The Lerner index is defined as $L_j = (P_j - MC_j)/P_j$, where P_j is the price and MC_j is the marginal cost. Following the framework of Weyl and Fabinger (2013), the demand curvature is defined as $|\sigma_d| = |(s_j \cdot \frac{\partial^2 s_j}{\partial P_j^2})/(\frac{\partial s_j}{\partial P_j})^2|$, which captures the non-linearity of the market share response to price changes.

Figure E.9: Illustration of the Tariff-Recycling Subsidy: Chinese Entrant EVs versus US Incumbent EVs



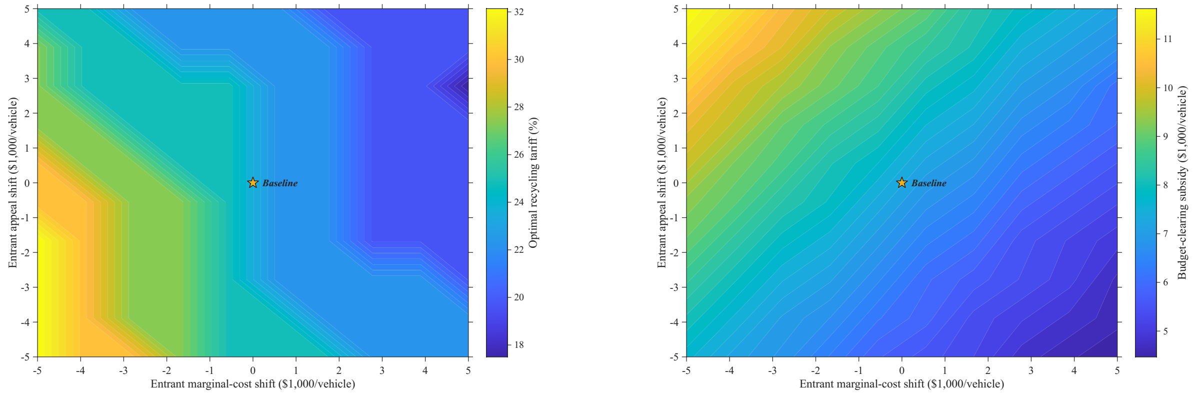
Notes: This figure illustrates the conceptual impacts of the tariff-recycling subsidy on the market equilibrium of Chinese entrant EVs and US incumbent EVs. The green solid curve represents the market demand. The solid red dot represents the initial equilibrium for Chinese entrant EVs, and the solid blue dot represents the initial equilibrium for US incumbent EVs. The solid red and blue lines denote the initial tangents (slopes) at these equilibrium points. The hollow red and blue circles represent the new equilibrium positions following the policy intervention. The dashed red and blue lines denote the new tangents at these new equilibria.

Figure E.10: Optimal US Policies under Alternative Quality and Cost of the Introduced Chinese EVs



(a) Policy-regime regions

(b) Welfare gain of tariff recycling



(c) Optimal recycling tariff

(d) Budget-clearing subsidy

Notes: Each panel jointly varies the constructed primitives of the ten Chinese EV models introduced into the US market (Appendix C.2): the horizontal axis shifts their marginal cost, in dollars per vehicle (a positive shift means the baseline construction understates costs), and the vertical axis shifts their perceived quality by a dollar-equivalent amount (a positive shift means the entrants are more attractive to US consumers than in the baseline). At each of the 10 × 10 grid points we re-solve the full optimal-policy search of Section 7 with the baseline tariff and subsidy grids. Panel (a) shades in gray the region where a stand-alone subsidy delivers a larger welfare gain than tariff recycling; recycling dominates the tariff-only design at every grid point. Panels (b)–(d) show the welfare gain of the optimal recycling policy relative to the 2023 US status quo (in $billions, including environmental benefits), the optimal recycling tariff, and the budget-balancing subsidy it finances. The star marks the baseline construction (zero shift in both dimensions).

F Appendix Tables

Table F.1: Summary Statistics

	China		US+CA		EU	
Variables	Mean	SD	Mean	SD	Mean	SD
Panel A. Internal Combustion Engine						
Sales	39105.45	60719.32	32958.00	68319.84	5005.03	12249.81
MSRP ($1,000)	31.26	26.21	50.32	25.95	53.14	29.47
Curb Weight (kg)	1481.79	320.71	1780.71	385.40	1559.62	362.01
Footprint (m^2)	8.04	1.39	8.96	1.16	8.15	1.21
Displacement	1.83	0.60	3.17	1.22	1.97	0.75
Horsepower	156.44	61.67	255.22	89.37	162.08	79.37
Fuel Economy (L/100km)	7.59	2.30	11.06	2.63	6.76	1.90
SUV	0.37	0.48	0.39	0.49	0.30	0.46
# of Obs.	7053		9974		38853	
Panel B. EV						
Sales	17128.09	41700.62	9423.24	28560.43	1522.19	3195.85
MSRP ($1,000)	32.45	20.20	66.47	32.19	69.07	30.19
Subsidy ($1,000)	3.20	1.33	2.38	2.37	1.70	1.91
Curb Weight (kg)	1675.80	450.78	1938.87	392.96	1896.26	372.99
Footprint (m^2)	7.98	1.55	8.72	1.21	8.42	1.22
Horsepower	186.33	66.10	297.83	162.97	254.20	131.97
Driving Range (km)	317.87	180.02	205.94	189.30	195.19	174.15
Plug-in Hybrid	0.25	0.43	0.45	0.50	0.52	0.50
SUV	0.45	0.50	0.41	0.49	0.48	0.50
# of Obs.	1167		526		5397	

Notes: The sample covers 13 countries with all automobile model sales between 2004 and 2023. The countries are Austria, Canada, China, France, Germany, Japan, the Netherlands, Norway, Spain, Sweden, Switzerland, the UK, and the US. All prices and subsidy amounts are normalized in 2023 US dollars ($).

Table F.2: Top 10 EV Models in China, 2023

Group	Brand	Model	MSRP	Sales
BYD Auto	BYD Auto	QINPLUS	18.90	327371
BYD Auto	BYD Auto	DOLPHIN	18.19	285970
BYD Auto	BYD Auto	YUANPLUS	21.01	282501
BYD Auto	BYD Auto	SEAGULL	11.41	280217
BYD Auto	BYD Auto	SONGPLUS	24.69	264762
SAIC	Wuling	WULINGBINGO	10.90	233735
GAC Group	GAC Aion	AIONY	20.62	228555
GAC Group	GAC Aion	AIONS	19.99	221227
BYD Auto	BYD Auto	SONGPRO	20.28	188007
SAIC	MG	MG4/MGMULAN	22.57	152337

Table F.3: Counterfactual: Add **Top 10** Chinese-manufactured EVs Sold in Europe to the US Market, Year = 2023

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Ban	**Ban**	**Add Top 10 China manufactured EV**					
		+ Subsidy	*Baseline*	*Moderate*	*Punitive*	*+ Redistribute*	*+ Quota*	*+ Subsidy*
Subsidy/Tariff/Quota		$7,500	2.5%	27.5%	102.5%	102.5%	0.5 Mn unit	$7,500 / 0%
Panel (a) Effects on EV adoption								
Weighted Price: ICE ($1,000)	42.62	42.85	42.47	42.48	42.56	42.62	42.47	42.71
Weighted Price: Non-Chinese EV ($1,000)	53.18	43.14	52.04	52.16	52.76	48.60	52.04	41.74
Weighted Price: Chinese EV ($1,000)	0.00	0.00	51.20	62.98	92.44	93.21	53.65	50.86
Total Sales (1,000)	15,327	15,508	15,462	15,402	15,345	15,409	15,445	15,645
Total EV Sales (1,000)	1,380	2,029	1,854	1,636	1,442	1,680	1,794	2,482
EV Share (%)	9.00	13.08	11.99	10.62	9.40	10.90	11.61	15.86
Q1	6.80	11.31	9.22	7.86	6.95	8.59	8.83	13.47
Q2	7.56	11.20	10.19	8.97	7.83	9.10	9.86	13.82
Q3	10.51	14.47	13.75	12.49	11.12	12.59	13.41	17.51
Q4	11.15	15.36	14.80	13.17	11.71	13.32	14.36	18.65
Chinese EV % of total EV	0.00	0.00	34.16	21.16	7.11	5.85	30.85	23.75
Profit, CHN EV ($Bn)	0.00	0.00	10.23	5.48	1.73	1.67	8.81	9.86
Panel (b) Effects on US Welfare: △ Welfare = △ CS + △ Domestic Profit + △ Gov Revenue + △ Env. Benefits								
△ Welfare ($Bn)		5.72	14.34	13.45	7.07	9.94	14.53	19.27
△ Consumer Surplus ($Bn)		8.71	16.04	10.77	3.74	7.20	14.72	24.70
Q1		2.00	1.73	0.90	0.18	0.95	1.50	3.71
Q2		1.80	2.84	1.84	0.53	1.26	2.59	4.68
Q3		2.27	6.02	4.28	1.58	2.48	5.61	8.27
Q4		2.64	5.45	3.75	1.45	2.51	5.02	8.04
△ Government Revenue ($Bn)		-11.82	0.75	4.34	3.87	0.00	2.07	-11.34
△ Profits, All US firms ($Bn)		6.73	-3.97	-2.47	-0.74	1.76	-3.59	2.38
△ Profit, US EV		8.53	-1.91	-1.15	-0.33	2.90	-1.72	6.11
△ Profit, US ICE		-1.81	-2.06	-1.32	-0.41	-1.14	-1.87	-3.73
△ Env. Benefits ($Bn)		2.10	1.53	0.81	0.20	0.98	1.33	3.52
△ Mfg Jobs (Thousands)		7.16	-26.05	-13.49	-3.13	-0.50	-22.54	-16.64

Notes: The counterfactual is based on the year 2023. All monetary values are normalized to 2023 USD. Distribution and marketing services are assumed to be provided at cost by US firms, so they generate no profits and affect welfare only through consumer prices. All average numbers are calculated as sales-weighted averages across models. For Column (6), the budget-balancing EV subsidy that cycles back to domestic EV makers is about $3,372. Q1 to Q4 are income quartiles, where Q4 represents the wealthiest consumers.

Table F.4: Optimal Policy Responses under Alternative Entry Scenarios: United States vs. Germany

	US Market			Germany Market		
Policy Scenario	Baseline	+1 model	+3 models	Baseline	+1 model	+3 models
Tariff Only						
Tariff Rate	26.5%	27.0%	27.0%	44.0%	44.5%	44.5%
Subsidy ($1,000)	0.00	0.00	0.00	0.00	0.00	0.00
ΔW^{EB} ($Bn)	41.10	43.78	46.56	23.16	24.97	25.95
Subsidy Only						
Tariff Rate	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Subsidy ($1,000)	9.60	9.80	10.10	12.00	12.00	12.00
ΔW^{EB} ($Bn)	43.26	46.45	49.75	22.81	24.87	26.00
Unconstrained Optimum						
Tariff Rate	21.5%	21.5%	21.5%	37.0%	35.5%	35.5%
Subsidy ($1,000)	8.50	8.70	9.00	10.60	9.70	9.70
ΔW^{EB} ($Bn)	45.72	48.89	52.17	25.95	27.71	28.77
Tariff-funded Subsidy						
Tariff Rate	24.0%	25.0%	26.0%	36.5%	36.0%	36.5%
Subsidy ($1,000)	7.38	7.20	7.05	10.87	9.64	9.36
ΔW^{EB} ($Bn)	45.60	48.65	51.78	25.95	27.71	28.77

Notes: This table reports the welfare-maximizing policy pair (tariff on Chinese EV imports and per-unit subsidy on domestic EV sales) in two markets under alternative dynamic-entry scenarios. In the *Baseline* columns no dynamically introduced domestic model is added. In the *+1 model* and *+3 models* columns, one and three domestic models are dynamically added to the market, respectively. The number of Chinese entrants is held fixed at $N = 10$ throughout. The four row panels correspond to distinct policy scenarios. *Tariff Only* fixes the subsidy at zero; *Subsidy Only* fixes the tariff at zero; *Unconstrained Optimum* optimizes the two instruments jointly; *Tariff-funded Subsidy* restricts attention to the budget-balanced recycling path, along which tariff revenue collected on Chinese imports is rebated as a per-unit subsidy to domestic EVs. Within each panel, ΔW^{EB} denotes the change in total welfare inclusive of environmental benefits, measured in billions of US dollars relative to the 2023 status quo. The underlying policy grid in the dynamic counterfactuals is finer than that used in the baseline static analysis: tariffs are searched in 0.5 percentage-point increments and subsidies in $100 increments.

Table F.5: Welfare under Alternative Per-Job Valuations and MCPF Multipliers: **Top 10** Chinese EV Entry, United States

	(1)	(2)	(3)	(4)
	Add top 10 China manufactured EV + Optimal designs			
Tariff / Subsidy	*Tariff Only* 27.5% / $0.00k	*Subsidy Only* 0.0% / $9.60k	*Both* 22.5% / $8.40k	*Recycling* 25.0% / $7.47k
Δ *Welfare incl. monetized job value ($Bn):*				
Slattery (2025), $10.7k/job (LB)	40.20	42.20	44.89	44.78
Bartik (2015), $12.25k/job	40.11	42.09	44.81	44.70
Bartik (2015) × Moretti (2010), $31.85k/job	38.88	40.72	43.81	43.68
Annual wage, $70k/job (UB)	36.48	38.05	41.84	41.70
Allcott et al. (2026), $169k/job	30.26	31.12	36.74	36.55
Δ *Welfare incl. MCPF penalty ($Bn):*				
$\chi = 1.1$	40.88	41.47	45.14	45.33
$\chi = 1.3$	40.88	38.51	44.54	45.33
$\chi = 1.5$	40.88	35.56	43.94	45.33

Notes: This table reports the welfare effects of introducing the top 10 Chinese EV models into the US market under four optimal-policy regimes (*Tariff Only*, *Subsidy Only*, the joint unconstrained optimum *Both*, and budget-balanced *Recycling*), across two distinct robustness exercises. The upper panel varies the social value of a manufacturing job across five alternative per-job-year valuations; the $169,000 value is the fiscal cost per additional auto-manufacturing job estimated for the IRA's EV credits, included as a stress test rather than as a per-job-year social value. Each cell in this panel reports $\Delta\text{Welfare}^{\text{Job}}(w) = \Delta\text{Welfare}^{\text{EB}} + w \cdot \Delta\text{Jobs}$ in $Bn, where $\Delta\text{Welfare}^{\text{EB}}$ and ΔJobs are the welfare and manufacturing-employment changes reported in Table 4. The lower panel applies a marginal-cost-of-public-funds (MCPF) penalty that scales only the net fiscal deficit, leaving fiscal surpluses untouched (returned lump-sum at par). Each cell in this panel reports $\Delta\text{Welfare}^{\text{MCPF}}(\chi) = \Delta\text{Welfare}^{\text{EB}} - (\chi - 1) \cdot \max\{\text{Gov. Deficit}, 0\}$ in $Bn, where χ denotes the MCPF multiplier and three values $\chi \in \{1.1, 1.3, 1.5\}$ are reported, spanning a range consistent with the public-finance literature. See Appendix C.4 for the construction of ΔJobs and a description of each per-job-year benchmark, and Appendix C.5 for the MCPF panel. All monetary values are in 2023 US dollars and reported relative to the 2023 status-quo baseline.

Additional References

Abadie, Alberto, Alexis Diamond, and Jens Hainmueller. 2010. "Synthetic Control Methods for Comparative Case Studies: Estimating the Effect of California's Tobacco Control Program." *Journal of the American Statistical Association* 105 (490):493–505.

Allcott, Hunt, Reigner Kane, Maximilian S. Maydanchik, Joseph S. Shapiro, and Felix Tintelnot. 2026. "The Effects of "Buy American": Electric Vehicles and the Inflation Reduction Act." NBER Working Paper 33032, revised March 2026.

Ballard, Charles L., John B. Shoven, and John Whalley. 1985. "General Equilibrium Computations of the Marginal Welfare Costs of Taxes in the United States." *American Economic Review* 75 (1):128–138.

Bartik, Timothy J. 2015. "The Social Value of Job Loss and Its Effect on the Costs of U.S. Environmental Regulations." *Review of Environmental Economics and Policy* 9 (2):179–197.

Dahlby, Bev. 2008. *The Marginal Cost of Public Funds: Theory and Applications*. Cambridge, MA: MIT Press.

Goulder, Lawrence H. and III Williams, Roberton C. 2003. "The Substantial Bias from Ignoring General Equilibrium Effects in Estimating Excess Burden, and a Practical Solution." *Journal of Political Economy* 111 (4):898–927.

Moretti, Enrico. 2010. "Local multipliers." *American Economic Review* 100 (2):373–377.

Saez, Emmanuel, Joel Slemrod, and Seth H. Giertz. 2012. "The Elasticity of Taxable Income with Respect to Marginal Tax Rates: A Critical Review." *Journal of Economic Literature* 50 (1):3–50.

Slattery, Cailin. 2025. "Bidding for Firms: Subsidy Competition in the United States." *Journal of Political Economy* 133 (8):2563–2614.