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Global shocks, green policy, and the welfare logic of Türkiye's steel trade*

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Abstract

This paper revisits the classical concepts of trade creation and trade diversion through the lens of contemporary global disruptions that are reshaping the political economy of trade in the twenty-first century. The focus is on the global steel economy, an arena where protectionism, geopolitical rivalry, and decarbonization collide most visibly, and where Türkiye's position reveals the dilemmas faced by mid-sized, trade-dependent economies. The discussion in this paper traces how welfare today depends as much on carbon performance and adaptive capacity as on traditional price and tariff structures, calling for a new generation of research that links trade policy, climate governance, and distributional outcomes. Rather than offering formal estimation, this paper seeks to provoke inquiry: How can welfare be redefined under climate constraints? Can integration remain a source of collective prosperity when carbon becomes the new currency of competitiveness? These are the questions Güzin Erlat might ask today, and the ones her students must now answer.

Key words: Global trade, steel industry, protectionism, climate policy, welfare, competitiveness, Türkiye.

JEL codes: F13, F14, F18, F64

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1. Introduction - in the footsteps of Güzin Erlat

When Güzin Erlat completed her doctoral dissertation at Ankara University's Faculty of Political Science in 1978, international trade theory was still dominated by the classical models of customs-union welfare. Her thesis, *İktisadi Birleşmelerin Dış Ticaret Etkileri: Ticaret Yaratma ve Ticaret Saptırmanın Ex Ante Ölçülmesi Üzerine Bir Deneme* (Erlat, 1978), situated Türkiye's prospective association with the European Economic Community within the analytical framework pioneered by Jacob Viner (1950), James Meade (1955), and Richard Lipsey (1957). Erlat's contribution lay in applying the theoretical concepts of *trade creation* and *trade diversion* to a concrete national context, using ex ante modelling to estimate how integration could reshape Türkiye's trade patterns and welfare outcomes. Her work represented one of the important attempts in Turkish academia to connect welfare theory with measurable trade effects, bridging abstract analytical reasoning with empirical policy relevance.

This paper builds on that intellectual lineage by revisiting welfare-based trade theory in light of contemporary pressures, while acknowledging Erlat's lasting influence on how integration and welfare are analyzed in the Turkish context.

While theory continued to evolve, the most significant advances in the trade literature came from rapid strides in empirical work fueled by the exponential growth of micro data and computing power. The welfare-based insights of the Viner–Meade–Lipsey tradition evolved through the gravity model of trade, which became the central framework for measuring trade creation, diversion, and welfare in an increasingly interdependent world. Building on Tinbergen's (1962) early intuition and the formal foundations of Anderson and van Wincoop (2003), the structural gravity approach provided a theory-consistent lens to evaluate policy shocks and integration effects. Subsequent refinements by Anderson and Yotov (2010), Head and Mayer (2014), and Costinot and Rodríguez-Clare (2014), later synthesized by Yotov et al. (2024), incorporated multilateral resistance, general-equilibrium feedback, and counterfactual simulation, turning gravity into the standard empirical framework of modern trade analysis.

As Jadhav and Ghosh (2023) document, this literature broadened its scope to include institutions, environmental policy, and global value chains, transforming customs-union theory from an abstract welfare model into a data-driven evaluation of integration and sustainability. In this sense, the analytical tradition to which Güzin Erlat contributed did not fade; it matured into a systematic, evidence-based discipline that continues to reinterpret welfare under the evolving architecture of global trade.

As these advances reshaped the academic landscape, the global economy itself was experiencing a profound transformation. The world that once inspired theoretical clarity has become more fragmented, politicized, and contested, blurring the boundary between trade policy, industrial strategy, and climate governance. Nearly five decades after Erlat's thesis, the organizing principles of world trade have shifted in ways that challenge the liberal integration frameworks of her era. What was once governed by regional integration schemes and common external tariffs has given way to a landscape dominated by unilateral trade actions, reciprocal retaliation, and power-driven negotiations. Tariff discrimination has not disappeared, on the contrary, it has intensified outside the institutional setting of customs unions, resurfacing through trade wars, strategic sanctions, and targeted industrial policies.

Recent U.S. actions under renewed Section 232 measures, imposing 50 percent tariffs on steel imports in early 2025, exemplify how protectionism has re-emerged as a tool of industrial and electoral strategy.[1] At the same time, China's state-subsidized overcapacity continues to depress global steel prices, with exports exceeding 115 million tons in 2024, aggravating tensions across both advanced and emerging economies.[2] The climate transition has introduced yet another layer of asymmetry: carbon intensity now functions as a de facto trade criterion, reinforced by the Carbon Border Adjustment Mechanism (CBAM) of the European Union (EU) and by the proliferation of green industrial subsidies. Together, these developments redefine the welfare logic that once underpinned classical customs-union theory, demanding a renewed examination of trade creation and diversion under the combined pressures of protectionism, carbon pricing, and geopolitical fragmentation.

Positioned at the nexus of these transformations, the steel industry provides the most revealing testing ground for the new political economy of trade. Globally, steel accounts for around 7–8 percent of total carbon emissions (Islam, 2025) and remains one of the most policy-distorted industries in world commerce. Its production is heavily subsidized in major economies, its exports frequently targeted by anti-dumping duties, and its markets chronically exposed to geopolitical shocks, from Russia's invasion of Ukraine to renewed US–China tariff confrontations. Because of these features, steel epitomizes the interaction between classical *trade diversion* forces and the emerging dynamics of *carbon diversion*. It is the sector

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[1] *The Economist, Trump's real threat: industry-specific tariffs,* https://www.economist.com/finance-and-economics/2025/07/17/trumps-real-threat-industry-specific-tariffs, accessed: 17 July, 2025.

[2] *The Wall Street Journal. Backlash against Chinese steel gives preview of Trump trade tensions,* https://www.wsj.com/world/china/backlash-against-chinese-steel-gives-preview-of-trump-trade-tensions-8e5fb48f, accessed: 8 May, 2025.

where welfare gains and losses can now be traced not only through price and tariff effects but also through variations in emission intensity and technology adoption.

For mid-sized, trade-dependent economies such as Türkiye, these global asymmetries are not abstract, they define the operating environment of an industry that sits at the core of national industrial policy. The steel sector constitutes one of Türkiye's largest industrial bases, representing roughly 12 percent of manufacturing value added (OECD, 2023a; TÜİK, 2023) and ranking among its top five export industries (Ministry of Trade, 2024; Turkish Steel Producers Association 2024). Türkiye's deep trade integration with the EU, its primary export destination, means that the EU's decarbonization policies, particularly the CBAM, will directly reshape its competitive landscape. At the same time, exposure to low-priced imports from East and Southeast Asia, intensified by global overcapacity, continues to erode domestic profitability and shift market shares. The sector thus embodies, in a single industrial case, the cumulative pressures of protectionism, carbon pricing, and geopolitical fragmentation that define the post-liberal trade order.

This paper follows in the footsteps of Güzin Erlat by extending the classical framework of trade creation and trade diversion to the contemporary realities of carbon pricing, protectionism, and geopolitical fragmentation. Rather than offering causal inference or formal estimation, the paper aims to take stock of where the global trading system stands at this historical juncture, how the pursuit of climate goals, industrial competitiveness, and strategic security are becoming increasingly entangled. The ensuing discussion explores the knots and tensions that emerge as these agendas intersect and considers the directions in which economic research must evolve to untangle them. By tracing the shifting boundaries between welfare, sovereignty, and sustainability, the paper seeks to open a forward-looking conversation on the future of integration, one that honors Erlat's analytical legacy while confronting the uncertainties of a climate-constrained world economy.

The plan of the paper is as follows: Section 2 traces the major turning points in the global steel economy, China's industrial overcapacity, renewed protectionism, geopolitical realignments, and the European Union's Green Deal and CBAM. Section 3 discusses how these pressures interact in Türkiye's domestic context, highlighting the structural vulnerabilities and strategic opportunities facing its steel industry. Section 4 develops an empirical framework, within a structural-gravity setting, to operationalize trade creation, diversion, and carbon conditionality for Türkiye's steel trade. Section 5 concludes by outlining a forward-looking research agenda, identifying key questions for future empirical and policy-oriented work on welfare, competitiveness, and sustainability. In doing so, the study aims to honor Erlat's enduring question, whether integration promotes collective welfare or merely reallocates it, while updating its scope to the decarbonizing world economy of the 2020s.

2. Turning points in the global steel economy

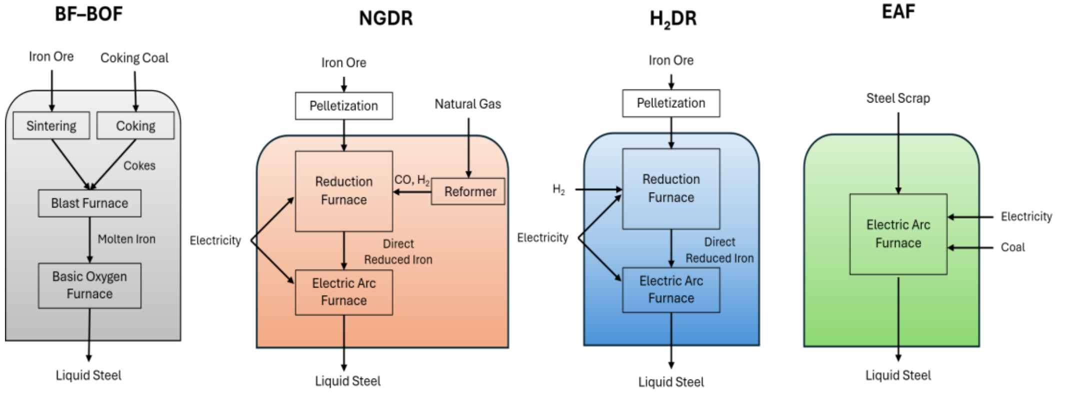
The global steel economy has undergone a series of profound turning points that have successively redefined the logic of trade creation and diversion. What began in the 2000s as a story of industrial expansion, driven by China's rise, has evolved into a complex interplay of overcapacity, protectionism, and geopolitical realignment. The once-predictable mechanisms of price formation and market access have become entangled with strategic, security, and environmental objectives. Together, these forces mark a transition from a liberal trade regime to a fragmented system where welfare outcomes depend as much on political and carbon intensity differentials as on traditional cost competitiveness. The following subsections trace four critical shifts that have reshaped the steel economy's global landscape: China's industrial overcapacity, the return of protectionism, the geopolitical disruptions of recent years, and the emergence of sustainability as a new frontier of trade policy.

Before we begin: How steel is made

Before turning to the structural shifts in global steel trade, a brief overview of steel production methods is necessary. The industry relies on four principal pathways, each with distinct implications for cost, energy use, and carbon intensity (Figure 1). These differences are not just technical; they shape how countries compete, how trade flows adjust, and how carbon policies like the EU's CBAM redistribute welfare.

In the blast furnace–basic oxygen furnace (BF–BOF) route, iron ore is first sintered and reduced with coke made from coal inside a blast furnace, where both reduction and melting occur simultaneously. The molten iron is then refined in a basic oxygen furnace to produce crude steel. This traditional pathway dominates global production, especially in China, but it is also the most carbon-intensive, emitting roughly 1.6 tons of CO_2 per ton of liquid steel, according to Lee et al. (2025).

Figure 1
How Steel is Made



Note: Authors' elaboration inspired by Lee et al. (2025).

The natural-gas direct-reduction (NGDR) method replaces coal with reformed natural gas containing hydrogen and carbon monoxide. Iron ore pellets are reduced in a shaft furnace, and the resulting direct-reduced iron (DRI) is melted in an electric furnace. This process reduces emissions to about 1.4 tons of CO_2 per ton of steel, lowering intensity by roughly 10–15 percent relative to BF–BOF systems.

The hydrogen direct-reduction (H_2DR) pathway uses hydrogen instead of carbon-based gases as the reducing agent, producing water vapor rather than CO_2 during reduction. When powered by low-carbon electricity and "green" hydrogen, emissions can fall below 1 ton CO_2 per ton of steel, about 40 percent of conventional levels, but the overall footprint depends strongly on how the hydrogen and electricity are produced.

Finally, the electric arc furnace (EAF) route melts recycled steel scrap using electricity. Because it bypasses the iron-ore reduction stage entirely, its direct process emissions are minimal (roughly 0.4 tons CO_2 per ton of steel). Yet the total footprint still varies with the carbon intensity of the power grid. EAFs are now central to decarbonization strategies in countries with abundant renewable power or large scrap reserves.

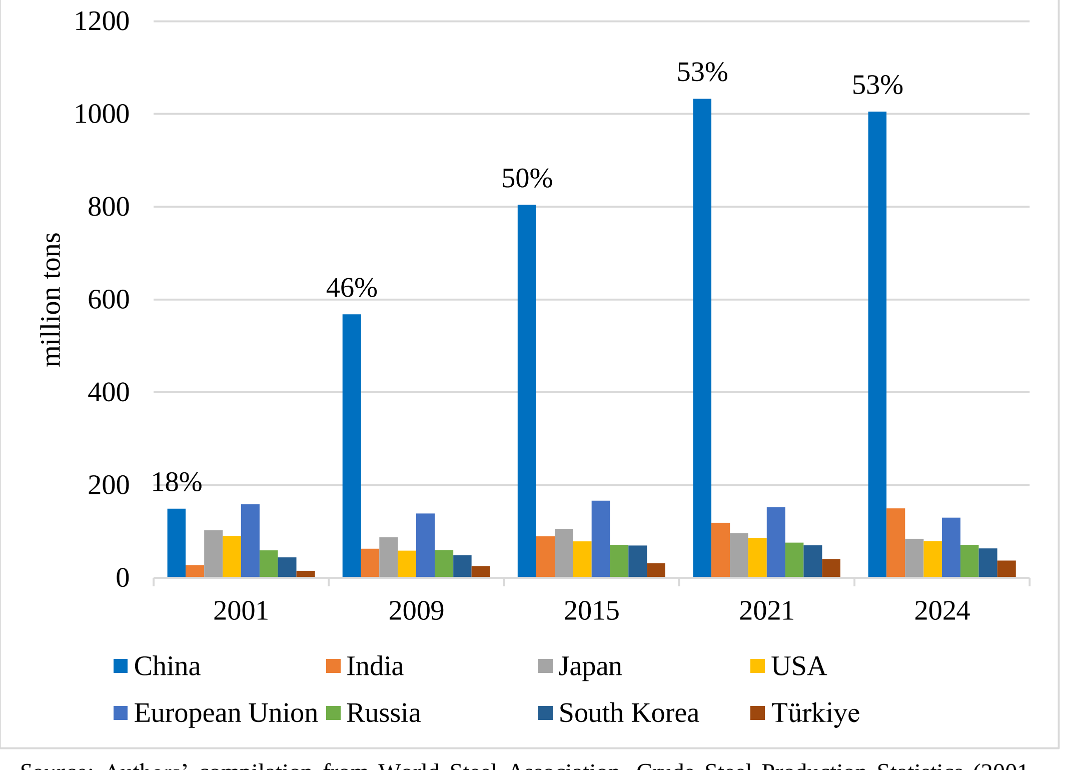
Globally, BF–BOF accounts for approximately 70–72% of crude-steel production, EAF for 28–30%, NG-based DRI for 5–7%, and hydrogen-based DRI still below 1% as of 2023 (IEA, 2024; WSA, 2024). These figures place Türkiye, where EAF exceeds 70%, in stark contrast to the global distribution.

2.1. China's overcapacity and global trade imbalances

As shown in Figure 2, the world's steel industry has been transformed over the past two decades by the extraordinary expansion of Chinese production. In 2001, China accounted for less than one-fifth of global output; by 2024, it exceeded one billion tons, over half of all steel produced worldwide. This surge, which began with the country's post-WTO industrial acceleration, has reshaped not only market structure but also the welfare logic of international trade. Rather than a labor-intensive story, China's steel expansion reflected capital and energy intensive growth in BF–BOF production, supported by preferential credit and input subsidies. Over time, this evolved into a state-guided system characterized by chronic overcapacity and persistently low export prices.

Figure 2

Global Crude-Steel Production by Region, 2000–2024

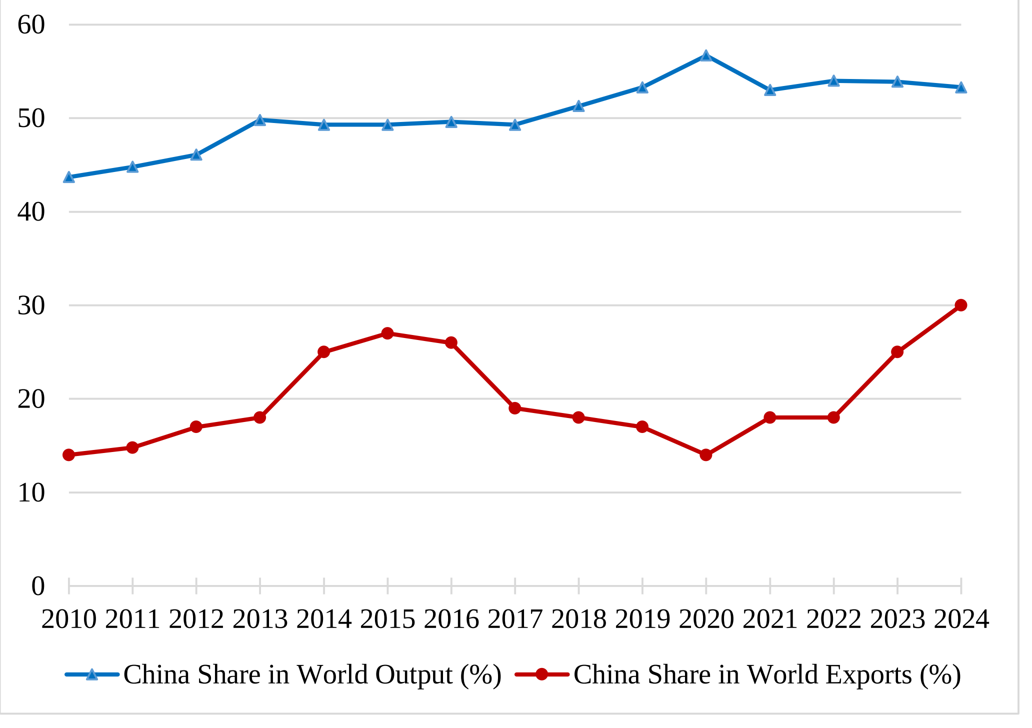


Source: Authors' compilation from World Steel Association, Crude Steel Production Statistics (2001–2024).

Figure 3 shows how China's role in the global steel market has evolved from dominance to near-monopoly levels. Its share in world crude steel production rose steadily from 44 percent in 2010 to a peak of 57 percent in 2020 and has since stabilized just above 50 percent. In other words, one country now produces more than half of all steel in the world, amounting to over 1 billion tons annually.

Figure 3

China's Share in World Steel Production and Exports, 2010–2024



Source: World Steel Association, Crude Steel Production and Trade Statistics (2010–2024).

Export shares followed a far more cyclical path. China's portion of global steel exports climbed from 14 percent in 2010 to a record 27 percent in 2015, reflecting the overcapacity surge of that decade. As domestic stimulus programs absorbed supply, the export share fell to 14 percent by 2020, before rebounding sharply to 30 percent in 2024, the equivalent of 117 million tons, nearly matching the entire output of the European Union. The rebound reflects China's post-2020 slowdown in construction and domestic demand, which redirected surplus capacity abroad. Relaxed export controls and supply disruptions in Russia and Ukraine further boosted shipments, turning exports once again into a release valve for domestic overcapacity.

The technological composition of this expansion remains overwhelmingly BF-BOF-based, with basic-oxygen furnaces still accounting for around 90 percent of Chinese output, down only slightly from 95 percent in 2010. Despite gradual efficiency gains, this marginal shift underscores how deeply carbon-intensive production remains embedded in China's industrial model. The combination of sheer scale and high-carbon intensity means that shifts in China's internal policy, capacity cuts, energy quotas, or stimulus rounds, continue to set the marginal price and emissions trajectory of the world steel market.

Table 1

Regional HRC Prices and Price Gaps, 2019–2023

Year	Gap* vs Türkiye (%)	Gap** vs EU (%)	Ex-China HRC SS400 (USD/mt FOB)	Import HRC in Türkiye (USD/mt CFR)	Domestic HRC in Europe (USD/mt ex-works)
2019	+3	–7	497.70	482.60	526.23
2020	+2	–13	501.10	493.10	523.82
2021	–3	–19	872.20	899.60	1,121.35
2022	–8	–31	696.30	753.80	946.87
2023	–5	–18	595.60	628.70	768.15

Notes: The table focuses on the post-2019 period, when global steel prices became structurally distorted by overcapacity, trade wars, and geopolitical shocks. Earlier periods reflect more cyclical pricing dynamics and are not directly comparable due to differences in product definitions and market coverage. FOB = Free on Board; CFR = Cost and Freight; ex-works = domestic mill price. All prices are annual averages derived from monthly SteelOrbis quotations. Positive values indicate Chinese prices were higher; negative values indicate lower. EU domestic prices converted from Euros to U.S. dollars using ECB annual averages. * Gap vs Türkiye (%) = [(China FOB – Türkiye CFR) / Türkiye CFR] × 100. ** Gap vs EU (%) = [(China FOB – EU ex-works USD) / EU ex-works USD] × 100.

Source: Authors' compilation from SteelOrbis (Hot-Rolled Coil Prices by Region, 2019–2023), *https://www.steelorbis.com/steel-market/hot-rolled-coil.htm*

The extent of the steel price distortion by China is evident in Table 1, which compares annual hot-rolled coil (HRC) prices across major producing regions between 2019 and 2023. Throughout this period, Chinese export prices consistently trailed both Turkish import and European domestic benchmarks. After 2021, the gap widened sharply: Chinese prices averaged 18–31 percent below European domestic levels and 5–8 percent below Turkish import prices, despite similar input-cost structures. Even in years of market recovery such as 2023, the differential remained near double-digit levels. These persistent discounts indicate not a productivity advantage but a policy-induced price distortion, sustained by preferential credit, energy subsidies, and local-government support for capacity retention. In welfare terms, this represents a clear case of state-driven trade diversion, where market share is determined by industrial policy rather than efficiency.

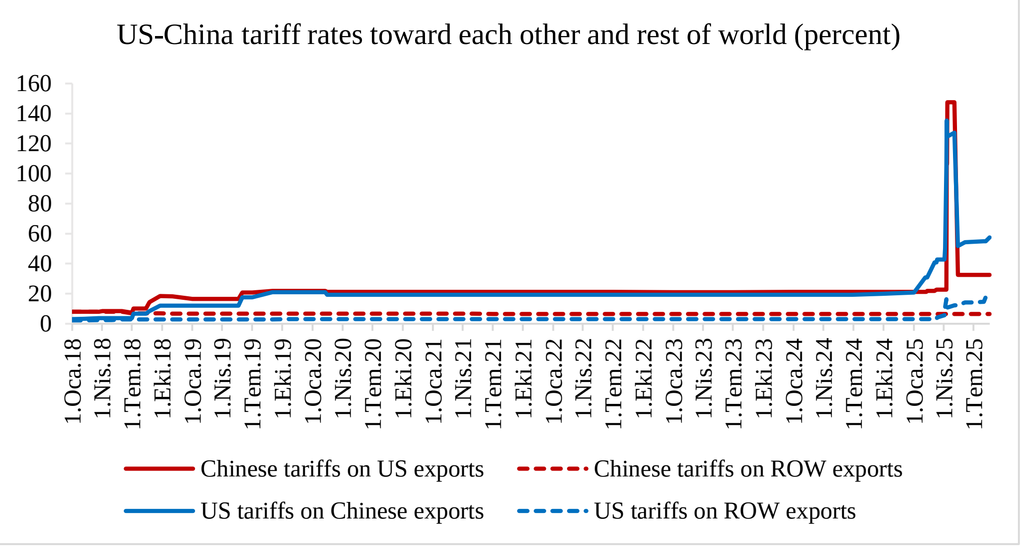
In welfare terms, such distortions undermine the classical logic of trade creation. While lower prices temporarily raise consumer surplus, they erode producer returns, shrink investment capacity, and shift the geography of industrial employment. For Türkiye, whose mills rely predominantly on EAF technology using recycled scrap, the challenge is acute. EAF production is cleaner, emitting roughly one-quarter of the CO_2 per ton of steel compared with China's BF–BOF plants, but cannot compete with state-subsidized exports. The resulting squeeze forces domestic producers to cut margins or reduce output, reversing the expected pattern of integration benefits: efficient, low-carbon producers are displaced by high-emission ones enjoying policy-based cost advantages.

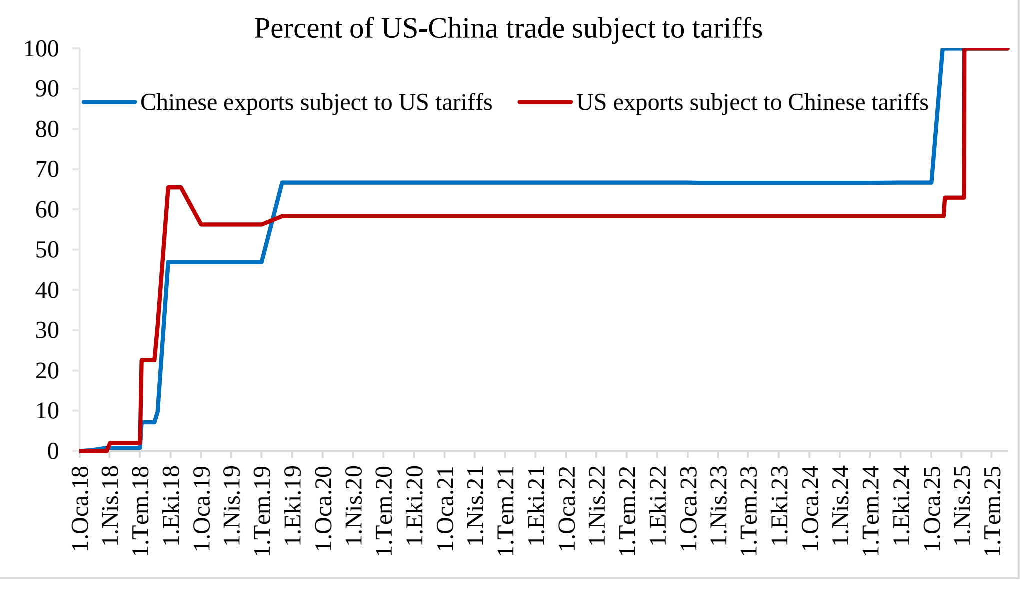
Extensive evidence documents the role of administered credit, below-market energy pricing, and local-government support in sustaining China's steel overcapacity. OECD (2023b) estimates that Chinese steel producers receive the highest level of measurable industrial support among G20 economies, while the Global Forum on Steel Excess Capacity reports recurrent interventions in the form of debt rollovers, preferential loans and factor-price distortions. By contrast, Turkish EAF producers operate in a high-cost electricity environment and face no comparable production subsidies. Consequently, the cost differentials reflected in Table 1 stem less from productivity gaps than from structural asymmetries in state support.

2.2. The return of protectionism and trade wars

The second major turning point in the global steel economy is the return of overt protectionism. What began as temporary crisis management in the late 2010s has since evolved into a sustained policy regime in which national security, industrial revival, and electoral politics converge. As shown in Figure 4, tariff escalation became the defining feature of that regime. The United States' use of Section 232 of the Trade Expansion Act, first invoked in 2018 and re-applied at higher levels in 2025, marked the re-emergence of tariffs as a central instrument of industrial policy. Under the second term of Donald J. Trump, the nominal duty on all steel imports reached 50 percent, extending far beyond the emergency levels of

Figure 4
Timeline of U.S. Section 232 Measures, 2018–2025





Source: Adapted from Chad P. Bown, "US–China Trade War Tariffs: An Up-to-Date Chart," Peterson Institute for International Economics (PIIE), September 25, 2025. (Available at *https://www.piie.com/research/piie-charts/2019/us-china-trade-war-tariffs-date-chart*).

2018–2019 and signaling a return to unilateral leverage as a tool of domestic economic management.

While the United States accounts for less than 5 percent of global steel output, its tariff actions echo across world markets. The earlier 2018 Section 232 measures triggered immediate retaliation by the European Union, China, and Canada. The renewed 2025 increases again produced ripple effects, this time embedded in a wider U.S.–China tariff war that pushed average bilateral rates above 50 percent and covered nearly all trade between the two economies. Each escalation on one side was mirrored by retaliation on the other, amplifying global price volatility and redirecting trade flows toward non-tariffed producers in Asia, Africa, and the Middle East. The numerical scale of these shifts is summarized in Table 2, which compares the 2018 and 2025 rounds of Section 232 actions and their modeled spillovers on world prices.

Table 2

Selected Section 232 Actions on Steel Imports, 2018 vs 2025

Year	Tariff Rate (%)	Coverage	Exemptions / Adjustments	Estimated Spillover to World Prices (%)
2018*	25	Flat, long, tubular products	Temporary exemptions for EU, Canada, Mexico (later removed)	+4
2025**	50	All semi-finished and finished steel products	Quota-based exemptions for EU under Global Arrangement	+9

Notes: (a) The 2018 tariff level and coverage are verified legal measures published in the Federal Register (available at *https://www.federalregister.gov*). (b)The 2025 figures reflect policy announcements and OECD modeling projections, pending formal publication in the Federal Register. (c) "Estimated Spillover to World Prices" refers to modeled average increases in global hot-rolled coil prices following tariff implementation.

Sources:

*2018 data: U.S. Federal Register, Presidential Proclamation 9705 (March 15, 2018) and Proclamation 9759 (June 4, 2018), "Adjusting Imports of Steel into the United States."

**2025 data: OECD Steel Committee, Steel Market Developments Interim Report 2025; U.S. Department of Commerce policy briefings (January 2025).

The 2018 measures, verified through Presidential Proclamation 9705, introduced a 25 percent tariff on flat, long, and tubular products, initially granting temporary exemptions to the EU, Canada, and Mexico. The 2025 figures, drawn from OECD modeling and U.S. Department of Commerce briefings, represent announced but not yet formally enacted policy intentions under the Global Arrangement on Sustainable Steel and Aluminum (GASSA). These would expand coverage to virtually all semi-finished and downstream categories and raise the nominal tariff rate to 50 percent, lifting global benchmark steel prices by an estimated 9 percent. Though US imports from Türkiye have historically represented only a small share of its market, such measures indirectly affect Turkish producers by diverting excess supply from Asia and Latin America into Europe, the Mediterranean, and North Africa, Türkiye's core export regions.

In welfare terms, the resurgence of protectionism reopens a long-standing theoretical debate: whether discriminatory trade policies act as "building blocks" toward deeper integration or as "stumbling blocks" that erode multilateral welfare. Classical customs-union theory allows for the former possibility when preferential arrangements redirect trade toward more efficient partners. The recent wave of protectionism, however, departs sharply from this logic. Evidence from the US–China trade war shows that contemporary trade restrictions are not primarily efficiency-enhancing or regionally integrative but instead reflect a form of strategic protectionism associated with national security concerns, supply-chain vulnerabilities, and industrial policy objectives (Fajgelbaum and Khandelwal, 2021). These motivations blur the boundary between legitimate industrial strategy and disguised import substitution, weakening the conventional welfare rationale underpinning discriminatory trade policies.

2.3. Geopolitical disruptions – Russia–Ukraine and the Middle East

The third turning point in the global steel economy stems from geopolitical disruptions, conflicts, sanctions, and shifting alliances that have re-engineered trade routes and redefined welfare outcomes. Since 2022, the Russia–Ukraine war and successive waves of Western sanctions have turned geopolitical risk into a structural variable of the steel market.

Table 3 shows how EU sanctions on Russia and Belarus following the 2022 invasion triggered a sharp realignment of import origins. Russia's share of the EU's steel imports fell from 13 percent in 2021 to zero by 2024, while Ukraine's dropped from 9 to 6 percent as production was interrupted. In contrast, suppliers such as India and South Korea expanded their foothold, each now accounting for roughly 12–15 percent of EU steel imports. What emerged was a new pattern of geopolitical trade creation: trade flows not driven by comparative advantage but by exclusion and substitution within alliance boundaries.

Table 3
EU's Steel Imports by Origin

Years	2018	2021	2024
China	9%	5%	7%
Egypt	2%	3%	5%
India	9%	12%	12%
Japan	1%	3%	5%
Russia	13%	13%	0%
South Korea	10%	7%	12%
Taiwan	4%	5%	8%
Türkiye	20%	15%	15%
Ukraine	6%	9%	6%
Vietnam	2%	5%	10%

Notes: Top 10 countries in 2024 are listed.

Source: Authors' compilation from Eurofer (2025).

Empirical research confirms the scale and persistence of such effects. Using a structural-gravity framework, Felbermayr et al. (2025) estimate that sanctions now affect more than one-quarter of global trade, producing large and durable contractions for target economies but only marginal losses for sanctioning states. Earlier work by Dai (2021) shows that trade declines often begin before sanctions formally take effect and dissipate only slowly, highlighting strong anticipatory and hysteresis dynamics. Doornich and Raspotnik (2020) trace similar fragmentation effects in EU–Russia trade, while Felbermayr et al. (2020) find heterogeneous welfare outcomes across partners in the case of Iran, again dependent on pre-existing trade intensity and network position.

For Türkiye, these shifts initially created opportunity. Between 2021 and 2023, exports to the EU rose by nearly 40 percent as European buyers substituted away from sanctioned suppliers. Yet Table 4 shows that these gains were offset by collapsing demand in the Middle East and Eastern Mediterranean. Exports to Israel, Türkiye's largest destination in 2023, fell from 5.7 to just 0.7 percent of total exports in 2024 amid the Gaza conflict[3] and Red Sea disruptions. At the same time, exports to Romania and Italy expanded sharply, together absorbing more than 15 percent of Türkiye's steel exports, underscoring the pivot toward EU markets. Smaller but notable increases in sales to Egypt, Greece, and Ukraine suggest regional re-orientation rather than broad-based expansion.

Sanctions thus operate as both trade-creating and trade-diverting instruments. They open short-term windows for neutral exporters but also inject long-term volatility into global welfare. The heterogeneous outcomes documented by Felbermayr et al. (2025) and Dai (2021) capture this pattern precisely: immediate contraction for targets, transient gains for bystanders, and gradual normalization once sanctions fatigue sets in.

Table 4

Türkiye's Steel Exports by Destination

	2018	2021	2024
Canada	2.70%	2.50%	2.20%
Egypt	2.30%	2.30%	3.40%
Greece	1.70%	1.60%	3.20%
Iraq	2.70%	3.10%	4.40%
Israel	5.00%	5.70%	0.70%
Italy	7.40%	6.60%	7.10%
Romania	4.90%	4.50%	8.20%
Serbia	0.60%	1.10%	2.60%
Spain	4.90%	6.10%	4.00%
Ukraine	0.80%	1.30%	3.20%

Notes: Top 10 countries in 2023 and 2024 are listed.

Source: Authors' compilation from UN Comtrade data.

From a policy perspective, these dynamics add a geopolitical dimension to classical welfare theory. Decisions on tariffs, quotas, or procurement are now conditioned as much by security alignment as by price or technology. Steel, central to both infrastructure and defense, has become an instrument of strategic diplomacy.

[3] Official trade statistics record a sharp decline in Türkiye's steel exports to Israel after October 2023. However, trade-monitoring reports indicate that a portion of these shipments may have been rerouted or recorded as exports to Palestine for logistical and political reasons. As such, official statistics used in Table 4 may overstate the decline in actual delivered volumes (Reuters, 2024).

The redirection of Russian exports toward China and Iran, and the growing South–South steel trade, reinforce the formation of political blocs of production rather than efficiency-based specialization.

2.4. The European green deal and CBAM: Sustainability as a new trade frontier

The fourth turning point in the global steel economy is the environmentalization of trade policy. With the European Union's Green Deal and the creation of the CBAM, competitiveness in steel is no longer defined by cost or productivity alone but increasingly by carbon intensity. This shift redefines comparative advantage: producers that decarbonize their systems gain preferential access to the EU market, while those that do not face implicit carbon tariffs.

Introduced under the European Green Deal, CBAM aims to prevent carbon leakage, the relocation of emission-intensive production to countries with weaker climate regulations. Importers of covered goods (initially cement, aluminum, fertilizers, hydrogen, electricity, and steel) must declare the embedded emissions of their products and, from 2026 onward, purchase CBAM certificates at a price linked to the EU Emissions Trading System (ETS). The mechanism thus extends the EU's internal carbon price to imports, ensuring that both domestic and foreign producers face comparable carbon costs. During the transitional phase (2023–2025), only emissions reporting is required; full financial compliance will begin in January 2026.

Table 5 traces the trajectory of EU carbon prices alongside key milestones in the rollout of CBAM between 2018 and 2026. The EU ETS price, which averaged around €15 per ton CO_2 in 2018, rose more than fivefold by 2024, surpassing €80 per ton. For coal-based blast-furnace steel, this implies an added cost of roughly €120–150 per ton, effectively establishing a carbon benchmark for global producers. Under full implementation, beginning in 2026, steel imported with a carbon intensity above the EU reference value will incur a surcharge equivalent to this embedded-carbon cost, transforming the carbon price from a domestic climate instrument into a global determinant of competitiveness.

The potential magnitude of CBAM's impact is underscored by recent modeling studies, though their results vary by assumption. Using a multi-regional input–output framework, Li et al. (2024) estimate that, at average 2024 carbon prices, full CBAM implementation could lower embodied emissions in steel exports to the EU by 25.9 million tons annually and global embodied emissions by about 626 million tons, reductions of roughly 31 and 21 percent, respectively, relative to a no-CBAM baseline. By contrast, Siy et al. (2023), applying a GTAP general-equilibrium model, find more uneven welfare outcomes: moderate welfare gains for the EU, China, and Russia; mild losses for the United States; and mixed environmental effects, emission declines in high-carbon exporters but increases within the EU due to production reshoring.

Table 5

EU Carbon Price and CBAM Implementation Timeline, 2018–2026

Year	Average EU ETS Carbon Price (€/t CO_2)	Key CBAM and ETS Milestones	Estimated Cost Impact on Coal-Based Steel (€/t steel)
2018	15	ETS Phase 4 reform adopted	≈ 20–25
2019	25	ETS market-stability reserve tightened	≈ 35–40
2020	30	*European Green Deal* announced	≈ 45–55
2021	53	*Fit-for-55* legislative package released	≈ 80–95
2022	82	CBAM legislative agreement reached	≈ 120–145
2023	84	CBAM Regulation adopted – transitional phase (1 Oct 2023)	≈ 125–150
2024	81	First CBAM quarterly reporting	≈ 120–145
2025 (est.)	78	Ongoing transitional reporting and system testing	≈ 115–140
2026 (est.)	80	Full CBAM implementation; free-allocation phase-out begins	≈ 120–145

Notes: Estimated steel cost calculated using average CO_2 intensity of 1.5–1.8 t CO_2 per t steel.

Sources: Authors' compilation from European Commission (2024); EU ETS Registry (https://climate.ec.europa.eu/eu-action/carbon-markets/eu-emissions-trading-system-eu-ets/union-registry_en) ; DG TAXUD CBAM Reports (https://taxation-customs.ec.europa.eu/carbon-border-adjustment-mechanism/cbam-registry-and-reporting_en).

Together, Tables 5 and 6 situate these model results within a technological context. Average emissions from EAFs, the dominant route in Türkiye, are around 0.4 t CO_2 per t steel, compared with 1.6–1.8 t CO_2 for BF–BOF systems typical of China and much of Europe. Even under moderate carbon-price assumptions (€80–100 per t CO_2), these intensity differentials generate a cost gap of €100–150 per t steel, large enough to reverse conventional cost hierarchies.

Under these conditions, the welfare and equity dimensions of CBAM remain contested. Wirdyansyah (2025) cautions that CBAM may impose disproportionate adjustment costs on exporters of carbon-intensive goods such as iron, fertilizers, and cement, raising questions of climate justice and technology access. Böhringer et al. (2022) emphasize that, while border carbon adjustments can address leakage and competitiveness concerns in theory, their legal complexity and administrative burden may erode efficiency and provoke disputes. Meanwhile, Rossetto (2023) argues that CBAM could indirectly accelerate steel decarbonization by incentivizing scrap recovery and recycling, linking trade policy to circular-economy objectives.

Table 6

Carbon Intensity of Crude-Steel Production (tons CO_2 per ton steel)

Region Technology	EU (BF–BOF)	EU (EAF)	China (BF–BOF)	Türkiye (EAF)	World Average
2020 est.	1.80	0.45	2.10	0.42	1.65
2024 est.	1.60	0.40	1.95	0.38	1.50

Notes: Values represent mid-points of published ranges for process-level CO_2 emissions (t CO_2 / t steel), combining direct and indirect emissions. 2020 intensities reflect baselines in IEA (2020) and WSA (2024); 2024 estimates apply ≈ 8–10 % efficiency gains for BF–BOF and ≈ 5 % for EAF, consistent with IEA (2023) Net Zero by 2050 updates and OECD (2024) technology-mix data. Global averages weight processes by ≈ 70 % BF–BOF and 30 % EAF output shares. Figures are representative industry averages, not plant-level measurements.

Sources: Authors' compilation from International Energy Agency (2020), Iron and Steel Technology Roadmap; IEA (2023), Net Zero by 2050 Scenario Database; World Steel Association (2024), Sustainability Indicators 2024; OECD Steel Committee (2024), Steel Market Developments 2023–24.

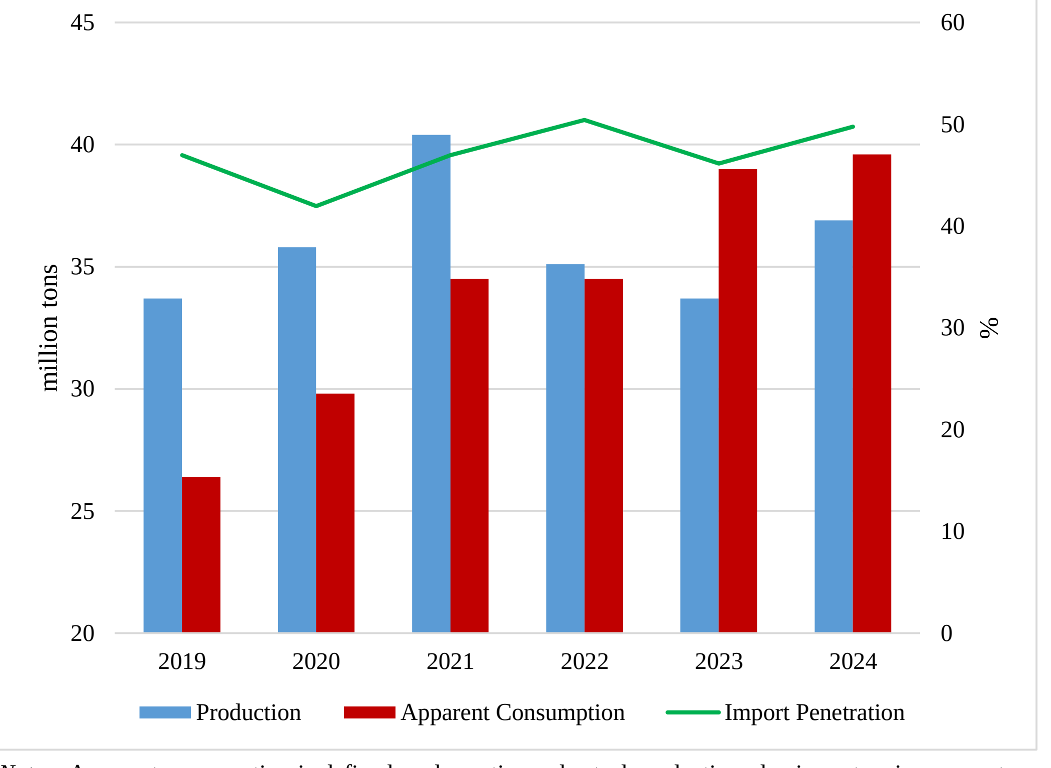
3. Türkiye steel sector under structural pressure

The global forces described in Section 2 -China's overcapacity, renewed protectionism, geopolitical realignments, and the environmentalization of trade- converge most visibly in Türkiye's steel industry, which is positioned between a decarbonizing European market and cost-driven Asian exporters. Section 3 therefore examines how these global pressures are internalized within Türkiye's domestic steel economy.

3.1. Cost and price asymmetries: The overcapacity channel

After two consecutive years of contraction, Türkiye's crude-steel output rose by 9.5 percent in 2024, reaching 36.9 million tons. Yet this rebound remains fragile. As shown in Figure 5, production has not regained its 2021 peak, while import penetration continues to rise, approaching 45 percent of apparent domestic consumption, the highest level of the decade. The modest recovery in 2023 and 2024 may reflect post-earthquake reconstruction demand and short-term restocking by domestic buyers rather than a genuine improvement in competitiveness.

Figure 5
Türkiye's Crude-Steel Production, Apparent Consumption, and Import Penetration, 2019–2024



Notes: Apparent consumption is defined as domestic crude-steel production plus imports minus exports. Import penetration denotes the ratio of steel imports to apparent consumption.

Source: Authors' compilation from World Steel Association (2025).

This widening gap between domestic supply and demand reflects the global price distortions discussed in Section 2.1. Average import prices from East Asia remain well below Turkish mill prices, and the cost asymmetries that underpin this gap are structural rather than cyclical.

Energy represents roughly one-third of total production costs in EAFs, and industrial electricity prices have long been above EU averages in Türkiye. Financing constraints and exchange-rate volatility further erode competitiveness, offsetting the advantage of lower nominal wages. These conditions make domestic producers acutely sensitive to any surge of low-priced imported steel.

3.2. Geopolitical re-routing: The diversion channel

The second channel through which global shocks reach Türkiye's steel industry is geopolitical. The Russia–Ukraine war and subsequent Western sanctions have fundamentally reconfigured regional trade routes. Table 3 shows that following the 2022 sanctions on Russia and Belarus, their combined share in EU steel imports collapsed from nearly 30 percent before the war to below 5 percent by 2024. Türkiye, alongside India, Japan and South Korea, filled part of this void, with exports to the EU rising by roughly 70 percent over the same period.

Yet this reallocation represents geopolitical trade creation rather than a structural gain in competitiveness. Table 4 indicates that while Turkish shipments to European partners such as Italy and Romania increased, exports to Middle Eastern destinations contracted sharply, Israel's share alone fell by nearly 90 percent due to due to the escalation of hostilities in Gaza, disruptions in Eastern Mediterranean trade routes, and protest-driven boycotts in Türkiye's private sector. The composition shift thus replaced lost markets rather than expanding total demand.

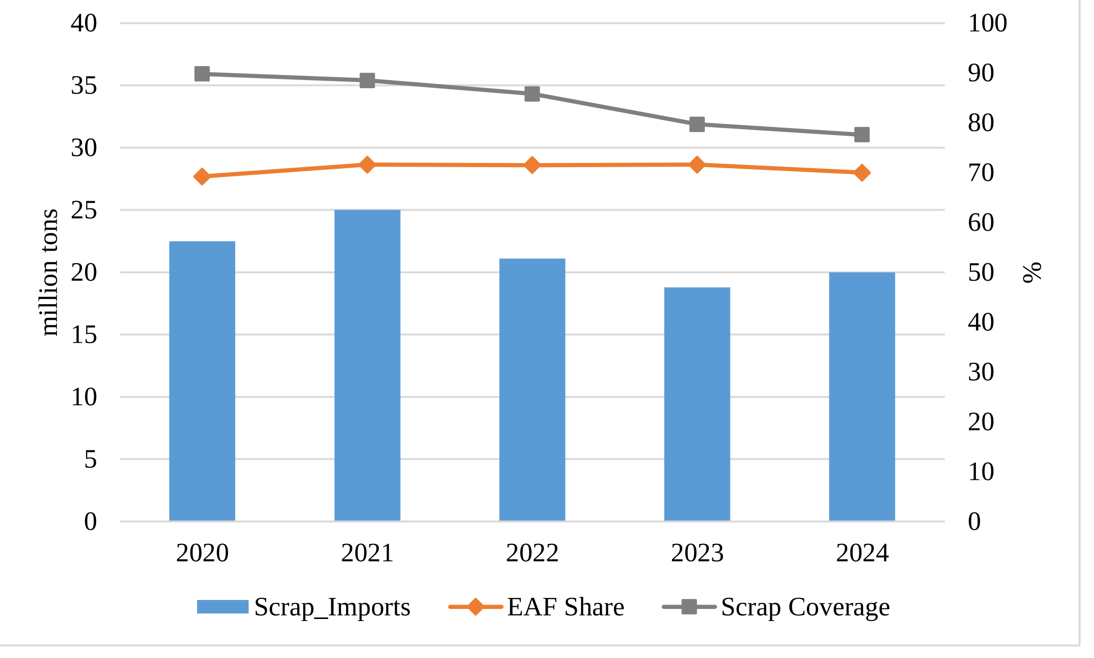
This pattern underscores Türkiye's dual exposure and adaptive resilience. The sharp contraction of 2022 was followed by a rapid rebound as Turkish producers redirected output toward European markets and benefited from post-war supply shortages. Yet this flexibility also reveals the sector's dependence on exogenous demand shocks rather than on productivity gains or sustained competitiveness. Export surges rely on policy-driven access to the EU and on temporary regional dislocations, while sales to nearby markets remain sensitive to geopolitical instability. In this sense, the quick correction after 2022 reflects tactical agility more than structural strength, a recovery built on volatility rather than on stability.

3.3. Conditional advantage: The carbon & material channel

For Türkiye, CBAM represents both a challenge and an opening. The EU remains its largest export destination, absorbing over 40 percent of Turkish exports, so any carbon-price differential directly affects market access. Yet Türkiye's EAF-based production confers a structural advantage: its average emission intensity is roughly half the EU average. With moderate investment in renewable electricity and robust emissions verification, Turkish producers could transform CBAM from a stumbling block into a cornerstone of green competitiveness.

At first glance, Türkiye's steel industry appears well positioned for a low-carbon future. More than 70 percent of total output is produced through EAFs and induction furnaces, compared with less than 30 percent via BF–BOF routes. This structure yields process-level emissions around 0.4 tons CO_2 per ton of steel, roughly one-fourth of the intensity associated with traditional BF–BOF production in Europe and Asia.

Figure 6
Türkiye's Scrap-Metal Imports, EAF Share, and Scrap-Coverage Ratio, 2020–2024



Notes: The EAF share represents the proportion of total crude-steel output produced through electric routes. Scrap-metal imports show annual scrap inflows (million tons). The scrap-coverage ratio indicates the share of EAF production that can be met by imported scrap.

Source: Authors' compilation from KPMG (2025).

Yet this apparent edge is conditional and fragile. The EAF route relies heavily on electricity and scrap metal; two inputs whose carbon and price characteristics lie largely outside producers' control. The national power grid remains mainly fossil-based: renewables accounted for 43 percent of generation in 2024, meaning that the carbon footprint of "electric" steel is still tied to the country's energy mix. Even more constraining is the industry's dependence on imported scrap. As shown in Figure 6, annual scrap-metal imports fluctuated between 16 and 25 million tons during 2015–2024, covering roughly 90 percent of EAF demand at the start of the decade but only 78 percent by 2024. This downward trend in self-sufficiency signals a growing material vulnerability that parallels the sector's carbon exposure.

Each tightening of global scrap supply, driven by construction cycles or export restrictions, translates directly into higher domestic costs and erodes the stability of Türkiye's low-carbon advantage. The paradox is thus clear: every step toward decarbonization increases reliance on imported raw materials. Without a robust domestic recycling and scrap-traceability system, the transition to green steel risks substituting carbon dependence with material dependence.

3.4. Adaptive momentum and policy outlook

Despite these structural pressures, there is emerging evidence that parts of Türkiye's steel industry are beginning to move, albeit unevenly, from defensive adjustment toward more proactive forms of transformation. Field-based assessments by the Istanbul Policy Center document a growing set of producer-led initiatives, including investments in renewable-powered furnaces, pilot DRI facilities, waste-heat recovery systems, energy-efficiency upgrades, and digital monitoring, reporting, and verification platforms (Baş, 2023; Baş, 2025). These initiatives signal a shift away from short-term cost containment toward longer-term technological repositioning, particularly among large producers exposed to EU markets and climate-related trade regulation.

At the same time, IPC reports caution against interpreting these developments as a sector-wide transition. Many investments remain fragmented, compliance-driven, and constrained by high electricity carbon intensity, imported scrap dependence, and the absence of binding sectoral decarbonization targets (Baş, 2023; Baş, 2025). From this perspective, current dynamics reflect a hybrid phase in which defensive adjustment and selective transformation coexist, leaving the pace and depth of structural change contingent on broader energy-policy alignment and institutional support.

The policy environment is gradually aligning with this transition. PwC (2023) outlines measures to expand renewable integration in industrial zones, develop national scrap-management and traceability systems, and strengthen measurement, reporting, and verification standards in anticipation of CBAM compliance. If implemented consistently, these reforms could translate Türkiye's partial technological advantage into a credible carbon-competitiveness strategy.

The outcome, however, will hinge on two interdependent adjustments. First, decarbonizing the electricity grid is indispensable: without cleaner power, EAF production cannot deliver verifiable emission reductions. Second, closing the scrap loop through recycling infrastructure and certification systems is essential to stabilizing material costs and ensuring CBAM eligibility. Progress on these fronts would not only enhance export competitiveness but also reduce exposure to global price volatility.

Taken together, these technological and policy adjustments imply a deeper shift in how trade creation itself must be understood under carbon-constrained integration. Historically, Türkiye's welfare gains from the EU–Türkiye Customs Union were driven by tariff preferences and geographic proximity. Today, they increasingly depend on adaptive capacity -the ability to produce and verify low-carbon steel within integrated European value chains. In this sense, welfare outcomes now follow the geography of emissions intensity rather than that of nominal tariffs.

4. An empirical framework: A structural-gravity model for trade creation, diversion, and green conditionality

The empirical unit is bilateral merchandise trade in steel products, defined primarily at the HS 72 (iron and steel) and, where relevant, HS 73 (articles of iron or steel) classification levels. The sample covers the period 2001–20##, which encompasses the four major tensions shaping global steel trade: (i) Industrial overcapacity, driven by China's rapid expansion from roughly one-fifth of global output at the start of the century to more than half today; (ii) Renewed protectionism, reflected in the return of tariffs and trade wars after 2018; (iii) Geopolitical conflicts, including Russia's invasion of Ukraine and Israel's occupation of Gaza, both of which disrupted regional supply chains and redirected trade flows across Eurasia and the Mediterranean; and (iv) Environmental conditionality, embodied in the EU's Green Deal and the introduction of the CBAM.

The panel structure is $country \times country \times year$, denoted (i, j, t), and includes domestic trade flows X_{iit}^{steel} to identify non-discriminatory policy shocks - such as carbon-pricing measures or domestic energy-price changes- separately from discriminatory, partner-specific effects.

The analysis remains global in coverage but is centered on Türkiye, whose steel sector lies at the intersection of the forces described in previous sections. Türkiye's trading relations with both the EU and East and Southeast Asia provide a natural contrast between carbon-constrained and cost-driven markets. Interaction terms specific to Turkish exports will therefore serve as the main identification device for assessing how each class of global shock translates into trade creation, trade diversion, or welfare shifts for a mid-sized, energy-importing, EAF-based producer.

The empirical framework draws on several complementary data sources. Bilateral export and import values and quantities can be obtained from UN Comtrade and the World Integrated Trade Solution (WITS) databases, while data on production, capacity, and utilization come from the World Steel Association's annual statistics. Price and cost indicators can be compiled from the World Bank's Metals Monitor, the OECD Steel Committee reports, and the Turkish Steel Producers Association. Energy variables, including industrial electricity prices and grid-emission factors, can be taken from the International Energy Agency (IEA) and Türkiye's national energy balance. Policy information can be drawn from official releases by the U.S. Department of Commerce and the Federal Register for Section 232 tariffs, the European Commission's trade-policy and TRQ communications for EU safeguard measures, the European Commission's DG TAXUD databases for CBAM implementation phases, and the official EU and U.S. sanctions databases for conflict-related restrictions. Scrap-metal prices and quantities, an essential cost determinant for Türkiye's predominantly EAF-based production, can be obtained from Platts/LSEG price indices and national customs records on scrap imports.

All variables should be harmonized into a balanced panel measured in current U.S. dollars and aligned to a consistent industry classification. The inclusion of both international and domestic flows ensures that the estimation can distinguish between trade creation arising from policy-induced market opening and trade diversion driven by shifts in competitiveness, input costs, or regulatory asymmetries.

4.1. Baseline structural-gravity specification

Building on the data framework described above, the empirical analysis relies on a structural-gravity specification that captures how trade flows respond to economic size, trade costs, and policy-induced shocks in a theoretically consistent way. The model follows the modern gravity tradition that integrates general-equilibrium foundations and multilateral resistance terms. Within this structure, bilateral steel exports from country i to country j in year t, denoted X_{ijt}^{steel}, are modeled as a multiplicative function of exporter-specific production capacity, importer-specific demand, and time-varying bilateral frictions.

The empirical representation can be written as

$$X_{ijt}^{steel} = \exp[\alpha_{it} + \delta_{jt} + \psi_{ij} + \lambda_t \cdot \mathbf{1}\{i \neq j\} + \mathbf{Z}_{ijt}\beta] \cdot \varepsilon_{ijt},$$

where α_{it} and δ_{jt} denote exporter–time and importer–time fixed effects, respectively, which capture the evolving economic mass, production capacity, and aggregate demand of each country. The term ψ_{ij} represents asymmetric pair fixed effects that absorb all time-invariant bilateral trade costs such as distance, historical links, or geographic contiguity. The term $\lambda_t \cdot \mathbf{1}\{i \neq j\}$ introduces a global time-varying component that captures common shocks to international trade relative to domestic transactions, such as the rise and fall of globalization or global business-cycle effects. The vector $\mathbf{Z}_{ijt}$ contains the policy and structural variables of interest, which include the global shocks discussed in Sections 2 and 3, while β measures their partial effects on trade flows. The error term ε_{ijt} is assumed to be heteroskedastic, consistent with the multiplicative structure of the Poisson pseudo-maximum-likelihood (PPML) estimator.

This specification should be estimated using the PPML estimator, which has become the standard in gravity analysis due to its ability to accommodate zero trade flows, account for heteroskedasticity, and provide consistent estimates in the presence of log-linearization bias. In cases where the variance–mean restriction of the PPML is violated, the generalized PPML (G-PPML) estimator proposed by Larch et al. (2025) may be employed as a robustness check to improve efficiency. The inclusion of domestic trade flows X_{iit}^{steel} allows for the identification of non-discriminatory policy effects, such as those associated with CBAM or energy-cost shocks, that operate equally across all partners, in contrast to bilateral policies like tariffs, quotas, or sanctions that vary by trading relationship.

If multiple steel sub-sectors are analyzed jointly, such as flat versus long products or upstream versus downstream categories, the model can be expanded to include sectoral fixed effects by replacing α_{it} and δ_{jt} with exporter-sector–time and importer-sector–time effects, and by introducing sector-specific bilateral fixed effects ψ_{ij}^{k}. This specification permits consistent estimation across product categories while preserving the theoretical structure of the gravity model.

The structural-gravity form provides the foundation for tracing how the four global pressures -industrial overcapacity, protectionism, geopolitical fragmentation, and climate conditionality- are transmitted through bilateral trade flows. Each of these mechanisms will be operationalized in the variable set $\mathbf{Z}_{ijt}$, allowing for direct identification of trade creation and diversion effects and for the quantification of Türkiye's relative exposure under different policy and market regimes. The next subsection details these variables and their interpretation within the empirical framework.

4.2. Policy and structural variables

The variable set $\mathbf{Z}_{ijt}$ includes the policy, market, and structural factors through which global shocks are transmitted to bilateral steel trade. Each variable corresponds to one of the major forces identified in previous sections. Together, they provide a coherent framework for quantifying the sources of trade creation and diversion within a unified structural-gravity model, while enabling an explicit focus on Türkiye as a case of mid-sized industrial exposure.

Overcapacity and its spillovers into world markets. A central measure is a proxy for Chinese export pressure, denoted $ChinaDump_{jt}$, defined as China's share of total steel imports into market j in year t or, alternatively, as the year-on-year change in Chinese export volumes to that destination. This variable reflects the persistent oversupply that has characterized global steel trade since 2001 and allows the model to trace how China's domestic production surpluses translate into shifts in third-country market shares. An interaction term $ChinaDump_{jt} \times \mathbf{1}\{i = TUR\}$ identifies whether Turkish exporters experience disproportionately stronger displacement effects in destinations where Chinese exports surge.

Protectionism and trade-policy interventions. These include a set of time-varying policy indicators such as $S232_{jt}$, capturing the imposition of U.S. Section 232 tariffs on imports from all sources, and $EU\_Safeguard_{jt}$, denoting the status of the European Union's steel safeguard and tariff-rate quota (TRQ) regime. Both variables can be defined as binary indicators or as weighted averages reflecting the share of affected steel categories in total imports. Their interaction with a Turkish exporter dummy, $Policy_{jt} \times \mathbf{1}\{i = TUR\}$, measures whether the redirection of trade toward or away from Türkiye represents a case of policy-induced trade creation or diversion.

Geopolitical shocks and sanctions. The variable $Sanction_{ijt}$ represents the presence of economic sanctions, embargoes, or conflict-related restrictions between trading partners. This can be drawn from the EU and U.S. sanctions databases and coded to reflect the intensity or duration of the measure. Because sanctions often reallocate trade to neutral countries, the model distinguishes between positive and negative welfare effects by interacting the variable with regional dummies. For instance, $Sanction_{ijt} \times \mathbf{1}\{i = TUR, j \in EU\}$ captures the reallocation of EU demand toward Turkish exports following sanctions on Russia and Belarus, while $Sanction_{ijt} \times 1\{i = TUR, j \in ME\}$ captures the adverse effects of regional conflict on Türkiye's sales to the Middle East.

Environmental and regulatory conditionality. The variable $CBAM_{jt}$ measures the implementation phase of the European Union's Carbon Border Adjustment Mechanism, distinguishing between the transitional reporting period (2023–2025) and the financial compliance phase beginning in 2026. The variable $CarbonDiff_{ijt}$ measures the difference between the emission intensity of steel produced in exporter i and the benchmark emission intensity in the EU. The interaction $CBAM_{jt} \times CarbonDiff_{ijt} \times \mathbf{1}\{i = TUR\}$ tests whether Türkiye's EAF-based production, characterized by relatively low process emissions, generates a competitive advantage in EU markets as carbon pricing becomes binding. Given the ongoing rollout of CBAM, full empirical testing of this effect will become feasible once post-2026 data are available.

Finally, a set of exporter-specific structural variables captures cost and input conditions that directly influence trade competitiveness. These include $ElecCost_{it}$, representing industrial electricity prices, $GridCO2_{it}$, reflecting the carbon intensity of the national power grid, and $ScrapPrice_{it}$ or $ScrapImportShock_{it}$, measuring volatility in scrap-metal availability or prices. These variables can be interacted with the indicator $\mathbf{1}\{i = TUR\}$ and with the international trade dummy $\mathbf{1}\{i \neq j\}$ to estimate how changes in energy costs or scrap availability alter Türkiye's export performance relative to domestic sales. Such terms are crucial for evaluating whether short-term fluctuations in input markets contribute to trade diversion effects even in the absence of explicit policy shocks.

Taken together, these variables enable the decomposition of observed trade flows into components attributable to market fundamentals, protectionist interventions, geopolitical realignments, and climate-related regulations. The inclusion of both international and domestic transactions ensures that non-discriminatory policies, such as CBAM or national energy costs,can be distinguished from bilateral or targeted measures. By centering identification on Türkiye through interaction terms, the model provides a structured empirical foundation for measuring how a medium-sized, trade-dependent steel producer adjusts to the overlapping pressures of overcapacity, protectionism, geopolitical fragmentation, and decarbonization.

4.3. Identification, estimation, and interpretation

The empirical model outlined above identifies the effects of industrial, policy, geopolitical, and environmental shocks on bilateral steel trade by exploiting variation across exporters, importers, time, and policy exposure. Identification relies on three complementary dimensions.

First, the inclusion of exporter–time and importer–time fixed effects isolates country-specific production and demand changes from policy shocks, ensuring that estimated coefficients reflect only the bilateral or cross-sectional components of variation.

Second, the asymmetric pair fixed effects absorb all time-invariant bilateral characteristics, such as distance, historical trade relations, or geographic proximity, preventing omitted-variable bias from static trade frictions.

Third, the inclusion of domestic flows allows the model to distinguish non-discriminatory policies, such as CBAM or national energy prices, from discriminatory measures such as tariffs or sanctions that vary by partner.

This combination of high-dimensional fixed effects, domestic reference flows, and policy interactions provides the theoretical consistency and empirical precision recommended by the structural-gravity literature.

Interpretation of the estimated coefficients follows the logic of welfare-based trade analysis. Positive coefficients on policy variables such as CBAM or sanctions indicate trade creation for the affected exporter–importer pairs, while negative coefficients signal trade diversion. In the case of Türkiye, a positive and significant coefficient on the interaction term $CBAM_{jt} \times CarbonDiff_{ijt} \times \mathbf{1}\{i = TUR\}$ would imply that the country's relatively low-emission EAF-based production route enhances its competitiveness in the European market as carbon pricing becomes binding. Conversely, a negative coefficient on $ChinaDump_{jt} \times \mathbf{1}\{i = TUR\}$ would indicate that Chinese overcapacity continues to divert trade away from Turkish producers in third markets. The coefficients on energy and scrap variables provide insight into the extent to which domestic cost shocks translate into export responses or inward substitution, revealing whether fluctuations in input markets induce reallocation between domestic and external sales.

Dynamic extensions can be incorporated through either event-study or difference-in-differences (DiD) designs, depending on the nature of each policy shock. For discrete interventions, such as the 2018 and 2025 rounds of U.S. Section 232 tariffs or the 2022–2024 sanctions on Russia and Belarus, a standard DiD specification can estimate the average treatment effect on bilateral steel trade after controlling for exporter-time, importer-time, and pair fixed effects. For gradual or multi-phase policies, such as the implementation of the EU's CBAM, an event-study formulation with lead and lag indicators allows for the identification of anticipation, adjustment, and persistence effects. Together, these methods permit tracing both the average and temporal dimensions of trade creation and diversion, clarifying whether the effects of protectionism and carbon pricing are transitory or structural.

The estimated model thus permits a comprehensive welfare interpretation. Within the gravity framework, trade creation corresponds to an expansion of efficient trade flows consistent with comparative advantage, while trade diversion reflects the reallocation of trade toward less efficient or policy-favored partners. By embedding these mechanisms into an empirically tractable structure, the model allows for a forward-looking evaluation of how Türkiye’s steel industry navigates a global economy increasingly shaped by overcapacity, protectionism, geopolitics, and decarbonization. The next section concludes by discussing how this empirical foundation can support a new research agenda on trade and welfare under climate constraints.

It is important to note that the inclusion of exporter–time and importer–time fixed effects implies that variables varying only at the exporter-year or importer-year level are absorbed and cannot be estimated directly. This design choice is deliberate and consistent with modern gravity practice, as it removes bias arising from country-level shocks such as aggregate output changes or global demand cycles. Identification therefore relies on variation across trading partners within a given exporter– or importer–year. To capture the influence of country-level factors, the model employs interaction terms that vary bilaterally -for example, by multiplying exporter-specific variables such as electricity costs with importer-region indicators, or importer-specific variables such as CBAM with exporter-specific characteristics like carbon intensity. Similarly, relative measures such as the carbon-intensity gap between partners provide variation that survives the fixed effects. This approach ensures that estimated coefficients are identified from within-pair differences and dynamic adjustments rather than from aggregate trends, preserving both internal validity and theoretical consistency.

5. Conclusion: A new research agenda for the next generation

The transformations traced throughout this paper mark not a closure of the classical trade-diversion framework but its reawakening under new constraints. The contemporary global economy -fractured by protectionism, geopolitical rivalry, and the imperatives of decarbonization- demands a rethinking of what integration and welfare mean when market access depends as much on carbon intensity as on comparative advantage. In this environment, the insights of Güzin Erlat’s generation acquire renewed relevance. Her insistence that integration be evaluated through its welfare consequences rather than its ideological appeal remains essential, yet the channels through which welfare is created or diverted have multiplied. Today, they run through the veins of the carbon economy.

The first implication is analytical. Trade theory must incorporate environmental externalities and policy heterogeneity not as residual corrections but as central determinants of competitiveness. The framework proposed here, uniting overcapacity, protectionism, geopolitics, and carbon conditionality within a structural-gravity setting, offers one possible bridge. It allows future researchers to measure not only how trade shifts but also how its welfare content changes as the composition of energy and technology evolves.

Future studies might ask: How does the inclusion of carbon intensity alter the measured elasticity of trade with respect to tariffs or transport costs? Do climate policies create "green comparative advantage" that persists even after policy convergence? Under what conditions does carbon pricing lead to genuine trade creation rather than disguised protectionism? Extending this model across sectors - cement, aluminum, fertilizer- could generate a comparative mapping of "carbon diversion" across the industrial spectrum. Empirical work using panel estimations, event studies, and counterfactual simulations can test whether climate policies redistribute welfare more efficiently than tariffs ever did.

The second implication is institutional. The post-liberal trade order now revolves around selective cooperation rather than universal liberalization. Mechanisms such as the EU's CBAM or the GASSA point toward a hybrid regime of carbon clubs, where market access is conditional on verifiable decarbonization. Türkiye's experience as a mid-sized, energy-importing steel producer illustrates how these emerging arrangements can either deepen integration or entrench fragmentation.

Here, critical questions arise: Can carbon clubs evolve into credible substitutes for multilateral trade governance, or will they reinforce a two-tier global system? How can mid-income economies like Türkiye align domestic energy and industrial policies to remain inside these preferential "green circles"? What institutional design best reconciles carbon legitimacy with trade fairness? The policy challenge lies in transforming compliance into adaptive capacity -investing in renewable energy, scrap management, and emissions verification systems that convert carbon constraints into competitiveness gains. Future research should examine how such industrial strategies interact with international rule-making, particularly the balance between environmental legitimacy and development equity.

The third implication is generational. The welfare question that animated the pioneers of customs-union theory was fundamentally ethical: who gains, who loses, and why? The same question now resurfaces in a world of unequal climate responsibilities. As green transition policies redistribute the costs of decarbonization, new forms of welfare asymmetry emerge -between clean and carbon-intensive producers, between early adopters and latecomers, between those with technological capacity and those without.

This invites a new empirical frontier: How do carbon-related welfare gains distribute across income groups, regions, and generations? Can environmental adjustment be measured through the same welfare metrics that guided traditional trade theory? What does a “just transition” mean in a world where welfare is conditioned by carbon differentials? The next generation of economists will need to measure these asymmetries with the same empirical rigor that Güzin Erlat brought to the study of tariff preferences, but with a broader understanding of welfare that encompasses environmental justice and intergenerational equity.

Operationalizing green competitiveness in Türkiye’s steel sector requires aligning industrial policy with the incentives embedded in CBAM. Priority areas include accelerating grid decarbonization, establishing a national scrap-management and traceability system, and supporting renewable-powered DRI investments. These measures would allow Türkiye to convert carbon constraints into durable export advantages rather than defensive compliance.

The analytical tools of the past century -gravity models, welfare decompositions, policy simulations- remain indispensable, but their purpose must expand to include the distribution of carbon, adaptive capacity, and credibility. The steel sector, because of its centrality to both industrialization and decarbonization, will continue to serve as the laboratory for this intellectual renewal. As researchers revisit classical theories through the lens of climate constraint, they reaffirm Erlat’s enduring lesson: that the purpose of integration, whether regional or planetary, is not simply to move goods across borders but to improve the shared conditions of human welfare. If Güzin Erlat were writing today, she would likely trace how trade diversion now follows the path of carbon intensity rather than tariff discrimination -a reminder that the questions she posed still guide the search for welfare in a changing world.

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Özet

Küresel şoklar, yeşil politikalar ve Türkiye'nin çelik ticaretinin refah mantığı

Bu makale, yirmi birinci yüzyılda ticaretin politik ekonomisini yeniden şekillendiren güncel küresel sarsıntılar ışığında, ticaret yaratma ve ticaret saptırma kavramlarını klasik çerçevesi içinde yeniden ele almaktadır. Çalışmanın odağında, korumacılık, jeopolitik rekabet ve karbonsuzlaşmanın en görünür biçimde kesiştiği alanlardan biri olan küresel çelik ekonomisi yer almakta; bu bağlamda Türkiye'nin konumu, ticarete bağımlı orta ölçekli ekonomilerin karşı karşıya kaldığı ikilemleri ortaya koymaktadır. Makaledeki tartışma, günümüzde refahın yalnızca fiyatlar ve gümrük tarifeleri gibi geleneksel unsurlara değil, aynı zamanda karbon performansı ve uyum kapasitesine de giderek daha fazla bağlı hâle geldiğini izlemekte; ticaret politikası, iklim yönetişimi ve bölüşümsel sonuçları birlikte ele alan yeni bir araştırma kuşağına duyulan ihtiyaca işaret etmektedir. Biçimsel bir tahmin sunmak yerine, bu çalışma sorgulamayı teşvik etmeyi amaçlamaktadır: İklim kısıtları altında refah nasıl yeniden tanımlanabilir? Karbon rekabetçiliğin yeni para birimi hâline gelirken, ekonomik bütünleşme kolektif refahın bir kaynağı olmaya devam edebilir mi? Bunlar, bugün Güzin Erlat'ın sorabileceği sorular ve artık öğrencilerinin yanıtlaması gereken meselelerdir.

Anahtar kelimeler: Küresel ticaret, çelik sanayi, korumacılık, iklim politikası, refah, rekabetçilik, Türkiye.

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