Commercial Embeddedness and Sanctions Busting: Intra-Industry Trade, Dependence, and Economic Asymmetry

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Abstract

Why do some third-party states expand trade with sanctioned targets while others do not? Existing research often treats commercial opportunity as a function of commercial dependence (or trade share), assuming that sanctions busting becomes more likely when the target occupies a larger share of a third party's trade portfolio relative to other states. This paper argues that dependence is important but incomplete. Trade share captures commercial exposure, but not how bilateral trade is organized between states. I develop a typology of commercial logics to distinguish dependence from commercial embeddedness, which I measure through intra-industry trade. Using directed dyad-year data on third-party trade with sanctioned targets from 1963–2023, I show that third-party trade share and intra-industry trade are both associated with sanctions busting, but that these relationships vary with the economic size difference between the third party and target. Among economically similar states, sanctions busting is concentrated where trade is both commercially important and intra-industry in nature, consistent with embedded interdependence. Among highly asymmetric states, sanctions busting is concentrated at comparatively lower levels of third-party trade share when intra-industry trade is present, suggesting uneven commercial opportunities that commercial dependence alone cannot capture. Sanctions busting is therefore best understood as emerging from distinct configurations of commercial exposure and embeddedness that vary with the economic size difference between third parties and targets.

Keywords: economic sanctions; sanctions busting; intra-industry trade; trade dependence; interdependence; economic coercion

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Introduction

Economic sanctions are designed to restrict a target state's access to goods, capital, and markets or, what Hufbauer et al. (2009) call customary trade. Yet sanctions rarely operate in a closed sender-target dyad. Targets remain embedded in broader commercial systems, and third-party states often retain incentives to maintain or expand trade with sanctioned economies. These third-party ties can undermine coercion by replacing lost trade, supplying goods through alternative channels, or allowing targets to adjust toward new commercial partners. Sanctions busting is therefore central to understanding why economic coercion often falls short of sender expectations (Caruso 2003, 2005; Early 2009, 2015; Early and Spice 2015; Barry and Kleinberg 2015; Preble 2023).

When senders withdraw from target markets, third-party firms face less competition, improved terms of trade, and new opportunities to sell goods or acquire inputs (Kaempfer and Lowenberg 1988; Early 2009, 2015). Existing work therefore often measures commercial incentives through aggregate trade dependence. If the target accounts for a larger share of a third party's trade, then the third party has more to lose from disruption and may be more likely to maintain or expand trade after sanctions (Early 2009, 2015; Early and Spice 2015; Preble 2023). This paper argues that this logic is useful, but existing methods for analyzing trade-based sanctions busting obscure what I refer to as commercial logics: the distinct mechanisms through which different kinds of trade relationships create incentives to maintain or expand commerce with sanctioned targets. These commercial logics refer to the distinct ways that trade relationships generate incentives for third parties to maintain or expand commerce with sanctioned targets while acknowledging that these incentives exhibit heterogeneity. Some sanctions-busting ties reflect dependence on an important market while others reflect embedded intra-industry relationships that are costly to unwind. Then, still others appear in economically asymmetric dyads where opportunities may arise through niche substitution or uneven exposure. Existing aggregate measures of trade dependence tend to collapse these mechanisms into a single commercial-opportunity story that obscures variation.

To capture these logics, I use intra-industry trade (IIT), which measures the extent to which states import and export within the same product categories (Grubel and Lloyd 1971; Greenaway and Milner 1986; Thies and Peterson 2016). IIT therefore captures not simply how much states trade, but whether exchange is reciprocal and sectorally embedded. This matters because sanctions disrupt not only aggregate trade flows, but also the commercial relationships that organize production, distribution, and market access. I argue that sanctions bust-

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ing follows multiple pathways: among economically similar or moderately different dyads, IIT captures commercial embeddedness, while in highly asymmetric dyads, sanctions busting may reflect dependence-driven opportunity, niche substitution, or asymmetric exposure.

To uncover these patterns, I use Standard International Trade Classification trade data from the Atlas of Economic Complexity (Harvard Growth Lab 2021) from 1963-2023 to estimate fixed-effects logit models. I then disaggregate the commercial space along three dimensions: economic similarity between the dyads, trade dependence, and intra-industry trade share. This approach makes visible forms of heterogeneity that are obscured when all dyads are pooled into a single model of commercial dependence. My analysis shows that intra-industry trade and third-party trade share are both associated with sanctions busting, but they do not operate as interchangeable indicators of commercial opportunity. Rather, their effects depend on the economic structure of the dyad. Among economically similar states, sanctions busting is concentrated where trade relationships combine high commercial importance with intra-industry exchange. In these cases, sanctions busting appears to reflect a logic of embedded interdependence with third parties most likely to expand trade with targets when the relationship is both valuable and organized around reciprocal product-level exchange. Among highly asymmetric dyads, however, the pattern is different as sanctions busting occurs at lower levels of third-party trade share, especially where some intra-industry exchange is present. This asymmetric dynamic suggests that commercial opportunity in these relationships may operate through niche substitution, asymmetric exposure, or sector-specific dependence rather than broad aggregate trade dependence. Overall, these findings indicate that sanctions busting is not generated by a single commercial logic.

I make three important contributions with this research. First, the paper brings IIT into the study of sanctions busting as a measure of commercial embeddedness rather than simply another trade variable. Second, it shows that dependence and embeddedness are distinct as trade share captures exposure while IIT captures the organization of exchange. Third, it demonstrates that economic asymmetry between dyads conditions the meaning of both measures, highlighting how actions busting is not generated by one, single commercial logic. Instead, it emerges through different mechanisms that are obscured when all dyads are pooled into a single aggregate-dependence framework.

The remainder of the paper proceeds as follows. First, I review existing research on sanctions busting, commercial opportunity, and the political economy of trade composition, highlighting how aggregate measures of trade dependence obscure important variation in the structure of commercial relationships. Second, I develop a theoretical argument linking sanctions busting to distinct commercial logics: dependence, embedded intra-industry exchange, and

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economic asymmetry. Third, I describe the construction of the directed dyad-year dataset, the coding of sanctions-busting trade, and the measures of intra-industry trade, third-party trade share, and economic similarity. Fourth, I then present the empirical results, showing that intra-industry trade and trade dependence are both associated with sanctions busting but operate differently across economically similar and asymmetric dyads. I conclude by discussing what these findings imply for sanctions enforcement, the study of economic interdependence, and future research on the commercial foundations of sanctions busting.

Trade Composition and Sanctions Busting

Sanctions busting occurs when third-party states, often through their firms and constituents, ignore the presence of economic sanctions levied against target states and increase their economic engagement with those targets (Early 2015). This increased economic engagement undercuts the efficacy of sanctions and dulls the pain that sanctions are meant to inflict (Caruso 2003; Barry and Kleinberg 2015; Early 2015; Early and Spice 2015; Peksen and Peterson 2016). Sanctions busting can occur through foreign aid, foreign direct investment, remittances, and goods trade (Biglaiser and Lektzian 2011; Early and Jadoon 2016). This paper focuses on trade-based sanctions busting because trade is the channel through which the interaction between commercial dependence and trade composition can be observed most directly.

The logic behind sanctions busting is that sanctions create commercial incentives for firms in third-party states. When senders restrict trade with a target, they create market gaps, price changes, and opportunities for third parties to take advantage of favorable commercial conditions (Kaempfer and Lowenberg 1988; Early 2009, 2015). Much of the existing literature studies these incentives through aggregate trade flows. This is useful, but it masks variation at the sectoral, industry, and firm level. It also implies that firms engaged in trade are affected by sanctions in broadly similar ways. Disaggregating trade flows makes it possible to ask whether different forms of trade generate different incentives to maintain, expand, or replace economic relationships after sanctions are imposed.

This concern is not unique to sanctions research. Scholars of trade and conflict have long shown that the composition of trade matters. Disaggregated trade can reveal whether particular commodities, industries, or trade portfolios expose states to different risks and opportunities (Dorussen 2006; Reuveny and Kang 1998; Kavaklı, Chatagnier, and Hatipoğlu 2019). For example, work on oil and conflict demonstrates that particular commodities can have foreign-policy effects that are obscured in aggregate trade measures (Colgan 2013, 2015;

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Polachek 1980). The broader point is that aggregate trade may conceal variation in opportunity costs. A disruption to agricultural exports, oil imports, or manufacturing supply chains may impose different costs on firms and states (Dorussen 2006). If sanctions operate by disrupting trade, then the type of trade being disrupted should matter.

The sanctions-busting literature has not fully incorporated this insight. Existing work has made major gains by showing that third parties respond to commercial opportunities, institutional constraints, alliances, and market conditions (Early 2009, 2015; Early and Spice 2015; Preble 2023; Willis and Preble 2026; Su 2020; Golub 2020). The use of aggregate trade means that the literature often treats commercial opportunity as if it were experienced evenly across firms and industries, yet that assumption is unlikely to hold. Firms embedded in specialized supply chains, firms selling differentiated goods, and firms operating in narrow markets may face different incentives than firms trading highly substitutable commodities. The same aggregate trade share can therefore represent different underlying commercial relationships but is likely obscured when taken in total rather than employing careful disaggregation.

Intra-industry trade provides a way to recover some of this lost information. IIT refers to the exchange of similar goods within the same industry, and it has become increasingly important in the postwar global economy as firms pursue economies of scale, consumers demand variety, and production becomes organized across borders (Greenaway and Milner 1986; Milner 1999; Peterson and Thies 2012; Thies and Peterson 2016). In contrast to inter-industry trade, which is often characterized by specialization across different sectors, IIT reflects reciprocal exchange within similar product categories. This distinction matters politically because intra-industry trade has been linked to foreign-policy congruence, alliance formation, and reduced conflict (Peterson and Thies 2012; Thies and Peterson 2016). If IIT changes the political meaning of trade in conflict settings, it should also matter in sanctions settings, where economic coercion (and economic conflict) has the potential to disrupt commercial relationships while simultaneously creating incentives to find alternative routes around restrictions.

The central problem is therefore not simply whether third parties are dependent on sanctioned targets. Dependence matters, but dependence *and* embeddedness are not synonymous. Commercial dependence captures the importance of a market to a trading partner, but IIT captures the structure of the trade relationship itself. A dyad can be dependent without being deeply embedded in reciprocal product-level exchange, and a dyad can exhibit meaningful IIT even when the target is not a large share of the third party's total trade. The empirical challenge is to separate these dimensions and examine when each matters.

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Commercial Logics of Sanctions Busting

Sanctions create commercial opportunities by disrupting established trade between senders and targets in the form of network effects. When sender-state firms withdraw, third-party firms may gain access to displaced customers, suppliers, favorable prices, or market positions previously occupied by competitors (Kaempfer and Lowenberg 1988; Early 2009, 2015). These opportunities are not experienced uniformly, and their value depends partly on the commercial relationship that existed between the third party and target before sanctions were imposed.

I use the term *commercial logics* to describe the different configurations of trade exposure, exchange, and economic structure through which sanctions create incentives for third parties to maintain or expand commerce with sanctioned targets. Rather than distinguishing security motivations from commercial motivations, the argument begins from the established premise that commercial incentives matter (Early 2009) and asks how those incentives vary across different kinds of trade relationships, which I propose below.

The theory identifies two primary dimensions of commercial structure that are critical for understanding the emergence of trade-based sanctions busting. The first is *dependence*, reflected in the target's importance within the third party's overall trade portfolio. The second is *embeddedness*, reflected in reciprocal exchange within the same industries. Trade share (or *commercial dependence* captures the magnitude of the third party's exposure to the target, whereas intra-industry trade captures the organization of bilateral exchange. These dimensions can overlap, but they are not equivalent; economic similarity further conditions whether their combination represents reciprocal interdependence or a more uneven commercial relationship.

Dependence as a Preservation Logic

The first commercial logic is based on dependence. Third-party firms have stronger incentives to preserve a relationship when the sanctioned target accounts for a larger share of their existing trade. Losing an important market can reduce sales, disrupt access to inputs, strand relationship-specific investments, and force firms to identify alternative commercial partners. Firms with substantial prior exposure also possess information, contacts, distribution networks, and experience that make continued trade less costly than entering unfamiliar markets.

Third-party trade share captures this preservation logic. As the target becomes more im-

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portant within the third party's trade portfolio, the costs of allowing the relationship to contract increase. Commercial constituencies with a stake in the target market may also pressure governments to avoid restrictions or weak enforcement (Early 2009; Kastner 2007). Even without explicit state support, firms may redirect transactions, use intermediaries, or expand forms of trade that remain outside the sender's restrictions. Dependence therefore generates incentives to protect existing commercial value.

> **H1:** Higher third-party trade share with a sanctioned target is associated with a higher probability of sanctions busting.

Intra-Industry Trade as an Embeddedness Logic

Dependence captures how much a relationship matters, but not how it is organized. Two dyads can have similar aggregate trade shares while differing substantially in the composition and reciprocity of their exchange. One may consist primarily of one-way trade in a narrow range of products. The other may involve simultaneous imports and exports within the same industries.

Intra-industry trade captures the latter form of exchange. IIT occurs when states both import and export goods within the same product categories (Grubel and Lloyd 1971; Greenaway and Milner 1986). It is commonly associated with differentiated products, economies of scale, demand for variety, overlapping production structures, and exchange among relatively similar economies (Milner 1999; Peterson and Thies 2012; Thies and Peterson 2016). These relationships involve more than access to a market. Firms may depend on established suppliers and distributors, product-specific knowledge, compatible production systems, brand recognition, or access to differentiated goods that are not easily replaced.

Sanctions can therefore threaten benefits on both sides of the exchange. Third-party firms may lose customers in the target while also losing access to inputs or product varieties supplied by target-state firms. I describe this as a *symmetry of deprivation*. The term does not imply equal aggregate costs. Rather, it means that reciprocal exchange exposes economic actors on both sides to losses from disruption, increasing incentives to preserve established ties, reroute transactions, or exploit openings created by sender withdrawal.

IIT thus represents a logic of commercial embeddedness. A dyad can exhibit meaningful embeddedness even when the target accounts for only a modest share of the third party's total trade. Conversely, a high trade share may reflect dependence on a narrow or one-directional flow without substantial reciprocal exchange.

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H2: Higher intra-industry trade between a third party and a sanctioned target is associated with a higher probability of sanctions busting.

H1 concerns the target's importance within the third party's trade portfolio, whereas H2 concerns the organization of bilateral exchange. Both can generate incentives for sanctions busting, but they need not do so in the same combinations or with the same substantive meaning across all dyads.

Economic Similarity and Embedded Interdependence

The relationship between IIT and sanctions busting should depend on the economic structure of the dyad. Intra-industry trade is most commonly associated with exchange among economies with relatively similar income levels, productive capabilities, and patterns of demand. In these dyads, simultaneous imports and exports within the same industries are more likely to reflect differentiated products, overlapping production, and reciprocal market relationships.

When high IIT coincides with high third-party trade share among economically similar states, the result is a form of *embedded interdependence*. The target is important within the third party's trade portfolio, and the relationship is organized through reciprocal within-industry exchange. Dependence raises the cost of losing the market, while embeddedness raises the cost of reorganizing the relationship. Firms may therefore possess both strong incentives and established commercial infrastructure to preserve or expand trade when sanctions disrupt existing exchange.

This is a configurational expectation rather than a claim that the continuous interaction between IIT and trade share must be positive throughout the sample. The expectation is that, among economically similar states, the dyads most likely to engage in sanctions busting will be located where commercial importance and reciprocal within-industry exchange coincide.

H3: Among economically similar dyads, sanctions busting is most likely where high third-party trade share coincides with intra-industry trade.

Moderately different dyads may display a weaker version of this pattern, but reciprocal exchange may remain commercially meaningful. Also, differences in economic size and productive capacity make IIT a less direct indicator of balanced interdependence.

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Economic Asymmetry and Uneven Commercial Opportunity

Highly asymmetric dyads should follow a different commercial logic. When a very large economy trades with a much smaller one, the sanctioned target may account for only a small share of the larger third party's total trade. Aggregate trade share can therefore indicate limited dependence even when the bilateral relationship is consequential to particular firms, industries, or products.

The same bilateral trade flow may be economically minor within the portfolio of a large third party while representing substantial productive capacity, market access, or substitutive potential from the target's perspective. Under these conditions, third-party trade share may understate the commercial significance of sector-specific relationships.

IIT also carries a different meaning in highly asymmetric dyads. Among economically similar states, it is more plausibly interpreted as broad reciprocal embeddedness. Among highly asymmetric states, positive IIT may instead be concentrated in a smaller number of industries or product categories. It can therefore identify specialized exchange without implying balanced aggregate interdependence. Firms in the larger economy may be capable of replacing sender-state suppliers, absorbing target exports, or filling market gaps without the target becoming important to the third party's overall trade portfolio.

Sanctions busting in these dyads can emerge through an *uneven commercial opportunity* logic. The third party need not be broadly dependent on the target. Commercial incentives may instead arise from niche substitution, specialized products, existing sectoral ties, or the ability of a large economy to redirect a small share of its productive capacity toward the target. The present data cannot distinguish conclusively among these mechanisms. They nevertheless imply the same observable pattern: sanctions busting should not be concentrated in the high-trade-share/high-IIT region associated with embedded interdependence.

Instead, positive IIT may identify commercially meaningful sectoral relationships at comparatively lower levels of third-party trade share. "Lower" refers to the distribution of third-party dependence and does not imply that bilateral trade is economically trivial.

> **H4:** Among highly asymmetric dyads, sanctions busting is more likely to be concentrated at comparatively lower levels of third-party trade share when intra-industry trade is present than in the high-trade-share/high-IIT region observed among economically similar dyads.

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Data and Methods

To evaluate the relationship between trade structure and sanctions busting, I construct time series cross-sectional data set of directed third-party–target dyad-year dataset from 1963–2023. The trade data are derived from 4-digit Standard International Trade Classification (SITC) flows and aggregated to the dyad-year level to capture bilateral exports, imports, and total trade. This level of aggregation is necessary to generate an intra-industry trade measure using the approach employed by Thies and Peterson (2016). The data are cleaned and distributed by the Atlas of Economic Complexity and the Harvard Growth Lab (Harvard Growth Lab 2021).[1] I merge these trade data with sanctions episodes from the Global Sanctions Database (GSDB), which identifies sanctioned targets, sanction start and end years, and sanction types (Felbermayr et al. 2020).

Coding Sanctions Busting

The dependent variable is dichotomous, with a value of 1 indicating sanctions-busting trade between a third-party state and a sanctioned target in a given year. Rather than relying on raw trade levels, I construct a dyad- and episode-specific measure that identifies meaningful increases in trade relative to pre-existing relationships. The coding follows the operationalization developed in Preble (2023), while retaining alternative threshold specifications for robustness.

First, I establish a baseline level of trade for each third-party–target dyad within each sanctions episode. Using the GSDB, I identify the start of each sanctions episode and assign a unique episode identifier. Baseline exports and imports are defined as trade in the first year of the sanctions episode and remain fixed for the duration of the episode. I then calculate the percent change in exports and imports relative to this baseline. A dyad exhibits trade expansion if either exports or imports increase by at least five percent. To ensure that these increases are substantively meaningful, I also calculate target trade share, defined as bilateral trade between the third party and target divided by the target state's total trade in that year.

I use the empirical distribution of target trade share to construct a minimum threshold for identifying sanctions busting. The main threshold is the product of the mean target trade share and the average percent change in target trade share across dyads. This threshold is therefore scaled to the observed magnitude and rate of change in trade relationships rather

1. For documentation on the Atlas of Economic Complexity data cleaning process, see https://atlas.cid.harvard.edu/about-data.

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than fixed arbitrarily.

A sanctions-busting tie is coded as present when three conditions are satisfied: (1) the target state is under sanctions; (2) exports or imports between the third party and target increase by at least five percent relative to the episode baseline; and (3) the dyad's target trade share meets or exceeds the specified threshold. Otherwise, the dyad-year is coded as zero. I also construct alternative thresholds using the mean, median, one standard deviation above the mean, two standard deviations above the mean, and the fixed five percent threshold associated with prior work by Early (Early 2009, 2015).

Intra-Industry Trade and Commercial Dependence

The key explanatory variable is intra-industry trade (IIT), measured as the share of bilateral trade occurring within the same industries. I define industries using 4-digit SITC codes, which makes it possible to observe whether a third party and target exchange similar goods rather than only whether they trade in the aggregate. Following the Grubel–Lloyd approach (Grubel and Lloyd 1971), for each industry k and dyad i, j, the industry-level IIT index is calculated as:

$$G_{ij}^{k} = 1 - \frac{\left|X_{ij}^{k} - X_{ji}^{k}\right|}{X_{ij}^{k} + X_{ji}^{k}}, \tag{1}$$

where X_{ij}^{k} represents exports from country i to country j in industry k, and X_{ji}^{k} represents exports from country j to country i in the same industry. The index ranges from 0 to 1. A value of 0 indicates purely inter-industry trade, while 1 indicates perfect intra-industry trade.

To construct a dyadic measure of IIT, I compute a weighted average of industry-level Grubel–Lloyd indices (Peterson and Thies 2012; Thies and Peterson 2016), where weights are based on each industry's share of total bilateral trade. This produces a continuous dyad-year measure between 0 and 1. The measure is lagged one year to capture the pre-existing structure of trade relationships prior to observed sanctions-busting behavior.

I also include third-party trade share, defined as the share of a third party's total trade accounted for by the sanctioned target. This is the main measure of commercial dependence. IIT and third-party trade share are conceptually distinct: IIT captures the structure of reciprocal exchange within similar industries, while third-party trade share captures the target's importance to the third party. I also construct a dichotomous IIT measure, where

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0 indicates inter-industry trade and 1 indicates any intra-industry trade.

Economic Similarity and GDP Bins

A key theoretical extension is that commercial relationships should not operate identically across all dyads. I measure economic asymmetry using the absolute difference between the third party's logged GDP and the target's logged GDP. Lower values indicate more similar economies, while higher values indicate greater asymmetry.

The preferred specification divides dyads into three groups using the lower and upper quartiles of GDP difference: similar economies, moderately different economies, and highly asymmetric economies. Because binning decisions can shape interpretation, I reproduce the main heat-map analysis using tertiles and strict tails, with similar and asymmetric economies defined using the 10th and 90th percentiles of GDP difference. These bins make it possible to examine whether the relationship among IIT, dependence, and sanctions busting changes as dyads become more economically asymmetric.

Control Variables and Estimation Strategy

The models include several covariates common in the sanctions-busting and international political economy literature. Full descriptive statistics are reported in Appendix 1. I include minimum distance between third-party states and targets, transformed using the inverse hyperbolic sine (Bellemare and Wichman 2020) to reduce skewness (Gleditsch 2001). I model economic size using logged GDP for third-party states and a polynomial specification for target GDP. GDP data come from the World Bank Development Indicators (World Bank, n.d.). Trade openness is measured as total trade over GDP for third-party states (Squalli and Wilson 2011). Regime characteristics are measured using liberal democracy scores for third-party states and targets from V-Dem (Coppedge et al. 2025). I also include sanction duration from the GSDB (Felbermayr, Gröschl, and Steinwachs 2018), alliance ties from ATOP (Leeds et al. 2002), and UN voting ideal-point distance from Bailey, Strezhnev, and Voeten (2017). Finally, I include sanction-configuration fixed effects to account for variation in sanction type and as a proxy for sanction severity (Willis and Preble 2026), with sanction-type coding from the GSDB (Felbermayr et al. 2020).

I estimate fixed-effects logit models with sanction-configuration and year fixed effects and standard errors clustered by third-party and target state. The baseline models examine IIT and third-party trade share as continuous predictors. I then estimate interaction models to evaluate whether IIT and trade share operate differently when modeled jointly. Be-

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cause both variables are bounded and highly skewed, and because the continuous interaction produces unstable upper-tail coefficients, the main substantive results use categorical interactions between IIT bins, third-party trade-share bins, and GDP-difference bins. This approach is diagnostic: it allows the paper to compare observed sanctions-busting rates with representative model-implied probabilities across substantively meaningful combinations of dependence, embeddedness, and economic asymmetry.

Results

Table 1 reports fixed-effects logit models of sanctions busting. The first set of results supports the central claim that commercial opportunity is not captured by aggregate trade dependence alone. Intra-industry trade is positive and statistically significant in Models 1, 2, 5, and 6. Dyads with higher levels of IIT are more likely to engage in sanctions busting even after accounting for third-party trade share, distance, economic size, regime type, sanction duration, year fixed effects, and sanction-configuration fixed effects. This provides support for H2 in that sanctions busting is more likely where dyadic trade is organized through intra-industry exchange rather than only through inter-industry exchange.

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Table 1: Fixed-Effects Logit Models of Sanctions Busting

Dependent Variable:	Sanctions busting					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
Variables						
Intra-industry trade	5.041***	5.429***			5.099***	4.882***
	(0.4642)	(0.4472)			(0.5379)	(0.5231)
Third-party trade share	0.0895***	0.1057***	0.0794***	0.2726***	0.0613***	0.0635***
	(0.0161)	(0.0210)	(0.0168)	(0.0981)	(0.0124)	(0.0131)
Minimum distance	-0.4423***	-0.4422***	-0.4770***	-0.4774***	-0.4055***	-0.3347***
	(0.0337)	(0.0338)	(0.0361)	(0.0360)	(0.0358)	(0.0322)
Third-party GDP, logged	1.186***	1.186***	1.140***	1.140***	1.262***	1.262***
	(0.0623)	(0.0624)	(0.0682)	(0.0683)	(0.0868)	(0.0818)
Target GDP, logged	1.152**	1.044**	-0.3961	-0.4425	1.420***	1.686***
	(0.4624)	(0.4657)	(0.4281)	(0.4217)	(0.5150)	(0.4942)
Target GDP, logged squared	-0.0268***	-0.0247**	0.0045	0.0054	-0.0336***	-0.0395***
	(0.0097)	(0.0098)	(0.0087)	(0.0086)	(0.0109)	(0.0105)
Sanction duration	0.0199***	0.0198***	0.0211***	0.0211***	0.0225***	0.0271***
	(0.0030)	(0.0030)	(0.0028)	(0.0028)	(0.0029)	(0.0034)
Third-party openness	0.3193	0.3200	0.3507	0.3512	0.5791	0.5101
	(0.1963)	(0.1979)	(0.2461)	(0.2455)	(0.5128)	(0.4237)
Third-party democracy	-0.2534	-0.2434	-0.0716	-0.0689	-0.0882	-0.2180
	(0.3390)	(0.3408)	(0.3403)	(0.3402)	(0.3326)	(0.3413)
Target democracy	-0.1761	-0.1830	0.0881	0.0904	-0.2382	-0.3073
	(0.1853)	(0.1874)	(0.1962)	(0.1968)	(0.1914)	(0.1932)
Intra-industry trade × Third-party trade share		-0.1388*				

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Dependent Variable:	Sanctions busting					
Model:	(1)	(2)	(3)	(4)	(5)	(6)
		(0.0757)				
Any IIT			1.412***	1.444***		
			(0.1215)	(0.1200)		
Any IIT × Third-party trade share				-0.1952**		
				(0.0859)		
High third-party trade share					1.674***	1.687***
					(0.1953)	(0.1874)
Ideal-point distance					-0.2505***	-0.1014
					(0.0862)	(0.0960)
Intra-industry trade × High third-party trade share					-2.715***	-2.850***
					(0.7820)	(0.8027)
Alliance						0.7342***
						(0.1322)
Fixed-effects						
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Sanction-configuration fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Fit statistics						
Observations	433,604	433,604	433,604	433,604	426,465	350,667
Log-Likelihood	-74,239.5	-74,149.4	-74,643.4	-74,566.5	-70,719.3	-59,211.3
Pseudo R^2	0.47828	0.47891	0.47544	0.47598	0.49279	0.49249
BIC	150,140.4	149,973.2	150,948.3	150,807.5	143,123.8	120,031.3

Clustered (thirdparty_iso3_code & target_iso3_code) standard-errors in parentheses

*Signif. Codes: ***: 0.01, **: 0.05, *: 0.1*

TThird-party trade share is also positive and statistically significant across all six models, supporting H1: sanctions busting is more likely when the target occupies a larger share of the third party's trade portfolio. Together, the baseline results support H1 and H2 by showing that both commercial dependence and intra-industry trade are associated with sanctions busting.

The interaction models qualify these baseline findings. In Models 2, 4, 5, and 6, the interaction between IIT and third-party trade share is negative. This should not be read as evidence that IIT reduces sanctions busting. Rather, it suggests that IIT and trade dependence capture partly distinct commercial logics. When dependence is already high, additional IIT contributes less than it does at lower levels of dependence; when aggregate dependence is lower, IIT identifies commercially meaningful ties that trade share alone may miss. The dichotomous IIT models reinforce this point: dyads with any IIT are more likely to engage in sanctions busting than dyads characterized entirely by inter-industry trade.

The remaining covariates largely behave as expected. Minimum distance is negative and significant, while third-party GDP and sanction duration are positive and significant across all models. Target GDP is positive and significant in Models 1, 2, 5, and 6, while the squared term is negative and significant in those same models, suggesting a non-linear relationship. The political controls are less consistent. Third-party openness, third-party democracy, and target democracy are not statistically significant, while ideal-point distance is negative and significant in Model 5 but weakens once alliance ties are included in Model 6. The alliance model has a smaller temporal scope and is therefore best treated as a robustness check.

The political controls are less consistent. Third-party openness, third-party democracy, and target democracy are not statistically significant once year and sanction-configuration fixed effects are included. Ideal-point distance is negative and significant in Model 5, but the relationship weakens once alliance ties are included in Model 6. Alliance ties are positive and significant in Model 6, though the smaller temporal scope of the alliance data means this specification is best interpreted as a robustness check rather than as the paper's core model. Thus, the baseline models support H1 and H2 as both commercial dependence and intra-industry trade are associated with sanctions busting. The more important question, however, is whether these two forms of commercial opportunity operate in the same way across all dyads. The negative interaction terms suggest that they do not, which motivates the categorical analysis below.

Figure 1 helps explain why the interaction results require closer inspection. Most dyad-years are located in the lower half of the third-party trade-share distribution, while observations

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become much rarer in the upper tail. Inter-industry observations are especially concentrated in the lowest trade-share category. By contrast, dyads with at least some IIT make up most observations in the upper portions of the distribution. Thus, the high-trade-share cells that generate some of the largest predicted probabilities represent a smaller and commercially distinctive subset of the data.



Figure 1: Distribution of dyad-year observations by third-party trade share and intra-industry trade

This distributional pattern matters because a continuous interaction assumes a common relationship across a trade-share variable whose meaningful variation is concentrated in a small upper tail. The next stage of the analysis therefore uses categorical interactions among IIT, third-party trade share, and economic similarity to identify where sanctions busting occurs within the commercial space defined by dependence, embeddedness, and economic asymmetry.

Table 2: Categorical Logit Robustness Across GDP-Difference Binning Strategies

GDP-difference bins	Observations	Log likelihood	Pseudo R^2	BIC
Quartile tails (25/75)	426,465	-59093.4	0.576	120,286.8
Tertiles (33/67)	426,465	-58647.3	0.579	119,394.6
Strict tails (10/90)	426,465	-59137.2	0.576	120,374.4

Figures 2–5 present the main categorical results (the fuller regressions that power these heat maps can be found in Appendix 3). Figure 2 reports observed sanctions-busting rates,

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Figure 3 identifies the dominant third-party/target dyad in each observed cell, Figure 4 reports representative model-implied probabilities, and Figure 5 reports observed-minus-predicted differences. These differences are cell-level diagnostics, not conventional residuals or out-of-sample prediction errors.

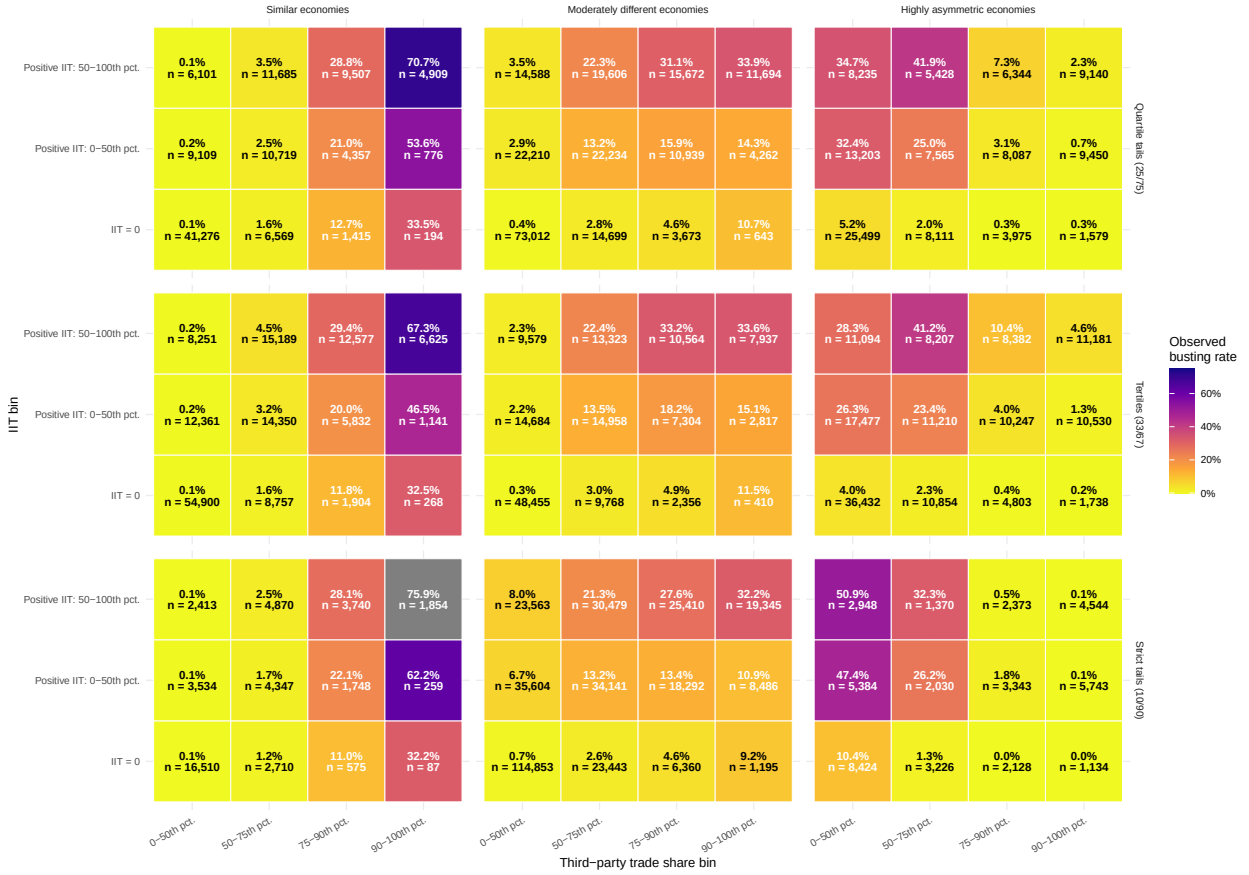


Figure 2: **Observed sanctions-busting rates across alternative GDP-difference classifications.** Each panel reports the percentage of directed third-party–target dyad-years coded as sanctions busting within a combination of third-party trade-share bin and intra-industry trade (IIT) bin. Columns distinguish economically similar, moderately different, and highly asymmetric dyads. Rows apply three alternative classifications of GDP difference: quartile tails (25th/75th percentiles), tertiles (33rd/67th percentiles), and strict tails (10th/90th percentiles). Within each panel, the horizontal axis divides third-party trade share into percentile regions, while the vertical axis distinguishes inter-industry trade from lower- and higher-positive IIT. Cell labels report the observed sanctions-busting rate and the number of dyad-year observations. Darker shading indicates a higher observed rate.

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Figure 3: Dominant third-party/target dyads within observed sanctions-busting cells. Each cell reports the third-party/target dyad contributing the largest number of sanctions-busting years within that commercial-logic category. Cell color reports the observed sanctions-busting rate for the corresponding GDP-difference, IIT, and third-party trade-share bin.

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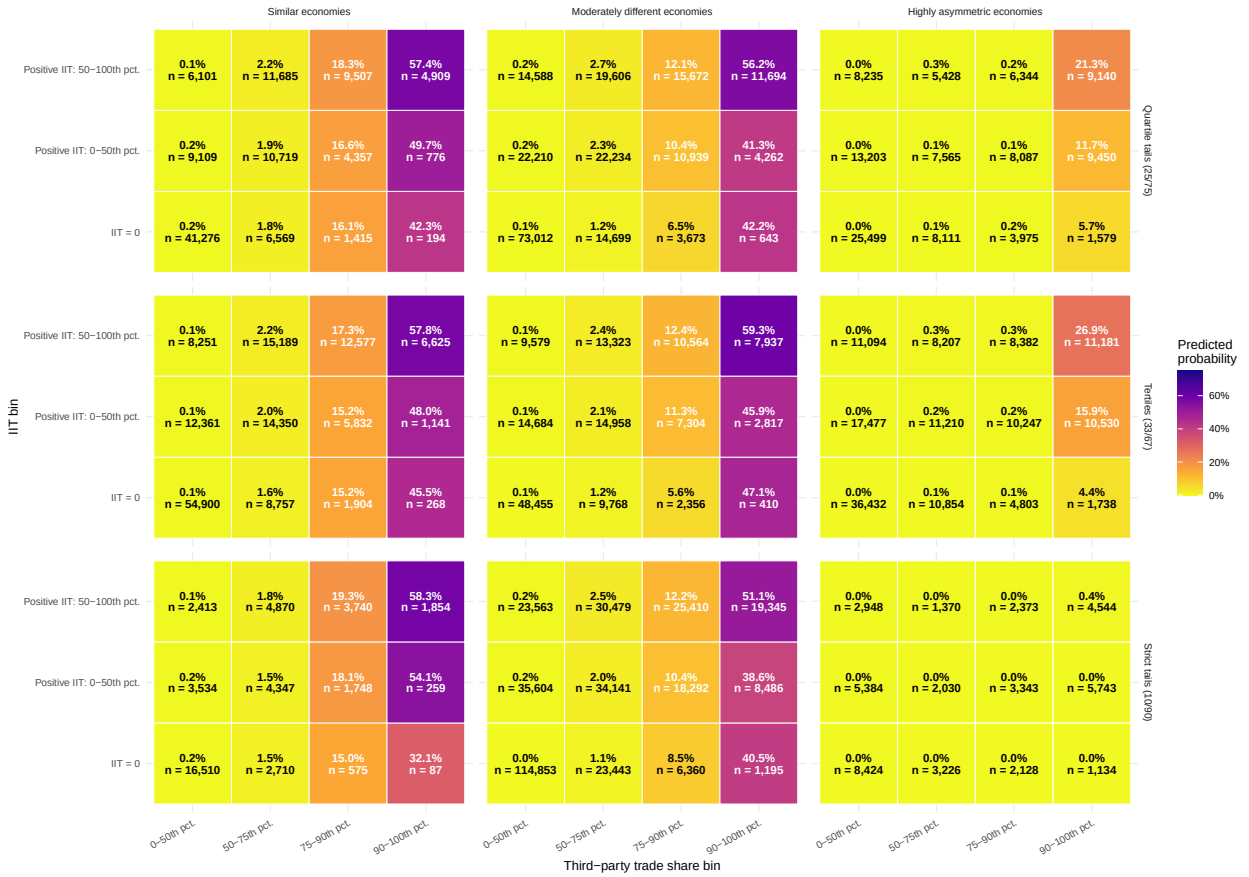


Figure 4: **Representative model-implied sanctions-busting probabilities across alternative GDP-difference classifications.** Each panel reports the probability of sanctions busting implied by a categorical fixed-effects logit model that interacts intra-industry trade bins, third-party trade-share bins, and GDP-similarity bins. Predictions are generated for each categorical combination with the remaining covariates held at GDP-bin-specific means or medians and the year effect fixed at a common prediction year. Columns distinguish economically similar, moderately different, and highly asymmetric dyads, while rows apply quartile-tail, tertile, and strict-tail classifications of GDP difference. Cell labels report the representative model-implied probability and the number of observations in the corresponding empirical cell. Darker shading indicates a higher predicted probability.

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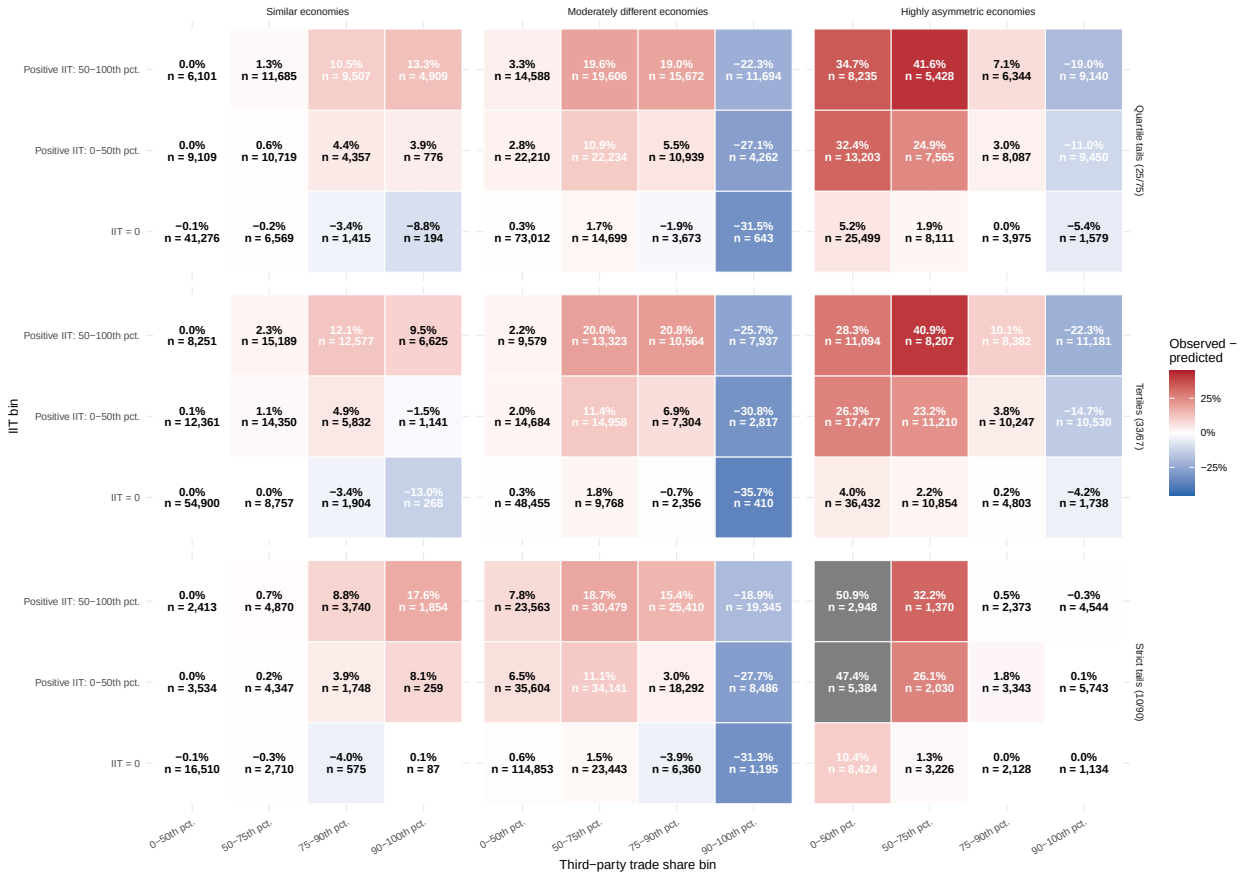


Figure 5: **Observed-minus-predicted sanctions busting across alternative GDP-difference classifications.** Each cell reports the observed sanctions-busting rate minus the corresponding representative model-implied probability from the categorical fixed-effects logit specification. Positive values indicate that sanctions busting occurs more frequently in the observed data than the model-implied probability suggests; negative values indicate that the representative predicted probability exceeds the observed cell rate. Columns distinguish economically similar, moderately different, and highly asymmetric dyads, while rows apply quartile-tail, tertile, and strict-tail classifications of GDP difference. Cell labels report the percentage-point difference and the number of observations in the corresponding empirical cell. Red shading indicates underprediction and blue shading indicates overprediction. These differences are cell-level descriptive diagnostics, not conventional observation-level residuals or out-of-sample prediction errors.

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The observed heat map provides the clearest descriptive evidence for the paper's argument. Among economically similar states, sanctions busting is rare when third-party trade share is low, regardless of IIT. Under the preferred quartile-tail specification, observed busting rates in the lowest trade-share category range from 0.1 to 0.2 percent across the three IIT categories. The rate rises sharply, however, as trade share and IIT increase together. In the 75th–90th percentile trade-share category, the busting rate is 13.0 percent for inter-industry dyads, 21.3 percent for low-IIT dyads, and 29.1 percent for high-IIT dyads. In the highest trade-share category, the rates rise to 34.8, 54.4, and 70.4 percent, respectively.

This pattern strongly supports H3. Among similar economies, sanctions busting is concentrated where dependence and embeddedness overlap. High trade share is associated with more sanctions busting even in inter-industry relationships, but the highest observed rates occur when the target is commercially important to the third party and the dyad is also characterized by reciprocal within-industry exchange. This is consistent with the embedded-interdependence logic: among similar economies, IIT is more likely to reflect differentiated products, reciprocal market access, and established sectoral relationships that firms may seek to preserve despite sanctions.

The moderately different dyads display an intermediate pattern. Sanctions-busting rates generally rise as trade share and IIT increase, but the pattern is less sharply concentrated in the upper-right cell. Under the quartile-tail specification, high-IIT dyads move from 3.6 percent in the lowest trade-share category to 22.4 percent in the 50th–75th percentile category, 31.3 percent in the 75th–90th percentile category, and 33.8 percent in the highest category. Inter-industry dyads show a much flatter progression. This suggests that IIT remains consequential among moderately different economies, but the combination of high dependence and high embeddedness is less dominant than it is among the most economically similar states.

Highly asymmetric economies follow a different pattern. Rather than concentrating in the high-trade-share/high-IIT region, observed sanctions busting shifts toward lower trade-share categories when IIT is present. Under the preferred quartile-tail specification, high-IIT dyads have observed busting rates of 34.5 percent in the lowest trade-share category and 41.6 percent in the 50th–75th percentile category, but only 2.4 percent in the highest category. Low-IIT dyads show a similar pattern, with rates of 32.5 and 25.0 percent in the first two trade-share categories, compared with 0.7 percent in the highest category.

This result supports H4. The commercial structure associated with sanctions busting among highly asymmetric dyads is not the same high-dependence/high-IIT structure observed

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among similar economies. Because the trade-share categories are percentile regions, the leftward concentration should be read as sanctions busting occurring at comparatively lower levels of third-party dependence, not in the absence of commercially meaningful exchange. In asymmetric dyads, relevant commercial opportunities may be narrow, sector-specific, or concentrated in particular product relationships even when the sanctioned target accounts for only a small share of the third party's total trade.

Figure 3 reinforces this point by showing that the observed patterns are not driven by a single recurring dyad or target. Different cells are populated by different third-party/target relationships. Similar-economy, high-IIT/high-dependence cells include dyads such as France–Great Britain, while asymmetric cells often feature lower-dependence commercial ties involving targets such as Cyprus, Oman, Jordan, and Qatar. The figure therefore gives empirical texture to the heat map results: the commercial logics identified in the aggregate data correspond to different types of dyadic relationships.

The predicted and observed-minus-predicted heat maps clarify how much of this structure is captured by the fitted categorical model. Among similar economies, the representative predicted probabilities reproduce the broad movement toward the upper-right portion of the commercial space. The model captures the general tendency for sanctions busting to become more likely as trade share rises and as trade becomes more intra-industry. At the same time, it understates the steepness of the observed pattern. Under the preferred specification, the observed busting rate in the highest-trade-share, high-IIT cell is 70.4 percent, compared with a representative predicted probability of 54.4 percent.

Among moderately different economies, the model-implied probabilities place more weight in the highest trade-share category than is reflected in the observed data, while understating several intermediate configurations in which IIT is present. This suggests that moderately different economies do not follow a simple monotonic progression from low dependence to high dependence. IIT appears consequential across a wider range of commercially meaningful, but not necessarily extreme, trade-share values.

The largest observed-minus-predicted differences appear among highly asymmetric economies. The fitted probabilities retain a dependence gradient, placing more probability in the highest trade-share cells. The observed data show the opposite pattern: sanctions busting is concentrated in lower trade-share cells when IIT is present. Under the preferred specification, observed busting exceeds the representative predicted probability by 34.5 and 41.2 percentage points in the first two trade-share categories among high-IIT dyads. In the highest trade-share category, the fitted probabilities exceed the observed rates. This reversal is

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especially important because it shows why a single dependence-based account can obscure the commercial logic operating among asymmetric dyads.

Taken together, the results show why IIT and third-party trade share should be treated as distinct dimensions of commercial opportunity. Trade share captures the third party's aggregate exposure to the target market. IIT captures the reciprocal sectoral organization of the dyadic trade relationship. Economic similarity conditions how those dimensions translate into incentives for sanctions busting. Among similar economies, sanctions busting is most common when dependence and embeddedness reinforce one another. Among highly asymmetric economies, sanctions busting is concentrated in lower-dependence cells where IIT is present, suggesting a narrower and more sector-specific commercial logic.

These findings have implications for sanctions enforcement. Where sanctions busting follows an embedded-interdependence pathway, enforcement strategies must account for within-industry relationships, differentiated goods, and firms with reciprocal commercial ties. Where sanctions busting occurs among asymmetric dyads at lower aggregate trade shares, strategies focused primarily on a target's largest trading partners may miss narrower but consequential commercial relationships.

The broader implication is that sanctions-busting research should move beyond aggregate operationalizations of commercial opportunity. Dependence matters, as H1 indicates, and IIT matters, as H2 indicates. Yet the high-dependence/high-IIT configuration anticipated in H3 is concentrated most clearly among economically similar states, while H4 characterizes dyads marked by clear economic asymmetry. Sanctions busting is therefore best understood not as one uniform response to commercial opportunity, but as a set of responses generated by different configurations of exposure, embeddedness, and economic asymmetry.

Conclusion

This paper has argued that sanctions busting emerges through multiple commercial logics. Existing research correctly identifies trade dependence as an important source of commercial opportunity. When a sanctioned target accounts for a substantial share of a third party's trade, firms have more to lose from disruption and stronger incentives to preserve the relationship. Yet trade share captures commercial exposure rather than the organization of bilateral exchange. Intra-industry trade provides a complementary measure by identifying reciprocal exchange within the same product categories and, consequently, a form of commercial embeddedness that aggregate dependence alone cannot reveal.

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The results show that both dimensions are associated with sanctions busting, but their substantive meaning varies with the economic relationship between the third party and target. Among economically similar states, sanctions busting is concentrated where high trade dependence coincides with intra-industry exchange. In these dyads, the relationship is both commercially important and organized through reciprocal sectoral ties, producing a pattern consistent with embedded interdependence. Firms have incentives to protect not only access to an important market, but also the established production, distribution, and exchange relationships through which trade occurs.

These findings have implications for sanctions enforcement given that strategies focused primarily on a target's largest trading partners may overlook commercially consequential ties that remain modest in aggregate terms. Monitoring trade volume and market share remains useful, but enforcement efforts should also consider the composition of trade, the industries connecting targets to third parties, the reciprocity of exchange, and the relative economic position of the states involved.

Several extensions would help clarify the mechanisms identified here. Product- and firm-level research could determine whether sanctions-busting trade is driven primarily by incumbent firms protecting established relationships, new entrants exploiting commercial openings, or intermediaries facilitating rerouted exchange. Future work should also distinguish the direction of economic asymmetry. Larger third parties may possess substitution capacity without depending on the target, while smaller third parties may become heavily exposed to relationships that remain comparatively unimportant to the target. Finally, the commercial logics of sanctions busting may vary across sanction instruments and over time as firms learn, intermediaries emerge, and targets reorganize their trade networks.

The broader lesson is that sanctions confront a heterogeneous commercial system rather than a collection of interchangeable third parties. Some trade relationships persist because the target is economically important. Others endure because exchange is embedded within reciprocal sectoral ties. Still others expand because asymmetry creates commercial opportunities that aggregate measures of dependence do not readily capture. Recognizing these distinct configurations provides a more precise account of why sanctions are circumvented, how coercive pressure erodes, and which commercial relationships are most likely to sustain sanctioned targets.

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Conflicts of Interest

The author has no conflicts of interest to declare.

Declaration of generative AI use

The authors report generative AI was not used in their research or preparation of this manuscript.

Data Availability

Data will be provided on request of reviewers or if accepted for publication at Harvard Dataverse.

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