1. Introduction

Cartels are temporary criminal arrangements among competitor firms that conspire to restrict competition. While cartels typically exercise market power through price fixing and output restrictions, their anticompetitive effects may also extend to exclusionary conduct that weakens competition from firms outside the cartel. This paper shows how cartel firms selectively exclude their closest non-cartel rivals from alliance networks, restricting their access to valuable resources and capabilities while protecting their collective market power. Following cartel formation, alliance networks become denser among cartel members while ties with close non-cartel rivals weaken.

More importantly, these co-cartel networks are disproportionately concentrated in (a) R&D alliances, which facilitate access to proprietary technological knowledge and innovation capabilities, and (b) joint ventures, which involve shared capital, productive assets, and operational capabilities. Such concentration may strengthen cartel members' technological and productive advantages while limiting outside rivals' access to these valuable resources, reinforcing their competitive disadvantage.

Further, I argue that denser alliance networks among cartel members facilitate coordination and monitoring of market conduct, enabling cartels to sustain their agreements and reducing the likelihood of cartel breakdown. In a discrete-time hazard model, I find that cartels with greater co-cartel alliance density, relative to their alliance density with non-cartel firms, face a significantly lower hazard of breakdown.

More importantly, these networks may strengthen cartel members' ability to sustain higher collusive overcharges by facilitating coordination and limiting opportunities for unilateral deviation. At the same time, greater reliance on these networks may reduce the need for explicit monitoring, punishment, and coercive enforcement mechanisms within the cartel. Consistent with these arguments, cross-cartel regressions show that greater relative co-cartel alliance density is associated with significantly higher cartel overcharges and lower antitrust fines relative to estimated sales exposure.

I examine these questions using a novel, hand-collected dataset of 920 international hard-core price-fixing cartels prosecuted between 1985 and 2017. The dataset is constructed primarily from enforcement records of the U.S. DOJ Antitrust Division and the European Commission, which together account for a substantial share of global cartel enforcement activity. I merge these data with alliance data from SDC Platinum and firm financial data from Compustat North America and Compustat Global. Using a difference-in-differences (DID) design with cartel formation and breakup as event years and cartel–non-cartel networks as the control group, I find that alliance network density among cartel members increases significantly relative to alliance density between cartel members and non-cartel competitors in the cartelized product market. Further, this shift in alliance network concentration is particularly pronounced for R&D alliances and joint ventures.

Further, I find that the reorganization of alliance networks disproportionately affects the cartel's closest and most consequential outside rivals. Following cartel formation, larger non-cartel firms experience a significantly greater decline in alliance network density with cartel members than smaller non-cartel firms. These findings are consistent with selective exclusion, whereby cartelization restricts economically important outside competitors' access to valuable alliance relationships.

Further, these exclusionary effects are significantly stronger when cartel market penetration is higher, as cartel members have greater capacity to restrict outsiders' access to alliance networks. Higher buyer concentration also intensifies these effects, consistent with greater competitive pressure between cartel members and outside rivals. However, the moderating effect of trade association involvement on alliance network density is not statistically significant.

Taken together, these findings highlight an important but understudied dimension of cartelization: its exclusionary effects on competitors outside the cartel through interfirm alliance networks. Cartel formation is associated not only with greater concentration of alliances among cartel members, particularly R&D alliances and joint ventures, but also with reduced alliance-network access for economically consequential non-cartel rivals. Moreover, greater concentration of alliances among cartel members is associated with longer cartel survival and higher collusive overcharges. This paper contributes to the literature on collusion and exclusionary conduct by identifying interfirm alliance networks as a potential channel through which cartels both sustain collusive market power and disadvantage outside competitors. More broadly, the findings suggest that the competitive consequences of cartelization may extend beyond conventional price and output restrictions to the organization of interfirm relationships that shape firms' access to technological and productive capabilities.

2. Prosecuted Price-Fixing Cartels and Data Collection

In this study, a cartel is an explicit agreement among legally independent competing firms to fix prices, rig bids, restrict output, or allocate markets or customers. This definition follows the one used by the U.S. Department of Justice and the OECD for hard-core cartels: the agreement is between actual or potential rivals, it is entered into voluntarily, it is intended to raise the members' joint profits, and it involves explicit communication among the members, whether written or verbal. Such agreements are per se violations of Section 1 of the Sherman Act and of Article 101 TFEU; the existence of the agreement is itself the offense, and no showing of effect on prices is required. The cartels in the sample are therefore distinct from tacit collusion, in which firms in a concentrated market independently arrive at parallel pricing without communicating. Tacit collusion is not unlawful under either regime, because there is no agreement to prosecute, and it is not part of this study. Every cartel in the data was identified through an enforcement action in which an antitrust authority alleged an explicit agreement among the participating firms.

This study uses a hand-collected dataset of international hard-core price-fixing cartels prosecuted across multiple jurisdictions between 1985 and 2017. The dataset draws primarily on publicly disclosed enforcement actions by the U.S. Department of Justice Antitrust Division and the European Commission, which together account for a substantial share of global cartel

enforcement activity. The dataset includes global cartel cases, with particular emphasis on cartels that fall within U.S. jurisdiction or are investigated or prosecuted by U.S. antitrust authorities. It involves both U.S. and non-U.S. firms, especially European, Canadian, and Japanese firms. Most of the cartel cases involve multijurisdictional enforcement where the United States is one of the prosecuting authorities.

Cartel cases were assembled from publicly disclosed enforcement actions, principally case filings, press releases, and decision documents issued by the U.S. Department of Justice Antitrust Division and the European Commission. For each prosecuted conspiracy, the product market, the identity of participating firms, and the start and end years of the collusive agreement were coded from these primary enforcement records. Where a cartel was prosecuted in more than one jurisdiction, information was reconciled across parallel proceedings to construct a single record per conspiracy.

I merged the cartel data with firm-level alliance and joint venture data from SDC Platinum, which provides global coverage of interfirm alliances, and with firm-level financial data from Compustat. Cartel firms were matched to SDC Platinum and Compustat using standardized firm names and the Python library RapidFuzz to generate candidate matches through fuzzy string matching. Candidate matches above the acceptance threshold were reviewed, followed by manual verification of firm identities. Because the sample includes a substantial share of non-U.S. cartel participants, firms were matched to both Compustat North America and Compustat Global.

A) Dependent Variable (for DID model): *Alliance Network Density* among co-cartel members and between cartel and non-cartel members. I construct an annual alliance network for each cartel based on alliance ties among its member firms and between its member firms and non-cartel firms operating in the cartelized product market. Alliance ties are drawn from SDC Platinum and include all joint ventures, R&D, marketing, manufacturing, licensing, and supply agreements announced between two firms in the network. In the primary measure, I treat an alliance as active for five years following its announcement.

Non-cartel firms are identified by product market: for each cartel, I assign the four-digit NAICS code of the cartelized product and define the set of non-cartel firms as all Compustat firms whose primary NAICS code falls in that industry group and that are not members of the cartel.

This yields, for each cartel-year, two networks: the cartel–cartel network, comprising the cartel's member firms, and the cartel–non-cartel network, comprising its member firms and the non-cartel firms in the cartelized product market. For each network, density is the share of possible alliance ties that are observed (observed ties ÷ possible ties), bounded between 0 and 1 and comparable across cartels of different sizes. The unit of analysis is therefore the cartel–network–year: each cartel contributes two observations per year, one for each network, over the years before formation, during collusion, and after breakdown.

B) Dependent variable (hazard model): *Cartel Breakdown*. Cartel breakdown is the year in which the collusive agreement ends, coded from the enforcement records as the end year of the conspiracy. I estimate a discrete-time hazard model in which the unit of analysis is the cartel-

year, each cartel is observed from its formation year until the year of breakdown, and the dependent variable equals 1 in the year the cartel breaks down and 0 in every prior year of collusion.

C) Dependent variable (cross-cartel regressions): *Gravity of Antitrust Infringement*. I construct a cartel-level measure of gravity of antitrust infringement that captures the monetary penalty imposed on the cartel relative to its economic scale. The construction follows the European Commission's method of setting fines, in which the value of sales associated with the infringement and the duration of participation determine the basic amount of the fine (European Commission, 2006). Gravity is defined as: Gravity = 100 × Worldwide Fines ÷ (Average Annual Cartel-Member Sales × Number of Cartel Firms × Cartel Duration in years)

The denominator approximates the cartel's total sales exposure over the duration of the infringement; Compustat sales of the matched member firms are used to compute average annual cartel-member sales. Higher values indicate greater penalties relative to the cartel's economic exposure, and lower values indicate that the cartel incurred lower fines per unit of exposure. As alternative specifications, I construct an affected-commerce-based measure by dividing worldwide fines by the affected commerce reported in the enforcement records, and winsorized versions of both measures at the 99th percentile. The resulting variable is one observation per cartel, expressed as fines as a percentage of sales exposure.

D) Dependent variable (cross-cartel regressions): *Cartel Overcharge*. Cartel overcharge is the price premium generated by collusion relative to the competitive, or “but-for,” price that would have prevailed in the absence of the cartel. Thus, overcharge captures the extent to which the cartel was able to sustain prices above the competitive benchmark. In the primary specification, I use total cartel overcharge, measured at the cartel level over the duration of the conspiracy. For regression analysis, I rescale the measure by dividing the original value by 1,000 for numerical convenience. As an alternative specification, I also examine overcharge expressed as a percentage of competitive sales.

Tables & Figures

Table 1. DID Estimation
Cartel Formation and Alliance Network Density

Dependent variable	Alliance network density (1)
Treatment × *Post*	0.0065***
	(0.0017)
Observations	28,556
R-squared	0.2987
Adjusted R-squared	0.2738
Cartel fixed effects	Yes
Year fixed effects	Yes

Notes. Hypothesis 1 results. This table reports the difference-in-differences estimate around cartel formation. *Treatment* is co-cartel alliance networks, and control is alliance networks between the cartel's member firms and non-cartel firms in the four-digit NAICS of the cartelized product market. *Post* includes all the years when the cartel is active, beginning from the cartel start year. *Pre* years include 5 years before the cartel start year. Robust standard errors are in parentheses, clustered at the cartel level. The number of cartels is 920. *Controls.* Cartel-member firm size (log employees), return on assets, and financial leverage; corresponding firm size, return on assets, and financial leverage measures for non-cartel firms.*** $p<0.01$; ** $p<0.05$; * $p<0.10$.

Table 2. DID Estimation

Cartel Formation and Alliance Network Density by Alliance Type

Dependent variables	R&D alliance network density (1)	Joint venture alliance network density (2)
Treatment × *Post*	0.0081***	0.0023***
	(0.0005)	(0.0006)
Observations	28,556	28,556
R-squared	0.256	0.256
Adjusted R-squared	0.243	0.242
Cartel fixed effects	Yes	Yes
Year fixed effects	Yes	Yes

Notes. Hypotheses 2 and 3 results. This table reports the difference-in-differences specifications around cartel formation for R&D alliances and JVs. *Treatment* is co-cartel alliance networks, and control is alliance networks between the cartel's member firms and non-cartel firms in the four-digit NAICS of the cartelized product market. *Post* includes all the years when the cartel is active, beginning from the cartel start year. *Pre* years include 5 years before the cartel start year. Robust standard errors are in parentheses, clustered at the cartel level. *Controls.* Cartel-member firm size (log employees), return on assets, and financial leverage; corresponding firm size, return on assets, and financial leverage measures for non-cartel firms. *** $p<0.01$; ** $p<0.05$; * $p<0.10$.

Table 3. Discrete-Time Hazard Model

Relative Co-Cartel Alliance Network Density and the Hazard of Cartel Breakdown

Dependent variable	Cartel breakdown hazard (1)
Relative Co-Cartel Alliance Network Density	-0.0477***
	(0.0145)
Hazard ratio	0.9534
Observations	4,372
Cartel deaths	679
Cartel clusters	725
Log pseudolikelihood	-1789.8701
Geography fixed effects	Yes
Industry fixed effects.	Yes

Notes. Hypothesis 4 results. This table reports a discrete-time complementary log-log model of cartel breakdown. The focal predictors and controls are lagged one year. Relative Co-Cartel alliance network density is the difference in alliance network density among co-cartel member firms with alliance network density between cartel member firms and non-member firms. Alliance ties use a five-year persistence window. Cluster robust standard errors are in parentheses. *Controls.* cartel-member firm size (log employees), return on assets, and financial leverage; non-member firm size (log employees), return on assets, and financial leverage; super-cartel indicator, worldwide fines, trade-association indicator, geographic diversity, number of cartel firms, leniency reform (post-1995 enforcement indicator), bid-rigging indicator, and government-major-buyer indicator. *** $p<0.01$; ** $p<0.05$; * $p<0.10$.

Table 4. Cross-Sectional Models

Relative Co-Cartel Alliance Network Density, Cartel Overcharge, and Gravity of Antitrust Crime

Dependent variables	Cartel Overcharge (1)	Gravity of Antitrust Crime (2)
Relative Co-Cartel Alliance Network Density	0.5093**	-0.0084**
	(0.2117)	(0.0040)
Observations	292	861
R-squared	1.0000	0.0188
Adjusted R-squared	1.0000	-0.0010
Industry fixed effects	Yes	Yes
Continent fixed effects	Yes	Yes

Notes. Hypothesis 5 and 6 results. This table reports across-cartel regressions for Cartel Overcharge and Gravity of Antitrust Crime. Relative Co-Cartel alliance network density is the difference in co-cartel and cartel-noncartel alliance network density. Robust standard errors are in parentheses. *** $p<0.01$; ** $p<0.05$; * $p<0.10$. *Controls:* cartel-member firm size, return on assets, and financial leverage; non-member firm size, return on assets, and financial leverage; super-cartel indicator, trade-association indicator, bid-rigging indicator, government-major-buyer indicator.

Table 5. DID Estimation

Cartel Breakup and Alliance Network Density

Dependent variables	Alliance network density (1)	R&D alliance network density (2)	Joint venture alliance network density (3)
Treatment × Post	-0.0057*	-0.0023*	-0.0043**
	(0.0019)	(0.0009)	(0.0006)
Observations	42,012	42,012	42,012
R-squared	0.1757	0.1698	0.1986
Adjusted R-squared	0.1554	0.1584	0.1554
Cartel fixed effects	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes

Notes. These results show that the *during*-cartel effect reverses after the cartel breakdown. The table reports difference-in-differences specifications around the cartel breakup. *Treatment* is co-cartel alliance networks, and control is alliance networks between the cartel's member firms and non-cartel firms in the four-digit NAICS of the cartelized product market. *Post* includes 10 years post-cartel period and *Pre* period includes *during*-cartel years. Robust standard errors are in parentheses, clustered at the cartel level. *Controls.* Cartel-member firm size (log employees), return on assets, and financial leverage, together with the corresponding firm size, return on assets, and financial leverage measures for non-member firms. *** $p<0.01$; ** $p<0.05$; * $p<0.10$.

Figure 1

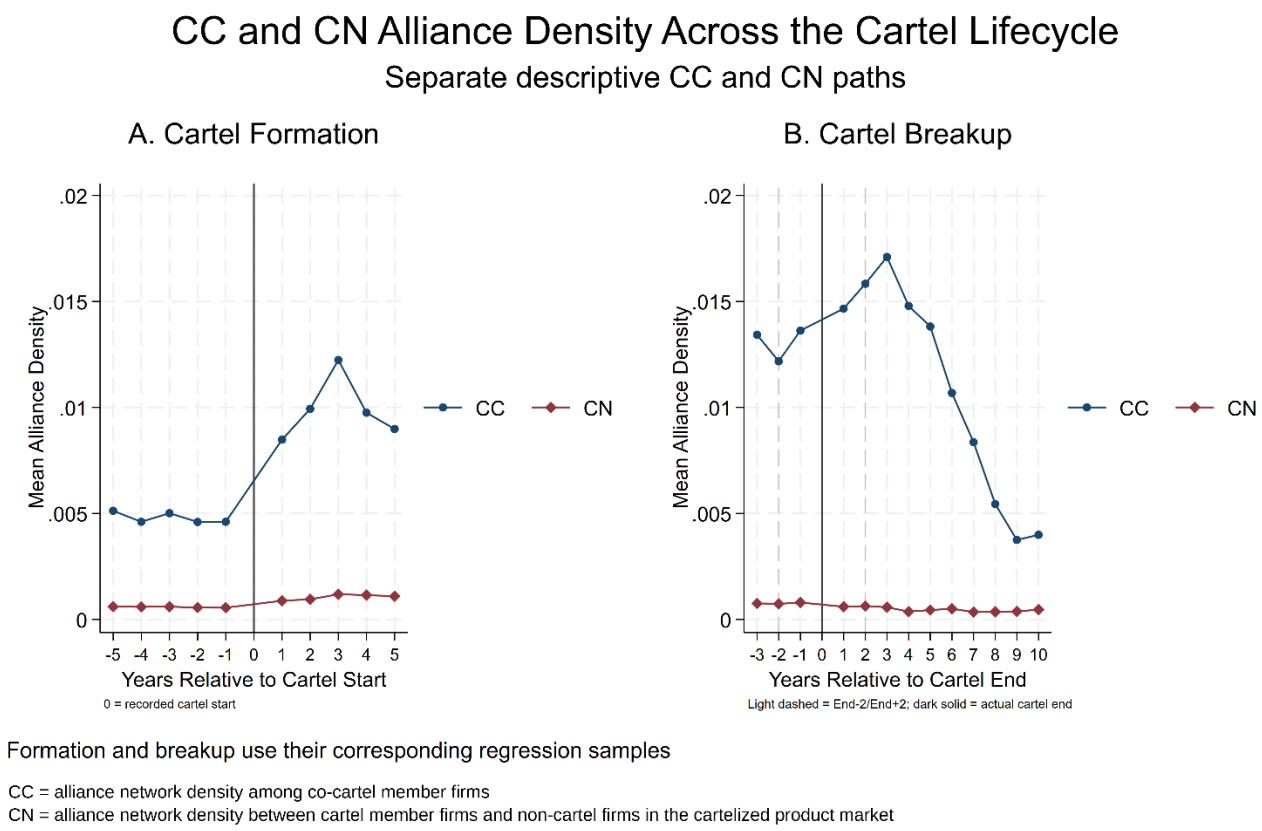
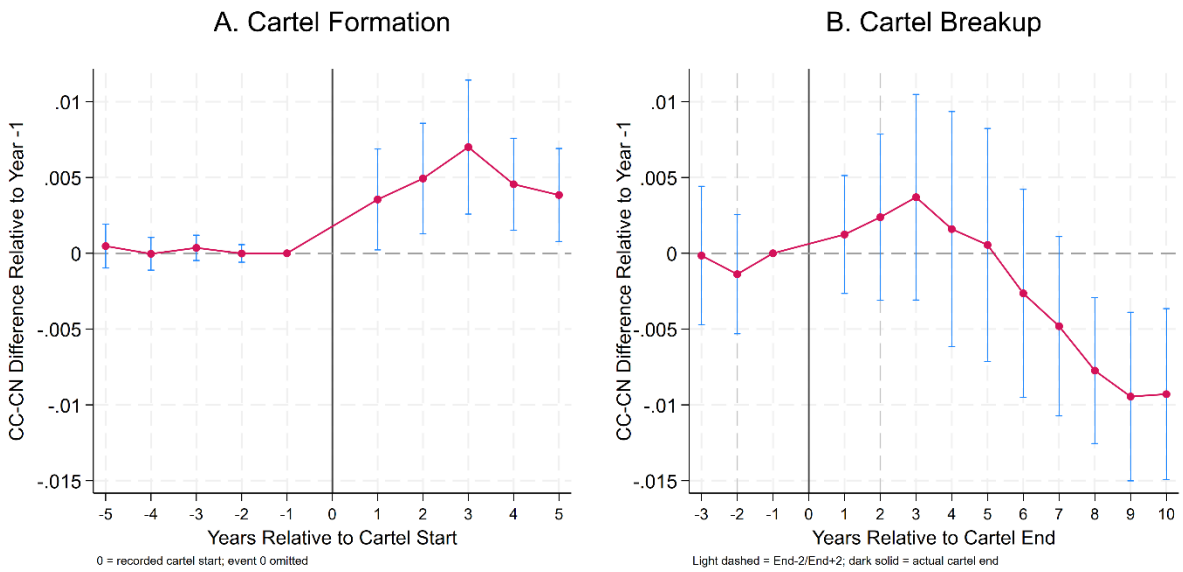


Figure 1. Unadjusted mean alliance network density for the co-cartel (CC) and cartel–non-cartel (CN) networks in event time around cartel formation (Panel A) and cartel breakup (Panel B).

Figure 2

CC-CN Alliance Density Across the Cartel Lifecycle



Formation window -5:+5 | Breakup window -3:+10 | Each event study uses year -1 as its reference

Formation: N = 12,126, Cartels = 830, Pre-trend p = 0.606 | Breakup: N = 19,834, Cartels = 860, Pre-breakup p = 0.455

CC = alliance network density among co-cartel member firms

CN = alliance network density between cartel member firms and non-cartel firms in the cartelized product market

Figure 2. Event-study estimates of the CC–CN difference in alliance network density around cartel formation (Panel A) and cartel breakup (Panel B), relative to the year before the event, with 95% confidence intervals.

Table 6. Controls and Their Description

Controls	Brief description
Cartel-member firm size	Size of cartel-member firms based on number of employees.
Cartel-member return on assets	Profitability of cartel-member firms relative to their assets.
Cartel-member financial leverage	Extent to which cartel-member firms rely on debt financing.
Non-cartel firm size	Size of non-cartel firms in the focal product market based on number of employees.
Non-cartel return on assets	Profitability of non-cartel firms relative to their assets.
Non-cartel financial leverage	Extent to which non-cartel firms rely on debt financing.
Super-cartel indicator	Whether the cartel is identified as a super-cartel involving broader or overlapping collusive activity.
Worldwide fines	Total monetary fines imposed on the cartel across jurisdictions.
Trade-association indicator	Whether a trade association was involved in or connected to the cartel.
Geographic diversity	Number of distinct geographic locations (headquarter countries of cartel firms) represented in the cartel.
Number of cartel firms	Number of firms participating in the cartel.
Leniency reform	Whether the observation falls in the post-1995 antitrust leniency-enforcement period.
Bid-rigging indicator	Whether the cartel engaged in bid-rigging conduct.
Government-major-buyer indicator	Whether a government entity was a major purchaser in the cartelized market.

Table 1. Quasi-Experimental Before-After Estimation (H1, H2)

Cartel Formation and Firm-Level Alliance-Network Density Between Non-Cartel Firms and Cartel Firms: Heterogeneous Effects by Rival Closeness

Dependent variables	Non-Cartel Alliance-Network Density with Cartel Firms **(1)**
Post	0.0009***
	(0.0003)
Non-Cartel Firm Size	0.0001***
	(0.0000)
Post × Non-Cartel Firm Size	-0.0001***
	(0.0000)
Observations	1,607,046
R-squared	0.0055
Adjusted R-squared	0.0052
Cartel fixed effects	Yes
Year fixed effects	Yes

Notes. This table reports regressions examining changes in non-cartel firms' alliance-network positions with cartel firms following cartel formation for Alliance-Network Density. The level of analysis is non-cartel firms' ego network with cartel firms per year per cartel. Non-cartel firms are firms in the four-digit NAICS of the cartelized product market. *Post* includes all the years when the cartels are active, beginning from the cartel start year. *Pre* years include 5 years before the cartel start year. Larger *Non-Cartel Firm Size* indicates closer rivals to the cartel. The interaction between *Post* and Non-Cartel Firm Size captures whether the post-cartel-formation change in these network outcomes varies with non-cartel firm size. The number of cartels is 495. Cluster robust standard errors are in parentheses, clustered at the cartel level. ***Controls*** include non-cartel firm ROA and financial leverage, and cartel-member average log sales, ROA, and financial leverage. Cartel-level time-invariant controls are absorbed by cartel fixed effects. *** $p<0.01$; ** $p<0.05$; * $p<0.10$.

Table 2. Quasi-Experimental Before-After Estimation (H3-H5)

Moderations: Cartel Formation and Firm-Level Alliance-Network Density Between Non-Cartel Firms and Cartel Firms: Heterogeneous Effects by Rivals' Closeness

Dependent variables	Non-Cartel Alliance-Network Density with Cartel Firms **(1)**
Post × Non-Cartel Firm Size	-0.0002***
	(0.0001)
Post × Non-Cartel Firm Size × ***Buyer Concentration***	-0.0002**
	(0.0001)
Post × Non-Cartel Firm Size × ***Cartel Market Penetration***	-0.0008***
	(0.0002)
Post × Non-Cartel Firm Size × ***Trade Association***	0.0001
	(0.0000)
Observations	1,590,486
R-squared	0.0069
Cartel fixed effects	Yes
Year fixed effects	Yes

Notes. This table reports regression moderation results (three-way interactions) for (1) Alliance-Network Density with cartel firms. Cartel Market Penetration is the share of cartel firms in the industry (NAICS4) of the focal cartel product market. Cartel Market Penetration is mean-centered. Trade Association indicates whether the trade association is involved with the focal cartel. The level of analysis is non-cartel firms' ego network with cartel firms per year per cartel. Non-cartel firms are firms in the four-digit NAICS of the cartelized product market. *Post* includes all the years when the cartels are active, beginning from the cartel start year. *Pre* years include 5 years before the cartel start year. Larger *Non-Cartel Firm Size* indicates closer rivals to cartel. The interaction between *Post* and Non-Cartel Firm Size captures whether the post-cartel-formation change in these network outcomes varies with non-cartel firm size. The number of cartels is 492. Cluster robust standard errors are in parentheses, clustered at the cartel level. ***Controls*** include non-cartel firm ROA and financial leverage, and cartel-member average log sales, ROA, and financial leverage. Cartel-level time-invariant controls are absorbed by cartel fixed effects. *** $p<0.01$; ** $p<0.05$; * $p<0.10$.

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