

Coordination and Collusion in Industrial Development

Luis Bosshart
Matthias Weigand*

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Abstract

Episodes of rapid industrialization often coincide with the rise of cartels and conglomerates. Do such arrangements impede development through collusion, or can they coordinate investment productively? We study this question in Germany between 1882 and 1933, as the country approached the technological frontier, emerged as a leading exporter, and legally enforceable cartels came to organize more than half of industrial output. Linking 5,651 cartel agreements to a new annual panel of 27,949 joint-stock firms, we develop a model in which market power creates current distortions but can relax financing constraints by increasing internal funds for investment. Using staggered variation in cartel enforceability across time, regions, and industries, we find that cartel participation increased patenting, exports, output, and employment. These effects were larger where financing constraints were tighter and investment opportunities stronger. Cartel members were also disproportionately drawn into the subsequent war economy. Upstream cartelization initially depressed downstream activity, but this effect later attenuated with a shift toward vertical contracting and lower input costs. The findings suggest that the developmental consequences of market power depend on firms' financing constraints, investment opportunities, and position in the production network. Where cartels formed in sectors of high developmental or strategic value, their enforceability functioned as a delegated, second-best instrument of industrial policy.

Keywords: cartels; industrialization; contracts; investment; financial frictions

JEL Classification: L13, L14, L41, N43, N44, O14

*Bosshart: Harvard Academy for International and Area Studies. lbosshart@fas.harvard.edu. Weigand: Harvard University, Department of Economics. Email: mweigand@g.harvard.edu. We are grateful to Melissa Dell, Ed Glaeser, Claudia Goldin, Nathan Nunn, and Jesse Shapiro for their guidance at every step of this project. Helpful and much appreciated suggestions, critiques, and encouragement were provided by Myrto Kalouptsi, Joachim Voth, and seminar participants at the London School of Economics. Financial support from the Kenneth C. Griffin Economics Research Fund, the Weatherhead Research Cluster on Business and Government, and the Cambridge University Press Dissertation Fellowship is gratefully acknowledged.

1 Introduction

Rapid industrialization often coincides with the rise of cartels and conglomerates. Do such arrangements impede development through collusion, or can they promote it by coordinating investment? When, if ever, should the law permit them? We trace their effects through the production network combining new historical data from Germany with a model of market power and development.

The last major Western power to industrialize, Germany remained an economy of imitators into the 1890s. By 1913, however, it had become a major exporter, reached the technological frontier, and achieved global leadership in chemicals, creating the industrial base for total war (Veblen, 1915; Gerschenkron, 1962). This ascent coincided with the spread of cartels: formal contracts among horizontal competitors, typically organized by product and region, that coordinated prices or output. Courts unexpectedly affirmed the enforceability of early agreements; by 1930, cartels organized more than half of national industrial output (Chandler, 1990). Germany’s export- and innovation-led industrialization combined with cartel-based industrial organization became influential among policymakers abroad, and later episodes of rapid catch-up growth followed a similar model (Johnson, 1982; Amsden, 1989).

Germany therefore provides a canonical setting for asking whether cartels promoted, impeded, or merely accompanied industrialization. We construct a new annual panel linking 27,949 joint-stock firms to the universe of 5,651 cartel agreements between 1882 and 1933. Archival digitization allows us to track cartel membership alongside firm-level exports, patents, investment, employment, governance, profits, and confidential records of war mobilization. To measure effects beyond cartel members, we combine the panel with input–output linkages, inter-cartel agreements, and county–industry data from five industrial censuses.

We document the horizontal and vertical effects of cartels in three steps. We begin with synthetic nitrogen fertilizer, an industry estimated to sustain half the world’s population today and documented by unusually rich corporate accounts and product-level records. Following a 1905 profit-sharing agreement among three chemical firms, retained earnings financed major invest-

ments in nitrogen capacity. Patenting rose; after a technological breakthrough and cartel-financed scale-up, fixed-nitrogen prices fell and synthetic output displaced Chilean natural nitrate on world markets. Formal agreements with agriculture shared some of these gains downstream while preserving upstream rents, consistent with evidence from a broader set of historical episodes.

Second, we distill this evidence into a dynamic model of market power and investment. Late industrialization required large, long-horizon investments, often where access to external finance was limited (Hirschman, 1958; Tilly, 1982). Firms finance upfront, cost-reducing investments under borrowing constraints. Cartelization raises markups and reduces current surplus, but also generates internal funds that can increase investment and future productivity. Enforceability is therefore most valuable when financing constraints bind, investment opportunities are strong, and future gains receive greater weight; its value falls when rents do not raise productivity or downstream distortions dominate. Upstream markups thus act as an implicit distortionary tax on downstream production. This gives a role to vertical contracting: inter-sector agreements, including two-part tariffs, can preserve upstream transfers while reducing downstream quantity distortions. Cartel enforceability can thus operate as a delegated, second-best instrument of industrial policy when direct subsidies are unavailable, especially in upstream sectors.

Third, we test the implications of the framework in the broader firm panel. The analysis is organized around firm-level, downstream, and aggregate margins. At the firm level, we ask whether cartelization led cartel member firms to expand through upgrading, measured by patenting and exporting, and scale, measured by output, employment, and capitalization. We examine whether these effects were accompanied by greater investment and retained earnings, whether cartelization altered board ties to other firms, banks, the state, and research institutions, and how the effects varied with industry-level financing constraints and investment opportunities. We also study the strategic value of this upgrading through military procurement, military innovation, and wartime production coordination.

Along the production network, we study downstream effects. We construct a measure of firm exposure to upstream cartels and estimate its impact on the same upgrading and scale outcomes, then assess whether inter-sector agreements mitigated these effects. At the aggregate level, we examine how the horizontal and vertical effects of cartelization shaped district-level employment, firm entry and exit, and industrial concentration.

Cartel formation was not random. Our empirical strategy therefore relies on the substantial variation in cartelization across products, regions, and over time created by the economic and legal fragmentation of historical Germany. This setting motivates two complementary empirical designs. First, we rely on the full panel variation in the timing of cartel entry across firms and markets. Despite increasing global integration, product markets within Germany remained geographically segmented (Wolf, 2009), while cartel organization differed markedly across industries and regions (Guinnane, 2020).¹ We document that cartel membership varied substantially across geography, and that observable differences before entry were modest: across predetermined firm, geographic, and industry characteristics, eventual cartel members closely resembled firms that never entered cartels.

Our baseline design compares changes within firms as they entered cartels with contemporaneous changes among firms outside cartels. We estimate specifications with firm and year fixed effects and complement them with event studies around first cartel entry, which trace outcome dynamics before and after formation and test whether entering firms were already on different trajectories.

Neither balance nor parallel pre-trends alone establishes a causal interpretation. We therefore organize the robustness analysis around four concerns. First, we address selection into cartels using flexible controls, matching, and reweighting. Second, we account for coincident industry- and region-specific shocks. Third, we address potential spillovers to nonmembers that could contaminate the comparison group. Finally, we show that the results are robust to alternative estimators, samples, and definitions of treatment and outcomes.

Our second design then uses changes in the legal enforceability of cartels. At the beginning of our period, it was highly uncertain whether cartel agreements could be enforced against their members. This changed sharply in 1897, when the Imperial Court upheld the enforceability of a joint-sales cartel in a landmark case. The decision was widely viewed as consequential and difficult to anticipate; contemporaries described the subsequent spread of cartels as arriving “like lightning” (Schäffle, 1898). Consistent with these accounts, our data showed a discrete increase in cartel formation after the ruling.²

¹Writing with reference to 1913, Wolf (2009) notes that “trade districts within Germany were no better integrated than districts on opposite sides of the borders.”

²The decision emerged from litigation involving a small wood-pulp cartel and helped establish freedom of contract

The ruling did not affect all industries equally. Early cartels used several organizational forms, including price agreements, production quotas, and joint-sales organizations; the 1897 decision directly validated the last of these.³ Industries with greater pre-1897 reliance on joint-sales cartels were therefore more exposed to the ruling. We measure reliance as the pre-1897 share of an industry's cartels organized through joint sales and interact it with an indicator for the post-1897 period in a shift-share design.

The relevance condition is that industries with greater reliance should face lower costs of forming a cartel once joint-sales agreements became legally secure. This is what we find: in the difference-in-differences first stage, the interaction of reliance with the post-1897 period predicts cartel membership with an F-statistic of 65.4. Event studies showed no differential trends in cartel formation across industries with different levels of reliance before 1897.

The exclusion restriction requires that reliance affected later firm outcomes through the legal shift rather than through correlated industry characteristics or contemporaneous shocks (Borusyak et al., 2022). Consistent with historical accounts, reliance was only weakly related to a broad set of predetermined industry characteristics. Our specifications flexibly control for predetermined firm, local, and industry characteristics, as well as geographic proximity to the litigated case and the judges who decided it. As an additional check, reliance was not differentially associated with cartel formation around other cartel-related decisions involving different organizational forms.⁴

Our two empirical designs thus examine cartelization using complementary sources of variation. The baseline uses the full variation in realized cartel entry across firms, markets, and years. The shift-share design instead isolates variation generated by a single unanticipated change in legal enforceability interacted with predetermined variation across industries.

We organize the presentation of our findings along the three margins emphasized by the framework. At the firm level, cartelization was followed by substantial upgrading and scale expansion. In years of cartel membership, the probability of patenting is 0.03 higher than in the years the same firm spent outside a cartel, against a baseline mean of 0.05, and the probability of export-

as a basis for enforcing cartel agreements. Its importance was reinforced by the broader consolidation of German private law during this period, which drew disproportionately from the regional law of the wood-pulp cartel region.

³Contemporaries emphasized the heterogeneity of early cartel organization, which often reflected local precedent, individual preferences, and other idiosyncratic factors. Once established, these arrangements provided organizational blueprints that tended to persist within industries.

⁴Additional robustness exercises omit the affected region and industry and vary clustering across markets and legal regions.

ing 0.17 higher, against a baseline mean of 0.10. Output is about 10 percent higher, employment about 11 percent, and capital about 31 percent. These differences emerge after a firm joins a cartel rather than before, and they persist; pre-entry trends are flat for every outcome. The shift-share instrumental variable supports these patterns.

The financing and organizational evidence fits the mechanism of the model. In years of cartel membership, profit is about 56 percent higher, retained earnings about 22 percent, and investment about 8 percent, while dividends do not rise. The additional rents were thus retained and invested rather than paid out. Boards changed as well; cartel members seated more interlocking directors and more directors tied to banks and to the state. The expansion was substantially larger in capital-intensive industries, where outlays were large and external finance scarce. Declassified war-economy records show that cartel members were more likely to hold military procurement contracts, by 0.04 in probability against a mean of 0.18, while the differences for secret war patents and seats on wartime production boards are small and imprecise.

Downstream, cartelized inputs first burdened and later benefited the firms that bought them. Before inter-sector agreements became widespread around 1904, a one-standard-deviation higher exposure to cartelized inputs went with about 18 percent less output and 7 percent less employment. Afterward the association turned positive: about 4 percent more output and 20 percent more employment. This pattern is consistent with historical accounts and the model prediction that vertical contracting could preserve upstream rents while mitigating downstream distortions.

At the level of districts and markets, the expansion was concentrated among incumbents. In five industrial censuses between 1882 and 1933, districts with more cartel-member firms recorded higher employment, over and above the growth in their number of firms. At the market level, a higher cartel share was associated with fewer entrants and exits and with higher concentration, small differences but precisely estimated. The aggregate pattern is therefore one of industrial expansion concentrated among incumbent producers.

Taken together, the results point to the trade-off at the center of the theoretical framework. Cartelization coincided with greater investment, upgrading, and expansion where financing constraints were more likely to bind, while vertical agreements attenuated some of the associated downstream distortions. A growth decomposition attributes 27% of the realized growth in district industrial employment over the sample period to the growth in cartel-member firms (95%

confidence interval 14%–40%). These gains, however, were concentrated among incumbents.

Related Literature. The idea that profits generated along an “optimal chain of disequilibria” can spur investment is longstanding in theories of late development (Hirschman, 1958; Amsden, 1989). We provide firm-level evidence on this mechanism in a canonical setting, revisiting earlier work on German cartels and financial constraints (Kuznets, 1930; Kaldor, 1935).⁵ More broadly, research on financial frictions in development has emphasized the role of retained earnings as a response to borrowing constraints. We study how product-market rents can finance dynamic investment gains at the cost of static output losses.⁶ In the context of China, Song et al. (2011) likewise show how firms finance new technologies through internal savings. In their analysis, the underlying financial constraint gradually eases; here, we study a setting where it remains binding.⁷ Closest to us is Itskhoki and Moll (2019), who study Ramsey-optimal transfers to constrained producers when lump-sum transfers are unavailable. Their tax instruments nevertheless permit direct reallocation, whereas resources in our setting reach producers indirectly through product-market rents.⁸

In doing so, our paper contributes to work on industrial policy as a problem of governance and delegation (Evans, 1995; Djankov et al., 2003). Rodrik (1995, 2004) emphasizes the process through which governments elicit information from firms, while Luo et al. (2025) study the trade-off between central direction and local adaptation.⁹ We examine a different form of decentralization: private contracts determine coordination and the allocation of rents within a legal framework. Despite their historical prevalence, less attention has been paid to cartels and market power as

⁵Internal funds also stabilize investment over the cycle, reducing exposure to fire-sale dynamics in downturns (Caballero and Simsek, 2013).

⁶This echoes the “paragons or parasites” view of business groups (Khanna and Yafeh, 2007), in which internal financing can substitute for imperfect external capital markets while concentrated organization may also generate distortions.

⁷Notably, retained earnings remained a financing model in the German economy far into the second half of the 20th century (Tilly, 1980).

⁸This parallel between market power and a uniform output tax mirrors Edmond et al. (2023). Accounts of finance in German industrialization have traditionally emphasized the role of banks (Jeidels, 1905; Riesser, 1911; Gerschenkron, 1962; Fohlin, 2005).

⁹The classic rationale for more centralized intervention is coordination failure across complementary investments (Murphy et al., 1989; Rodrik, 1996).

instruments of industrial policy (Johnson, 1982; Juhász and Steinwender, 2024).¹⁰¹¹ Relative to the taxes, subsidies, and tariffs emphasized in recent work (Juhász and Steinwender, 2024), cartel enforceability requires little direct expenditure but affords the state less control over which firms receive support and who bears its costs. Enforcing cartel contracts can shift resources toward upstream producers at low fiscal cost, but may favor incumbents over entry and impose distortions on downstream sectors. This trade-off echoes Acemoglu et al. (2006), where early development may favor investment over firm selection. The move from price to quality competition likewise rests on rising sunk outlays and comes with rising concentration (Sutton, 1991; 1998). Because basic industries supply strategically important inputs, directing resources upstream may also build geopolitical capacity. By examining how cartels shaped wartime production, we connect them to the accumulation of military and geopolitical power.¹²

Finally, we provide quasi-experimental evidence on the long-run effects of cartels on market development. Cartelization expanded incumbents while generating little entry, contributing to greater concentration (Autor et al., 2020; De Loecker et al., 2020; Kwon et al., 2024), and affected innovation and exporting across a broad range of firms and sectors (Schumpeter, 1942; Arrow, 1962; Aghion et al., 2005; Melitz and Ottaviano, 2008).¹³ Because we directly observe the extensive margin of otherwise clandestine collusion, we can study determinants of cartel formation and stability that are typically latent (Stigler, 1964; Green and Porter, 1984; Igami and Sugaya, 2022). In particular, we identify legal enforceability as a mechanism that increased formation and persis-

¹⁰At a general level, Gerschenkron (1962) emphasized institutional substitutes for the missing prerequisites of late development; Leff (1978) argued that diversified groups internalize missing capital, managerial, and product markets; and Amsden and Hikino (1994) cast them as microeconomic agents of late industrialization, pooling project-execution capabilities. Later work weighs these coordination and capability gains against entrenchment and weakened competition (Khanna and Yafeh, 2007; La Porta et al., 1999; Morck et al., 2005; Schneider, 2013). The vehicles included Japanese *zaibatsu* and postwar *keiretsu*, Korean *chaebol*, Indian managing agencies or business houses, Chinese *qiye jituan*, Indonesian *konglomerat*, Turkish holding companies, and Brazilian and other Latin American *grupos econômicos*/*grupos económicos*; Japan also authorized or tolerated depression, rationalization, export, and administrative-guidance cartels (Tilton, 1996; Schaefer, 2000). These forms were legally distinct—business groups coordinated commonly controlled affiliates, whereas cartels coordinated independent firms—but shared a willingness to trade competition and entry for scale, learning, and investment coordination.

¹¹While tariffs provide another instrument that economizes on fiscal capacity, they might be less suited to targeting upstream sectors in export-oriented economies (Antràs et al., 2024). On the rationale for upstream targeting, see Liu (2019). Evidence that the policy capacity required to effectively target firms and sectors through subsidies and tariffs abounds: see Barwick et al. (2025), Lane (2025), and Choi and Shim (2024).

¹²Our focus is on domestic strategic sectors rather than international alignment (Matray et al., 2026). On German business under war and dictatorship, see Feldman (1966) and Hayes (1987). Post-World War II US cartel policy (Crane, 2023).

¹³Closely related, Moscona (2024) traces how patent protection, another source of market power, raised innovation and downstream productivity in US agriculture, from producers to aggregate output.

tence, highlighting the role of contracts and commitment in development (North, 1990; Greif, 1993; Acemoglu and Johnson, 2005). More broadly, when intertemporal gains are large, organizational forms that bind future conduct may substitute for missing markets (Coase, 1937; Williamson, 1985; Ostrom, 1990; Baker et al., 2002); cartels provided one such form. We thus trace the emergence and consequences of a cooperative system of industrial organization associated with German development and later emulated across late-developing economies (Wade, 1990).¹⁴

2 Institutional Context

We describe the institutional context in three parts: German industrial upgrading and its financing, the rise and legal enforceability of cartels, and a case study of synthetic nitrogen. Additional historical evidence is collected in Appendix B.1.

2.1 Industrial Upgrading and Financing

Industrial upgrading. Germany approached the industrial frontier as a latecomer. In the mid-nineteenth century, its producers relied heavily on technology “borrowed from English and French sources” (Veblen, 1915). Manufacturers initially competed largely through low-cost imitation of established products.¹⁵

In the early twentieth century, the nature of German competition changed markedly. Firms established strong positions in chemicals, electrical engineering, machinery, steel, optics, and shipbuilding, alongside substantial improvements in product quality and proprietary technology. British policy increasingly reflected concern not with imitation but with Germany’s emergence as a technological and industrial rival.¹⁶ Observers warned of a “deliberate and deadly rivalry” for industrial supremacy (Williams, 1896). By 1913, Germany had become the leading industrial economy on the European continent and was approaching Britain in world export markets, with particular strength in advanced industrial sectors (Chandler, 1990; Hesse, 2023).

¹⁴Cartels spread across interwar Europe (Hewitt, 2024), while Japanese industrial policy later drew on German institutional experience (Johnson, 1982). Lenin likewise treated German wartime economic organization as a reference point for planning (Lenin, 1917).

¹⁵The British Merchandise Marks Act of 1887, for example, responded to concerns that imported goods could be mistaken for domestic products by requiring foreign origin to be identified in such cases; “Made in Germany” consequently became a warning label attached to German manufactures (Payn, 1888).

¹⁶Drafted in response to German competition, the British Patents and Designs Act of 1907 required foreign patentees to work their patents domestically or risk revocation absent adequate justification.

Capital requirements. Moving toward the technological frontier required large and sustained capital expenditures (Chandler, 2005). Firms had to finance both technological development and expansion into foreign markets.

German firms invested heavily in industrial experimentation, process development, and commercialization, fostering close links with universities and fundamental research.¹⁷ German scientists won a large share of early Nobel Prizes, especially in chemistry, where many laureates conducted research within or in close connection with industrial firms (Appendix Figure A.2). Capital thus helped connect scientific research to industrial application.

Exporting imposed a second financing demand. Reaching foreign markets required substantial commercial and organizational investment, especially for more sophisticated products. Foreign market entry was therefore itself capital intensive.¹⁸

Technological development and export expansion also had strategic consequences. Innovation created dual-use capabilities, while export success increased dependence on German supply.¹⁹ Industrial upgrading thus increased both German productive capacity and its strategic importance abroad.²⁰

Internal finance. Rapid industrial ascent in Germany took place amid persistent financial frictions. Equity markets were fragmented, and new issuance could dilute control, while bank lending was limited by monitoring and collateral requirements (Tilly, 1982). Retained earnings consequently became an important source of investment finance. In the chemical industry before 1900, internal operating surpluses financed over one-half of expansion (Prion, 1931). Contemporary evidence points to similar retention practices across German industry.²¹ This reliance persisted as German firms approached the frontier and remained important after the First World War, when

¹⁷As frontier research became increasingly capital-intensive, the late nineteenth century saw the “industrialization of invention” (Meyer-Thurow, 1982).

¹⁸Greater product sophistication, including maintenance and servicing requirements, also encouraged joint ventures and direct investment above reliance on exports alone.

¹⁹British observers, for example, raised concerns about reliance on German chemical inputs such as potash and saltpeter (Williams, 1896).

²⁰As foreign governments came to regard these industries as strategically important, restrictions on patents, imports, and market access could further raise the cost of serving foreign markets. The British patent-working requirement of 1907 and later trade barriers, including the Dyestuffs Act of 1920 and the Safeguarding of Industries Act of 1921, reinforced this shift.

²¹One Rhenish ironworks, for example, made it a rule to pay no dividend above 5 percent regardless of earnings, placing the remainder in reserve and investment funds (Williams, 1896).

wartime disruption and postwar inflation left liquid capital scarce (Whale, 1930; Brunnermeier et al., 2025).²² Retained earnings thus directly expanded investment capacity.

2.2 Cartels, Legal Enforceability, and Downstream Bargaining

Cartels. Reliance on retained earnings sat uneasily with the competitive environment of German industry under the imperial trade code of 1869 (Pierenkemper, 2007). Contemporaries increasingly described pressure on prices and margins as “ruinous competition,” often linking it to excess capacity and contrasting it with stabilization (Schmoller, 1894).²³ Margin compression also reduced the resources available for investment.

Cartels provided a contractual mechanism for limiting competitive pressure. A cartel coordinated prices, output, or sales among otherwise independent firms.²⁴ Early arrangements were modest: local coal and salt syndicates coordinated terms through ad hoc contracts (Marburg, 1964).

Variation and legal enforceability. Cartel organization varied substantially along three dimensions: across products and regions, across legal forms, and over time in enforceability. First, agreements were typically organized by product and region, reflecting markets deeply segmented by transport costs, commercial practice, and the legacy of separate states (Liefmann, 1905; Wolf, 2009).

A second source of variation originated in the legal environment. No general cartel law existed, so agreements fell under a patchwork of contract, association, and other private-law rules that differed across regions and organizational forms (Langhorst, 1926; Nörr, 1994). Before the Civil Code took effect in 1900, private law itself varied territorially; codification unified much of private law, but association law remained regionally specific thereafter (Zeller, 1895; Guinnane, 2020).

Third, enforceability changed over time through discrete and often unexpected shifts. Through the 1880s, cartels relied largely on voluntary adherence and mutual interest, and members who violated quotas were seldom compelled to comply (Kestner, 1912). Early Imperial Court decisions suggested that collective restraints on price undercutting could be consistent with freedom

²²The importance of self-financing persisted well beyond our period of analysis: between 1954–68, internal funds financed roughly 80% of gross investment (Tilly, 1980).

²³Related arguments appear in Kuznets (1930) and Kaldor (1935).

²⁴We follow the contemporary definition of a cartel as an “association between independent firms of the same industry, formed for the purpose of market influence” (Liefmann, 1905, p. 9). Unlike merger, cartelization coordinated market conduct while preserving separate ownership and control.

of trade, but the scope of enforceability remained uncertain.

A more decisive break occurred in 1897, in a dispute among Saxon wood-pulp producers. Their cartel was an unincorporated association that assigned each member a production quota and required all output to be sold through a joint sales office (*Verkaufsstelle*); a member who sold outside it owed a contractual penalty of thirty marks per ton. When one member sold on its own account, the cartel sued to collect the penalty. The member argued that the penalty was void, invoking the guarantee of freedom of trade in the imperial trade code (§152 of the *Gewerbeordnung*), which had until then been read to leave such restraints unenforceable. The Imperial Court rejected this defense, the first time it had done so: freedom of contract allowed firms to bind their own commercial conduct, so the penalty was valid and enforceable (Nörr, 1994). The ruling thus placed freedom of contract above an unrestricted freedom to compete, and it made the exclusive-sales obligation of a joint sales office something a court would uphold. Contemporaries described the subsequent spread of cartels as proceeding “like lightning” (Schäffle, 1898).

Subsequent decisions altered enforceability unevenly. Courts revisited penalties and boycotts, withdrawal rights, and regional association statutes, sometimes overturning prior interpretations (Langhorst, 1926). Enforceability therefore advanced through discrete legal shifts rather than a smooth process of convergence.

The Cartel Decree of 1923 marked another institutional break. It created a specialized Cartel Court and introduced the first general rules governing cartel conduct (Goldbaum, 1924). Although formally directed against the misuse of economic power, the decree primarily institutionalized cartel contracting by requiring written agreements and creating a dedicated forum for disputes. Cartel agreements continued largely to be upheld (Langhorst, 1926). Some firms moved toward tighter coordination through *Interessengemeinschaften* (communities of interest), which combined operations and divided earnings while stopping short of full merger (Friedländer, 1921).

Downstream bargaining. Upstream coordination, however, created scope for mutually beneficial bargaining with downstream industry. On the one hand, downstream producers sought relief from cartel input prices; on the other, cartels could profitably expand sales if additional output could be placed without undermining coordinated prices. This created a role for negotiation across stages of production. Such bargaining often produced nonlinear pricing arrangements: high

posted prices were combined with rebates or discounts tied to use, destination, or additional purchases. These schemes allowed cartels to preserve coordinated prices while expanding sales to downstream buyers.

A decisive shift in the stability of these cross-sector agreements came in 1903–1904, when the German Ministry of the Interior organized “adversarial hearings” that brought cartel members and downstream producers into non-binding negotiations mediated by experts and public officials (Reichsministerium des Innern, 1906). These proceedings increasingly formalized vertical bargaining over such pricing arrangements alongside horizontal coordination within cartels.

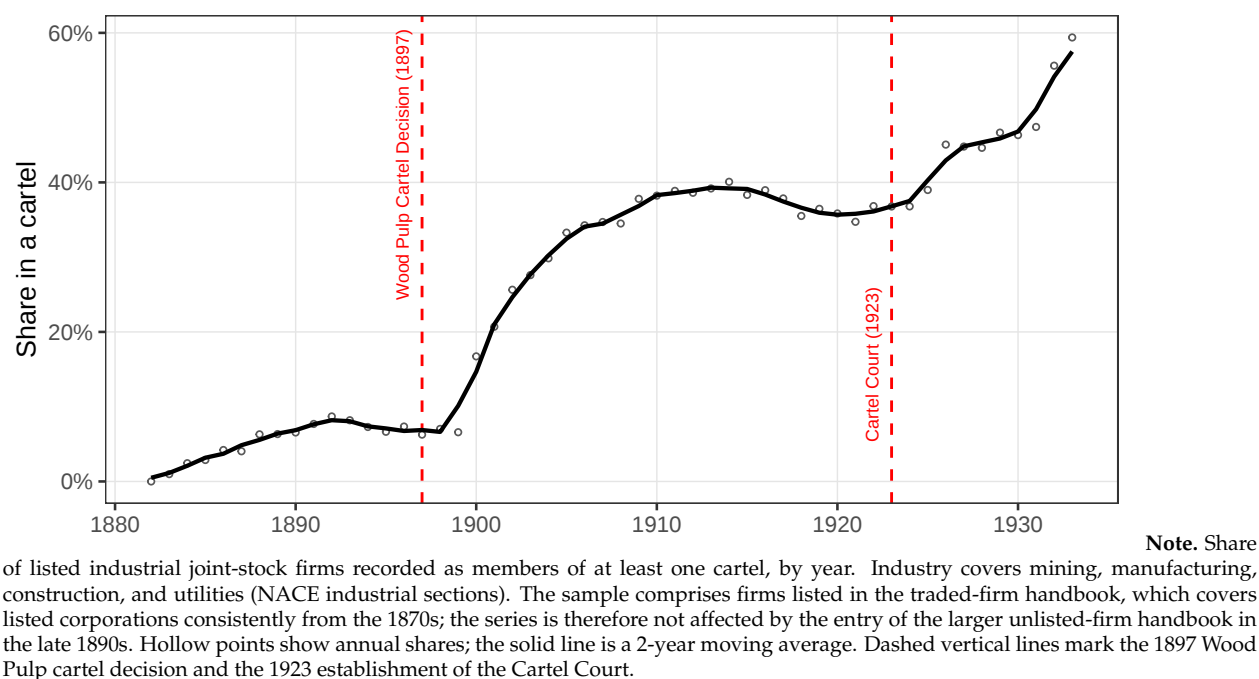
Why did courts and public authorities tolerate, and at times facilitate, these horizontal and vertical agreements? One answer lies in a broader acceptance of private ‘rationalization’ as a middle course between unrestricted competition and direct state planning (Sombart, 1928). In this model, organized industry was largely left to govern itself, while the state mediated conflicts and set the rules of coordination (Langhorst, 1926; Marburg, 1964). This approach also reflected a broader concern with national economic strength: industrial coordination supported domestic productive capacity, which in turn carried strategic value (Gerber, 2001).²⁵ Direct state intervention nevertheless remained exceptional, concentrated above all in the compulsory potash and coal syndicates during the First World War (Tosdal, 1913; Levy, 1935).

By the 1930s, Germany was widely described as a land of cartels, with more than half of industrial output organized through such arrangements (Chandler, 1990). This broader model of organized industry also became an important reference point abroad.

Figure 1 documents the spread of cartel membership among listed industrial firms. The share belonging to at least one cartel rises from 0% to 57% over the sample period, with particularly sharp increases around 1900 and in the early 1920s.

²⁵The case for autonomous national productive capacity can be traced to List (1841). In 1891, Chancellor Caprivi explicitly linked expansion of this capacity to the imperative to “export goods” (Torp, 2010).

Figure 1: Cartel Membership among Listed Industrial Firms



2.3 Case Study: Synthetic Nitrogen

Synthetic nitrogen fixation shows the same sequence at the level of a single group of firms. Around 1900 rising food demand strained the world supply of nitrogen fertilizer, then drawn largely from Chilean saltpeter shipped across the Atlantic;²⁶ fixing nitrogen from the air promised to free European agriculture from that dependence. Fixing nitrogen at industrial scale took a long and capital-intensive effort across competing, uncertain technologies that arm's-length capital markets financed poorly. The episode can be followed closely, from digitized corporate accounts, financing records, patents, prices, and production statistics (Figure 2).

The German dye industry had by then competed prices down toward cost in the manner contemporaries called ruinous, and its leading firms sought relief in combination. Amid the greater contracting certainty the court decisions had brought, in 1905 the dye makers BASF and Bayer, with the smaller Agfa, pooled their profits in fixed quotas of 43, 43, and 14 percent (Abelshauser et al., 2004; Plumpe, 2016). Market power in their established products, synthetic dyes and indigo above all, held prices above cost and generated rents whose static burden fell on the buyers of dyes.

²⁶Appendix Figure A.3 shows the caliche fields of the Atacama from which that saltpeter came.

These rents increased retained earnings at the partner firms, which turned them to a newer line of business. Panel A of Figure 2 shows the nitrogen program financed mainly from retained earnings, with coordinated capital raises and partner-guaranteed state loans rather than arm's-length markets, through years when external capital was scarce: a stake in Norwegian arc-nitrogen production, a Ruhr colliery to secure energy inputs, and the first full-scale synthetic-nitrogen plants at Oppau and Leuna.²⁷

Innovation followed the investment. Panel B of Figure 2 shows nitrogen-chemistry patents rising from about twenty a year in the 1890s to over two hundred by the late 1920s, accelerating after BASF placed the chemist Fritz Haber under contract in 1908; his laboratory synthesis of ammonia became the industrial Haber–Bosch process by 1912. Output and prices moved with it. The real price of fixed nitrogen fell by about half by the late 1920s (Panel C), and synthetic output overtook Chilean nitrate around 1920 (Panel D), consistent with the scale-up of a lower-cost process, though the records show prices and quantities rather than the unit costs that would confirm it. Synthetic nitrogen displaced Chilean imports and secured an input the state came to rely on in wartime.

The nitrogen combination joined two forms of coordination. Horizontally, the partner firms pooled their operations, first in an enlarged *Interessengemeinschaft* of the dye industry, a profit-pooling combination short of full merger,²⁸ and, from 1919, in the German Nitrogen Syndicate, which brought the competing nitrogen producers under a single agreement. Vertically, the same syndicate incorporated the downstream side, seating the Reich, agriculture, and organized labor on its board.²⁹ The vertical arrangement had a specific purpose. Its founding terms set the conditions of downstream trade: governance representation for buyers, transparent prices, a state veto over price increases, and distribution through farmer organizations. A cartel supplying an essential input cannot credibly promise to hold prices down once buyers depend on it, so efficient downstream terms are not self-enforcing. With the state a party to the agreement, those terms held: the syndicate kept to negotiated prices, passing the cost reductions through to farmers while

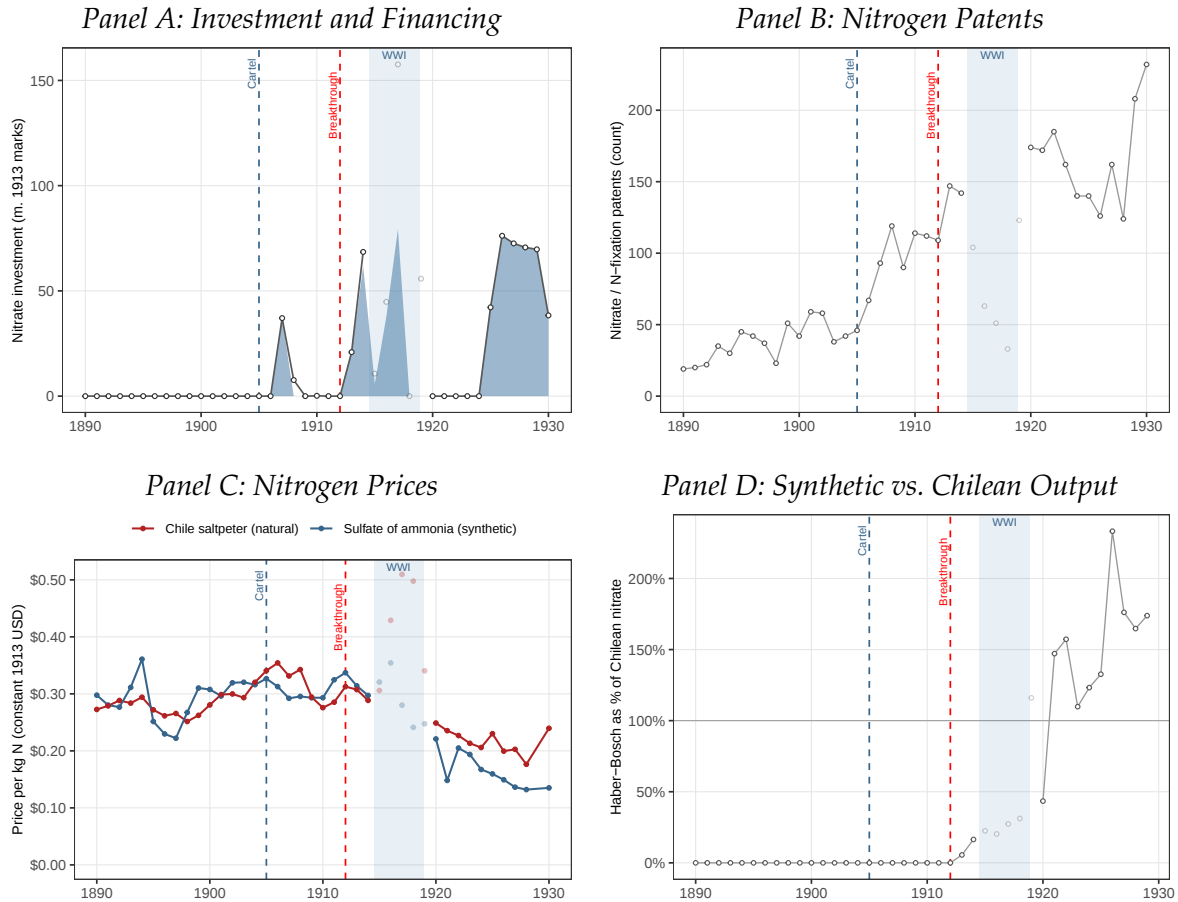
²⁷Three rival nitrogen-fixation technologies competed at the time, and the partners invested across all of them, which raised the cost of the program. Electric-arc fixation was associated with Kristian Birkeland, Sam Eyde, and Norsk Hydro; calcium cyanamide with Adolf Frank and Nikodem Caro; and direct ammonia synthesis with Fritz Haber and Robert Le Rossignol, industrialized by BASF.

²⁸The Hoechst–Cassella–Kalle group and the Weiler-ter-Meer works joined the enlarged *Interessengemeinschaft* in 1916, and Griesheim-Elektron followed in 1917; the combination became the nucleus of *IG Farben* in 1925.

²⁹The syndicate did not sell directly to farmers at first. Its output was channeled by contract: 50 percent through the German farmers' purchasing association, 10 percent through the agricultural trade bank (*Delhabank*), 10 percent to compound-fertilizer manufacturers, and 30 percent through the existing BASF and DAVV sales organizations.

preserving the rents that financed upstream investment.

Figure 2: Cartels, Financing, and Synthetic Nitrogen



Note. Case study of synthetic nitrogen, reconstructed from corporate accounts, financing records, patents, prices, and production statistics. Panel A: annual flow of investment into synthetic-nitrogen research and capacity (million constant 1913 marks, deflated by the German consumer price index from the Jorda-Schularick-Taylor macrohistory database), with the cartel-financed part shaded; from a manually curated financing database, in which retained earnings are counted as cartel-financed. Panel B: count of nitrogen-chemistry patents (CPC subclasses C01B/C01C/C05C) per year in the digitized Patentblatt corpus. Panel C: price of contained nitrogen (constant 1913 USD per kg N) for natural Chile saltpeter and synthetic sulfate of ammonia, from Chemiker-Zeitung trade quotes. Panel D: world Haber-Bosch nitrogen as a percent of Chilean nitrate nitrogen. Dashed lines mark the 1905 cartel agreement and the 1912 Haber-Bosch breakthrough; the band marks the First World War, whose years are drawn faint and left out of the connecting line.

3 A Model of Cartels and Investment Finance

The model has two periods, one upstream sector, one downstream buyer, and a single conduct parameter. A cartel raises current profit and withholds current output. When external finance is scarce, the retained profit can pay for cost-reducing investment that the upstream sector could not otherwise fund. Market power therefore trades a static loss today against a dynamic gain tomorrow. The surplus-maximizing degree of market power balances the two; it rises as external finance

grows scarcer and as the social discount factor rises. A two-part tariff between the upstream sector and the buyer removes the period-2 loss without removing the period-1 funds. Enforcing cartel agreements can then serve as a second-best industrial policy.

3.1 Setup

An upstream sector sells to a downstream buyer over two periods, $t = 1, 2$, under complete information. The buyer has quasilinear payoff $V(Q_t) + x_t$, with x_t the numeraire, giving inverse demand $P(Q) = V_Q(Q)$ with $V_Q > 0 > V_{QQ}$. Period costs are $C_1(Q)$ and $C_2(Q, I)$, with marginal cost constant or increasing in output. Investment $I \geq 0$, chosen in period 1 at unit price, lowers period-2 total and marginal cost: $C_{2,I} < 0$ and $C_{2,QI} < 0$.

Upstream conduct is indexed by $\mu \in [0, 1]$, with $\mu = 0$ competition and $\mu = 1$ monopoly; we call any setting with $\mu > 0$ a cartel. Conduct is set once and holds across both periods, the outcome of a durable commitment or control structure rather than a choice made anew once investment is sunk.³⁰ Period- t output solves the conduct equation

$$V_Q(Q_t) + \mu V_{QQ}(Q_t) Q_t = C_{t,Q},$$

which nests competition at $\mu = 0$ and monopoly at $\mu = 1$; market power contracts output and raises operating profit for $\mu < 1$.³¹

3.2 Market Power, Profits, and Investment

Retained profit can fund investment. The private marginal value of investment is

$$\Pi_{2,I}(\mu, I) = \underbrace{-C_{2,I}}_{\text{cost saving}} + \underbrace{[(1 - \mu)V_{QQ}Q_2]}_{\text{margin on induced output}} Q_{2,I}, \quad (1)$$

³⁰The commitment may be sustained by state enforcement of a private conduct agreement, up to some admissible level, or by persistent ownership and control. Appendix C.4 provides an oligopoly foundation: n sellers with profit internalization $\lambda \in [0, 1]$ give $\mu = \frac{1+\lambda(n-1)}{n}$.

³¹Induced outputs are positive, locally unique, and differentiable, with $Q_{1,\mu} < 0$, $Q_{2,\mu} < 0$, and $Q_{2,I} > 0$, by the standard local stability condition $(1 + \mu)V_{QQ}(Q_t) + \mu V_{QQQ}(Q_t)Q_t - C_{t,QQ} < 0$. Operating profits are $\Pi_1(\mu) = P(Q_1)Q_1 - C_1(Q_1)$ and $\Pi_2(\mu, I) = P(Q_2)Q_2 - C_2(Q_2, I)$, with period-2 profit concave in investment, $\Pi_{2,II} < 0$. The conduct equation gives the envelope conditions $\Pi_{1,\mu} = (1 - \mu)V_{QQ}(Q_1)Q_1$ and $\Pi_{2,\mu} = (1 - \mu)V_{QQ}(Q_2)Q_2$, both positive for $\mu < 1$ and zero at $\mu = 1$.

the cost saving plus the induced output valued at marginal revenue net of marginal cost, so the second term is nonpositive and zero at $\mu = 1$.

In period 1 upstream can borrow $b \geq 0$ at the gross market rate $1 + r$, so the market discount factor is $\delta \equiv 1/(1 + r) \in (0, 1]$. Unconstrained investment $I^p(\mu; r) = \arg \max_{I \geq 0} \{-I + \delta \Pi_2(\mu, I)\}$ has an interior maximum at $\delta \Pi_{2,I} = 1$.³²

Assumption 1 (Financial constraints). *External finance is limited: upstream borrows at most B , $b \leq B$. Investment cannot exceed internal funds plus external finance, $I \leq B + \Pi_1(\mu)$.*³³

Actual investment is unconstrained investment capped at the financeable bound,

$$I(\mu) = \min\{I^p(\mu; r), B + \Pi_1(\mu)\}, \quad (2)$$

giving a finance-constrained regime ($I = B + \Pi_1$) and an unconstrained one ($I = I^p$, including no investment, $I^p = 0$).³⁴

Assumption 2 (Binding finance). *The financeable bound in (2) binds for every $\mu \in [0, 1]$: $I(\mu) = B + \Pi_1(\mu) \leq I^p(\mu; r)$, equivalently $\delta \Pi_{2,I}(\mu, I(\mu)) \geq 1$, so upstream would invest more if it could. Then $I_\mu = \Pi_{1,\mu} \geq 0$ (zero at $\mu = 1$) and $I_B = 1$.*

We maintain binding finance throughout: investment has a high private return but external finance is limited, so a marginal unit of retained profit goes to investment.³⁵

Along the constrained path, market power raises operating profit and the investment it finances, lowers period-2 marginal cost, and raises period-2 profit.³⁶

³²The loan and its repayment are transfers that cancel out: the numeraire x_t nets the loan and the dividend period by period, so neither enters total surplus.

³³Upstream cannot issue equity, so period-1 dividends are nonnegative, $D_1 = \Pi_1(\mu) - I + b \geq 0$, giving $I \leq \Pi_1(\mu) + b$. Since $\delta(1 + r) = 1$, the receipt and repayment of the loan cancel in present value, so borrowing only relaxes the period-1 constraint; upstream borrows up to B and invests subject to $I \leq B + \Pi_1(\mu)$.

³⁴ $I^p = 0$ when upstream appropriates nothing at competition, $\Pi_{2,I}(0, \cdot) = 0$, e.g. under constant marginal cost and no fixed cost, where price equals marginal cost (Appendix C.5).

³⁵The regime arises when upstream also sells in a price-taking outside market that adds $A\phi(I)$ to period-2 profit, with scale $A \geq 0$ and $\phi_I > 0$, $\phi_{II} \leq 0$: at $I = B + \Pi_1(\mu)$ finance binds whenever $\delta[\Pi_{2,I}(\mu, I) + A\phi_I(I)] \geq 1$, and the left-hand side rises in A , so a larger outside market makes binding finance more likely.

³⁶In the constrained regime these comparative statics hold at any level of μ . Operating profit rises with market power, $\Pi_{1,\mu} > 0$ for $\mu < 1$ by the envelope condition; and so does the investment financed by those retained earnings, $I_\mu = \Pi_{1,\mu}$ (Assumption 2). Marginal cost $C_{2,Q}(\cdot, I)$ falls with μ because $C_{2,QI} < 0$ and $I_\mu > 0$. Period-2 profit rises as well, $d\Pi_2/d\mu = \Pi_{2,\mu} + \Pi_{2,I}I_\mu > 0$ for $\mu < 1$, with $\Pi_{2,\mu} \geq 0$ by the envelope condition and $\Pi_{2,I} > 0$ by Assumption 2.

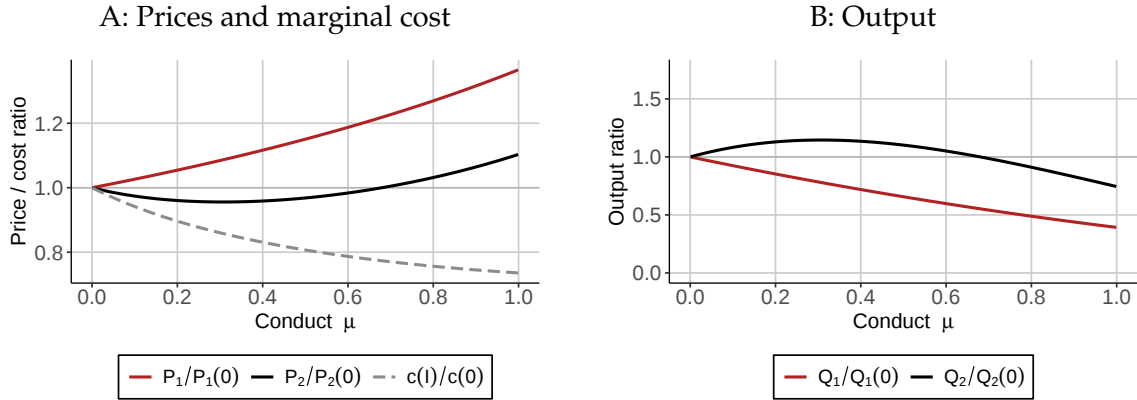
Proposition 1 (Output and prices under market power). *At an interior, finance-constrained $\mu \in (0, 1)$, in period 1 market power contracts output and raises price, $Q_1(\mu) < Q_1(0)$ and $P_1(\mu) > P_1(0)$. In period 2 two forces work against each other,*

$$\frac{dQ_2}{d\mu} = \underbrace{Q_{2,\mu}}_{<0} + \underbrace{Q_{2,I} \Pi_{1,\mu}}_{>0}.$$

If period-2 marginal profit under conduct μ is strictly decreasing in Q , period-2 output can rise above its competitive level, $Q_2(\mu, I(\mu)) > Q_2(0, I(0))$. This occurs when the cost reduction at $Q_2(0, I(0))$ exceeds the market power wedge at that output. Prices fall below competitive levels, $P_2(\mu) < P_2(0)$, under the same condition.

The period-1 term is the static contraction. In period 2 the financed investment works against it, so output can exceed, and price fall below, the competitive levels. Figure 3 plots both periods; Appendix Figure A.5 decomposes the two period-2 terms and plots the investment response.

Figure 3: Prices and Output under Market Power



Note. Each panel plots against market power μ over $[0, 1]$, at the calibration of Appendix Table C.1. Prices and marginal cost (A) and output (B) are each relative to their $\mu = 0$ value, for periods 1 and 2.

3.3 Investment Wedge and Surplus

Differentiating period-2 surplus $V(Q_2) - C_2(Q_2, I)$ with respect to I at fixed conduct gives the marginal social value of investment,

$$S(\mu, I) \equiv \underbrace{-C_{2,I}}_{\text{cost saving}} + \underbrace{[-\mu V_{QQ} Q_2] Q_{2,I}}_{\text{value of output expansion}}. \quad (3)$$

Proposition 2 (Investment wedge). *Private and social marginal values of investment differ by the downstream surplus on the investment-induced output,*

$$S(\mu, I) - \Pi_{2,I}(\mu, I) = -V_{QQ}(Q_2)Q_2 Q_{2,I} = (P_2 - \text{MR}_2) Q_{2,I} > 0, \quad (4)$$

for any demand with $V_{QQ} < 0$, where $P_2 = V_Q(Q_2)$ and $\text{MR}_2 = V_Q(Q_2) + V_{QQ}(Q_2)Q_2$ are price and marginal revenue. The cost saving $-C_{2,I}$ is internalized in full; private and social marginal values differ on the investment-induced output, which upstream values at marginal revenue only.³⁷

Upstream values the output that investment adds at marginal revenue rather than price, so its marginal valuation of investment falls short of the social one. Its markup over marginal cost is a second distortion, a tax on downstream production. Both distortions fall on the downstream buyer.

Total surplus, with period-2 flows discounted at the social factor $\beta \in (0, 1]$, is

$$W(\mu) = V(Q_1) - C_1(Q_1) - I(\mu) + \beta[V(Q_2) - C_2(Q_2, I(\mu))]. \quad (5)$$

Proposition 3 (Marginal effect on surplus). *The marginal effect of market power on surplus splits into a dynamic gain and a static loss,*

$$W_\mu(\mu) = G(\mu) - L(\mu), \quad G \equiv [-1 + \beta S(\mu, I(\mu))] I_\mu, \quad L \equiv L_1 + \beta L_2, \quad (6)$$

where the loss in each period is $L_t \equiv [-\mu V_{QQ}(Q_t)Q_t](-Q_{t,\mu}) \geq 0$, the markup multiplied by the output withheld. Both L_1 and L_2 vanish at competition, so $L(0) = 0$.

The dynamic gain G is the value of the investment financed by market power: the discounted social return βS net of the unit cost of investment, scaled by how much market power relaxes the constraint, I_μ . Appendix Figure A.4 plots total surplus and the two components against μ .

Proposition 4 (Suboptimality of competition). *Let $\mu^W \in \arg \max_{[0,1]} W$. Under Assumption 2, $L(0) = 0$. The social value of output expansion vanishes at $\mu = 0$ where the markup is zero, so $S(0, I(0))$ reflects*

³⁷Whether upstream underinvests or overinvests in levels is a distinct question; when the market discount factor exceeds the social one, upstream can overinvest in levels even though $\Pi_{2,I} < S$ pointwise.

the cost saving alone. Then competition is not a local optimum, $W_\mu(0) > 0$, if and only if the discounted gross social return to the financed investment exceeds its immediate cost,

$$\beta S(0, I(0)) > 1. \quad (7)$$

Corollary 1 (Suboptimality of monopoly). *Under Assumption 2, at $\mu = 1$ market power no longer relaxes the finance constraint, $I_\mu(1) = \Pi_{1,\mu}(1) = 0$ by the envelope condition, so $G(1) = 0$ while $L(1) > 0$. Hence $W_\mu(1) = -L(1) < 0$ and $\mu^W \neq 1$: monopoly adds no further investment yet still bears a static loss.*

Corollary 2 (Interior optimum). *If W_μ is continuous and strictly decreasing on $(0, 1)$, then with $W_\mu(0) > 0$ (Proposition 4) and $W_\mu(1) < 0$ (Corollary 1) there is a unique interior maximizer $\mu^W \in (0, 1)$, at which the dynamic gain equals the static loss, $G(\mu^W) = L(\mu^W)$.³⁸*

Remark 1 (Two channels: financing and appropriability). Under binding finance, upstream invests up to the financeable bound. Market power expands investment by raising period-1 profit, supplying the *funds* to invest. A distinct channel operates when finance is slack but upstream appropriates nothing at $\mu = 0$, so it has no incentive to invest (e.g. at constant marginal cost and no fixed cost, $I^p(0) = 0$). In this case, competition is a local optimum, $W_\mu(0) = 0$, yet can be globally dominated because market power supplies the *incentive* to invest. Appendix C.5 formalizes this appropriability channel. Our baseline results focus on the financing channel.

3.4 Comparative Statics

Two comparative statics of the surplus-maximizing degree of market power follow: in external finance B and in the social discount factor β .

Proposition 5 (Scarce finance and a high discount factor raise optimal market power). *At an interior, finance-constrained μ^W with $W_{\mu\mu}(\mu^W) < 0$, the sign of $d\mu^W/dx$ is that of $W_{\mu x}(\mu^W)$.³⁹ A higher discount factor raises optimal market power. When investment has diminishing returns ($S_I \leq 0$, $L_{2,I} \geq 0$,*

³⁸This monotonicity is a further regularity condition on demand and cost curvature, as is $W_{\mu\mu}(\mu^W) < 0$ in Proposition 5.

³⁹The market rate does not move optimal market power: in the constrained regime $I_r = I_{\mu r} = 0$, so $d\mu^W/dr = 0$ and upstream already invests up to the financeable bound.

one strict), scarcer external finance raises it as well:

$$\frac{d\mu^W}{d\beta} > 0, \quad \frac{d\mu^W}{dB} < 0. \quad (8)$$

Appendix Figure A.8 plots μ^W as B and β vary.

3.5 Efficient Contracting

In the baseline, upstream sells at the linear price $P(Q_t)$ in each period. In period 2, once investment is sunk, that price holds trade below the efficient level. A two-part tariff removes this loss while leaving the period-1 funds in place. The efficient period-2 quantity $Q^E(I)$ equates marginal value and marginal cost, $V_Q(Q^E) = C_{2,Q}(Q^E, I)$. Define the period-2 surplus gain from efficient trade by

$$\Delta(\mu, I) \equiv [V(Q^E(I)) - C_2(Q^E(I), I)] - [V(Q_2(\mu, I)) - C_2(Q_2(\mu, I), I)].$$

Since $Q^E(I)$ maximizes period-2 total surplus given investment I , the recovered surplus $\Delta(\mu, I)$ is nonnegative, with equality when the conduct allocation is already efficient.

Proposition 6 (Efficient vertical terms raise surplus). *Fix a conduct level μ and maintain binding finance (Assumption 2). Suppose the parties can commit to an enforceable two-part tariff for period-2 trade, $\mathcal{T}(Q) = wQ + T$. Setting the marginal price to $w = C_{2,Q}(Q^E(I(\mu)), I(\mu))$ implements efficient period-2 trade, $Q^E(I(\mu))$. The fixed fee T is a lump-sum transfer, so it can be set to leave both parties at least as well off as under linear pricing. Therefore*

$$W^C(\mu) = W(\mu) + \beta \Delta(\mu, I(\mu)) \geq W(\mu).$$

The gain $\beta \Delta(\mu, I(\mu))$ is the period-2 surplus recovered by replacing conduct pricing with efficient vertical trade.

The contract is a Pareto improvement over linear pricing, but it is not self-enforcing.⁴⁰ Because finance binds, investment stays at $B + \Pi_1(\mu)$, set by period-1 profit and unchanged

⁴⁰At the efficient marginal price $w = C_{2,Q}(Q^E, I)$ upstream earns no margin on the marginal unit, and none on any unit when marginal cost is constant; absent commitment it would raise the price ex post, and anticipating this the parties revert to linear pricing.

by the period-2 terms. Define $S^C(I) \equiv -C_{2,I}(Q^E(I), I)$, the marginal social value of investment under efficient period-2 trade. Given investment, period-2 trade is undistorted, so $W_\mu^C(\mu) = [-1 + \beta S^C(I(\mu))] I_\mu - L_1(\mu)$. Only the period-1 static loss remains.

3.6 Mapping the Model to the Empirics

Cartel membership corresponds in the model to a move of the conduct index from $\mu = 0$ to $\mu > 0$. Three predictions follow, for cartel members, for downstream firms, and for districts and markets.

Prediction 1 (Cartel Members). Under binding finance, market power raises operating profit, investment, and period-2 profit, and, under the condition of Proposition 1, period-2 output (Section 3.2). A cartel member should therefore upgrade its plant and products and expand its scale, and it should do so out of retained profit rather than distributed earnings. Cost-reducing investment in the model corresponds to upgrading, and larger period-2 output to scale; Section 4.1 describes how we measure each, and how we measure the financing channel through investment, retained earnings, profit, and dividends.

The gain from market power is a financing gain, so it should be largest where the constraint binds hardest. By Proposition 3, the dynamic gain $G = [-1 + \beta S] I_\mu$ rises with the social return to investment. By Proposition 5, the surplus-maximizing degree of market power rises as external finance grows scarcer. The association between cartel membership and expansion should therefore be stronger in capital-intensive industries, where outlays are large and external finance scarce. It should also be accompanied by the ties through which firms fund and govern investment, interlocking directorates and bank connections, which we expect to grow denser with cartel membership.

Prediction 2 (Downstream Firms). An upstream markup raises the input price of downstream firms, which cut output (Proposition 1). In period 2 the upstream price can fall below its competitive level (Proposition 1), so the sign of the downstream association can reverse. A two-part tariff between the cartel and its buyers (Proposition 6) removes the period-2 markup and strengthens the reversal. We map period 1 to the years before agreements between cartels and their buyers became common and period 2 to the years after, a date Section 2.2 places at the adversarial hear-

ings. Exposure to cartelized inputs, defined in Section 4.1, should then be associated with lower downstream output and employment in the first period and with higher output and employment in the second.

Prediction 3 (Districts and Markets). The model has one upstream sector. Reading its cartel as the incumbents of a district or market, and firms outside the agreement as entrants, rents channeled to constrained producers finance capacity among incumbents while the static loss falls on buyers and on firms outside the agreement. At the level of districts and markets, cartel presence should therefore be associated with higher industrial employment together with lower entry, higher incumbent survival, and higher concentration.

The model also carries a policy reading that we do not test. State enforcement of cartel agreements moves rents to constrained producers without a budgetary transfer, though the static loss remains. Where direct subsidies are unavailable, such enforcement can serve as a delegated, second-best industrial policy. It pays only if the financed investment lowers cost by more than the static loss, that is, if rents turn into productivity and downstream losses stay contained.

Section 5 examines Prediction 1, Section 6.1 Prediction 2, and Section 6.2 Prediction 3.

4 Data and Empirical Strategy

4.1 Data

Units. Our data originate in the digitization and linkage of a large collection of primary sources. Appendix D describes each source and construction procedure in detail; here we summarize the main components. The analysis uses four units: firms, years, industries, and geographies. A firm (i) is a German joint-stock company, and a year (t) is a calendar year between 1882 and 1933. We assign each firm to four-digit NACE codes and to the municipality of its headquarters.⁴¹ For the analysis, we aggregate firms into a primary NACE three-digit category (industry s), and into district geographic units (geography d). A market is the intersection of an industry and a geography

⁴¹We map each of the 77,326 municipalities to one of the 928 Imperial German counties as of 1882. Counties nest within 89 districts and 26 states; Appendix Figure D.2 maps these four geographic levels. For each firm we also collect a large set of geographic and industry-level covariates, from county characteristics and distances to the seats of the legal system to industry characteristics such as capital intensity and product homogeneity, which serve as controls and as dimensions of heterogeneity.

(Wolf, 2009).

Firm panel. We construct the firm panel from two investor manuals, *Saling's Börsen-Jahrbuch* (Hertslet et al., 1882–1933) and the *Handbuch der deutschen Aktiengesellschaften* (Thieme, 1897–1933). Together, they provide annual coverage of listed and unlisted joint-stock firms. We digitize each firm entry and extract structured information on operations, balance sheets, income statements, executives, and supervisory-board members. The resulting unbalanced panel contains 27,949 firms and 377,667 firm-years. Coverage differs across outcomes: only select volumes reported physical output and employment, and not every volume reported dividends, so the samples below vary by outcome and each estimate uses the firm-years for which its outcome is observed.

Cartel membership. We classify firm i as a cartel member in year t if it belonged to at least one cartel that year. We compile cartel names from the *Kartell-Rundschau*, a trade journal reporting formations, dissolutions, and membership changes (Tschierschky and Borger, 1903–1929), supplemented by three cross-sectional surveys (Reichsministerium des Innern, 1906; Silberberg, 1910; Wagenführ, 1931). We then match these names to the operations abstracts in the investor manuals.⁴² This procedure links 8,336 firms to 5,651 distinct cartels. For each cartel we also record, from the same sources, its founding year and how it bound its members: by price agreements, production quotas, or sale through a common sales syndicate.

Court decisions. To measure changes in cartel enforceability, we digitize reported decisions from the two courts governing cartel law: 5,688 decisions of the Imperial Court through 1923 (Reichsgericht, 1882–1933) and 172 decisions of the Cartel Court thereafter (Reichsverband der Deutschen Industrie, 1924–1933). For each decision we record the parties with their industries and locations, the question decided, and the ruling, and we assign the decision to the judges who sat on the deciding senate. For each judge we geocode the places of birth, death, and legal training.

Main firm outcomes. Two groups of outcomes measure upgrading and scale. *Upgrading.* We measure upgrading toward the technological and export frontier through (i) an indicator of

⁴²Because cartel membership could affect firm prospects, the handbooks reported cartel affiliations. Wartime U.S. intelligence relied on the same feature, noting that the *Handbuch* carried “a statement concerning the principal price and market-regulating associations to which a corporation belonged” (OSS, 1944, p. vi).

whether the firm was granted at least one patent in the year, matched by firm name to the *Reichspatentblatt* (Reichspatentamt, 1918–1933), and (ii) an indicator of whether the operations abstract of the firm reports export activity. *Scale*. We measure the scale of production through (iii) physical output, (iv) employment, and (v) capital. Output requires the most construction. Firms report physical quantities in heterogeneous units, so we take the dominant physical dimension of each firm, harmonize convertible units to a common base, and sum over the items within it; where a firm reports no physical quantity, we fall back to its real revenue and then to its real wage bill. Employment is the total headcount, taken as the reported total where available and otherwise as the sum of workers, salaried employees, and officials. Capital is the share capital of the firm at year end, a stock, in constant 1913 marks. Output and employment are reported for fewer firm-years than the other outcomes; for both, we interpolate isolated interior gaps in the reported series so that all specifications share a common coverage.

Financing outcomes. Four outcomes follow the financing channel of the model. Investment is the count of distinct financial holdings the firm carries at year end, a stock and the empirical proxy for the investment flow of the model. Retained earnings are the balance-sheet reserves, a stock. Profit is the net earnings reported in the income statement, and dividends the distributed payout, both flows. All money amounts are in constant 1913 marks.

Organizational outcomes. From the board rosters we count, for each firm and year, the interlocking directors (those who also sit on the board of another firm, cartel member or not) and the directors affiliated with a bank, with the state, or with science or engineering, identified from the offices and titles attached to their names in the rosters.

Input–output linkages. To measure spillovers to firms outside cartels, we use the input–output table of German industry for 1936 (Fremdling and Staeglin, 2014), the earliest such table available for Germany. Combining its input weights with time-varying cartel shares by industry gives, for each firm, an exposure to cartelized inputs. Section 6.1 defines this measure and uses it.

Industrial censuses. We assemble a county–industry panel of employment from the five industrial censuses of 1882, 1895, 1907, 1925, and 1933.

War-economy records. From declassified records covering military procurement, secret war patents, and wartime production boards, we construct three firm-level indicators of involvement in the war economy of 1914–18: whether the firm held a military procurement contract, whether it held a secret war patent, and whether one of its directors sat on a war board.

4.2 Empirical Strategy

Our first design aims to compare firms entering cartels with otherwise similar firms before and after cartel formation. As described in Section 2.2, the setting provides substantial variation in cartels across products, regions, and over time, reflecting historical economic and legal fragmentation. Cartel organization therefore differed substantially across products and regions, while discrete changes in enforceability generated uneven shifts over time. This variation is visible in our data. Cartel formation occurred in distinct waves rather than evolving smoothly, with pronounced increases around major shifts in legal enforceability (Figure 1). Membership also varied substantially across geography (Figure 4, Panel A).

We begin by using this variation across the full sample of firms. For firm i in year t ,

$$y_{it} = \beta D_{it} + \alpha_i + \delta_t + \varepsilon_{it}, \quad (9)$$

where y_{it} is a firm outcome, D_{it} indicates cartel membership in year t , α_i denotes firm fixed effects, and δ_t year fixed effects. Firm fixed effects absorb time-invariant differences across firms, while year fixed effects absorb shocks common to all firms in a year. Thus, β captures the within-firm association between cartel membership and the outcome relative to firms not in cartels in the same year. Indicator outcomes enter in levels, so β can be interpreted as a change in probability; continuous outcomes enter in inverse hyperbolic sine, so β can be interpreted as an approximate percent change. We cluster standard errors by firm.

Consistent with cartel entry depending in part on this fragmented environment, observable differences between eventual members and firms that never entered a cartel were modest. Figure 4, Panel B, relates future membership to predetermined firm, geographic, and industry characteristics measured in the first observed year for each firm, controlling for year and listing status. No estimated association exceeds 0.11 per standard deviation; firm size is the strongest, but still

limited, predictor.

The balance comparison describes differences in predetermined characteristics. A corresponding dynamic question is whether entering and comparison firms were already on different outcome trajectories before cartel entry. We examine this using an event-study specification,

$$y_{it} = \sum_{k \neq -1} \beta_k \mathbb{1}\{t - e_i = k\} + \alpha_i + \delta_t + \varepsilon_{it}, \quad (10)$$

where e_i is the year firm i first enters a cartel and k indexes years relative to entry, with $k = -1$ omitted.⁴³ Coefficients for $k < 0$ trace differences before entry, while those for $k \geq 0$ trace subsequent dynamics.

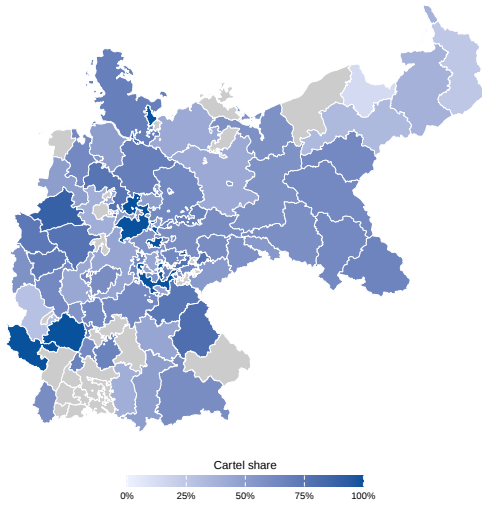
Together, balance results and pre-entry trends are informative about the timing and predictability of cartel entry, but they do not by themselves establish a causal interpretation. Cartel formation could still coincide with shocks that differentially affected entering firms, and membership could affect firms used as comparisons. Appendix E therefore organizes the robustness analysis around four concerns. First, we examine selection into cartels by flexibly controlling for predictors of formation and by matching and reweighting on pre-cartel characteristics (Appendix E.1). Second, we address coincident industry, geographic, and market shocks using industry-by-year, district-by-year, and market-by-year fixed effects and by excluding strategically exposed sectors (Appendix E.2). Third, we assess spillovers to the comparison group by varying market and treatment definitions and excluding nonmembers in cartelized markets (Appendix E.3).⁴⁴ Finally, we assess robustness across choices of estimator, sample, measurement, and clustering using heterogeneity-robust estimators, subsample and leave-one-out exercises, alternative variable definitions, and alternative clustering schemes (Appendix E.4). Appendix Table A.1 reports summary statistics for every variable used in the analysis.

⁴³The event study treats first cartel entry as absorbing. Because cartel membership was highly persistent, this convention closely tracks contemporaneous membership; Appendix E.4 shows that the results are similar under alternative estimators and treatment definitions.

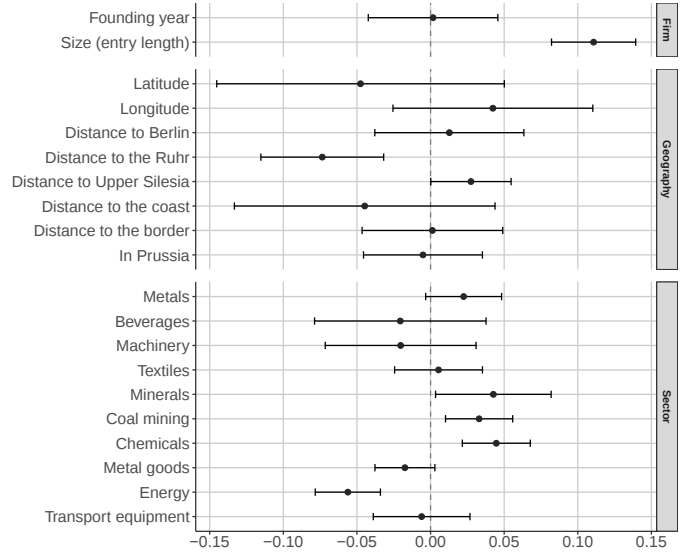
⁴⁴Cartel membership was highly persistent: about 66% of entrants remained documented members a decade after entry (Appendix Figure A.1, Panel A). Cartelized markets were also often nearly complete: 29% contained no nonmember, while the median nonmember share was 33% (Panel B). This is consistent with accounts of outsiders as exceptional.

Figure 4: Cartel Descriptives

Panel A: Cartel Share by District



Panel B: Pre-Cartel Balance



Note. Panel A: share of listed industrial firms ever in a cartel within the sample window, by 1882 district (the government region, else province or state; industries pooled); districts with fewer than three firms are grayed. Panel B: coefficients with 95% confidence intervals from one joint linear-probability regression of future cartel membership on predetermined characteristics, over all firms, taken at each firm's first observed year, with year and listing-status fixed effects and standard errors clustered by decade. The characteristics are firm founding year and size; county-centroid geography (latitude and longitude, and distances to Berlin, the Ruhr, Upper Silesia, the coast, and the national border, with a Prussia indicator); and indicators for the largest industries. Continuous characteristics enter as inverse-hyperbolic-sine transforms; all are standardized, so each coefficient is the partial association per standard deviation with a firm ever entering a cartel, holding the others fixed. Sample 1882–1933.

4.3 Enforceability Instrument

The within-firm design uses all the variation in cartel membership, whatever its source. Our second design uses only the part of that variation that a change in the law produced. The change is the 1897 ruling of the Imperial Court described in Section 2.2. In a dispute among Saxon wood-pulp producers, the court upheld a cartel contract that obliged the cartel members to sell only through the common sales syndicate of the cartel. With this ruling the court upheld the enforceability of cartel contracts in general. The design compares, before and after the ruling, industries for which the ruling mattered more with industries for which it mattered less, and uses that difference as an instrument for cartel membership.

Share. Whether the ruling mattered for an industry depends on how its cartels had bound their members. Early cartels bound their members in different ways. Some set minimum prices or allocated production quotas and relied on the cartel members to honor them. Others sold through

a common sales syndicate (*Syndikat*, *Verkaufsstelle*, or *Kontor*) and obliged each cartel member to sell its output through it. The exclusive-sales obligation of a syndicate is what the ruling upheld. Industries whose cartels already sold through syndicates therefore gained more legal certainty from the ruling than industries whose cartels relied on other arrangements.

We measure this reliance from the cartel membership sources introduced in Section 4.1. For each three-digit industry, we take the cartels founded before 1897 and compute the fraction of them that sold through a common sales syndicate. We standardize this fraction across industries.⁴⁵ We call the result the syndicate share of industry s , σ_s ; it is fixed over time.

Shift and estimation. The shift is an indicator equal to one from 1897 on. For firm i in industry s and year t , the instrument is

$$Z_{st} = \sigma_s \cdot \mathbb{1}\{t \geq 1897\}. \quad (11)$$

The endogenous variable is cartel membership D_{it} , here an indicator equal to one from the first documented year of cartel membership of the firm onward. We use this definition because the ruling lowered the cost of forming and keeping a cartel rather than the cost of any single year of cartel membership. We estimate equation (9) by two-stage least squares with firm and year fixed effects, instrumenting D_{it} with Z_{st} . Standard errors are clustered by two-digit industry, one level above the three-digit industry at which the share varies. Because the firm fixed effects absorb the level of each firm, the effect of the ruling is identified from firms observed both before and after 1897.

Relevance. The first stage requires that cartel membership rose more after 1897 in industries with a higher syndicate share. The first-stage F -statistic is 65.4 for exporting and lies between 15.6 and 65.4 across the outcomes, above the conventional threshold of ten in every column. Appendix Figure A.7 reports an event study of the first stage: it regresses cartel membership on the syndicate share interacted with 5-year bins of time from 25 years before to 30 years after the ruling, with firm and event-time fixed effects. The coefficients are centered on zero before the ruling and rise after it. The syndicate share thus predicts cartel membership only once the ruling was handed down.

⁴⁵For the few firm-years whose industry has no cartel founded before 1897 (4% of the sample), the share is set to the cross-industry mean.

The aggregate series shows the same timing: cartel formation came in waves, the first following the ruling (Figure 1).

Exclusion. The exclusion restriction is that, conditional on the fixed effects and controls, the syndicate share affects the outcomes of a firm after 1897 only through the cartel membership of that firm. The threat is an industry characteristic, correlated with the syndicate share, that changed the path of firm outcomes around 1897 for another reason.

Three considerations bear on this threat. First, the historical record ties the choice of binding arrangement to local precedent, the preferences of the organizers, and the accident of who coordinated first, rather than to industry fundamentals. Once chosen, an arrangement served as the template for later cartels in the same industry (Section 2.2). Second, Appendix Figure A.6 regresses the syndicate share, and the share recentered on its mean within broader industry groups, on each of eight industry characteristics measured largely outside the German cartel setting (capital intensity, skill intensity, external finance dependence, asset tangibility, natural-resource share, contract intensity, value-to-weight, and product homogeneity) and on the proximity of an industry to the litigation. None of these associations is systematic. Third, we control for proximity to the litigation, through the input linkage of the industry to the wood-pulp industry and the distances to the county of the litigating cartel and to the places where the deciding judges were trained, each switched on from 1897, and for the product homogeneity of the industry interacted with the post-1897 indicator.

5 Firm-Level Effects

5.1 Upgrading and Scale

Prediction 1 suggests that cartel membership may be associated with upgrading toward the technological and export frontier and with an expansion of scale. We begin with the within-firm design introduced in Section 4.2. Table 1 reports results from estimating equation (9) with the five main firm outcomes as dependent variables: exporting and patenting (columns 1 and 2), and output, employment, and capital (columns 3 to 5). Each column uses the firm-years for which the outcome is observed. Exporting and patenting are observed for 282,816 firm-years of 26,877 firms, capital

for nearly as many, and output and employment for fewer, since the handbooks report physical quantities and headcounts for a subset of firms.⁴⁶

Upgrading. In its years of cartel membership, a firm is more likely to export and more likely to patent than in its years outside a cartel, relative to firms outside cartels in the same year. The probability of exporting is 0.17 higher (column 1), against a baseline mean of 0.10. The probability of being granted a patent is 0.03 higher (column 2), against a baseline mean of 0.05, or about 51 percent of the mean. Both coefficients are significant at the 1% level.

Scale. In years of cartel membership, output is about 10 percent higher (column 3), employment about 11 percent higher (column 4), and capital about 31 percent higher (column 5). All three coefficients are significant at the 1% level. The three outcomes move together, which is consistent with an expansion of production rather than a change in factor proportions.

Dynamics. Figure 5 reports results from estimating the event study of equation (10) for the same five outcomes, in 5-year bins from 30 years before to 25 years after the first year of cartel membership. Before the first year of cartel membership, the coefficients are close to zero for every outcome. The joint tests of the pre-period leads in Appendix E.1.3 do not reject parallel trends. After the first year of cartel membership, the coefficients rise over the first bins and stay high to the end of the window. The upgrading and the expansion of scale thus follow cartel membership rather than precede it, and they persist.

The results presented in this subsection suggest that cartel membership, on average, is associated with more exporting and patenting and with larger output, employment, and capital. This is the pattern Prediction 1 describes.

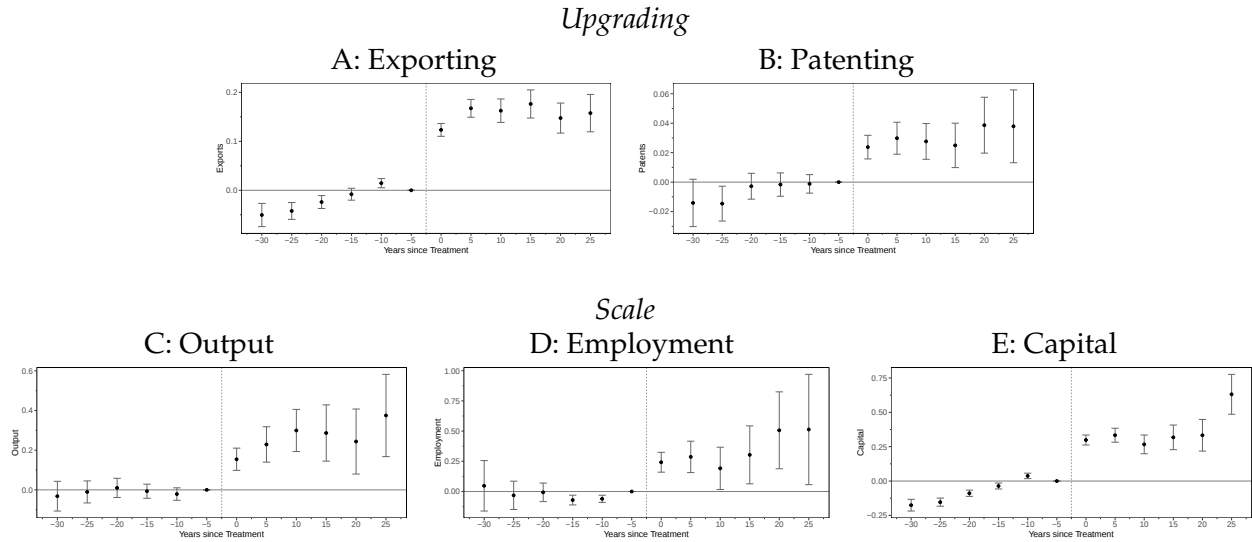
⁴⁶The level means of output and employment are not a useful base for comparison, since output is measured in firm-specific physical units and the firm fixed effects absorb the cross-firm level; we therefore read their coefficients as approximate percent changes (Section 4.2).

Table 1: Cartel Membership and Firm Outcomes

	Upgrading		Scale		
	Exports (1)	Patents (2)	Output (3)	Employment (4)	Capital (5)
Cartel Member	0.17*** (0.01)	0.03*** (0.00)	0.10*** (0.03)	0.10*** (0.03)	0.27*** (0.02)
R ²	0.52	0.49	0.99	0.83	0.90
Observations	282,816	282,816	49,277	50,384	199,981
Firms	26,877	26,877	3,893	4,592	21,972
Years	52	52	52	52	51
Outcome def.	(0/1)	(0/1)	(ihs)	(ihs)	(ihs)
Outcome mean	0.10	0.05	16.36	7.43	13.95
Standard errors	Firm	Firm	Firm	Firm	Firm
Sample	Full	Full	Operations	Operations	Capital
Firm fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓

Note. Table presents results of estimating equation (9). Outcomes are exporting, patenting, output, employment, and capital, as introduced in Section 4. Each column is estimated on the firm-years for which its outcome is observed (the Sample row). Observations are at the firm-year level; the numbers of firm-years, firms, and years are shown in the table. The Outcome def. row gives the scale of each outcome: (0/1) an indicator, (ihs) the inverse hyperbolic sine. Standard errors are clustered at the firm level. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

Figure 5: Cartel Membership and Firm Outcomes: Event Study



Note. Figure presents results of estimating equation (10), with 95% confidence intervals, in 5-year bins of years relative to the first year of cartel membership; the bin before it is the reference. Upgrading: exporting (A), patenting (B); scale: output (C), employment (D), capital (E), as introduced in Section 4. Standard errors are clustered at the firm level.

5.2 Instrumental-Variable Estimates

Table 2 reports results from estimating equation (9) by two-stage least squares, with cartel membership instrumented by the enforceability instrument introduced in Section 4.3 and the same five outcomes as dependent variables. Panel A uses the bare instrument. Panel B adds the proximity controls and the product homogeneity interaction. The instrumented estimates point the same way as the within-firm estimates. In Panel B, the probability of exporting is 0.54 higher under instrumented cartel membership (column 1), against a mean of 0.10, and the probability of patenting 0.08 higher (column 2), against a mean of 0.05. Output, employment, and capital are higher as well (columns 3 to 5). The exporting and capital coefficients are significant at the 5% level or better and the patenting coefficient at the 10% level; the output and employment coefficients are less precisely estimated. The first-stage F -statistic lies between 15.6 and 65.4 across the columns. The estimates change little from Panel A to Panel B.

The instrumented estimates are larger than the within-firm estimates. The ratio is about 3.16 for exporting and 2.29 for capital, and larger for output and employment. The instrumented output and employment columns rest on few firms observed on both sides of 1897. Two readings are consistent with this gap. First, the two-stage estimate puts its weight on the firms whose cartelization the ruling moved. These firms were concentrated in industries whose cartels sold through syndicates, and cartel membership may have mattered more for them. Second, cartel membership is under-recorded in some years, which attenuates the within-firm coefficient but not the instrumented one. We therefore read the two designs as agreeing in sign and in the ordering of outcomes, and we take the within-firm estimates as the conservative magnitudes.

Table 2: Cartel Membership and Firm Outcomes: Instrumental-Variable Estimates

	Upgrading		Scale		
	Exports (1)	Patents (2)	Output (3)	Employment (4)	Capital (5)
<i>Panel A: Baseline</i>					
Cartel member	0.53*** (0.11)	0.10** (0.05)	0.79*** (0.18)	2.26** (0.86)	0.65** (0.26)
R ²	0.51	0.49	0.99	0.83	0.89
<i>Panel B: Controls</i>					
Cartel member	0.54*** (0.10)	0.08* (0.05)	1.37* (0.71)	1.57 (1.10)	0.62** (0.25)
R ²	0.51	0.49	0.99	0.83	0.89
Distance controls	✓	✓	✓	✓	✓
Industry characteristics × Post-1897	✓	✓	✓	✓	✓
Observations	273,782	273,782	49,209	50,365	196,372
Firms	23,716	23,716	3,879	4,578	20,488
Years	52	52	52	52	51
Outcome def.	(0/1)	(0/1)	(ihs)	(ihs)	(ihs)
Outcome mean	0.10	0.05	16.36	7.43	13.95
Standard errors	Industry	Industry	Industry	Industry	Industry
Sample	Full	Full	Operations	Operations	Capital
Firms observed pre- and post-1897	828	828	879	253	3,842
First-stage <i>F</i> (Panel A)	40.8	40.8	83.0	27.3	35.3
First-stage <i>F</i> (Panel B)	65.4	65.4	30.6	15.6	41.9
Firm fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓

Note. Table presents results of estimating equation (9) by two-stage least squares. Cartel membership is an indicator equal to one from the first documented year of cartel membership of the firm onward, instrumented by the standardized share of the cartels founded in the three-digit industry of firm *i* before 1897 that sold through a common sales syndicate (*Syndikat*, *Verkaufsstelle*, or *Kontor*), interacted with an indicator for the years from 1897 on. Panel A uses the bare instrument; Panel B adds three measures of proximity to the decision, each switched on from 1897 (the Leontief input linkage between the industry of the firm and the wood-pulp industry, the distance from the county of the firm to the county of the litigating cartel, and the distance to the nearest place of legal training of the judges on the deciding senate), and the product homogeneity of the industry interacted with the post-1897 indicator. The first-stage *F*-statistic (cluster-robust) is reported per panel and column, and the row “Firms observed pre- and post-1897” counts the firms whose outcome is observed on both sides of the ruling. Outcomes are exporting, patenting, output, employment, and capital, as introduced in Section 4; each column is estimated on the firm-years for which its outcome is observed (the Sample row). Observations are at the firm-year level; the numbers of firm-years, firms, and years are shown in the table. The Outcome def. row gives the scale of each outcome: (0/1) an indicator, (ihs) the inverse hyperbolic sine. Standard errors are clustered by two-digit industry. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

5.3 Financing and Governance

Prediction 1 also concerns the financing of the expansion. If cartel rents relaxed a financing constraint, cartel members should show higher profit and retained earnings and higher investment rather than higher dividends. The association between cartel membership and expansion should

also be stronger where outlays are large and external finance scarce.

Financing. Table 3 reports results from estimating equation (9) with the four financing outcomes as dependent variables. In years of cartel membership, investment is about 8 percent higher (column 1), retained earnings about 22 percent higher (column 2), and profit about 56 percent higher (column 3). These three coefficients are significant at the 1% level. The dividend coefficient is near zero, with a standard error of 0.16 (column 4). Figure 6 reports the event-study estimates for the same four outcomes. Profit and retained earnings rise after the first year of cartel membership, investment rises with them, and dividends stay flat. That profit and retained earnings rise together with investment, and not with dividends, is consistent with the finance-constrained regime in Section 3.2, in which a marginal unit of retained profit goes to investment.

Governance ties. Table 4 reports results from estimating equation (9) with the four board outcomes as dependent variables. In years of cartel membership, firms have more interlocking board members, more bank-affiliated and more state-affiliated board members, and more board members with a scientific or engineering title (columns 1 to 4). All four coefficients are significant at the 1% level. The associations also hold when the outcomes are measured as shares of the board, and in regressions that control for board size (Appendix Tables A.6 and A.7). In the event-study estimates, each association appears after the first year of cartel membership (Appendix Figure A.10). Denser bank ties are consistent with the role of universal banks as creditors and board members in large investments (Gerschenkron, 1962; Fohlin, 2005). Denser state ties are consistent with the procurement relationships documented in Section 5.4.

Heterogeneity. To assess whether the results differ by the financial frictions firms faced, we consider heterogeneity of the main results by capital intensity. Large fixed outlays had to be financed up front, so capital-intensive industries were the ones in which a financing constraint was most likely to bind. We measure capital intensity at the industry level as the ratio of investment to value added, from Manova (2013), and we split industries at the cross-industry median.⁴⁷ In Table 5, we repeat the main estimation with an interaction of the treatment with an indicator for industries

⁴⁷Capital intensity is one of the industry characteristics introduced in Section 4.1; firms in industries without a value enter the below-median group.

above the median. The interaction is positive for exporting, patenting, employment, and capital (columns 1, 2, 4, and 5), and significant at the 1% level for exporting, patenting, and employment. For employment, the association is concentrated almost entirely in capital-intensive industries: about 1 percent below the median and about 23 percent above it. The output interaction is small and imprecisely estimated (column 3). Appendix Tables A.4 and A.5 report the same split for the financing and board outcomes. The association between cartel membership and expansion is thus concentrated in capital-intensive industries, the industries in which the financing channel has the most scope.

Instrumental-variable estimates. The instrumented estimates for the financing outcomes point the same way (Appendix Table A.2). Under instrumented cartel membership, investment, retained earnings, and profit are higher, each significant at the 1% level, while the dividend coefficient is near zero and insignificant. The first-stage F -statistic lies between 39.4 and 48.6. Appendix Table A.3 reports the instrumented estimates for the board outcomes.

The results presented in this subsection suggest that cartel membership, on average, is associated with higher investment and retained earnings, with higher profit but not higher dividends. Organizationally, cartel members have denser interlocking, bank, state, and science ties. The expansion documented in Section 5.1 is also concentrated in capital-intensive industries. Taken together, these results are consistent with a mechanism in which cartels sustained investment in the face of financing frictions.

Table 3: Cartel Membership and Financing

	Investment (1)	Retained Earnings (2)	Profit (3)	Dividends (4)
Cartel Member	0.07*** (0.01)	0.20*** (0.03)	0.44*** (0.13)	0.00 (0.16)
R ²	0.49	0.81	0.41	0.77
Observations	60,918	172,651	183,980	16,395
Firms	4,701	16,318	18,629	3,716
Years	52	51	51	51
Outcome def.	(ihs)	(ihs)	(ihs)	(ihs)
Outcome mean	1.35	11.82	8.37	10.86
Standard errors	Firm	Firm	Firm	Firm
Sample	Investment	Statement	Statement	Dividend
Firm fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓

Note. Table presents results of estimating equation (9). Outcomes are investment, retained earnings, profit, and dividends, as introduced in Section 4, each in inverse hyperbolic sine; each column is estimated on the firm-years for which its outcome is observed (the Sample row). Observations are at the firm-year level; the numbers of firm-years, firms, and years are shown in the table. Standard errors are clustered at the firm level. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

Table 4: Cartel Membership and Board Composition

	Interlocking (1)	Bank-Tied (2)	State-Tied (3)	Science-Tied (4)
Cartel Member	0.32*** (0.01)	0.28*** (0.01)	0.18*** (0.01)	0.07*** (0.01)
R ²	0.62	0.58	0.61	0.46
Observations	281,483	281,511	281,496	282,096
Firms	26,849	26,872	26,863	26,862
Years	52	52	52	52
Outcome def.	(ihs)	(ihs)	(ihs)	(ihs)
Outcome mean	1.40	0.41	0.51	0.10
Standard errors	Firm	Firm	Firm	Firm
Sample	Full	Full	Full	Full
Firm fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓

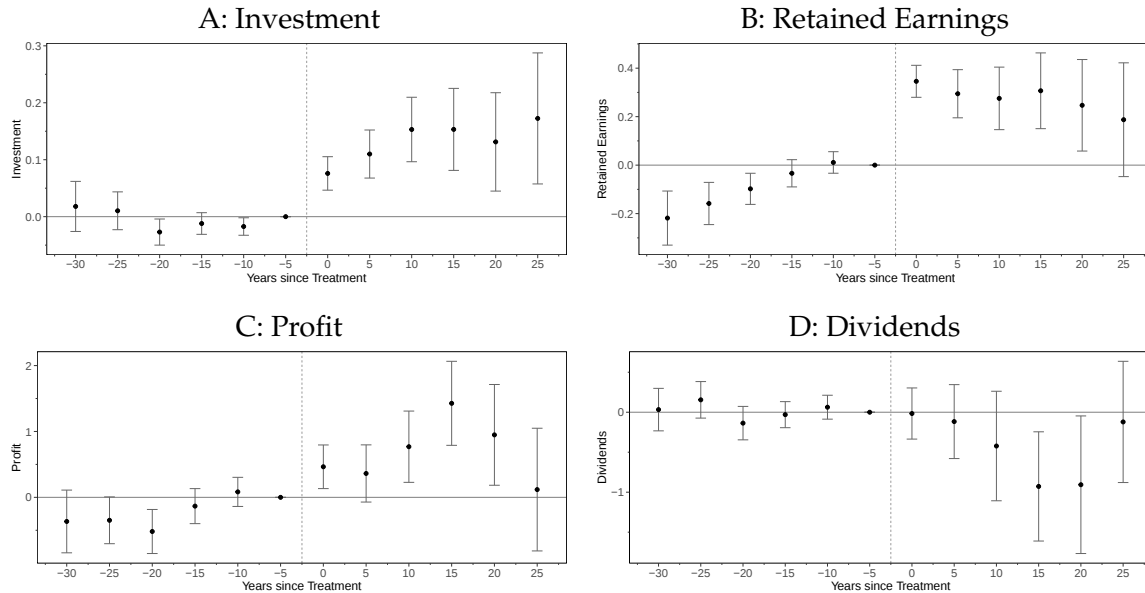
Note. Table presents results of estimating equation (9). Outcomes are the numbers of interlocking, bank-tied, state-tied, and science-tied board members, as introduced in Section 4, each in inverse hyperbolic sine. Observations are at the firm-year level; the numbers of firm-years, firms, and years are shown in the table. Standard errors are clustered at the firm level. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

Table 5: Cartel Membership and Firm Outcomes, by Capital Intensity

	Upgrading		Scale		
	Exports (1)	Patents (2)	Output (3)	Employment (4)	Capital (5)
Cartel Member	0.15*** (0.01)	0.01*** (0.00)	0.11*** (0.04)	0.01 (0.05)	0.23*** (0.02)
Cartel Member $\times$ Capital intensity	0.05*** (0.01)	0.03*** (0.01)	-0.05 (0.06)	0.21*** (0.06)	0.08** (0.03)
R ²	0.52	0.49	0.99	0.83	0.90
Observations	282,816	282,816	49,277	50,384	199,981
Firms	26,877	26,877	3,893	4,592	21,972
Years	52	52	52	52	51
Outcome def.	(0/1)	(0/1)	(ihs)	(ihs)	(ihs)
Outcome mean	0.10	0.05	16.36	7.43	13.95
Standard errors	Firm	Firm	Firm	Firm	Firm
Sample	Full	Full	Operations	Operations	Capital
Firm fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓

Note. Table presents results of estimating equation (9), with the treatment interacted with an indicator for industries above the cross-industry median of capital intensity. Cartel Member is the coefficient for firms in industries below the median and the interaction row the additional coefficient above it; firms in industries without a value enter the below-median group. Outcomes are exporting, patenting, output, employment, and capital, as introduced in Section 4. Observations are at the firm-year level; the numbers of firm-years, firms, and years are shown in the table. The Outcome def. row gives the scale of each outcome: (0/1) an indicator, (ihs) the inverse hyperbolic sine. Standard errors are clustered at the firm level. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

Figure 6: Cartel Membership and Financing: Event Study



Note. Figure presents results of estimating equation (10), with 95% confidence intervals, in 5-year bins of years relative to the first year of cartel membership; the bin before it is the reference. Panels: investment (A), retained earnings (B), profit (C), dividends (D), as introduced in Section 4, each in inverse hyperbolic sine. Standard errors are clustered at the firm level.

5.4 Cartel Members in the War Economy

Contemporary support for industrial coordination was framed partly in terms of national economic strength (Section 2.2). We therefore ask whether cartel members were more likely to be drawn into the war economy of 1914–18.

We use the war-economy records introduced in Section 4.1 and compare cartel members and firms outside cartels in the 1913 cross-section of 5,701 firms on three indicators of later involvement: a military procurement contract, a secret war patent, and a directorship on a war board. Table 6 reports results from regressing each indicator on cartel membership by 1913, controlling for three-digit industry fixed effects and for firm size and listing status in 1913. Cartel members were more likely to hold a military procurement contract, by 0.04 in probability against a mean of 0.18 (column 1). This coefficient is significant at the 10% level. The differences for a secret war patent and for a war-board directorship point the same way but are small and imprecisely estimated (columns 2 and 3). Albeit correlational, the greater involvement of cartel members in procurement is consistent with the view of contemporaries that organized industry was an asset of national strength.

Table 6: Cartel Membership in 1913 and War-Economy Involvement

	War Procurement (1)	Secret War Patent (2)	War Board (3)
Cartel Member by 1913	0.04 (0.02)	0.01 (0.01)	0.01 (0.01)
R ²	0.33	0.20	0.06
Observations	5,701	5,701	5,701
Industries	147	147	147
Outcome def.	(0/1)	(0/1)	(0/1)
Outcome mean	0.184	0.031	0.052
Standard errors	Industry	Industry	Industry
Controls	✓	✓	✓
Industry fixed effects	✓	✓	✓

Note. The sample is one observation per firm in the 1913 cross-section, in 147 three-digit industries. Each column regresses the indicator named in the column on an indicator of cartel membership by 1913, with three-digit industry fixed effects and controls for firm size and listing status (Controls). Outcomes are the three indicators of war-economy involvement, as introduced in Section 4. Standard errors are clustered by three-digit industry. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

6 Downstream and Aggregate Effects

6.1 Downstream Effects

Prediction 2 concerns the firms that buy cartelized inputs. An upstream markup taxes their production. The tax can reverse once cost-reducing investment passes through and agreements across the stages of production restore efficient trade. Cartelized inputs may therefore first burden and later benefit the firms that buy them. Section 2.2 dates the spread of such agreements to the state-backed cross-sector negotiations of 1904, which brought cartels and their customers into mediated bargaining over prices and rebates. We therefore split the sample at 1904, the year of those negotiations.

We first define exposure to cartelized inputs. The cartel exposure of firm i in industry s and year t is

$$Exposure_{it} = \sum_{s' \neq s} \omega_{ss'} CartelShare_{s't}, \quad (12)$$

where $\omega_{ss'}$ is the share of the inputs of industry s supplied by industry s' , from the input-output table of Section 4.1, and $CartelShare_{s't}$ is the size-weighted share of the firms of industry s' that are cartel members in year t . Exposure is high when a large part of the inputs of a firm comes from heavily cartelized industries. It averages 0.10 in the sample, with a standard deviation of 0.09, and we report the estimates per standard deviation.

We estimate equation (9) with cartel exposure in place of the treatment and control for the cartel membership of the firm itself. The coefficient then isolates the upstream channel from own cartelization. Table 7 reports the results for the five main firm outcomes. Panel A pools exposure over the sample. Panel B splits the sample into the years before 1904 and the years from 1904 on, after the initial state-backed negotiations between cartels and downstream producers.

Pooled over the sample, exposure is positively associated with every outcome (Panel A). A one-standard-deviation higher exposure is associated with a 0.03 higher probability of exporting, against a mean of 0.10 (column 1), and a 0.01 higher probability of patenting, against a mean of 0.05 (column 2). It is associated with about 11 percent more output (column 3) and 24 percent more employment (column 4). These four coefficients are significant at the 1% level. The coefficient for capital is positive but imprecisely estimated (column 5).

When the sample is split at 1904, the associations with the scale outcomes change sign (Panel B, columns 3 to 5). Before 1904, a one-standard-deviation higher exposure is associated with about 18 percent less output, 7 percent less employment, and 7 percent less capital. From 1904 on, it is associated with about 4 percent more output, 20 percent more employment, and 1 percent more capital. The differences between the two periods are significant at the 1% level for output, employment, and capital. Exporting and patenting, by contrast, are positively associated with exposure in both periods, with little change between them (columns 1 and 2).

The reversal in the scale outcomes has two readings, one from the model of Section 3 and one from the history of Section 2.2. Under the model, upstream market power reaches downstream firms in the first period as a higher input price, the tax of Proposition 1, and in the second period the upstream price can fall below its competitive level as cartel-financed investment lowers cost. In the history, the state-backed cross-sector negotiations of 1904 returned part of the upstream rents to downstream buyers while preserving upstream coordination. The two readings share a timing, which motivates the split at 1904.

These estimates are associations. They do not separate the input-price channel from the negotiation channel, and they do not establish that the negotiations caused the reversal.

Appendix Figure A.11 decomposes the sample total of each outcome into a direct part attributable to own cartel membership, an indirect part attributable to cartelized inputs, and a baseline. It then revalues the indirect part at the exposure coefficient of each period. For exporting, the direct part is 11% of the total and the indirect part 29%; for patenting, 4% and 35%. Because the indirect part rests on the exposure association, it is an upper bound. The direct part counts only the cartel membership of the firm itself and omits spillovers to other firms, so it is a lower bound.

Taken together, the downstream estimates suggest that higher exposure to cartelized inputs was associated with less output, employment, and capital before 1904 and with more afterward, while exporting and patenting were higher throughout. This is the sequence Prediction 2 describes.

Table 7: Cartel Exposure and Firm Outcomes

	Upgrading		Scale		
	Exports	Patents	Output	Employment	Capital
	(1)	(2)	(3)	(4)	(5)
<i>Panel A: Pooled</i>					
Cartel Exposure	0.29*** (0.04)	0.16*** (0.03)	1.12** (0.52)	2.44*** (0.48)	0.20 (0.13)
R ²	0.52	0.49	0.98	0.84	0.89
<i>Panel B: Before and from 1904</i>					
Cartel Exposure × Pre-1904	0.20*** (0.06)	0.14*** (0.04)	-2.16*** (0.60)	-0.82 (0.83)	-0.81*** (0.18)
Cartel Exposure × Post-1904	0.28*** (0.04)	0.16*** (0.03)	0.47 (0.49)	2.07*** (0.42)	0.08 (0.12)
R ²	0.52	0.49	0.98	0.84	0.89
Observations	272,955	272,955	40,203	38,879	195,713
Firms	23,633	23,633	3,853	4,550	20,417
Years	52	52	52	52	51
Outcome def.	(0/1)	(0/1)	(ihs)	(ihs)	(ihs)
Outcome mean	0.10	0.05	16.72	7.29	13.95
Standard errors	Firm	Firm	Firm	Firm	Firm
Cartel Member	✓	✓	✓	✓	✓
Firm fixed effects	✓	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓	✓

Note. Table presents results of estimating equation (9) with cartel exposure in place of the treatment. Cartel exposure is defined in equation (12); own cartel membership is controlled for throughout (Cartel Member row). Panel A pools exposure over the sample; Panel B splits the sample into the years before 1904 and the years from 1904 on, after the initial state-backed negotiations between cartels and downstream producers. Outcomes are exporting, patenting, output, employment, and capital, as introduced in Section 4; each column is estimated on the firm-years for which its outcome is observed. Observations are at the firm-year level; the numbers of firm-years, firms, and years are shown in the table. The Outcome def. row gives the scale of each outcome: (0/1) an indicator, (ihs) the inverse hyperbolic sine. Standard errors are clustered at the firm level. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

6.2 District Employment and Market Structure

Prediction 3 turns to districts and markets. Rents paid to incumbents may raise activity among them while narrowing entry. We examine this aggregate margin in two steps: local industrial employment from the censuses, and entry, exit, and concentration from the firm panel aggregated to markets.

District employment. Using data from the five industrial censuses between 1882 and 1933 introduced in Section 4.1, we combine census employment with the firm panel at the level of the district and census wave, 437 cells over 89 districts. Table 8 reports results from regressing district

employment on the number of cartel-member firms in the district, controlling for the total number of firms as a measure of local industrial scale, all in inverse hyperbolic sine. Column 1 includes the scale control and wave fixed effects only, column 2 district and wave fixed effects without the control, and column 3 both. With district and wave fixed effects and the scale control, the elasticity is 0.16 (standard error 0.04, column 3). Within a district, a census wave with 10 percent more cartel-member firms thus records about 1.6 percent more employment, over and above the growth in the number of firms.

A growth decomposition translates the elasticity into a share of observed growth. Between the 1882 and the 1933 census, district employment grew, and so did the number of cartel-member firms. Applying the elasticity to the observed growth in cartel-member firms, weighted by district employment, attributes 27% of the realized growth in district employment, in inverse hyperbolic sine, to the growth in cartel-member firms (95% confidence interval 14% to 40%). This decomposition should be read under two limits. First, it is an association rather than a causal effect, since it applies the observed growth in cartel-member firms rather than a no-cartel counterfactual. Second, it credits cartel-member firms with more than their own employment, since the elasticity absorbs whatever else accompanies their presence in a district.

Entry, exit, and concentration. Finally, we consider the aggregate association between cartel prevalence and market dynamics. To do so, we aggregate the firm panel to the level of a market, a NACE three-digit industry by district cell. We then relate entry, exit, survival, and concentration to the lagged share of firms in the market that belong to a cartel, with market and year fixed effects. The sample covers 110,264 market-years in 5,075 markets for entry, exit, and survival, and the market-years with a defined Herfindahl index for concentration. Table 9 reports the results. A higher lagged cartel share is associated with fewer entrants (column 1) and fewer exits (column 2), with a higher share of incumbents surviving to the next year (column 3), and with a higher Herfindahl index (column 4). All four coefficients are significant at the 1% level. The magnitudes are small. A cartel share higher by one standard deviation, 0.18, is associated with about 0.4 percent fewer entrants and 0.3 percent fewer exits in the following year. It is associated with a survival rate higher by 0.15 percentage points, against a mean of 96.13 percent, and with a Herfindahl index higher by 0.01, about 1% of its mean of 0.73.

In sum, the district and market estimates point to an expansion concentrated among incumbents. Districts with more cartel-member firms record higher employment, while cartelized markets admit slightly fewer entrants, lose slightly fewer incumbents, and are more concentrated. These are associations conditional on the fixed effects, and should be interpreted as such. Taken together, they are consistent with rents accruing to the firms inside the agreements and with the persistence of established producers that Section 2.2 describes for organized industry.

Table 8: Cartel Firms and Employment

	Employment		
	(1)	(2)	(3)
Cartel Firms	0.14*** (0.02)	0.16*** (0.04)	0.16*** (0.04)
R ²	0.90	0.96	0.96
Observations	437	437	437
Outcome def.	(ihs)	(ihs)	(ihs)
Outcome mean	11.79	11.79	11.79
Standard errors	District	District	District
Market size controls	✓		✓
District FE	✓	✓	✓
Wave FE		✓	✓

Note. Observations are district-by-census-wave cells over the 5 industrial censuses of 1882, 1895, 1907, 1925, and 1933, a district being the aggregation level above counties in Imperial Germany. The outcome is the inverse hyperbolic sine of census employment in the district, summed over industries and counties. Cartel Firms is the inverse hyperbolic sine of the number of firm-panel firms in the district at the census wave that are cartel members; Total Firms is the same count over all firm-panel firms and enters as a control for local industrial scale. Columns vary the fixed effects and the control. Standard errors are clustered by district. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

Table 9: Cartel Share and Market Entry, Exit, Survival, and Concentration

	Entrants (1)	Exits (2)	Survival Rate (3)	Market HHI (4)
Cartel Share in Market (t-1)	-0.02*** (0.01)	-0.05*** (0.01)	0.83** (0.35)	0.05*** (0.01)
R ²	0.29	0.23	0.19	0.73
Observations	110,264	110,264	110,264	96,399
Markets	5,075	5,075	5,075	5,034
Years	52	52	52	52
Outcome def.	(ihs)	(ihs)	(%)	(share)
Outcome mean	0.15	0.13	96.13	0.73
Standard errors	Market	Market	Market	Market
Market fixed effects	✓	✓	✓	✓
Year fixed effects	✓	✓	✓	✓

Note. Observations are market-years, a market being a NACE three-digit industry by district cell. Entrants and exits enter as the inverse hyperbolic sine of the count, survival as the percentage of active firms not exiting that year, and concentration as the Herfindahl index of firm size. The cartel share of the market enters lagged one year. All columns include market and year fixed effects. Standard errors are clustered by market. *, **, and *** denote significance at the 10 percent, 5 percent, and 1 percent level, respectively.

7 Conclusion

In this paper, we study legally enforceable cartels in Germany between 1882 and 1933. We examine their effects on cartel members, downstream firms, and broader industrial outcomes. Using staggered variation in enforceability across time, regions, and industries, we find that cartel participation increased exports, patenting, output, and employment. Our mechanism analysis is consistent with a model in which market power can also relax financing constraints by increasing internal funds for investment, at the cost of static distortions. Horizontal cartel coordination became increasingly coupled with bargaining across stages of production, which mitigated the resulting downstream costs.

Horizontal and vertical negotiation thus widened the set of interests brought into contractual coordination, substituting imperfectly for missing financial and vertical markets (Coase, 1960; Ostrom, 1990). This broadened the scope of coordination within what increasingly resembled a corporatist “national system” in Germany (Schmitter, 1974). We find that this system supported incumbent survival and investment while also being associated with greater involvement in the war economy, higher concentration, and lower entry.

Two limits to this form of economic organization follow from a welfare perspective. The first was deliberate: the relevant constituency stopped at the national boundary. Bargaining could internalize conflicts among the domestic firms and sectors represented within the system, but not costs imposed abroad. British and French authors writing during the First World War accordingly viewed German industrial organization as both a source of national strength and a threat to foreign producers and states (Hauser, 1915). The significance of this boundary would only increase with the renewed mobilization of German industry before and during the Second World War.

The second limit lay in time. Future firms, sectors, and technologies could not bargain with incumbents over the institutions being created. The same arrangements that supported investment and industrial expansion could therefore entrench established producers and impede later reallocation (Olson, 1982; Fernández and Rodrik, 1991).⁴⁸

Negotiated industrial governance was therefore effective within the constituency it organized, but bounded by that constituency. Its capacity to coordinate incumbent interests supported investment and adaptation; its exclusion of foreign interests and future entrants limited where those gains extended and who bore their costs. The welfare properties of negotiation thus depend not only on its capacity to reach bargains, but also on how the relevant community is constituted across space and time—a question that connects problems of representation with those of responsibility toward future generations (Habermas, 1996; Jonas, 1984).

⁴⁸The stabilizing effect on incumbents is already visible within our period. Institutions that supported German catch-up may therefore also have contributed to economic structures whose advantages proved less durable as technologies and comparative advantage changed. Recent evidence on the long-run reversal of regional fortunes within Germany is consistent with this possibility (Berbée et al., 2025).

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