When Are Cartels Stable Contracts?

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Abstract

Why do some industry cartels survive for decades, while many others are quickly undermined by price wars and fringe competition? I show that variation in cartels' longevity can be explained by differences in their costs of self-enforcement and service value to members. Analyzing the private costs and benefits of legal cartel contracts formed under the *Webb–Pomerene Export Trade Act*, I find that longer-lived cartels tended to export to relatively small buyers, to have wide industry coverage, to operate in periods of strong and stable export demand, and to sell under side-agreements with foreign competitors. Contracts in which the cartel operated a common sales agency, providing highly centralized control over members' operations, also tended to be more stable. However, cartel contracts also displayed sources of inherent instability. For example, cartels usually grew less stable the longer their contract remained in force. Agreements also tended to be less stable in industries with long and recent histories of cartel activity. Finally, cartels whose primary rationale was to fix price tended to be particularly unstable, because these contracts invited fringe competition and entry.

I. Introduction

The *Webb–Pomerene Export Trade Act of 1918* granted antitrust immunity to exporters to form industry cartels for overseas trade. Under the Act, export cartels were permitted to fix prices and set quotas, allocate exclusive markets, exchange pricing information, and coordinate marketing and advertising. While immune from antitrust suits, *Webb–Pomerene* cartels were entirely self–policing, as neither the government nor the courts intervened to enforce agreements or adjudicate disputes. Congress envisaged the Act as providing two benefits to United States exporters. First, "members would be able to offer and receive higher selling prices than they would were they forced to compete against each other," and second, members could lower their selling costs by "spreading overhead and eliminating duplicate sales organizations" (U.S. Federal Trade Commission (1967, 6)). Any offsetting costs, in the form of deadweight losses from price–fixing, were expected to be borne by foreign consumers. Following much the same rationale, many other industrialized trading nations have exempted export cartels from their domestic antitrust laws.

Economic theory confidently predicts that cartels should be short–lived, as firms succumb to the temptation to cheat or free–ride on their agreement. However, in reality, the stability of cartels varies widely. For example, while nearly one–quarter of *Webb–Pomerene* agreements collapsed within two years, another quarter survived for 15 or more years. The longest–running cartel, which covered United States exports of douglas fir timber, operated for 42 years before finally dissolving. Using carefully reconstructed records on *Webb–Pomerene* cartel agreements, I seek to explain why some cartels survived for decades while others were quickly undermined by price wars and fringe competition.

I follow George Stigler's (1964) seminal framework by hypothesizing that cartels' stability will vary with the information characteristics of their operating environment. Stigler conjectured that when cartel members cannot directly observe each other's prices and outputs, they will study deviations from their expected sales to infer whether they are a victim of cheating or free–riding. Randomness in industry demand and costs will complicate firms' efforts to accurately interpret

this information. Randomness thus directly raises the cartel's cost of enforcement and, in general, will be reflected in larger monitoring expenditures and an increased frequency of monitoring errors. An implication of Stigler's analysis, therefore, is that a cartel should dissolve when its monitoring costs grow to exceed the agreement's value to members, or when a monitoring failure causes the cartel's pricing discipline to unravel. To predict cartels' survival, Stigler analyzed how specific product, buyer and seller characteristics influenced monitoring.[1] Subsequent research has extended this list to include the timing of business cycles and cross–market linkages.

By showing how monitoring costs are influenced by cartels' informational environment, Stigler (1964) anticipated the modern literatures on moral hazard and hidden action in contract enforcement.[2] A cartel represents a contract among potential competitors, either to fix price or to share the cost of common marketing activities. However, under this contract, firms' private return generally exceeds the cartel's collective return. When firms can hide their actions from co–conspirators behind a shield of random demand and cost fluctuations, firms naturally will seek to maximize their private return. To limit this moral hazard, cartel enforcement must be structured to (1) discourage hidden deviations by members and (2) narrow the gap between firms' private and collective returns. *Webb–Pomerene* contracts discouraged hidden deviations by combining explicit reporting and monitoring procedures with a schedule of punishments. To align private and collective returns, some cartels avoided making specific investments, such as establishing brand names or dedicated distribution channels, that would have encouraged opportunistic behavior. Both actions widened the contracts' "self–enforcing range," or the region within which cartel discipline was sustainable in the absence of third–party intervention.[3]

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[1] Stigler (1964) focused much of his analysis on the preliminary question of when collusion would be feasible. In industries where collusion was not feasible, cartels should not be observed to form. Dick (1994) analyzes samples of cartelized and non–cartelized export industries to identify the determinants of collusion's feasibility. Explaining cartels' survival— which is the topic of this paper — requires asking when collusion will *remain* feasible in an industry.

[2] Hart and Holmstrom (1987) provide an excellent summary of this literature.

[3] Klein and Kenney (1989) introduce the concept of a contract's self–enforcing range to analyze opportunistic behavior or "hold–ups".

Past attempts to measure and explain the stability of cartel contracts often presented weak and conflicting results. The most frequently studied cartels have been prosecuted price–fixing conspiracies and government–sanctioned international cartels which, from a research perspective, suffered from two deficiencies.[4] First, they obscured the *private* costs and benefits of cartel agreements. Studies of prosecuted price–fixing cases tended to *overstate* private enforcement costs because cartels that were costly to enforce also tended to be more visible to antitrust agencies. For example, low industry concentration and large memberships increased cartels' cost of discipline and raised their profile, making them more susceptible to antitrust detection.[5] Studies of international cartels have tended to *understate* private enforcement costs because governments frequently assisted policing by making agreements legally–binding or cartel membership compulsory.[6] Second, these biases were compounded by the absence of complete records to accurately date the beginning and ending of cartel agreements. When cartel activity could not be tracked continuously, empirical researchers usually assumed that collusion continued unabated during unobserved periods. This biased upward cartels' measured lifespans, and hindered reliable identification of the reasons behind cartels' varying longevity.

The *Webb–Pomerene* data avoid each of these pitfalls. Cartels' private costs and benefits can be isolated clearly because the agreements were legal yet not state–enforced. Cartel durations are measured accurately using a chronology identifying the beginning and ending years of active cooperation among exporters. I exploit these advantages to study 111 *Webb–Pomerene* cartel

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[4] Posner (1970), Hay and Kelley (1974), Asch and Seneca (1976) and Fraas and Greer (1977) analyzed prosecuted price–fixing cases to identify industry characteristics that were conducive to collusion. Suslow (1988) and Marquez (1993) analyzed stability directly in samples of international cartel agreements, and Jacquemin *et.al.* (1981) analyzed Japanese export cartels' longevity. This research found conflicting conclusions about how demand growth and variability, industry concentration, cartel membership and industry coverage affected the frequency and stability of cartel agreements.

[5] Hay and Kelley (1974, 26) and Posner (1970, 410) found that prosecution rates were higher among conspiracies in unconcentrated industries and conspiracies with many participants. Both characteristics tend to raise cartels' enforcement costs.

[6] The Japanese export cartel agreements analyzed by Jacquemin *et. al.* (1981) typically were extended through government fiat to non–cartel members. Thirty percent of Suslow's (1988) sample of inter–war international cartels were directly or indirectly government–assisted, and during her period of analysis "legal systems operated to enforce contractual agreements among cartel members" (Griffin (1989, 180)).

episodes spanning nearly fifty years. I report two sets of findings. First, past research tends to overstate cartels' average duration, the frequency with which members re–organized after a cartel dissolves, and the propensity of cartels to grow more stable with age or experience in the industry. I find also that cartels' longevity varies directly with their primary motive and with their choice of internal organization, two influences that traditionally have been overlooked in cartel research.

Second, variation in cartels' lifespans can be traced to differences in their enforcement costs and net service value. These, in turn, are influenced by characteristics of cartels' informational environment as predicted by both Stigler (1964) and contract theory. For example, I find that cartels' longevity varied predictably with the average size of buyers, the variability of market demand conditions, cartels' industry coverage, business cycle timing in several markets, and the existence of side–agreements with cartel competitors. In contrast to earlier research, I find also that cartels became less stable both the longer that they had operated, and the more extensive and recent was their experience in the industry. Finally, cartels that sought primarily to exercise pricing power tended to be particularly short–lived, and this was only partially offset by those cartels' tendency to exercise tighter control over members' export operations.

II. *Webb–Pomerene* Cartels in Export Trade

By way of background, I elaborate upon three central issues: the cartels' antitrust exemption, their motives for operation, and the primary causes of their dissolution.

A. The Antitrust Exemption

The *Webb–Pomerene Export Trade Act* provided antitrust immunity to United States exporters by exempting them from the *Sherman Act*'s prohibition against contracts, combinations and conspiracies in restraint of trade. While the cartels were legal under antitrust law, neither the federal government nor the courts ever attempted to assist with contract enforcement. Cartels instead relied upon self–enforcement. Anticipating the threat of cheating, *Webb–Pomerene* contracts specified explicit procedures for investigating alleged infractions and resolving disputes

among members. Typically, the cartels created a governing body that was empowered to audit members' financial statements and shipping records. Members that failed to provide regular reports or to permit audits usually were fined by their cartel, and common penalties for selling infractions included liquidated damages and quota reductions. In extreme cases, members were punished by expulsion or dissolution of the entire agreement.[7]

Webb–Pomerene cartels automatically received antitrust immunity upon filing with the Federal Trade Commission (FTC) the names and addresses of their members and a copy of their articles of agreement. Failure to register within 30 days of formation exposed the cartel to standard antitrust oversight and penalties. To retain their registered status, cartels had only to satisfy extremely modest annual reporting requirements. The FTC sent a brief questionnaire each year to all registered cartels asking the value of their exports and their primary functions. In light of the Act's minimal compliance costs, and its requirement that cartels register to receive antitrust immunity, the *Webb–Pomerene* population should include virtually all industry export cartel agreements.

These same criteria also suggest, however, that some firms might have registered as a cartel yet never actually become active, or might have continued to file after effectively dissolving. To exclude these cases, I carefully distinguish between "registered" and "active" cartels. I define a cartel as active in a particular year if either (i) it operated a common sales agency to centralize order–taking, billing and shipping on behalf of members, or (ii) the cartel set export price guidelines for the industry while leaving the logistics of shipping to member firms.[8] Throughout the paper, I confine attention to *Webb–Pomerene* cartels during their active periods only.

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[7] A compendium of cartels' penalty clauses appears in U.S. Federal Trade Commission (1927).

[8] In Section V.B, I will examine directly how cartels' internal organization influenced their stability. Ideally, one would like to define a cartel's active duration as the period during which it significantly affected market prices or firms' costs. Previous studies have lacked this information and therefore have sought to date cartels with reference to either the duration of a written contract, or the timing of a specific event (eg., the exit of a key cartel member or the initiation of an antitrust indictment). This paper, by contrast, dates cartels by their *attempts* to affect price and cost to approximate more closely the 'ideal' dating based on price and cost effects. A cartel that fails to sustain a return sufficient to offset its enforcement costs will soon become inactive by the definition adopted in the paper. Cartels that pass this cost–benefit

Table I summarizes active cartels' most common functions. Four–fifths of the cartels set a common price and/or allocated markets, and slightly more than one–half centralized export distribution through a common sales agency. More than one–third conducted market research and one–fourth directly advertised and promoted members' exports. Other common cartel functions included consolidation of freight and insurance charges, and negotiation with foreign governments and international agencies over import licenses and tariff rates. As predicted by theory, cartels tended to export relatively homogeneous, less highly processed commodities. Approximately 30% covered agricultural and food products (rice, dried fruit, flour), another 30% covered raw or semi–finished industrial materials (lumber, copper, phosphate), and a further 10% covered simple manufactures (pencils, buttons, wooden doors).[9] Table II provides a partial listing of *Webb–Pomerene* cartels in each of these sectors.

The *Webb–Pomerene Act* placed only three restrictions on cartels' activities. While these statutory restrictions were broadly worded, each was narrowly interpreted and infrequently enforced. First, the Act prohibited cartels from influencing domestic market prices. However, both the FTC and the Courts effectively declined to enforce this provision. Larson (1970, 499) notes that the FTC had "a history of lax administration of the Act" regarding domestic spillovers, and on several occasions the courts rejected arguments that *Webb–Pomerene* cartels were liable for ancillary restraints of domestic trade stemming from export cooperation.[10] There also is no evidence that registration by *Webb–Pomerene* cartels led to heightened antitrust scrutiny of members' domestic operations.[11] Second, the Act prohibited cartels from directly constraining non–members. In practice, however, cartels were permitted to negotiate exclusive dealing

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criterion will remain active. When active cartels are defined by this standard, approximately three–quarters of all registered cartels were active in an average year.

[9] U.S. Federal Trade Commission (1967, App. C–2). Dick (1994) analyzes systematically the factors prompting *Webb–Pomerene* cartels to form.

[10] Posner and Easterbrook (1981, 76) noted that the "courts have permitted an entire industry to be organized into an export association despite any effect that competition (or lack of competition) in the world market may have on the domestic market." See in particular United States v. Minnesota Mining and Manufacturing Co. (92 F. Supp. 947, 965 (D. Mass. 1950)).

[11] In Section V, I will find that export cartels' stability was sensitive to domestic market conditions, which further suggests that the firms may have sought to influence domestic prices despite the statutory prohibition.

agreements that effectively excluded non–member exports into particular markets.[12] Finally, after World War II, the FTC prohibited agreements between *Webb–Pomerene* cartels and foreign producers (Hoff (1958, 149–52)). During the time span that I study, however, the FTC investigated just twelve agreements for possible violations and ultimately the Commission prosecuted only two cartels (U.S. Federal Trade Commission (1967, 109)).

B. Motives for Cartel Operation

Researchers typically have emphasized price–fixing as the primary motive for export cartels' formation.[13] Several observations lend support to this emphasis in the case of *Webb–Pomerene* cartels. First, among cartelized industries, the United States' share of the world export market averaged 26%, suggesting the potential for firms to exercise collective market power. In many industries the United States' export market share was significantly higher, such as in walnut board (95%), crude sulphur (90%), carbon black (80%) and phosphate (45%). Second, as earlier noted, four–fifths of *Webb–Pomerene* cartels directly fixed prices or allocated foreign markets among sellers. While in some cases these restraints were ancillary to other cartel objectives, they also provided an avenue to exploit potential market power. Third, the distribution of firm sizes among cartel participants suggests that price–fixing may have been more important than reaping scale economies in many cartels. One–third of cartel members were at least as large as a Fortune 500 firm in their era, and collectively these firms accounted for 90% of total *Webb–Pomerene* exports (U.S. Federal Trade Commission (1967, 44) and Larson (1970, 476–77)). Finally, econometric studies indicate that some *Webb–Pomerene* cartels did successfully fix price. Dick (1992) estimated that cartels marketing carbon black and crude sulphur raised export prices by an average of 6.5% and sustained these prices for more than two decades.

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[12] In Section V, I will find that the number of firms that formally joined the cartel was not a reliable predictor of its stability. One interpretation is that cartels were able to extend their influence to non–members as well, despite the statutory prohibition.

[13] Larson (1970), Amacher *et. al.* (1978) and Jacquemin *et. al.* (1981) all adopt this assumption.

However, other evidence indicates that many cartels did seek to share costs in common marketing activities. Dick (1992) estimated that cartels in canned milk, dried fruit, metal laths, milled rice and paperboard significantly expanded United States exports by exploiting economies of scale in joint marketing. Historical accounts of *Webb–Pomerene* cartels' activities confirm firms' cost savings from export cooperation. Scudder (1955, 45) enumerated one cartel's efficiencies: "[c]ollection and dissemination of trade information concerning credit and market conditions abroad ... resulted in a more efficient placing of orders. Reduction of overhead by pooling of administrative expenses as well as joint advertising and selling offices and agents helped considerably in the development of new markets. On this score one association noted that through such cooperation selling costs were reduced by about 50%."

I approach differences in cartels' rationale by dividing the paper's survival analysis into three parts. First, I will highlight similarities within the full sample by focusing upon factors that affected both price–fixing and cost–sharing cartels' expected longevity (Section V.A). Next, I will explore how cartels' primary motive affected their longevity directly, as well as indirectly through cartels' choice of their internal organization (Section V.B). Finally, as a further test of the effects of cartel motives, I will restrict attention just to those cartels whose primary motive appears to have been price–fixing (Section V.C).

C. The Reasons for Cartel Dissolutions

Webb–Pomerene cartels dissolved under two general sets of circumstances. The first were enforcement failures. Many price–fixing cartels were undermined by their failure to detect and punish members' attempts to undercut the agreed–upon price or to exceed quota allocations. Likewise, many cost–sharing cartels were undermined by their failure to discourage free–riding on joint marketing services, thereby preventing the cartel from recouping a competitive return on its sunk investments.[14] The Potash Export Association is one example of a *Webb–Pomerene*

[14] Market research, which more than one–third of the cartels performed, and advertising, which one–quarter supplied, were examples of joint services subject to internal free–riding. While all members benefited equally from these services, firms that under–reported their export sales

cartel that dissolved following an enforcement failure. Larson (1970, 494) notes that a "conflict of interests arose between the firms which had Canadian deposits and those which did not. In view of their plentiful new supply, certain firms began to chafe at the quotas assigned to them." After a period of falling prices resulting from firms exceeding their quotas, the cartel sought to re-establish pricing discipline. These efforts ultimately proved unsuccessful when cartel members found themselves unable to agree on new prices and quota allocations (U.S. Federal Trade Commission (1967, 24)).

Second, cartels also dissolved when their coordination costs outweighed their service value to members. Many cartels that sought to exercise export market power found themselves able to raise price only marginally when fringe competition intensified and entry barriers eroded in their industry. *Webb–Pomerene* cartels in cement, pine lumber and wire rope, for example, attributed their dissolutions directly to foreign price competition and entry. While cost–sharing cartels did not face entry and fringe competition threats (provided that they earned only a competitive return), they did face other sources of degradation in their service value. For example, cartels covering slightly more differentiated products such as textiles and office equipment dissolved after members discovered that "foreign market development could be better handled on an individual basis."[15] And cost–sharing cartels in wheat flour, clothespins and wood pipe dissolved when their export success allowed members to reach minimum efficient scale and internalize most scale economies in marketing.

Stigler's (1964) analytical framework applies to cartels that dissolved from either enforcement failures or inadequate service value. The two causes are complementary because a cartel's enforcement costs determine its maximum sustainable service value. When monitoring is swift and accurate, a cartel can raise its price or expand its joint marketing investments with little risk of triggering an enforcement failure. When monitoring is imperfect and cheating is

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would have been assessed for a smaller fraction of the cartel's research and advertising expenditures. Eventually, free–riding would have undermined the cartel's incentive to perform such activities.

[15] Examples in this paragraph are taken from U.S. Federal Trade Commission (1967, 26–27) and U.S. Federal Trade Commission (n.d.).

detected only slowly, however, "the conspiracy must recognize its weakness" (Stigler (1964, 46)). In this situation, the cartel must lower its price to limit the marginal return to price cutting, or it must scale back its joint marketing investments to limit the scope for free–riding. Both preventive actions lower the likelihood that the cartel will suffer an enforcement failure by narrowing the gap between firms' private and collective return. However, the actions also reduce the cartel's service value to members, and thus may hasten its dissolution for this reason. It follows that factors which raise cartels' enforcement costs also lower their maximum sustainable service value, and thus will prompt cartels to dissolve from either an enforcement failure or inadequate service value. I will interpret the survival regression results in Section V under both the enforcement failure and service value interpretations.

III. Re–assessing the Evidence on Cartels' Longevity

Drawing upon FTC files and reports, I construct a sample of 111 cartel episodes covering 93 industries and spanning the years 1918 to 1965.[16] I define an uninterrupted period of cartel activity as a "cartel episode" and use this as the basic unit of observation for empirical analysis. The sample's ending date right–censors 20 out of the 111 episodes, so that I do not observe the actual dissolution year for these cartels. To account for the effects of censoring, I compute sample statistics using life table methods and modify the survival regression analysis (in Section V) to accommodate right–censored observations.[17]

Table III reports the raw data on cartel dissolutions. The column labeled "at risk" counts the number of cartel episodes still in progress at the beginning of each year. "Exited" observations identify cartel episodes that ended by the conclusion of the year, and "censored" observations

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[16] Availability of data for industry characteristics was the sole selection criterion used in constructing the sample of cartel episodes. The sample's beginning date was determined by the passage of the *Webb–Pomerene Act*. The ending date was dictated by limits on the author's access to originally non–public cartel filings with the FTC.

[17] There is no evidence of left censoring in the data. While the *Webb–Pomerene Act* was passed in 1918, cartel registrations began slowly and remained relatively few in number until 1920 to 1922. There also is no direct evidence that exporters were tacitly colluding in the same markets prior to the Act's passage.

identify episodes that ended after 1965. Figures 1 and 2 summarize this information graphically. The survival function S(t) in Figure 1 records the probability that a cartel episode lasted for at least t years. The integrated hazard function H(t) in Figure 2 plots the integral of cartels' hazard rate, which measures the probability that an episode will end at date t conditional upon it having lasted until that date.

I begin the empirical analysis by comparing *Webb–Pomerene* associations with data on other cartels' longevity, resilience and life cycle characteristics. I also present new data linking cartels' longevity, primary motive and their choice of internal organization.

A. Cartels' Longevity. *Webb–Pomerene* cartels were relatively short–lived on average. The median *Webb–Pomerene* cartel remained active for approximately 5.3 years.[18] By way of comparison, Jacquemin *et. al.* (1981) reported a median lifespan of 8.5 years among government–enforced Japanese export cartels. Suslow (1988) found a median lifespan of 10.7 years — or just over twice the *Webb–Pomerene* average — among international commodity cartels, where host countries assisted enforcement in one–third of the cases.[19] Only Marquez (1993) found average lifespans comparable to those for *Webb–Pomerene* cartels, reporting a median of 5.2 years among international cartels.[20] While *Webb–Pomerene* cartels differed in their product and market coverage from international commodity and Japanese export cartels, a more important distinction is that they alone were privately–enforced agreements. The *Webb–Pomerene* data indicate that cartels were inherently less stable than earlier studies usually inferred, and that stripping other cartels of outside enforcement assistance typically would have hastened sharply their dissolution.

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[18] Table III indicates that the average cartel survived at least until year five with a 51.7% probability and at least until year six with a 45.8% probability. I assume a uniform distribution of cartel exits between these two durations to interpolate a median duration of 5.3 years.

[19] The summary statistics reported by Suslow (1988, Table 2) were not adjusted for censoring caused by World War II, which affected 40% of her sample and biased downwards reported cartel lifespans. The median reported here (10.7 years) makes this correction.

[20] Marquez (1993) did not identify the extent of government enforcement assistance within his sample.

B. Cartels' Resilience. *Webb–Pomerene* cartels usually did not re–organize after they dissolved. In just 17% of the sample industries (16 out of 93) did firms make repeated attempts to organize a cartel agreement. This suggests either that most breakdowns in cartel discipline stemmed from fatal enforcement problems that could not be corrected, or that cartels dissolved permanently after they outlived their initial value to members. By way of comparison, earlier research had found significantly higher repeat frequencies among other classes of cartels. For example, Suslow (1988) and Marquez (1993) found that between 36% and 64% of international commodity cartels made multiple attempts at fixing price. An explanation lies in the fact that host countries were nearly five times as likely to aid enforcement after an international cartel's initial episode (Suslow (1988, 28)). Anticipation of future government assistance would have led those cartels to re–organize more frequently. The *Webb–Pomerene* data indicate that when firms were forced to rely exclusively on private enforcement, they rarely made more than a single attempt at collusion.

C. Cartels' Life Cycle Characteristics. *Webb–Pomerene* cartels did not tend to grow more stable with experience or age. While longer–lived cartels were more likely to re–organize after dissolving, their prior experience did not prevent them from reverting to the sample's median lifespan in subsequent episodes.[21] A cartel's hazard rate also remained constant over its duration, rather than declining the longer that the cartel had been operating.[22] *Webb–Pomerene* cartels' failure to learn over time contrasts sharply with earlier findings. Suslow (1988) and Marquez (1993), for example, reported that international cartels' median lifespans rose between

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[21] These cartels' median lifespan in their first episode was 11.0 years and declined to 3.5 years in subsequent episodes.

[22] Estimating a Weibull distribution for hazard rates yields $h(age) = 0.0923\ (age)^{0.009}$. However, the exponent on age is statistically indistinguishable from zero at usual significance levels, implying that hazard rates were statistically invariant with respect to cartel age. Figure 2 confirms this conclusion graphically.

25% and 144% after their industry's initial experience with price–fixing.[23] This discrepancy stems from the fact that the frequency of government intervention rose continuously through time among multi–episode international cartels.[24] Cartel durations thus were measured with an increasingly large upward bias, giving the appearance that cartels grew more stable with industry experience. The *Webb–Pomerene* data indicate that privately–enforced cartels derived no stability advantage from prior experience. In Section V, I will find that after controlling for heterogeneity in other cartel characteristics, *Webb–Pomerene* cartels actually grew *less* stable as they aged and as they made repeated attempts at collusion.

D. Cartels' Motives and Organization. Cartels' stability varied directly with their primary motive and choice of internal organization. Previous research assumed that cartels were motivated solely by price–fixing, while information on cartels' organization usually was either unavailable or else was treated as exogenous rather than as a choice made by firms.[25] In contrast, *Webb–Pomerene* cartels differed in their primary motive — spanning both price–fixing and cost–sharing — and their choice of organization — three out of five cartels organized as common sales agencies to centralize order–taking, shipping and billing, while the others set price guidelines and left members responsible for shipping logistics. Differences in *Webb–Pomerene* cartels' primary motives and internal organization will make it possible to explain firms' organizational choice, and to isolate the independent effects of motives and organization on cartels' stability.

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[23] Among international cartels with multiple episodes, Marquez (1993, 2a) reported that the median lifespan rose from 4 to 5 years after the initial attempt, although the rise was not statistically significant. Suslow's (1988, 15, 35–37) sample identified a corresponding increase in median duration from 2 years and 10 months to 6 years and 11 months, which was statistically significant.

[24] Suslow (1988, 28) indicated that 40% of multi–episode cartels received enforcement assistance in their first episode, 50% did in their second episode and 60% did in their third episode.

[25] Jacquemin *et. al.* (1981), Suslow (1988) and Marquez (1993) each assume that cartels sought primarily to fix price to exploit collective market power. Suslow (1988) reported information on several features of international cartels' internal organization, but treated each of these as exogenous characteristics in her survival analysis. Neither the Marquez (1993) not the Jacquemin *et. al.* (1981) studies provided organizational detail.

Stigler (1964) argued that a common sales agency was second only to formal merger in its ability to process information efficiently to assist cartel monitoring. However, these gains in monitoring efficiency were partially offset by reduced administrative flexibility. In particular, Stigler (1964, 45) noted that common sales agencies were "ill suited to custom work and ... [imposed] serious administrative costs in achieving quality standards, cost reductions, product innovations, etc." These administrative costs should have proven to be more burdensome for cost–sharing cartels, which required flexibility to tailor joint marketing investments to individual exporters' requirements. Direct evidence on cartels' effects confirms that cartels with common sales agencies tended to restrict exports and raise price, while those with less centralized structures expanded industry exports by exploiting economies of sale in marketing (Dick (1992)).

Webb–Pomerene cartels without common sales agencies on average out–lived cartels with highly centralized internal structures. The median lifespan among cartels organized as common sales agencies was approximately 4.5 years, as compared with 7.4 years for cartels whose members shipped individually.[26] While cartels with common sales agencies were more effective at monitoring, they also tended disproportionately to have price–fixing as their primary motive. The stability of these cartels was threatened by entry and fringe competition, threats that were not faced by cost–sharing cartels (provided they earned only a competitive return). Moreover, the latter cartels enjoyed what Pirrong (1992, 102) has termed "survival value": the ability to survive even when entry is costless, because their operation raises total industry surplus. If price–fixing cartels' greater inherent instability was incompletely offset by their monitoring cost advantages, then cartels that organized as common sales agencies on average would have been shorter–lived.

To summarize, *Webb–Pomerene* cartels were relatively short–lived, re–organized only infrequently after dissolutions, and did not tend to grow more stable with experience or age. Cartels' motives and their internal organization varied, and these had independent influences on cartels' stability. In the remainder of the paper, I integrate these insights into a formal empirical

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[26] The relatively small number of observations (a sub–sample of 69 episodes) makes this difference statistically insignificant, but the ranking of median lifespans is contrary to expectations.

survival model. I estimate directly the effect on cartels' stability from product, buyer and seller characteristics, business cycle timing, cross–market linkages, and cartel motives and organization.

IV. Using Survival Analysis to Explain Cartel Stability

Survival analysis is well suited to exploring the link between cartels' enforcement costs and their stability. In this section, I briefly explain how the survival methodology will be applied to the *Webb–Pomerene* sample.[27] Elsewhere, I have analyzed the determinants of firms' decision to enter into a cartel agreement (Dick (1994)). In this paper, I assume that this decision was made in the past, and I focus on explaining existing cartels' longevity. The unit of observation is a cartel episode, whose length is measured in years. I denote by T_i the i^{th} cartel episode's length ($i = 1, \ldots, N$). The probability of an episode continuing to time τ is given by the survivor function

$$(1) \qquad S(\tau) = \text{Prob}(T_i \geq \tau) = \int_{\tau}^{\infty} f(x)\,dx = 1 - F(\tau)$$

where $f(\,)$ and $F(\,)$ are the probability and cumulative distribution functions for T_i, respectively. The probability that a cartel episode ends at time τ, given that it has survived until that time, is defined by the hazard or failure rate

$$(2) \qquad h(\tau) = \frac{f(\tau)}{S(\tau)} = \frac{f(\tau)}{1 - F(\tau)} \,.$$

Ending dates for some cartel episodes in the sample are right–censored by the conclusion of the FTC chronology in 1965. If C_i is the censoring date for the i–th episode, the cartel's actual duration is observed only if $T_i \leq C_i$. Define

$$t_i = \min \{T_i, C_i\}$$

and

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[27] Kiefer (1988) provides a lengthier summary discussion of how survival analysis can be applied to study the duration of economic phenomena and behavior.

$$\delta_i = \begin{cases} 1 & \text{if } T_i \leq C_i \quad \text{(no censoring)} \\ 0 & \text{if } T_i > C_i \quad \text{(censoring)} \end{cases} .$$

The joint probability density function of t_i and the censoring indicator variable δ_i is then

$$f(t_i)^{\delta_i} S(C_i)^{1-\delta_i} .$$

When the pairs (t_i, δ_i) are independent, the likelihood function can be written as

$$(3) \qquad L = \prod_{i=1}^{N} f(t_i)^{\delta_i} S(C_i)^{1-\delta_i} .$$

Expressing the likelihood function in terms of a vector x that describes a cartel's informational environment and a vector θ of parameters to be estimated, the function in (3) becomes

$$(4) \qquad L = \prod_{i=1}^{N} f(t_i ; \theta, x_i)^{\delta_i} [\, 1 - F(C_i ; \theta, x_i)]^{1-\delta_i} .$$

The first term reflects the probability that the cartel episode ends at time t_i, and the second captures the probability that this event occurs after the censoring date C_i. Applying logarithms and using the definition in equation (1), the log–likelihood function is

$$(5) \qquad \ln L(\theta) = \sum_{i=1}^{N} \delta_i \ln f(t_i ; \theta, x_i) + \sum_{i=1}^{N} (1-\delta_i) \ln S(t_i ; \theta, x_i) .$$

The likelihood function can be estimated either parametrically or semi–parametrically. The primary advantage of semi–parametric estimation is that it avoids the need to specify a functional form for the distribution of cartels' ending dates. Without a distributional assumption, however, it is possible only to identify the relative impact of covariates on a cartel's duration. Stated differently, semi–parametric estimation exploits only the relative sequencing of cartels' failure times and not their absolute age at dissolution. In contrast, parametric estimation techniques exploit information on both the sequencing and the actual timing of cartel breakups, but must impose specific distributional assumptions on the underlying baseline hazard rate.

The likelihood function also can be estimated using either continuous or grouped data techniques. Grouped methods can measure discrete lifespans, and may be appropriate because I observe cartel ending dates only at an annual frequency. As the time interval used for grouping the dependent variable lengthens, grouped data methods will yield more efficient regression

coefficient estimates than continuous data methods.[28] Both methods can be applied to either parametric and semi–parametric estimation and, in Section V, I report regression results using the four possible estimation techniques. The qualitative results are highly robust across techniques, providing additional confidence in the regression findings.

V. The Causes of Cartels' Stability

I apply the survival methodology to analyze three samples of *Webb–Pomerene* cartels. In Part A, I explore how common environmental influences affected price–fixing and cost–sharing cartels' stability in the full 111 cartel episode sample. In Part B, I re–estimate the model for a sub–sample of 69 episodes where the cartels' internal organization was known. I explore how a cartel's primary motive influenced its decision of whether to organize as a common sales agency, and I study how both of these attributes affected cartel longevity. Finally, in Part C, I analyze a sub–sample of 54 episodes for cartels whose primary motive apparently was to fix price. I find that the same factors that affected cartels' stability in the full sample remain significant to price–fixing cartels, and that these cartels dissolved particularly quickly as they aged and gained experience.

A. The Effect of Cartels' Environment

George Stigler (1964) sought to link cartels' survivability to characteristics of their operating environment. He predicted that cartels with dispersed buyers and little exogenous price variability would tend to have lower coordination and monitoring costs. Cartels could reduce these costs further by restricting the size of their membership, and by expanding their share of total industry sales. While Stigler's analysis was not explicitly dynamic, he implicitly understood that cartels also might learn over time how best to enforce against cheating or, alternatively, that firms might learn how best to avoid their cartel's monitoring efforts.

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[28] Lawless (1982) and Ryu (1993) explain the application of grouped data methods to survival analysis.

Extensions of Stigler's basic framework led economists to consider how business cycle timing could affect cartels' monitoring accuracy and firms' incentives to cheat. Others have considered how linking cartel agreements across markets may enhance their value and lower monitoring costs. In this section, I test each of these predicted links between cartels' operating environment and their stability.

As Section I noted, many of Stigler's insights have direct analogs in contract analysis. Moral hazard, hidden action, opportunism and measurement (or monitoring) costs — the staples of transaction cost theories of contract choice — each were present to varying degrees in *Webb–Pomerene* contracts.[29] The predictions about cartels' stability that I develop and test in this section thus can be translated readily into the language of contract analysis. In stressing this commonality, the paper offers a correspondence between cartel theory and contracting theory that traditionally has been overlooked. Also, Dick (1994) develops and tests a contracts–based theory of why *Webb–Pomerene* cartels formed, and what factors guided their choice of industry coverage and internal organization.

Table IV explains the construction and timing of the regression variables, and summarizes their descriptive statistics and predicted signing.[30] Recall that the dependent variable in a survival model reflects the conditional probability of failure. Thus, covariates that enter positively (negatively) tend to shorten (lengthen) a cartel's expected lifespan. I report regression results using grouped data methods in the first four columns of Table V, and report their continuous data method counterparts in the final four columns. The signing of covariates is consistent across the eight equations, and individual significance levels are relatively stable. The regressions' overall goodness of fit is summarized by likelihood ratio statistics, which test the

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[29] Allen and Lueck (1993) develop an empirical model of contract choice in agriculture that highlights these same components.

[30] In addition to the independent variables described in Part A, I include in all regressions a dummy variable WW2 equal to one if the cartel episode ended between 1939 and 1945. WW2 enters negatively, and usually is statistically significant. The variable should be interpreted as a control.

null hypothesis that all slope coefficients are jointly equal to zero.[31] In each equation, the likelihood ratio statistic is significant at below the 1% level. The model's overall fit and individual regressors' consistency both provide confidence in the regression results. I proceed next to evaluate individual regressors.

Buyer Size. Stigler (1964) predicted that cartels' enforcement costs should tend to be higher, and their service value should tend to be lower, when buyers are large relative to the size of the market.[32] In markets populated predominantly with small buyers, a cheating firm must extend more secret price cut offers to obtain a desired increase in sales. If any one offer is detected by other cartel participants with probability "p", then the probability that cheating is eventually detected when "n" offers must be extended is $1-(1-p)^n$. This probability increases rapidly with "n", and in the limit it approaches one.[33] Working in the same direction is the expectation that firms will find a cartel's coordination services to be less valuable when buyers are larger, since in these cases firms may deal individually with customers. Thus, both the enforcement failure and value of service hypotheses predict shorter cartel lifespans in markets with concentrated buyers.

To test this prediction, for each cartel I calculate the percentage of U.S. exports that were purchased by the four largest importing countries (BUYERSIZE). Because most cartels sold to a single buying broker in each importing country, BUYERSIZE will be directly correlated with the average size of a cartel's buyers relative to its total export market. Consistent with Stigler's prediction, Table V shows that *Webb–Pomerene* cartels selling to relatively larger buyers tended to dissolve sooner. BUYERSIZE always is significant at the 1% to 5% level in the grouped data regressions, and the variable is occasionally significant in the continuous data regressions. The

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[31] The statistics are distributed as chi–squared, with degrees of freedom equal to the number of parameter restrictions.

[32] Noting that "[n]o one has yet invented a way to advertise price reductions which brings them to the attention of numerous customers but not to that of any rival," Stigler (1964, 47) predicted that "oligopolistic collusion will often be effective against small buyers even when it is ineffective against large buyers."

[33] Larger buyers also have a greater financial incentive to search for price cut offers, both to reduce expenditures directly and to raise the probability that the cartel will be destabilized by such cuts.

economic significance of buyer size also is quite large. Using the specification in column (1), the average cartel had a 41% probability of dissolving by the end of its fifth year.[34] A one standard deviation increase in the concentration of its buyers raised this cartel's probability of dissolving within five years to 49%, or by nearly one–fifth.

Demand Stability. Stigler (1964) also predicted that cartel agreements should be easier to enforce in markets with relatively stable demand conditions. Demand stability lessens the potential for moral hazard by improving the cartel's ability to distinguish random pricing deviations from deviations caused by secret price–cutting. If cartels are enforced by means of a trigger price strategy, as conjectured by Green and Porter (1984), greater demand stability also should allow the cartel to operate with a lower trigger price. This will raise the cartel's service value to members by reducing the frequency of costly "price wars" when demand shortfalls do occur.[35] Finally, demand stability also should reduce the frequency with which the cartel must re-negotiate prices and market share assignments. Reduced contracting and coordination costs will serve to increase the agreement's net service value, and therefore should lengthen the cartel's expected duration.

As a measure of demand variability, I use the coefficient of variation in quarterly export prices during the cartel's lifespan, DMDVAR. To avoid endogeneity in export prices stemming from cartels' actions, I calculate DMDVAR using price indexes for one of four product categories— foods, crude materials, semi–manufactures or finished manufactures — depending on the cartelized product.[36] Table V indicates that export demand variability enters positively and is significant at the 1% confidence level. Consistent with Stigler's prediction, cartels that operated in noisier environments tended to dissolve sooner. The marginal economic effect of

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[34] The "average" cartel is defined by evaluating the likelihood function at variables' means and at zero for dummy variables. Throughout this section, I use column (1)'s specification to estimate the marginal economic effect of specific covariates.

[35] In the Green and Porter (1984) model, cheating does not occur in equilibrium. However, to support this equilibrium it is necessary to revert to competitive pricing or "price wars" whenever the trigger price is breached.

[36] While this construction assures that DMDVAR will be an exogenous measure of the noisiness of cartels' monitoring environments, this comes unavoidably at the cost of potentially ignoring commodity–specific information.

demand variability also is large. A one standard deviation increase in the instability of industry demand conditions raised the average cartel's probability of failing by its fifth year from 41% to 58%, or by over two–fifths.

Cartel Membership and Industry Coverage. Stigler (1964) initially predicted that enforcement costs should tend to rise with the number of colluding firms, reflecting the increased difficulty of detecting deviations from assigned market shares. More recent game theoretic analyses, however, suggest that cartels' stability may be relatively insensitive to the number of conspirators, provided that market demand grows proportionately with cartel membership (Green (1980) and Lambson (1984)). Stigler (1964) also offered a related prediction when he argued that the destabilizing effect of a large membership will be muted when the cartel covers a substantial share of the industry's total sales. Wider industry coverage expands the cartel's ability to pool information within its boundaries, and thus should improve the accuracy and cost effectiveness of monitoring. The net value of cartel services also should tend to increase with the agreement's industry coverage, and should decline with cartel membership to reflect higher coordination costs.[37]

I test these predictions by including two variables: MEMBERS, which equals the number of participants in the cartel, and WPSHARE, which is a dummy variable equal to one for *Webb–*

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[37] Coordination costs also should vary with dispersion in firms' size. Wiggins and Libecap (1987) predict that small firms will have the greatest incentive to cheat on a cartel agreement and, if their collective market share is large, they may undermine cartel discipline. While data limitations severely constrained testing this hypothesis, casual empiricism lends some support. Larson (1970, 470–71) reports that 71% of *Webb–Pomerene* firms with assets less than $1 million belonged to agricultural commodity cartels, and these smallest firms represented more than one–half of agricultural cartel membership. Consistent with Wiggins and Libecap (1987), agricultural cartels had the highest frequency of dissolution within the first five years of operation and one of the lowest frequencies of survival beyond 20 years (U.S. Federal Trade Commission (1967, Table II–6)). More systematic empirical analysis, however, proved inconclusive. As one measure of heterogeneity, I included the number of states in which a cartel's members were located. Geographic dispersion could raise cartel enforcement costs either directly by increasing monitoring expenditures, or indirectly by increasing the likelihood of input cost differences among firms. The variable always had the predicted positive sign, but it was never statistically significant at standard levels. A second heterogeneity measure, the ratio of the domestic industry's four largest to four smallest firms' outputs, also failed to enter significantly.

Pomerene cartels with at least a 50% share of their industry's total exports, and zero otherwise.[38] Table V indicates that a large industry export share had the expected effect of lengthening cartels' tenure. The dummy variable WPSHARE is statistically significant in three of the four estimated equations. Cartels' market share also had a large economic effect on their stability. A cartel with less than 50% coverage was nearly one and a half times as likely to dissolve by its fifth year as a similarly situated cartel that covered more than half of its industry's exports.

Contrary to Stigler's initial prediction, however, cartels with large memberships did not tend to be less stable. The variable MEMBERS instead frequently entered negatively, although its significance usually was marginal. This may be the consequence of endogeneity. Section V.B will report that large membership cartels were predominantly motivated by cost sharing, and that these cartels were relatively more stable because they avoided the threats of entry and fringe competition that worked to undermine price–fixing agreements. Thus, the coefficient on MEMBERS may partially reflect the higher survival value of cost–sharing cartels.

Finally, in the even numbered columns, I explore the joint effect of cartels' membership and industry coverage. I construct an interactive variable MEMBERS*(1–WPSHARE) that equals the number of firms in cartels having narrow industry coverage (WPSHARE = 0) and zero otherwise. I use this interactive variable to test Stigler's hypothesis that the impact of cartel membership on stability will be most severe when the cartel's narrow industry coverage offers little scope for information pooling. Table V finds support for Stigler's prediction, with the interactive variable entering positively and significantly in each case.

Age and Experience. Two final seller characteristics are the cartel's age and prior experience with collusion. Cartel services may increase in value over time as participants develop and adopt more effective price–fixing or cost–sharing strategies. Further, if cartels

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[38] For most episodes, it was only possible to identify cartel coverage using this binary scale. *Webb–Pomerene* cartels' coverage ranged from as high as 70–80% for industries such as sulphur and carbon black to as low as 3% for industries such as powdered milk and milled flour (U.S. Federal Trade Commission (1967, 41)). Both MEMBERS and WPSHARE were measured at the start of a cartel episode. While this dating was dictated by data availability, it also lessened potential endogeneity concerns.

become more skilled at detecting cheating, their stability should rise with age and across successive episodes. This enhanced skill may come from developing more precise estimates of industry demand or rivals' costs, or from adapting their enforcement strategies. At the same time, however, cheating firms also may learn how to avoid detection, which makes the effect of learning theoretically ambiguous. Moreover, any tendency towards increasing stability among price–fixing cartels will be undermined by growth in fringe competition and entry if buyers learn to extract secret price cuts. Among cost–sharing cartels, the value of cartel services and the probability of continued operation may fall with age or experience as firms individually reach minimum efficient scale for independent export marketing.

I begin by considering the impact of prior experience on cartels' current stability. To do so, I create a variable EXPERIENCE that measures the length of an industry's preceding cartel episode, depreciated for each year elapsed since the prior episode's conclusion.[39] This variable embodies the joint hypotheses that (i) stability depends upon the extent of prior success in colluding (proxied by the length of previous episodes), and (ii) that more recent and extensive experience should have a greater influence on current stability. EXPERIENCE should enter negatively if cartels grew more stable across episodes. EXPERIENCE instead enters positively and usually significantly in Table V, which rejects the hypothesis that cartels became more stable with experience. To the contrary, cartels without (or with only very limited) prior experience tended to be longer–lived.[40] In economic terms, lengthening a cartel's prior industry experience by one standard deviation raised by nearly one–third its probability of dissolving before the end of the fifth year.

The intuition behind EXPERIENCE's positive sign is as follows. Entry and fringe competition are attracted by monopoly profits generated from a price–fixing agreement. In

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[39] I experimented with different annual depreciation rates: 20% performed slightly better than 10% and significantly better than with no depreciation. Note that EXPERIENCE equals zero for cartels' first episode.

[40] In regressions not reported here, I replaced EXPERIENCE with a dummy variable that identified simply whether a cartel had ever before existed in the industry. This dummy variable entered positively and often significantly, but both its coefficient value and significance level were lower than those for EXPERIENCE.

industries where price–fixing cartels recently have been active for an extended period, accumulated profits will have attracted significant sunk investments by cartel competitors. When the cartel attempts to fix price again, idle fringe capacity can be brought on–line and will act more quickly to undermine the cartel's pricing discipline. In the case of cost–sharing cartels, firms will be closer to their minimum efficient scale for individual exporting the longer and the more recently their cartel has been in operation. When these cartels re–organize after a hiatus, therefore, their net service value should tend to be lower and their expected longevity should tend to be shorter.

Next, I investigate whether cartels' stability rose with their age in a single episode. Increased stability could reflect either a rise in the cartel's service value or an improvement in its monitoring capability as a result of learning–by–doing. To analyze this question, it is necessary to place a distributional assumption on cartels' baseline hazard rate in the parametric regression models. For the continuous data model, I assume that the baseline hazard function follows a Weibull distribution of the form $h_0(t) = t^{(\alpha-1)}$ where t measures the cartel's age and α is a parameter to be estimated. The Weibull distribution is sufficiently flexible to allow the hazard rate to remain constant through time ($\alpha = 1$), as well as to permit positive or negative learning ($\alpha < 1$ or $\alpha > 1$, respectively). Columns (7) and (8) in Table V estimate values for α lying between 1.520 and 1.588. The estimates imply that cartels' conditional probability of failure rose approximately in proportion to the square root of their age. Thus, doubling a cartel's age increased its likelihood of immediate dissolution by approximately 45%.[41]

In the grouped data model, I assume that the change in the integrated baseline hazard rate between years (t–1) and t satisfies $\int_{t-1}^{t} h_0(u)\,du = \exp\{\delta_0 + \delta_1 t\}$.[42] If $\delta_1 = 0$, then the hazard rate is constant over time. If $\delta_1 > 0$ ($\delta_1 < 0$), then there is negative (positive) learning over the cartel's tenure. Columns (3) and (4) in Table V estimate that δ_1 lies between 0.064 and 0.078

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[41] This positive duration dependence will be understated in Table V if unobserved heterogeneity remains in the data (Kiefer (1988, 672)).

[42] This specification yielded the highest value for Akaike's Information Criterion, defined by the value of the log–likelihood function minus the number of parameters estimated in the model.

and is significantly different from zero. The estimates imply that a cartel in its tenth year had a 38% to 48% higher probability of immediately dissolving than the cartel did in its fifth year of operation. Both sets of models conclude, therefore, that *Webb–Pomerene* cartels tended to become less rather than more stable as they aged.

Business Cycle Timing. Recent extensions of Stigler's (1964) analysis identify business cycles as an additional determinant of the timing of cartel breakdowns. Green and Porter (1984) predict that colluding firms will revert to competitive pricing (as part of an equilibrium enforcement strategy) whenever an unexpected downturn in industry demand causes price to fall below a trigger level. Thus, cartels' service value should tend to be lower, and the probability of a dissolution should tend to be higher, during a recession. Rotemberg and Saloner (1986) predict that the gains from cheating will be greater, and therefore that collusion will be harder to sustain, when demand is unusually high relative to its trend. However, their conclusion rests upon the assumption that demand shocks are independently and identically distributed over time. When Rotemberg and Saloner's model is modified to allow the possibility that strong demand today signals strong demand tomorrow, Haltiwanger and Harrington (1991) show that this conclusion is reversed and collusion again becomes more difficult to sustain during recessions.[43] Thus, while oligopoly theory suggests that cartel breakdowns should be tied to business cycle timing, it provides conflicting predictions about the precise form that this relationship will take.

Actual (or anticipated) business cycle timing also may influence cartels' stability. If some cartel members are likely to have exited from the industry by the end of the next downturn because of bankruptcy constraints, then the expected horizon over which the potential colluders can cooperate is shortened. By introducing a last period for firms, the standard endpoint unraveling problem should arise, and therefore cartels should be less stable during demand

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[43] The intuition behind Haltiwanger and Harrington's (1991) result is that if strong demand today signals strong demand tomorrow, firms will be less willing to forego large cartel profits in the immediate future (when demand is expected to be strong) by cheating today. Haltiwanger and Harrington's emphasis on the direction of changes in demand, rather than its relation to trend levels, is more consistent with standard methods for dating business reference cycles.

downturns. In addition, firms that expect to exit from the industry may become unwilling to pay for cartel services, forcing the cartel to dissolve for a lack of resources.

To test these conjectures, I define business cycle timing based on U.S. export price movements. To assure exogeneity with respect to a cartel's actions, business reference cycles are measured using one of four broad export price indexes — foods, crude materials, semi-finished manufactures or finished manufactures, depending on the cartelized product.[44] I begin by evaluating the impact of actual export business cycle timing on cartels' stability. I define a dummy variable CYCLE that equals one if the cartel's sector was in a peak-to-trough period (a downtum) during the cartel's final year, and equals zero if the sector was in a trough-to-peak period (an uptum). The endpoint unraveling hypothesis predicts that CYCLE will enter the survival regression with a positive coefficient. Consistent with this hypothesis, the odd-numbered columns in Table V indicate that cartels were consistently more likely to collapse during actual demand downturns in their export market. The economic effect of business cycle timing also was quite large. The probability of an average cartel dissolving by its fifth year increased from 41% to 74% if the export sector was in a downturn.

Next, I consider whether anticipated and unanticipated business cycles had different effects on cartels' stability. To answer this question, I decompose export price movements using an AR(1) regression into a trend and a residual. Using the trend series, I define a dummy variable ANTCYCLE that equals one if the sector was in an anticipated downturn in the cartel's final year, and equals zero if the sector was in an anticipated upturn. Using the residual series, I define a continuous variable UNANTCYCLE as the unanticipated business cycle component equal to the AR(1) regression's standardized residual in the cartel's dissolution year. The even-numbered columns in Table V indicate that cartels' dissolution was sensitive to anticipated business cycle timing. The positive coefficient on ANTCYCLE indicates that cartels usually

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[44] Qualitatively similar regression results were found when business cycles were dated using movements in U.S. export volumes or real GNP in Great Britain, which was a common destination for many *Webb-Pomerene* exports. As before, ensuring exogeneity in the price cycle series comes at the cost of potentially overlooking some exogenous, commodity-specific cyclical price variation.

were less stable during (anticipated) downturns, which again is consistent with an endpoint unraveling story. In contrast, cartels' stability apparently was insensitive to unanticipated business cycle timing. The variable UNANTCYCLE is only once marginally significant at the 10% level.

Cross–Market Linkages. A final extension of Stigler's (1964) analysis implies that cartels may lower their enforcement costs by pooling monitoring or punishment across several markets (Telser (1980), Bernheim and Whinston (1990)). The value of services received by member firms also should tend to rise with the number of markets in which the cartel operates. Cross–market pooling could have arisen between *Webb–Pomerene* cartels and foreign producers, and across *Webb–Pomerene* cartels' export and domestic markets. While both links nominally were illegal under the *Webb–Pomerene Act*, enforcement was lax and historical accounts suggest that some markets were linked by agreements (Larson (1970)).

I begin by testing whether side–agreements between *Webb–Pomerene* and foreign cartels affected the longevity of industry export agreements. Twelve *Webb–Pomerene* cartels negotiated market–division agreements with foreign producers. For these cartels, I include a dummy variable SIDE–AGREE set equal to one. The dummy appears negatively in Table V and usually is statistically significant, which implies that inter–cartel agreements did increase stability among *Webb–Pomerene* contracts. Greater stability could have come from the cartels directly pooling their enforcement efforts, or from the cartels extending coordination of industry pricing to increase their service value to members. Regardless of the precise channel, the economic magnitude of SIDE–AGREE was large. Cartels that negotiated a side–agreement had an average expected lifespan of 15 years, or nearly three times the average longevity of cartels that did not coordinate efforts with foreign producers.

Next, I consider whether firms might have used legal *Webb–Pomerene* agreements to help enforce illegal collusion domestically. A cross–market enforcement strategy would involve firms monitoring against cheating in their domestic market and punishing cheaters in their export market. As a punishment mechanism, therefore, an export cartel would have been most valuable

when firms' domestic monitoring costs were not prohibitive. To test this hypothesis, I investigate how export cartels' longevity varied with domestic market conditions, and in particular with domestic demand variability and business cycle timing. To construct exogenous measures, I calculate both of these variables using production indexes for broad sectors — mining, non-durable manufacturing, or durable manufacturing — depending on the cartelized product. Demand variability is measured by the coefficient of variation in quarterly domestic output during the cartel episode, USVAR. If export cartels' punishment services were more valuable when domestic demand conditions were relatively stable, then USVAR will enter positively. Business cycle timing is reflected in a dummy variable USCYCLE equal to one if the domestic sector was in a downturn during the export cartel's final year of operation. For reasons discussed earlier in relation to export business cycle timing, the predicted sign of USCYCLE is indeterminate.

The positive, significant coefficient on USVAR in Table V indicates that export cartels were shorter lived when demand was highly variable in their domestic sector. The negative and often significant coefficient on USCYCLE implies that *Webb–Pomerene* cartels usually were more stable during downturns in their domestic sector. Thus, domestic and export business cycles tended to have opposite effects on cartels' stability. A possible explanation is that export cartels acted as an escape valve for excess supply that would otherwise have destabilized a tacit domestic agreement. Thus, when the domestic sector entered a downturn, firms could have sustained their collusive domestic price by diverting sales to the export market through the cartel.

B. The Effects of Cartels' Motives and Organization

Section III.D provided suggestive evidence that cartels' primary motive affected their choice of internal organization, and that motives and organization had separate effects on cartels' longevity. I explore these linkages further by analyzing a sub–sample of 69 cartel episodes where it is known whether the cartel organized itself as a common sales agency for members. I begin by linking cartels' organizational choice to predictors of price–fixing motives. I then use

this information to decompose cartels' organizational choice into two parts: an exogenous component unrelated to their primary motive, and an endogenous component tied to price–fixing motives. This decomposition allows me to estimate separately the effects of cartels' organization and motives on their stability.

Cartels that were organized as common sales agencies centralized exporting logistics by negotiating prices and terms of sale, assigning orders to member firms, bargaining with shippers over freight and insurance rates, and collecting remittances. Cartels that did not serve as the common selling agent established pricing guidelines, but allowed members to handle most other shipping logistics individually.[45] Stigler (1964) conjectured that cartels whose primary motive was price–fixing would more commonly organize as common sales agencies. To review, Stigler (1964, 45) argued that centralized selling would limit a cartel's flexibility in providing the "quality standards, cost reductions, [and] product innovations" sought by cost–sharing cartels. In addition, common sales agencies' superior monitoring capabilities should prove more valuable to price–fixing cartels, whose enforcement needs were complicated by the possibility of entry and fringe competition. These threats would not be faced by cost–sharing cartels, provided that they earned only a competitive return.

To test Stigler's conjecture, I estimated a probit relationship in which the dependent variable was a dummy (AGENCY) equal to one if the cartel was organized as a common sales agency. This criterion was met in 58% of the cartel episodes within the sub–sample.[46] Oligopoly theory suggests four predictors of price–fixing incentives: the United States' export market share in that industry (MKTSHARE), the cartel's membership size (MEMBERS), a dummy for homogeneous goods (HOMOG), and a dummy for cartels that negotiated a side–agreement with foreign producers (SIDE–AGREE).[47] Price–fixing cartels were expected to concentrate in industries with a large United States export market share, to have fewer members, to cover the most

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[45] For additional detail, see U.S. Federal Trade Commission (1967, 49–56).

[46] In the full cartel population, the corresponding percentage was 56%.

[47] In Dick (1994), I expand upon this much abbreviated specification of the determinants of cartels' internal organization. There, I test between traditional oligopoly theory and transaction cost theories of organization.

homogeneous products, and to be more likely to cooperate with rivals abroad. Each characteristic raises firms' potential return from collectively exercising market power. If price–fixing cartels tended to organize as common sales agencies, then the expected signing for the probit coefficients is MKTSHARE > 0, MEMBERS < 0, HOMOG > 0 and INTL > 0.

The probit results were,

$$\text{AGENCY} = \underset{(1.95)^{**}}{1.355\ \text{MKTSHARE}} - \underset{(-1.76)^{*}}{0.88\ \text{E–2 MEMBERS}} + \underset{(1.64)^{*}}{0.498\ \text{HOMOG}} - \underset{(-1.27)}{0.573\ \text{SIDE–AGREE}}$$

* significant at 10% level ** significant at 5% level

where asymptotic t–statistics are reported in parentheses. The first three variables were signed in the expected direction, and each was significant at the 10% level or lower. Only SIDE–AGREE was incorrectly signed and it was not statistically significant. The probit's predictive power, given by the percentage of correct predictions, was 68.1%. Both the goodness of fit measure and the individual variables' results lend support to Stigler's hypothesis linking price–fixing and common sales agency cartels.

Next, I use the probit regression's results to estimate the independent effects of cartels' organization and primary motive on their stability. The probit regression decomposes each cartel's decision of whether to organize as a common sales agent into a component linked just to its price–fixing motive (the probit equation's fitted value, which defines a series PRICE–FIX) and a component linked just to monitoring cost advantages (the probit equation's residual, which defines a series MONITOR). Table VI re–estimates the survival model for the 69 cartel episode sub–sample.[48] The same explanatory variables that were significant in the full sample continue to enter significantly and with the same signing, providing confidence in the results' robustness.

The pure monitoring cost advantage of cartels with common sales agencies (MONITOR) enters negatively, as expected, and it is significant in three of the four specifications at the 5%

[48] In light of the reduced sample size, I removed from the regressions the two variables that were used in the probit (SIDE–AGREE and MEMBERS) and the BUYERSIZE variable, which was not always significant in the full sample regressions.

level or lower. The conclusion drawn is that, setting aside the influence of motives, cartels that organized as common sales agencies were longer lived on average. One explanation is that these cartels could more accurately monitor members' export sales, thus lowering their probability of an enforcement failure. A complementary interpretation is that cartels with common sales agencies had higher net service value, reflected in their wider range of services offered to members, which also would have raised their expected lifespan.

The pure effect of price–fixing motives (PRICE–FIX) enters positively, as expected, and it is significant in three out of four specifications at the 10% level or lower. The implication is that, setting aside the influence of internal organization, cartels whose primary motive for forming was to fix price were shorter lived on average. These cartels faced the additional threats of entry and fringe competition tending to undermine stability. Stated in reverse, cartels whose primary motive was to share common costs enjoyed 'survival value' because they raised industry surplus without elevating price, and therefore were not threatened by entry or fringe competition. Empirically, cost–sharing cartels' survival value dominated their tendency to dissolve naturally as members grew large enough to exploit scale economies in export marketing individually.

C. Evidence from Price–Fixing Cartels

In this final section, I confine my attention to cartels whose primary motive appears to have been price–fixing. The preceding section found that price–fixing cartels tended to be shorter–lived, presumably because they faced the additional costs of monitoring against entry and fringe competition. Here, I investigate whether price–fixing cartels' stability was particularly sensitive to characteristics of their operating environment. Using Section V.B's probit results, I created a sub–sample of 54 episodes in which cartels had a greater than 50% predicted probability of organizing as a common sales agency. The sub–sample therefore was constructed specifically to include cartels with small memberships, a large export market share and little product differentiation across sellers. Oligopoly theory predicts that these cartels should have had the strongest price–fixing incentives. Using this sub–sample of likely price–fixing cartels, I again

re–estimated the survival model. The regression results, reported in Table VII, identify several noteworthy findings.

First, the sign of each estimated coefficient is the same as those in the full sample, while the standard errors tend to be slightly lower. The generally higher significance levels suggest that stability among price–fixing cartels was particularly sensitive to their operating environment. The results' consistency with Table V also indicates that the qualitative conclusions drawn for the full sample were not driven solely by cartels whose primary motive was cost–sharing.

Second, price–fixing cartels tended to grow particularly unstable with age. In column (2) of Table VII, the estimated values of δ_0 and δ_1 imply that a cartel in its tenth year was slightly more than twice as likely to dissolve immediately than it was during its fifth year of operation. In column (4), the estimated value for α implies that a cartel's conditional probability of dissolving rose slightly more than proportionately with its age. In both equations, cartels' survival rate fell approximately twice as quickly with age as the full sample estimates in Table V implied. Figure 3 compares survival functions for the 54 price–fixing cartels and 15 cost–sharing cartels.[49] While price–fixing cartels had a slightly higher likelihood of surviving until age 8, in almost every subsequent year these cartels were less stable.

Finally, the effect of prior experience on stability is particularly pronounced among price–fixing cartels. EXPERIENCE now enters significantly at the 1% level or lower in each of the regressions. EXPERIENCE's positive coefficient indicates that price–fixing cartels with recent and extensive prior experience tended to collapse earlier than did cartels without such experience. An explanation for this phenomenon, offered earlier, is that price–fixing cartels that operated over an extended period were more likely to have generated monopoly returns. These returns would have attracted fringe investment and entry, and both forces would have undermined the sustainability of future price–fixing contracts. Cost–sharing cartels faced neither of these destabilizing forces.

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[49] The latter were identified as cartels with a predicted probability of less than 0.5 from Section V.B's probit regression.

VI. Conclusion

In this paper, I used original data on a group of legal, self–enforcing cartels to study the dynamics of cartel contracts. I reported two main sets of findings. First, drawing inferences from earlier research tends to overstate the stability of cartel contracts, the frequency with which firms re–organize after early attempts to collude, and the propensity of cartels to learn from experience or age. Second, I showed that variation in the longevity of these contracts could be explained by differences in cartels' private costs and benefits. Within this framework, cartel lifespans varied significantly and predictably with factors first emphasized by George Stigler (1964), including buyer size, the stability of market demand, cartels' industry coverage, business cycle timing in several markets, and the existence of side–agreements among cartel competitors. After controlling for these and other factors, cartels also grew less stable as they aged and as they made repeated attempts to collude. Adopting a common sales agency tended to extend a cartel's lifespan, while emphasizing price–fixing tended to destabilize agreements.

Finally, while this paper has explained variation in cartels' stability in terms of their relative enforcement costs, the data also shed light on the absolute cost of sustaining cartel contracts, measured against firms' expected gains. Several observations suggest that this net cost was quite high. Over fifty years, fewer than 3,000 firms registered a total of 263 export cartel agreements. Further, exactly one–half of these agreements never became active in any meaningful sense (Weiner and Parzych (1972, 120)). In any given year, an average of just 31 *Webb–Pomerene* cartels were active and collectively they represented less than 5% of total United States merchandise exports (U.S. Federal Trade Commission (1967, 23)). Several factors may explain firms' reluctance to form export cartels. For firms that sought to lower export marketing costs, export brokers may have offered firms many of the same benefits as formal cooperation without the costs of cartel enforcement. For firms that sought to exploit collective foreign market power, their ability to influence industry prices may have been far less than simple market share measures might indicate.

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Figure 1: Webb–Pomerene Survival Function

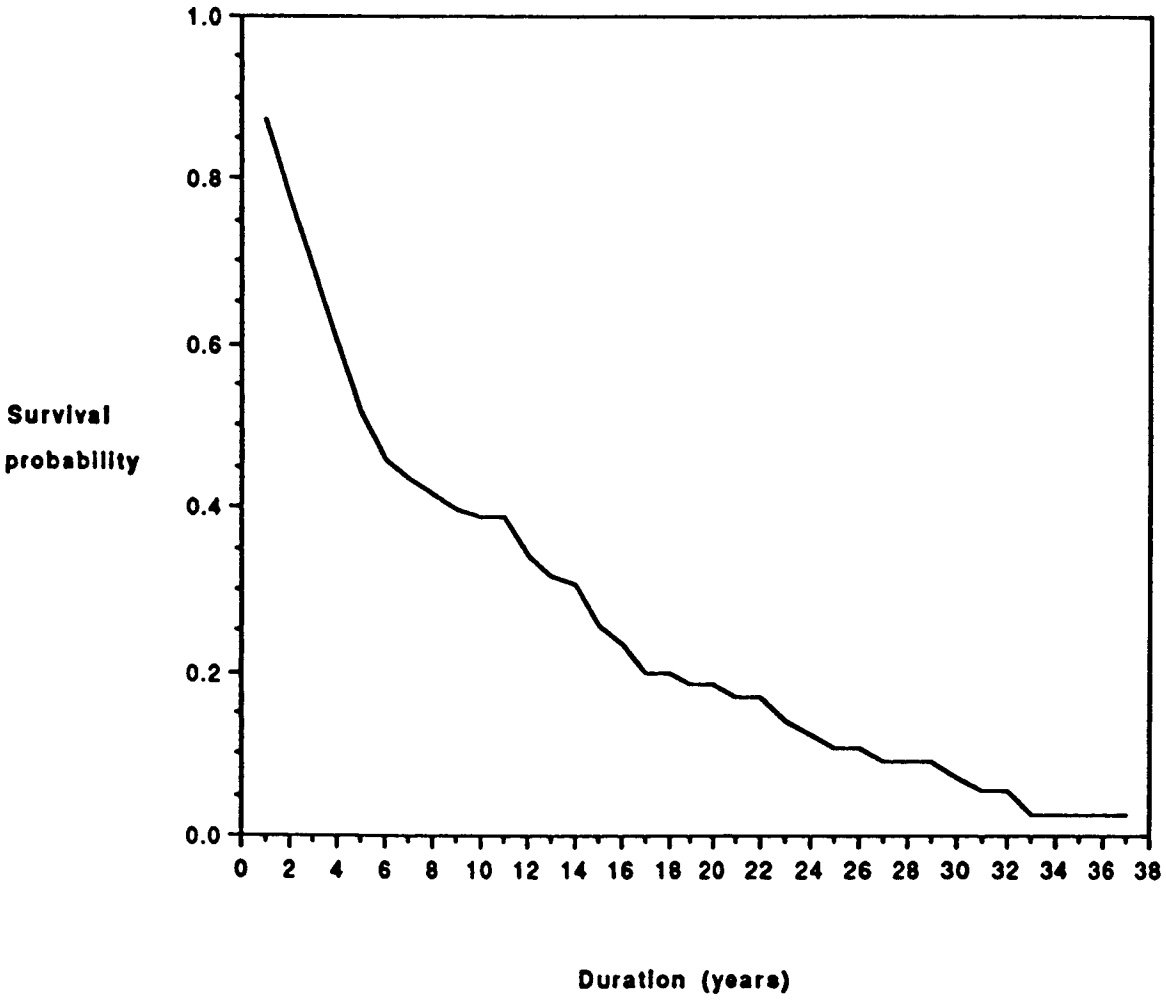

Figure 2: Webb–Pomerene Integrated Hazard Function

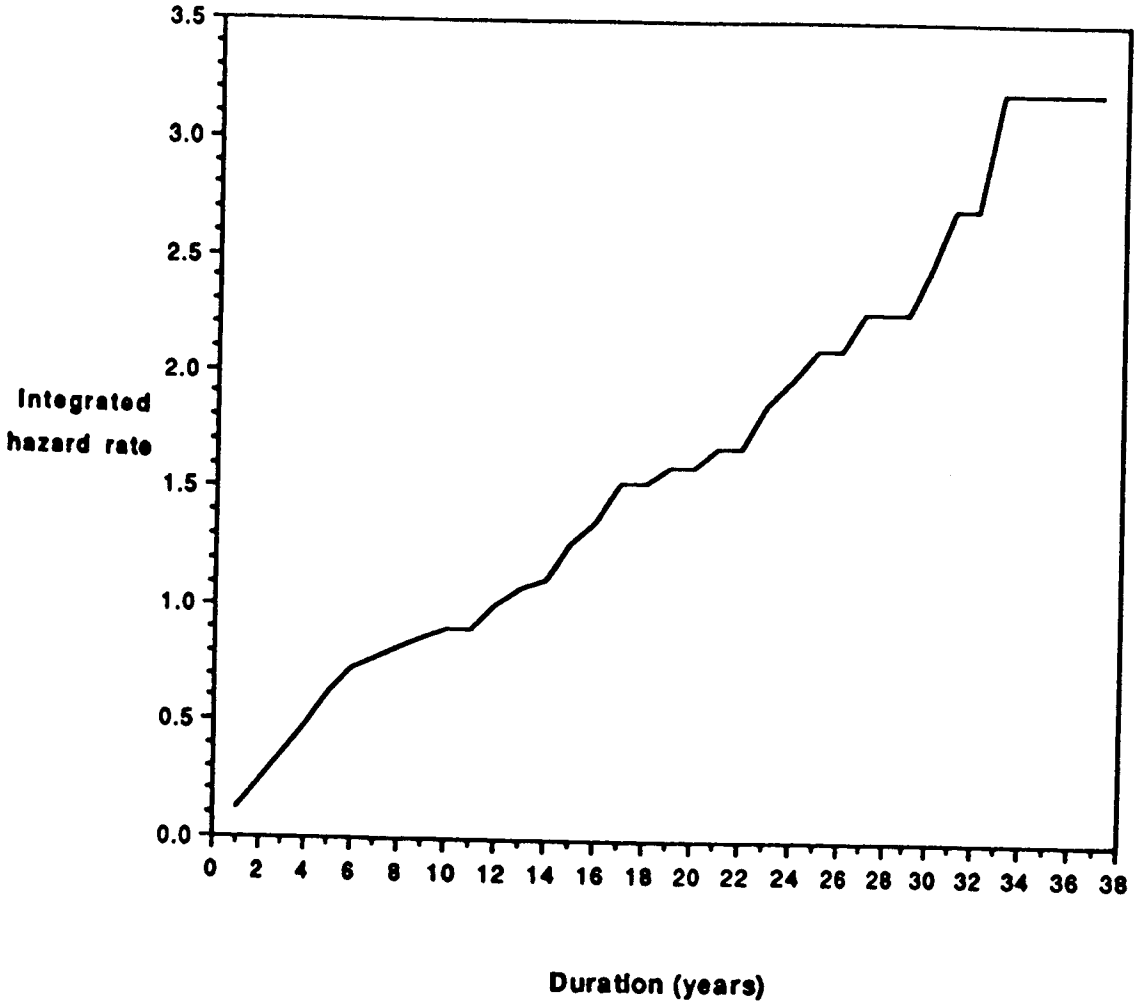

Figure 3: Survival Functions for Price–Fixing and Cost–Spreading Cartels

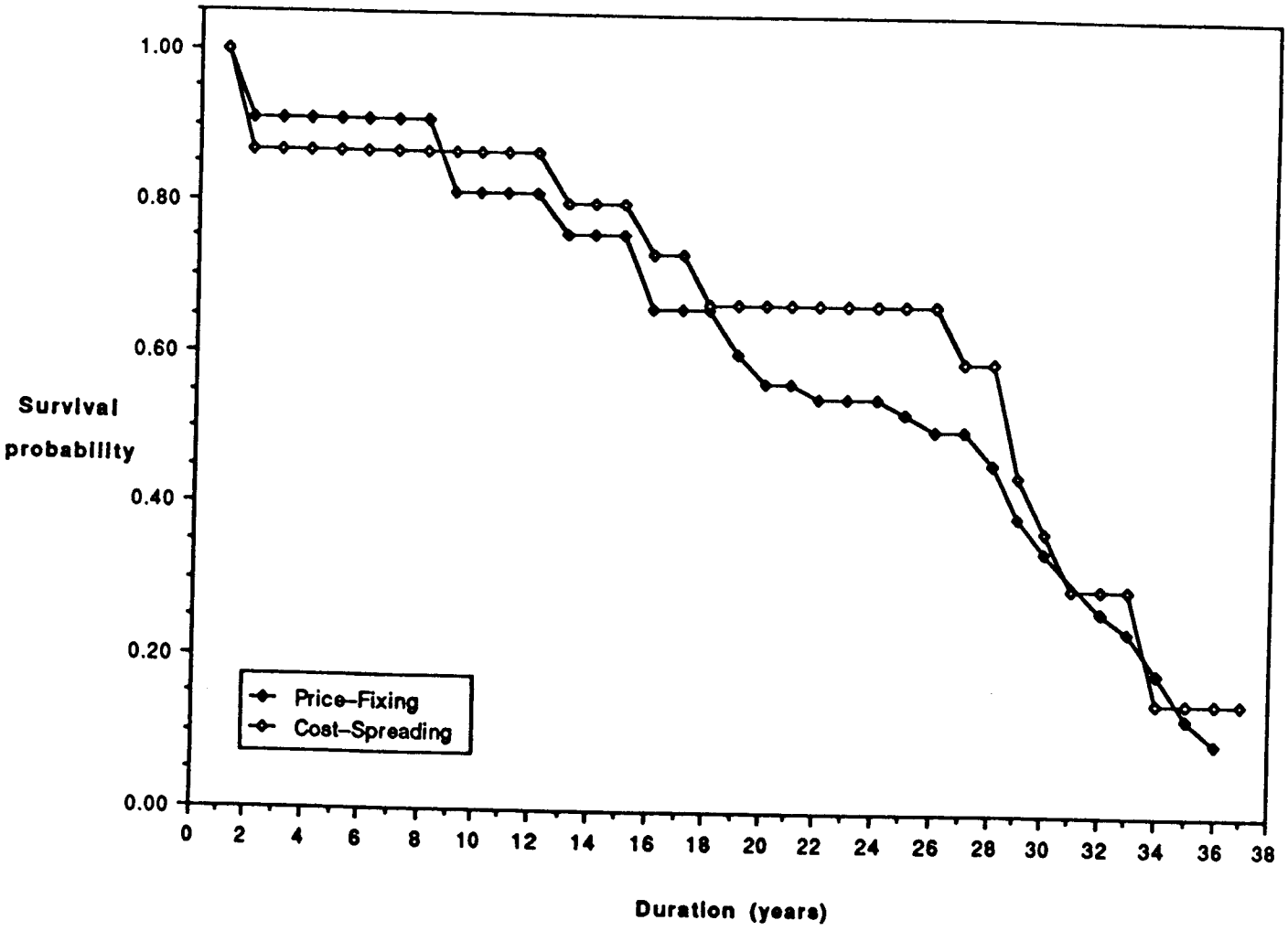

Table I

Functions Performed by 23 Active *Webb–Pomerene* Cartels in 1962

Function	No. of associations
Price setting and market allocation	19
Foreign sales offices and/or agents	13
Market research and information	9
Sales to U.S. government agencies	9
Freight and insurance	8
Negotiating with foreign governments and agencies	7
Promotional activities	6
Publications	6
Representing members before U.S. agencies	5
Statistical services	4
Engineering and related services	4
Distributing and licensing activities	4
Market development	3
Foreign storage facilities	2
Financing	2
Credit information	1

Source: United States Federal Trade Commission (1967, 48).

Note: Data are based on 23 (out of 26) *Webb–Pomerene* cartels that were active in 1962. Each association performed two or more of the functions listed.

Table II

Illustrative List of *Webb–Pomerene* Cartels in the Sample

Agricultural and Food Products (30%)

American Association of Feed Exporters
American Corn Products Export Association
California Dried Fruit Export Association
Flour Millers Export Association
General Milk Company Inc.
Pacific Fresh Fruit Export Association
Vegetable Oil Export Company

Raw or Semi–finished Industrial Materials (30%)

Alabama–Florida Pitch Pine Export
American Surface Abrasives Export Association
Anthracite Export Association
Carbon Black Export Inc.
Cerium Export Association
Export Petroleum Association Inc.
Florida Pebble Phosphate Export Association
Gulf Pitch Pine Export Association
Sulphur Export Corporation

Simple Manufactures (10%)

American Door Export Association
American Paper Exports Inc.
American Textile Trading Co.
Associated Button Exporters of America, Inc.
Consolidated Steel Corp.
Export Clothes Pin Association of America
U.S. Export Wallboard Association

Other (30%)
American Railway Car Export Association
American Tanning Materials Corp.
Electrical Manufacturers Export Association
Machine Affiliates Trading Corp.
Typewriter Manufacturers Export Association
U.S. Office Equipment Export Association

Table III: Life Table for Full Cartel Sample

(111 cartel episodes)

Duration (≤ years)	At Risk	Exited	Censored	Hazard Rate	Survival Rate	(Standard Error)
1	111	14	1	.1261	.8739	(.0315)
2	96	11	2	.1146	.7737	(.0398)
3	83	9	2	.1084	.6898	(.0442)
4	72	9	0	.1250	.6036	(.0471)
5	63	9	2	.1429	.5174	(.0484)
6	52	6	0	.1154	.4577	(.0485)
7	46	2	0	.0435	.4378	(.0484)
8	44	2	2	.0455	.4179	(.0482)
9	40	2	1	.0500	.3970	(.0480)
10	37	1	1	.0270	.3863	(.0479)
11	35	0	1	.0000	.3863	(.0479)
12	34	4	1	.1176	.3408	(.0474)
13	29	2	0	.0690	.3173	(.0469)
14	27	1	0	.0370	.3056	(.0466)
15	26	4	0	.1538	.2586	(.0450)
16	22	2	1	.0909	.2350	(.0439)
17	19	3	1	.1579	.1979	(.0418)
18	19	0	0	.0000	.1979	(.0418)
19	15	1	0	.0667	.1847	(.0411)
20	14	0	2	.0000	.1847	(.0411)
21	12	1	0	.0833	.1693	(.0404)
22	12	0	0	.0000	.1693	(.0404)
23	11	2	0	.1818	.1386	(.0385)
24	9	1	0	.1111	.1232	(.0372)
25	8	1	1	.1250	.1078	(.0356)
26	6	0	0	.0000	.1078	(.0339)
27	6	1	0	.1667	.0898	(.0339)
28	5	0	0	.0000	.0898	(.0339)
29	5	0	0	.0000	.0898	(.0339)
30	5	1	0	.2000	.0718	(.0315)
31	4	1	0	.2500	.0539	(.0283)
32	3	0	1	.0000	.0539	(.0283)
33	2	1	0	.5000	.0269	(.0237)
34	1	0	0	.0000	.0269	(.0237)
35	1	0	0	.0000	.0269	(.0237)
36	1	0	0	.0000	.0269	(.0237)
37	1	0	1	.0000	.0269	(.0237)

Note: At risk observations identify cartel episodes still in progress at the beginning of each year. Exited observations identify cartel episodes that ended by the conclusion of the year. Censored observations identify episodes that ended after the sample's conclusion, 1965. The hazard rate equals the probability that a cartel episode ended in year t, conditional upon having lasted until that date. The survival rate equals the probability that a cartel episode lasted at least until that date. Standard errors pertain to the survival rate.

Table IV

Summary of Regression Variables

(111 observations, except as noted)

Variable Name	Description (data source)	Predicted Effect on Cartel's Hazard Rate	Mean	Standard Deviation
AGENCY	Dummy = 1 for cartels exporting through a common sales agency [1] (1, 6)	–	0.58	0.50
ANTCYCLE	Dummy = 1 if cartel episode ends in an anticipated peak–to–trough period for export price, by product category [2] (2, 8)	+	0.54	0.50
BUYERSIZE	Percent of U.S. exports sold to four largest importing countries (4)	+	56.35	18.72
CYCLE	Dummy = 1 if cartel episode ends in a peak–to–trough period for export price, by product category [1] (2, 8)	+	0.54	0.50
DMDVAR	Coefficient of variation in quarterly export prices during the cartel episode, by product category [1] (2, 8)	+	0.03	0.03
EXPERIENCE	Length of prior cartel episode(s) discounted 20% annually during interim period (1)	?	0.81	2.52
HOMOG	Dummy = 1 for homogeneous goods[3]	–	0.47	0.50
LENGTH	Cartel episode length in years (1)		8.75	8.45
MEMBERS	Number of members in cartel (1)	+	18.32	23.97
MKTSHARE	U.S. share of world exports (4, 6)	–	0.26	0.19
MONITOR	Residual value from probit regression in Section V.B, capturing cartels' monitoring cost advantage [2]	–	–0.20	0.53
PRICE–FIX	Predicted value from probit regression in Section V.B, capturing cartels' price–fixing motives [2]	+	0.78	0.42

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[1] Data are available for 69 observations.

[2] Each cartel episode was assigned to either the foods, crude materials, semi–finished manufactures or finished manufactures sector.

[3] Defined as agricultural foodstuffs and raw industrial materials.

SIDE–AGREE	Dummy = 1 if *Webb–Pomerene* cartel negotiated side–agreement with foreign producers (6)	–	0.14	0.34
UNANTCYCLE	Unanticipated export price shock in cartel episode's final year, constructed as the residual from AR(1) regression of quarterly export prices [1] (2, 8)	?	0.08	0.47
USCYCLE	Dummy = 1 if cartel episode ends in a peak-to-trough period for U.S. industry output, by product category [4] (5)	+	0.22	0.41
USVAR	Coefficient of variation in quarterly U.S. industrial output during the cartel episode, by product category [4] (5)	+	0.03	0.04
WPSHARE	Dummy = 1 for cartels covering ≥ 50% of industry exports (1, 6)	–	0.38	0.49
WW2	Dummy = 1 if the cartel episode ends between 1939 and 1945		0.18	0.39

Notes: MEMBERS and WPSHARE pertain to the start of the cartel episode. BUYERSIZE and MKTSHARE are measured as close as possible to the middle of the cartel episode. Timing for the remaining variables pertains to the entire length of the cartel episode.

Data Sources: (1) United States Federal Trade Commission (1967), (2) United States Department of Commerce (1972), (3) Mitchell (1988), (4) United Nations (1952), (5) United States Board of Governors of the Federal Reserve System (1972), (6) United States Senate (1946), (7) Moore and Zarnowitz (1986), (8) Mintz (1967), (9) Burns and Mitchell (1946).

[4] Each cartel episode was assigned to either the mining, non–durable manufactures or durable manufactures sector.

Table V — Full Sample Regression Results

(111 observations; t–statistics in parentheses)

	Grouped Data Models			
	Semi–Parametric		Parametric	
Variable	(1)	(2)	(3)	(4)
BUYERSIZE	0.012*** (3.34)	0.013*** (3.94)	0.012* (1.61)	0.014** (1.88)
DMDVAR	14.013*** (46.89)	15.345*** (51.34)	13.921*** (4.39)	15.023*** (4.66)
MEMBERS	–0.83 E–2* (–1.62)	...	–0.92 E–2* (–1.63)	...
WPSHARE	–0.510*** (–2.72)	...	–0.626** (–2.07)	...
(1–WPSHARE) x MEMBERS	...	0.016*** (2.54)	...	0.015*** (2.26)
EXPERIENCE	0.145*** (2.62)	0.087** (1.62)	0.153*** (2.52)	0.075* (1.31)
δ_0	...	...	–3.938*** (–7.57)	–4.533*** (–8.39)
δ_1	...	...	0.078*** (3.87)	0.064*** (3.42)
CYCLE	0.912*** (4.63)	...	0.937*** (3.25)	...
ANTCYCLE	...	0.890*** (4.49)	...	0.893*** (3.04)
UNANTCYCLE	...	0.290* (1.51)	...	0.217 (0.81)
SIDE–AGREE	–0.937*** (–4.11)	–0.905*** (–4.14)	–0.816** (–2.07)	–0.794*** (–2.26)
USVAR	13.135*** (43.97)	12.942*** (43.33)	14.094*** (3.99)	14.046*** (3.98)
USCYCLE	–0.463*** (–2.33)	–0.472*** (–2.36)	–0.565** (–1.91)	–0.518** (–1.69)

WW2	−0.944*** (−4.70)	−1.022*** (−5.05)	−1.012*** (−3.00)	−1.082*** (−3.25)
Log−likelihood	−241.98	−242.09	−257.41	−259.07
Likelihood ratio test (d.f. = 10)	77.82***	77.59***	83.44***	79.95***

Notes:

1) *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

2) The parameters δ_0 and δ_1 pertain to the distributional assumption that the baseline hazard rate satisfies $\int_{t-1}^{t} h_0(u)\,du = \exp\{\delta_0 + \delta_1 t\}$.

Table V Continued — Full Sample Regression Results

(111 observations; t–statistics in parentheses)

	Continuous Data Models			
	Semi–Parametric (Proportional Hazard)		Parametric (Weibull)	
Variable	(5)	(6)	(7)	(8)
BUYERSIZE	0.011 (1.60)	0.013* (1.81)	0.71 E–2 (1.46)	0.90 E–2 * (1.67)
DMDVAR	11.515*** (3.51)	12.518*** (3.72)	9.649*** (3.49)	10.646*** (3.97)
MEMBERS	–0.65 E–2 (–1.17)	...	–0.62 E–2*** (–2.44)	...
WPSHARE	–0.444 (–1.48)	...	–0.354* (–1.90)	
(1–WPSHARE) x MEMBERS	...	0.014** (2.21)	...	0.95 E–2** (2.09)
EXPERIENCE	0.124** (2.14)	0.081 (1.45)	0.090*** (2.63)	0.044 (1.45)
α	...	...	1.588*** (9.51)	1.520*** (10.00)
CYCLE	0.838*** (2.92)	...	0.578*** (3.09)	...
ANTCYCLE	...	0.852 *** (2.89)	...	0.578*** (3.16)
UNANTCYCLE	...	0.176 (0.64)	...	0.168 (0.60)
SIDE–AGREE	–0.900** (–2.18)	–0.892** (–2.40)	–0.447 (–1.55)	–0.473* (–1.76)
USVAR	11.668*** (3.36)	11.679*** (3.33)	8.820*** (3.67)	9.224*** (3.58)
USCYCLE	–0.390 (–1.32)	–0.385 (–1.26)	–0.365* (–1.72)	–0.353 (–1.41)
WW2	–0.762** (–2.31)	–0.843 (–2.56)	–0.665** (–2.41)	–0.743*** (–2.52)
Constant	...	...	–3.034*** (–9.32)	–3.514*** (–11.22)
Log–likelihood	–320.67	–320.72	–118.91	–120.70

Likelihood ratio test (d.f. = 10)	65.64***	65.73***	85.36***	81.78***

Notes:

1) *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

2) The parameter α pertains to the distrubutional assumption that the baseline hazard rate satisfies $h_0(t) = t^{(\alpha-1)}$.

Table VI — Sub–Sample Regression Results
(69 cartel episodes with data on internal organization
t–statistics in parentheses)

	Grouped Data Models			
	Semi–Parametric		Parametric	
Variable	(1)	(2)	(3)	(4)
DMDVAR	33.593*** (88.38)	35.899*** (94.47)	35.726*** (3.85)	39.059*** (4.04)
WPSHARE	–1.266*** (–5.67)	–1.476*** (–6.84)	–1.340*** (–3.50)	–1.520*** (–3.84)
EXPERIENCE	0.230*** (4.25)	0.211*** (3.72)	0.243*** (3.72)	0.222*** (3.41)
δ_0	...	...	–5.421*** (–8.74)	–5.222*** (–9.68)
δ_1	...	...	0.128*** (5.06)	0.139*** (5.20)
CYCLE	1.552*** (7.12)	1.563*** (7.47)	1.581*** (4.02)	1.572*** (3.99)
USVAR	15.029*** (39.69)	16.119*** (42.59)	13.912*** (2.98)	14.714*** (3.10)
USCYCLE	–1.229*** (–4.75)	–1.098*** (–4.33)	–1.324*** (–3.11)	–1.178*** (–2.86)
WW2	–0.715*** (–2.96)	–0.921*** (–3.82)	–0.764** (–2.16)	–0.962*** (–2.60)
PRICE–FIX	0.607*** (2.99)	...	0.551* (1.48)	...
MONITOR	...	–0.771*** (–3.35)	...	–0.696*** (–2.21)
Log–likelihood	–144.49	–159.80	–142.97	–158.56
Likelihood ratio test (d.f. = 8)	70.32***	73.46***	76.91***	79.36***

Notes:

1) *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

2) The parameters δ_0 and δ_1 pertain to the distributional assumption that the baseline hazard rate satisfies $\int_{t-1}^{t} h_0(u)\,du = \exp\{\delta_0 + \delta_1 t\}$.

Table VI Continued— Sub–Sample Regression Results
(69 cartel episodes with data on internal organization
t–statistics in parentheses)

	Continuous Data Models			
	Semi–Parametric (Proportional Hazard)		Parametric (Weibull)	
Variable	(5)	(6)	(7)	(8)
DMDVAR	26.939*** (3.24)	28.355*** (3.42)	21.512*** (3.45)	20.828*** (3.50)
WPSHARE	–1.184*** (–3.18)	–1.354*** (–3.49)	–0.585*** (–2.88)	–0.538*** (–2.57)
EXPERIENCE	0.201*** (3.20)	0.182*** (2.90)	0.100*** (2.80)	0.113*** (3.27)
α	. . .	. . .	1.906*** (8.32)	1.912*** (8.03)
EXCYCLE	1.414*** (3.70)	1.421*** (3.71)	10.681*** (3.42)	0.722*** (3.53)
USVAR	14.517*** (3.23)	15.282*** (3.41)	7.054*** (2.86)	6.688*** (2.60)
USCYCLE	–1.050*** (–2.58)	–0.950*** (–2.43)	–0.560** (–1.98)	–0.667*** (–2.49)
WW2	–0.576 (–1.58)	–0.732** (–1.96)	–0.0498** (–2.35)	–0.431** (–1.94)
Constant	. . .	. . .	–3.272*** (–13.54)	–3.504*** (–12.77)
PRICE–FIX	0.434 (1.14)	. . .	. . .	0.336* (1.60)
MONITOR	. . .	–0.627** (–2.00)	–0.268 (–1.38)	. . .
Log–likelihood	–158.30	–157.01	–63.85	–63.77
Likelihood Ratio test (d.f. = 8)	62.62***	60.05***	70.62***	70.78***

Notes:

1) *, ** and *** denote significance at the 10%, 5% and 1% levels, respectively.

2) The parameter α pertains to the distrubutional assumption that the baseline hazard rate satisfies $h_0(t) = t^{(\alpha-1)}$.

Table VII — Sub–Sample of Likely Price–Fixing Cartels

(54 cartel episodes with predicted probability of price–fixing exceeding 0.50, t–statistics in parentheses)

	Grouped Data Models		Continuous Data Models	
	Semi–Parametric	Parametric	Semi–Parametric (Prop. Hazard)	Parametric (Weibull)
Variable	(1)	(2)	(3)	(4)
DMDVAR	34.105*** (79.39)	32.345*** (3.03)	28.108*** (2.74)	19.303*** (3.26)
WPSHARE	–1.365*** (–5.62)	–1.392*** (–3.08)	–1.221*** (–2.76)	–0.475*** (–2.44)
EXPERIENCE	0.316*** (5.89)	0.312*** (4.32)	0.265*** (3.87)	0.132*** (4.88)
α	...	...	...	2.185*** (6.17)
δ_0	...	–5.255*** (–8.87)	...	...
δ_1	...	0.147*** (4.92)	...	...
CYCLE	2.044*** (8.55)	2.027*** (4.16)	1.746*** (3.74)	0.832*** (3.51)
USVAR	18.390*** (43.01)	16.309*** (3.03)	16.187*** (2.74)	6.770*** (2.85)
USCYCLE	–1.539*** (–5.49)	–1.550*** (–3.41)	–1.223*** (–2.38)	–0.693*** (–3.29)
WW2	–1.122*** (–4.02)	–1.060*** (–2.46)	–0.887*** (–1.96)	–0.558** (–2.30)
Constant	...	...	...	–3.219*** (–14.48)
Log–likelihood	–105.57	–125.82	–110.18	–42.931
Likelihood ratio test (d.f. = 7)	65.80***	70.69***	55.03***	67.56***