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MARGARET LEVENSTEIN

This article uses the records of the Dow Chemical Company to analyze the role of distributors in facilitating collusion in the late nineteenth and early twentieth centuries. It compares collusion in three closely related markets: salt, bromine, and bleach. Where national distributors with well-established reputations had facilitated the entry of small producers into integrated markets, distributors could also facilitate collusion. Mass-producing entrants, like Dow, joined collusive distribution arrangements while improving their innovative production processes. In the longer run, they integrated forward to escape the output restrictions and arms-length relationship with customers imposed by collusive agreements.

This article explores the relationship between two well-known nineteenth-century institutions—the pool and the distributor. In the second half of the century, market integration in a variety of industries caused prices to decline; many firms turned to pools to limit competition and increase prices.[1] In order to succeed, however, pools had to solve the problems inherent in any attempt to collude. First, the pool needed to induce unanimous participation by producers. Otherwise, a single producer, refusing to join the pool, would be able to "free ride" on the high prices resulting from the output restrictions made by pool members. Second, the pool had to prevent its member firms from engaging in secret cheating. A common procedure was for the pool to take over certain distribution functions. Because firms did not directly offer their

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[1] The aggregate (wholesale) price level fell by 39.2 percent in the two decades in which many of these pools emerged (1870 to 1890). The price index for chemicals and drugs fell even more precipitously over the same period (55 percent). See U.S. Department of Commerce, *Historical Statistics*, Series E52 and E60, p. 201. Clark, *History*, mentions pools in wood products, cotton textiles, paper, and steel and iron products during this period (pp. 329–32, 484, 622–24, 631, 653, 717–21, 784–85). Several of these pools, in paper and steel and iron products, are discussed at greater length in Lamoreaux, *Great Merger Movement*. Railroad pools are discussed at length in Chandler, *Visible Hand*; and Ulen, "Cartels." Chandler also discusses the structure of a pool in the explosives industry (p. 439).

output for sale, they could not shade the price or offer rebates. In many cases the pool took physical possession of the producer's entire output as it was produced, to rid the firm of any temptation to sell outside. Finally, the pool needed to create barriers to entry and to induce any new entrants to cooperate with the pool (without bankrupting the pool). Given the multitude of difficulties to overcome, many economists have assumed that attempts to collude were infrequent and uniformly unsuccessful.

In many industries, however, another institution, the national distributor, could facilitate collusion. Descendants of powerful antebellum firms, national distributors had made fixed investments in information about and in developing reputations with customers. They had invested in a network of salesmen and in the expertise necessary to provide technical services to customers. They also often had more sophisticated technical skills than manufacturers, to whom they provided quality control and other technical services. Distributors selling a large number of products had an incentive to make these fixed investments, whereas small manufacturers selling a single uniform product did not.

This investment in information and reputation put distributors in a unique position to monitor and enforce cooperative pooling agreements. They knew who was buying and who was selling, so they could detect cheating. They offered a variety of distribution services that, given their established reputations, could not be easily replicated by a competitor, so producers had an incentive to join and remain in the pool in order to obtain the imprimatur of the distributor. In addition, the importance of their reputations created a barrier to entry in distribution greater than that which existed in production.

By the end of the century, technological advances, growth in market size, and high prices (where collusion was successful) led to the entry of new producers using continuous-process, mass-production techniques. As new entrants these firms did not have established reputations with networks of customers, and so had to turn to the established, pool distributors to sell their product. Unlike potential entrants using traditional methods, whom distributors might have refused to accommodate, the mass producing-entrant could offer the distributor goods at low cost. In return for cooperating with pool distributors, the mass-producing entrant enjoyed high prices. The profits earned from cooperation with the pool and the relief from the difficulties of having to sell one's own product protected these entrants while they perfected their own production processes, many of which were initially woefully inadequate.

In the long run, however, the mass producer came into direct conflict with the pool. The pool restricted output, but the mass producer wanted to increase output to take advantage of scale economies. The pool relied on an independent distributor to stabilize cooperation, but the mass producer needed to integrate vertically to identify and develop new

customers and new markets.[2] The mass producer could only break from the pool, however, when it could operate independently of the pool's distributors. Unlike the older manufacturers, the new mass producer had an incentive to invest in distribution, because its optimal scale of production was larger relative to the fixed investment required for distribution and because the increasing returns inherent in the new technology encouraged the development of new markets not served by existing distributors. During its period of cooperation with the pool, the mass producer used its profits to develop technical and marketing capabilities that gave it independence from pool distributors: then the mass producer destroyed the pool. In the reconfigured industry, non-competitive price setting continued, but the now vertically integrated mass producer increasingly relied on a variety of other strategies—product diversification, marketing, and technological innovation—to prevent competition from decreasing profits.

After the demise of the pool, distributors continued to serve markets in which economies of scope in distribution outweighed the advantages to vertically integrated selling. But the number of markets where this was the case was shrinking, in part because of the development of customer-specific products by vertically integrated mass producers. The distribution firms that thrived were those that used their technical and marketing expertise to integrate backward into production.[3]

Earlier research on the declining importance of national distributors during the nineteenth century has focused on changes in the relative costs and benefits of forward integration for manufacturing firms.[4] Urbanization and larger average firm size increased the density of markets and decreased the average cost of acquiring the information necessary to reach customers.[5] Mass producers, especially manufacturers of new products, found existing distribution networks unable to provide the range of marketing services desired.[6] Similar changes influenced the decisions of the firms examined in this article when they considered vertical integration. In particular, the desire to increase information flows between the manufacturer and the consumer, in order to develop and improve products, was crucial in the mass producer's

[2] Levenstein, "Information Systems," pp. 116–45, discusses changes in the relative costs and benefits of vertical integration for an innovative firm over its life cycle.

[3] Consider, for example, the growth of Mallinckrodt Chemical Works, a leading bromine distributor, now a part of the Imcera Group, with almost two billion dollars in sales, the twentieth largest chemical firm in the United States. Similarly Merck, an important bromine distributor after 1902, now has almost ten billion dollars in sales and is the third largest pharmaceutical firm in the country (*Chemical Week* 16 August 1992, p. 17). In the salt industry, the second largest U.S. producer, Morton salt, began as a salt distributor for the New York salt pool (Sutton, *Sunk Costs*, p. 329; and Eskew, *Salt*, p. 131).

[4] See Chandler, *Visible Hand*; Porter and Livesay, *Merchants*; and Levenstein, "Information Systems," chap. 3.

[5] Porter and Livesay, *Merchants*, pp. 10–11.

[6] Chandler, *Visible Hand*, p. 287; and Porter and Livesay, *Merchants*, p. 11.

decision to integrate. But this earlier work ignored the quandary in which the mass producer found itself: the decision to integrate was simultaneously a decision to disrupt the existing pricing mechanisms and therefore likely to provoke a price war. It also ignored an apparently important function of national distributors during this transitional period to integrated national markets.

In this article I examine the relationship between pools and distributors in three closely related markets, salt, bromine, and bleach.[7] In each of these industries, producers tried to collude. I use the correspondence and internal memoranda of an entrant, the Dow Chemical Company, to analyze the role of the distributor and the changing relationship between the entrant and the distributor as the entrant matured. Dow introduced mass-production techniques into the manufacture of both bleach and bromides. The experience of those industries, especially bromine in which collusion was successfully maintained with the support of national distributors, contrasts with that of salt. Although salt was the primary product for Dow's bromine competitors, collusion was much less successful because the economics of the industry could not support the existence of national distributors.

INCREASING COMPETITION, INCREASING COLLUSION: POOLS IN THE SALT INDUSTRY

The nineteenth century opened with salt markets balkanized by high transportation costs. Despite knowledge of richer sources of salt further inland, coastal producers from Cape Cod to Key West continued to compete successfully until the beginning of the nineteenth century, protected by high overland transportation costs.[8] Inland, high transport costs protected producers in upstate New York and the Kanawha Valley (in western Virginia, later West Virginia) from competition with one another and from salt used as ballast on trans-Atlantic crossings. Until 1820 Kanawha producers had a regional monopoly of the area north of Louisville, because ships could not easily transport salt imported in New Orleans past the falls of the Ohio River. The introduction of steamships on the Mississippi River system decreased the cost advantage of Kanawha producers in this market, including the largest single city, Cincinnati.[9] Five years later the opening of the Erie

[7] Salt, bleach, and bromine producers all used the same natural resource input—salt water brine—from which they extracted their respective products: sodium chloride, chlorine, and bromine. In many cases firms produced more than one of these products.

[8] Salt production took place in Key West, Long Island, Cape Cod, and the coastal areas of New Jersey, Virginia, North and South Carolina, and Delaware. Weiss, *Revolutionary Saltworks*, pp. 13–15; Fost, "Salt Industry," p. 4; Eskew, *Salt*, pp. 33–34; and Haynes, *American Chemical Industry*, pp. 57–58, 169–70.

[9] Stealey, *Antebellum Kanawha Salt Business*, pp. 42–43. Cincinnati was an important market for salt not simply because it was the largest urban area in the region, but also because

Canal led to increases in output for New York producers and increased competition in midwestern markets.[10] The construction of canals across Ohio and Indiana extended the reach of New York producers in midwestern markets and facilitated the entry of new producers in Ohio.[11] These trends were reinforced with the arrival of the railroad.[12]

Salt output increased dramatically as transport costs fell and markets expanded geographically (Table 1).[13] By the beginning of the nineteenth century, salt production was migrating westward, first into New York State, then into West Virginia, Michigan, and Ohio.[14] In 1810 the United States imported more than twice as much salt as it produced (250,000 barrels produced and 600,000 barrels imported). By 1829 domestic output had more than tripled.[15] Total domestic output continued to grow in the second half of the century, at least doubling between 1864 and 1880, and increasing some eightfold between 1880 and 1914 (Table 1).[16] New entrants developed supply sources further west.[17] By the end of the century, Kansas, California, Louisiana, Texas, and Utah were all substantial salt producers, producing more than any other states but

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meat-packing, which consumes large quantities of salt, was concentrated there. The westward migration of meat-packing to Chicago would later be another blow to the Kanawha salt producers (Stealey, *Antebellum Kanawha Salt Business*, pp. 42–43, 189–90).

[10] New York produced 70,000 barrels of salt in 1816, the year construction on the Erie Canal began. It produced 150,000 barrels by 1825, the year that construction was completed. One might guess that the Canal reached the Onondaga salt district in 1819, when output increased from 80,000 to 105,000 barrels in one year. Output doubled again by 1831, when it reached 300,000 barrels, and again by 1841 (670,000 barrels), and again by 1858 (1,400,000 barrels). See USGS1882. Eskew, *Salt*, claims that salt interests influenced the routing of the Erie Canal through Syracuse and that salt taxes and tariffs paid for about half the cost of constructing the canal (pp. 59–62).

[11] Eskew, *Salt*, pp. 59–60; and Stealey, *Antebellum Kanawha Salt Business*, pp. 45–46. West Virginia producers regularly complained that they were at a competitive disadvantage with New York and Ohio producers because their state governments pursued more active canal construction policies than the Virginia General Assembly was willing to undertake, especially in the politically weaker western portion of the state. They also argued that the Ohio authorities manipulated canal rates to favor local producers (Stealey, *Antebellum Kanawha Salt Business*, pp. 45–46).

[12] Stealey, *Antebellum Kanawha Salt Business*, p. 47.

[13] New product markets developed later. More than two-thirds of salt output is now consumed by the chemical industry (Fost, "Salt Industry," p. 2). Most of this salt is produced by chemical firms for their own use. Another important use for salt, road de-icing, is also a twentieth-century phenomenon.

[14] West Virginia's salt output doubled between 1827 and 1834 (from 157,000 to 340,000 barrels). Michigan's output doubled between 1861 and 1862 (from 125,000 to 243,000 barrels), again from 1862 to 1864 (243,000 to 529,000 barrels), and again between 1864 and 1874 (529,000 to 1,028,000 barrels). By 1876 Michigan's output had surpassed that of New York (1.5 million barrels compared with 1.1 million). Ohio had begun to produce salt by the turn of the century, but we have no output data before 1880, when it was already a substantial producer. Ohio's output tripled between 1893 and 1896 and doubled again by 1906 (from 543,000 barrels to 1,662,000 to 3,237,000).

[15] Haynes, *American Chemical Industry*, p. 170.

[16] The total output figure for 1864 is actually the sum of the output from Michigan, West Virginia, and New York, all of which had salt superintendents and collected salt data before the federal government began to do so in 1880.

[17] The only case of an incumbent firm expanding to another region was Joy Morton & Company, predecessor of Morton Salt, which purchased plants in Kansas and built a new plant in Wyandotte, Michigan, in 1893 (Eskew, *Salt*, pp. 139–40).

TABLE 1
THE SALT INDUSTRY, 1867–1914

Year	Output (barrels)[a]	Average Price of a Barrel of Salt (nominal $)	Value of Output ($1,000)	Value of Output (real $1,000)[b]	Average Price of a Barrel of Salt (real $)	Net Exports (barrels)
1867	1,993,834	—	—	—	—	−728,842
1868	2,289,013	—	—	—	—	−991,068
1869	2,293,735	—	—	—	—	−1,058,116
1870	2,370,975	—	—	—	—	−1,282,232
1871	2,403,166	—	—	—	—	−1,177,101
1872	2,310,666	—	—	—	—	−1,141,639
1873	2,315,417	—	—	—	—	−1,822,819
1874	2,232,839	—	—	—	—	−2,214,194
1875	2,517,754	—	—	—	—	−1,854,853
1876	2,541,264	—	—	—	—	−1,723,484
1877	2,946,594	—	—	—	—	−1,713,426
1878	3,291,123	—	—	—	—	−1,618,834
1879	3,722,472	—	—	—	—	−1,767,433
1880	4,285,338	—	4,828.6	16,650	—	−1,863,228
1881	4,333,746	—	4,200.0	14,483	—	−2,038,393
1882	6,412,373	0.67	4,320.1	14,897	2.32	−1,745,547
1883	6,192,231	0.69	4,251.0	15,182.1	2.45	−1,667,660
1884	6,514,937	0.64	4,197.7	15,547.0	2.39	−1,664,557
1885	7,038,653	0.69	4,825.3	17,871.5	2.54	−1,564,162
1886	7,707,081	0.63	4,825.3	17,871.5	2.32	−1,496,538
1887	8,003,962	0.51	4,093.8	15,162.2	1.89	−1,471,974
1888	8,055,881	0.54	4,374.2	16,200.7	2.01	−944,591
1889	8,005,565	0.52	4,195.4	15,538.5	1.94	−945,084
1890	8,876,991	0.54	4,752.3	17,601.1	1.98	−894,674
1891	9,987,945	0.47	4,716.1	17,467.0	1.75	−782,138
1892	11,968,890	0.47	5,654.9	20,944.1	1.75	−751,407
1893	11,897,208	0.35	4,154.7	15,387.8	1.29	−471,353
1894	12,968,417	0.37	4,739.3	18,228.1	1.41	−589,356
1895	13,669,649	0.32	4,423.1	17,692.4	1.29	−723,975
1896	13,850,726	0.29	4,040.8	16,163.2	1.17	−658,956
1897	15,973,202	0.31	4,920.0	19,680.0	1.23	−512,718
1898	17,612,634	0.35	6,212.6	24,850.4	1.41	−525,029
1899	19,708,614	0.35	6,867.5	27,470.0	1.39	−493,217
1900	20,869,342	0.33	6,944.6	27,778.4	1.33	−568,897
1901	20,566,661	0.32	6,617.4	26,469.6	1.29	−589,910
1902	23,849,231	0.24	5,668.6	21,802.3	0.91	−592,122
1903	18,968,089	0.28	5,287.0	19,581.5	1.03	−400,378
1904	22,030,002	0.27	6,021.2	22,300.7	1.01	−354,129
1905	25,966,122	0.23	6,095.9	22,577.4	0.87	−252,966
1906	28,172,380	0.24	6,658.4	24,660.7	0.88	−234,235
1907	29,704,128	0.26	7,608.3	27,172.5	0.91	−218,387
1908	28,822,062	0.26	7,553.6	27,976.3	0.97	−242,352
1909	30,107,646	0.28	8,343.8	30,903.0	1.03	−168,554
1910	30,305,656	0.26	7,900.3	28,215.4	0.93	−49,996
1911	31,183,968	0.27	8,345.7	29,806.1	0.96	−39,745
1912	33,324,808	0.28	9,402.8	32,423.5	0.97	47,877
1913	34,399,321	0.29	10,123.1	34,084.5	0.99	93,449
1914	34,804,686	0.29	10,197.4	33,878.4	0.97	205,252

[a] Salt output from 1867 to 1881 is the sum of output in the largest producing states, Michigan, New York, and West Virginia, and so undoubtedly underestimates national output.
[b] Values are deflated using Consumer Price Index, Series E135 (1967 = 100), U.S. Department of Commerce, *Historical Statistics*.
Note: Dash indicates information is unavailable.
Source: See the Appendix.

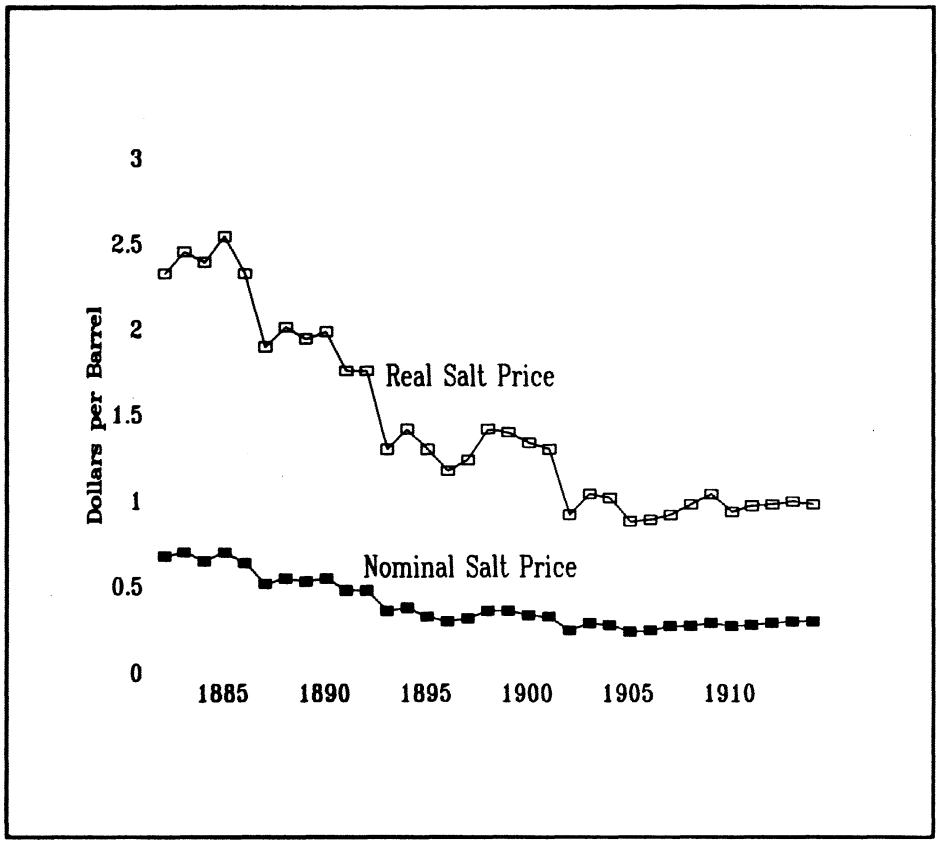

FIGURE 1

SODIUM CHLORIDE SALT PRICES: NOMINAL AND REAL PRICES, 1882–1914

Note: Real prices are deflated using U.S. Department of Commerce, *Historical Statistics*, Consumer Price Index, Series E135, pp. 210–11.
Source: See the Appendix.

Michigan, New York, and Ohio.[18] Beginning in 1882, net imports began to decrease, though the country did not become a net exporter until just before World War I (Table 1).

During this period of expansion of output, prices fluctuated wildly, but the secular trend was clearly downward (Table 1 and Figure 1). Spot prices of salt ranged from $250.00 (during the war of 1812) to $1.00 per barrel over the period 1790 to 1860.[19] The price of coarse salt in Philadelphia averaged about $2.70 per barrel between 1821 and 1824; and except for the Civil War, declined steadily thereafter, reaching 75 cents by 1880.[20] Salt prices continued to fall during the last quarter of

[18] *USGS1909*, pp. 910–11.
[19] Haynes, *American Chemical Industry*, p. 169.
[20] Bezanson, Gray, and Hussey, *Wholesale Prices*, p. 187; and Jenks, "Michigan Salt Association," p. 15.

the century (Figure 1). The nominal price fell steadily after 1882, from 67 cents per barrel to 35 cents in 1893, reaching a pre–World War I trough in 1905 at 23 cents per barrel (Table 1 and Figure 1).[21] Thus although total output quadrupled between 1880 and 1896, the real value of total output stayed almost the same (Table 1). Not surprisingly, although producers took advantage of opportunities to expand output to new markets, they also tried to forestall competition and falling prices by cooperating with other firms. But, as these price trends suggest, they did so with little effect.

Between the formation of the first documented salt pool in 1817 and the creation of the first "salt trust" in 1898, salt producers established at least 14 pools.[22] Producers participated in pools in all the major producing regions (New York, West Virginia, Ohio, and Michigan). The salt pools faced the same fundamental contradiction that always faces attempts to raise prices by restricting output. The success of a pool in raising price above marginal cost creates incentives for producers to cheat—selling outside the pool at a price in between the pool price and marginal cost. A successful pool, moreover, invites entry into the industry. Incumbent firms who had hoped to enjoy the profits of collusion are instead forced to share profits with newcomers or to lower prices. This dilemma does not, however, seem to have prevented firms in most industries from attempting to collude; instead, it led to enormous creativity by firms attempting to design mechanisms that would create disincentives to cheating and barriers to entry.

The salt pools were not only creative but persistent in this respect. Nonetheless, their attempts to collude remained largely unsuccessful,

[21] In real 1967 dollars the price of salt also fell over this period. Starting at $2.45 per barrel in 1883 (the first year for which we have official government data), the price fell to successive troughs in 1896 ($1.17 per barrel), in 1902 (91 cents), and finally reached 87 cents in 1905. It then increased, levelling off at about 97 cents between 1908 and 1914. See Table 1.

[22] This number is undoubtedly too low, as it is based on those cases where the pool's existence has been well established in the secondary literature. Little research has been done on the Syracuse industry, where we know pools existed, but about which we have few details. The 14 documented pools are the Saginaw and Bay Salt Company (founded in Michigan in 1868), the Michigan Salt Association (1876), the Salt Company of Onondaga (New York 1860), the Onondaga Salt Association (New York 1871), an unnamed association of Ohio producers (1871), Steele, Donnally, and Steeles (West Virginia 1817), the Kanawha Salt Company (West Virginia 1818), Armstrongs, Grand & Company (West Virginia 1827), Dickinson, Armstrongs and Company (West Virginia 1830), Hewitt, Ruffner and Company (West Virginia 1836), Kanawha Salt Association (West Virginia 1847), Ruffner, Donnally and Company (West Virginia 1851), the United Salt Company of Ohio (1898), and the United States Salt Company (Ohio 1896): see Jenks, "Michigan Salt Association," pp. 4–11; Haynes, *American Chemical Industry*, p. 171; Stealey, *Antebellum Kanawha Salt Business*, pp. 22–36, 77–84, 90–99, 158, 168–84; Eskew *Salt*, pp. 88–90; Bownocker, "Salt Deposits," p. 18; and PSA file #960035, letter from B. E. Helman to Herbert Dow, 23 November 1896. Both government reports and the secondary literature also mention several joint selling agencies that were not pools, but the distinction between the two is not explicit. Although a theoretical distinction would focus on the exclusive nature of the distribution contracts, in practice the distinction probably reflected the percentage of output controlled by the common agent (Bownocker, "Salt Deposits," p. 18; and Stealey, *Antebellum Kanawha Salt Business*).

despite the implicit cooperation of many state governments.[23] Salt producers in a region (usually a state, though there were attempts at interstate coordination) would agree to sell their output to a jointly owned and controlled selling agent (the pool). The pool would set uniform prices and distribute the salt of all participating producers. In some cases, the pool established quality controls, standardized grades of salt, and rationalized salt transport. The agreements sometimes established output quotas or "dead-rented" salt furnaces, paying firms not to produce for an entire year.[24]

The pool structure offered salt producers two advantages in trying to cope with the difficulties in sustaining collusion. First, by taking physical control of salt output, pools limited secret cheating. Reports in the secondary literature suggest that the salt pools were fairly successful in this respect. Second, by creating a common intermediary that provided distribution services and credit, initiators of the pool hoped to induce participation by current producers and to create barriers to new entry.

These arrangements did sometimes lead to a temporary increase in prices. But they always broke down within a year or two, if not sooner. If the pool contracted to buy output at high prices with no output restrictions, it was quickly bankrupted as induced increases in output led to overflowing inventories.[25] In cases where the pool had not committed to high prices, participating firms had an incentive to sell outside, particularly if their output was restricted by the pool.[26] In all cases, higher prices led to new entry—from existing producers in other regions and increasingly from regions to the west where new and richer sources of supply were located.[27] Thus despite their attempts to

[23] For example, states reported the output of individual firms at regular intervals. In Michigan, inspectors made daily output reports for every plant (Jenks, "Michigan Salt Association," p. 13). West Virginia inspectors made quarterly reports of output and capacity (Stealey, *Antebellum Kanawha Salt Business*, p. 62). New York had a Superintendent of Salt by 1797, who made at least annual reports of salt output (Eskew, *Salt*, p. 52; and USGS1882). Abreu, Milgrom, and Pearce, "Information," make the provocative suggestion that very frequent reporting of output data could actually lessen the participants' ability to sustain collusion.

[24] The contractual mechanism that salt pools used to restrict output was called a "lease-back." The pool leased the production facilities of a salt manufacturer and then leased the facility back to the owner. The lease-back had a provision limiting output and requiring the owner to sell the output back to the pool. Lease-backs were used in several Kanawha Valley pools. An example of one such agreement is given in detail in Stealey, *Antebellum Kanawha Salt Business*, pp. 77–79.

[25] This was the case for Steele, Donnally, and Steeles, the first cooperative organization among the Kanawha Valley producers (Stealey, *Antebellum Kanawha Salt Business*, pp. 23–24) and an unnamed 1868 association of producers in the Pomeroy region (Jenks, "Michigan Salt Association," p. 11).

[26] Instances in which cooperation broke down because of cheating by pool participants include the Saginaw and Bay Salt Association (Jenks, "Michigan Salt Association," p. 6), the Michigan Salt Association (ibid., p. 18), Dickinson, Armstrongs and Company (Stealey, *Antebellum Kanawha Salt Business*, pp. 83–84), and the 1847 reincarnation of the Kanawha Salt Association (ibid., pp. 159–62).

[27] Particularly in the West, where transportation costs provided some protection from imported

stabilize the industry, salt manufacturers faced fluctuating (and declining) prices and new competition from both foreign imports and new domestic producers.

Collusion was not sustainable in the nineteenth-century salt market for two reasons: there were no barriers to entry in production, and there were none in distribution. On the production side, the natural resource input was available in greater or lesser concentration virtually everywhere; the production technology was simple; no major innovations were introduced during this period; and fixed costs and economies of scale were limited.[28]

The salt pools were attempts to sustain collusion by creating barriers to entry in the distribution of salt. But given the nature of the salt market at that time and the inability of salt pools themselves to transform the salt market, barriers to entry in salt distribution were limited and difficult to sustain. Salt customers were ubiquitous, and little specialized information about customers was necessary for successful marketing. Customers were sufficiently dense that local markets could support the relatively small fixed investment necessary to engage in salt distribution. Salt distributors, as a consequence, tended to be locally oriented and no more informed about national or international markets than producers themselves. Quality was not difficult to measure, so distributors did not have to make a large fixed investment in the ability to measure and grade quality or in a reputation for quality, which would have had little value to consumers.

As a result, the distribution services offered by pools distinguished them only slightly from other salt distributors. Moreover, the salt pools' attempts to bring together all producers also created problems not faced by ordinary distributors. With no advantage to a national distribution network, salt pools remained regional. Attempts to form national coalitions were few, and they were failures.[29] Even within a region,

salt, high pool prices induced search for new sources of supply. See Wright, "Origins," for more discussion of the relationship between economic activity and changes in the incentives for "discovery" of natural resource "endowments" as the United States developed.

[28] The ease of entry into salt production is illustrated by the Michigan case. The first commercial production began in 1860. Within eight years, output had expanded to over half a million bushels a year, about one-sixth of the national output. The financial and human capital necessary for entry were so modest that much of the new entry was from lumber mills producing salt as a way to reduce the cost of disposing of sawdust and scraps. The technology used by Ohio salt producers in the early twentieth century was essentially the same as that used before the Civil War (Bownocker, "Salt Deposits," p. 17). Similarly, West Virginia producers engaged in no systematic study of their production technology and made only incremental changes during the first half of the century (Stealey, *Antebellum Kanawha Salt Business*, p. 48). Unlike the bromine industry, no firm with the capability to engage in technological innovation emerged before the mergers that created the salt trusts at the end of the century.

[29] There were failed attempts at interstate cooperation in 1870, 1871, and 1881 (Jenks, "Michigan Salt Association," p. 12). These finally resulted in the "salt trusts" at the end of the century. The National Salt Company of New Jersey was formed in 1899 and went bankrupt in 1902. It was by then controlled by the International Salt Company, formed in 1901 (Dewing, *Corporate*

unanimous participation among producers was difficult to achieve because of the large number of producers and the geographic dispersion of production.[30] Pools had difficulty mediating tensions between producers with different interests. Although they were legally distinct entities, the salt pools, unlike ordinary distributors, were not economically distinct from producers. Pools were jointly owned by producers, either through the issuing of stock or the creation of a joint-partnership agreement. In West Virginia the pools were controlled by the largest producers. Smaller producers were reluctant to join pools that they feared would not represent their interests.[31] Similar concerns complicated collusion in other regions.[32]

The salt pools attempted to limit entry and establish a competitive advantage relative to other distributors by creating product quality and packaging standards. They were aided in these efforts by state governments, acting at the pool's behest.[33] But a state's salt inspectors could only operate within the state, whereas competition was increasingly national. Their regulation of quality was also not informed by contact

Promotions, pp. 206–20). By 1910 International was in financial difficulties and was selling off parts of its far-flung acquisitions. Morton Salt gained control of the International Salt Company of Illinois and took it out of the larger trust (Eskew, *Salt*, pp. 149–56). The two firms, International and Morton, are today the two largest sellers of salt in the United States, in an industry with a four-firm concentration ratio of 99.5 percent (Sutton, *Sunk Costs*, p. 137). They have been accused of collusion in several antitrust suits during the twentieth century. But their ability to raise prices is limited by the potential entry of a large number of chemical firms that produce salt for their own direct consumption (and whose output is not, therefore, included in the concentration ratio above). See Fost, "Salt Industry"; and Sutton, *Sunk Costs*.

[30] Examples of pools that operated despite at least one local firm declining to participate include Armstrongs, Grand & Company; Dickinson, Armstrongs and Company; Ruffner, Donnally and Company; and Saginaw & Bay Salt Company (Stealey, *Antebellum Kanawha Salt Business*, pp. 79–85, 168; and Jenks, "Michigan Salt Association," p. 4).

[31] Stealey, *Antebellum Kanawha Salt Business*, p. 85.

[32] For example, similar tensions led to the demise of Saginaw & Bay Salt Company in 1871 (Jenks, "Michigan Salt Association," p. 7). The financial instability of the salt pools limited their ability to induce the cooperation of all producers. Pool finances depended completely on the success of the collusive strategy. They had no other financial resources. Salt pools did not have long-term contracts for the sale of output to customers. Financial stability was particularly important to small producers deciding whether to contract with the pool or to sell through an independent commission merchant who might well be offering better and more secure credit terms. See Stealey, *Antebellum Kanawha Salt Business*, pp. 90–102. Many of the salt pools paid manufacturers part in cash and part in notes issued by the pool. In some cases, credits with the pool could be redeemed in merchandise at a store owned by the pool (ibid., pp. 93–94). The possibility of bankrupting the pool might have increased the credibility of the salt pool's threat to lower prices if all producers did not agree to sell through the pool.

[33] Jenks, "Michigan Salt Association," reports that the Saginaw and Bay Salt Association, one of the first Michigan salt pools, drafted Michigan's first (1869) salt-inspection law "to keep up the quality of the product and prevent injury to the reputation of Saginaw salt" (p. 13). Stealey, *Antebellum Kanawha Salt Business*, says that Kanawha salt producers not only supported the passage of state salt-inspection laws, but controlled the administrative body that set and enforced standards for packaging and quality (p. 64). New York State had a salt superintendent who inspected all output by 1800. New York passed a new law to improve salt quality in 1850 (Eskew, *Salt*, pp. 52–53, 124).

with customers: they had no specialized information about customers that could be used to market the salt of their state's producers to any particular advantage. Although contemporary observers remarked favorably on the role played by pools in standardizing salt quality, the value to consumers was not sufficient to give pool salt a competitive advantage or to induce stray producers to join the pool.[34]

Salt pools attempted to cultivate reputations for their region's salt through relationships with private distributors who did have information about customers. Salt pools selected exclusive distributors in large markets, but these distributors were themselves local in scope. Agreements limited them to selling in a particular geographical region; pools frequently became enmeshed in controversies between their own, geographically adjacent distributors. Occasionally a distributor would work closely with a pool, providing information about market conditions. But the attempt to build a reputation in conjunction with an independent distributor was undermined by the lack of a long term relationship; at least one distributor switched pools.[35] Attempts to use distributors to detect cheating also failed. Distributors with sufficient information to detect cheating were also in a position to take advantage of the pool, and did so.[36]

The salt pools themselves tried to monitor quality and establish standard grades, but their contact with customers continued to be mediated through small, independent distributors who frequently saw their interests as in conflict with the pools.[37] Pools were in a position to decrease the costs of providing information about quality to customers—through the adoption of uniform standards—and establish regional reputations for quality. But differences in—or a reputation for—quality were not sufficiently important to the consumer or sufficiently difficult to replicate to create a barrier to entry. Pools were not in a position to cultivate long-term relationships with customers nor to provide customer-specific products, either of which might have given a pool an advantage relative to potential competition. In the post–World War I era, Morton Salt, having integrated backward into production, was able to act successfully as a price leader (for a much consolidated) indus-

[34] Ripley, "Michigan Salt Association," says "much credit must be given the [Michigan Salt Association] for the improvement of the quality of the salt manufactured in the state" (p. 13).

[35] Morton switched from the New York salt pool to the Michigan Salt Association in the 1870s (Eskew, *Salt*, pp. 125–33).

[36] In general, an agent with information about the pool's strategy was in a position to collude with customers or outsiders. The particular instances of betrayal of the salt pool by distributors all seem to be attempts by former distributors to use their knowledge of the pool's activity to arbitrage between different cities where the pool hoped to charge different prices. For example, Stealey, *Antebellum Kanawha Salt Business*, writes that "Frederick F. Brooks, who had been [the] Queen City agent . . . being knowledgeable about the business . . . had purchased one thousand barrels of salt from the company agent in Madison, Indiana, in August 1853, to hold until the price was advanced for the packing season" (p. 174).

[37] Jenks, "Michigan Salt Association," p. 16.

try.[38] But the growth of Morton and its national reputation was built on the "when it rains, it pours" advertising campaign and on packaging innovations. These marketing tools gave economic value to a national reputation. But until there was an economic basis for such a national distributor, barriers to entry in distribution did not exist, and collusion could not be sustained.[39]

INCREASING COMPETITION, INCREASING COLLUSION: THE SUCCESSFUL BROMINE POOLS

When commercial production of bromine commenced before the Civil War, demand for the chemical was limited to use in daguerreotype photography.[40] Output was low, and prices were high. Liquid bromine sold for six to eight dollars per pound. Pennsylvania salt manufacturers produced bromine as a by-product. In bromine, a high value to weight product, declining transport costs had less impact than in salt. Instead, market expansion was initiated by the Civil War discovery of bromine's sedative properties. With an increase in demand, production increased and moved westward to the salt-producing regions of the Ohio and Kanawha River Valleys (in Ohio and West Virginia), which had higher concentrations of bromine in their underground brine. The price fell to $4.50 per pound by the end of the war. The price continued to fall, reaching 90 cents in 1870; and output continued to increase as American bromine expanded into international markets. In 1880 the leading industry publication reported that "since [1870] the cheapness of American bromine has gained for it a largely increased sale abroad."[41] Prices fell further, reaching a trough in 1884 at 20 cents per pound (Table 2 and Figure 2).

As in salt, bromine producers responded to this fall in prices by organizing a pool. Despite similarities in the producing firms—all bromine producers were also salt producers until 1892—the bromine pools were much more successful than any of the salt pools. Unlike the persistent decline in salt prices through the century (Figure 1), the

[38] Sutton, *Sunk Costs*, p. 139.

[39] See Eskew, *Salt*, pp. 158–63. The subsequent importance of Morton Salt and its marketing strategy in consolidating and stabilizing the industry suggests that one could tell a more nuanced story in which entrepreneurial failure also played a role. No one today would buy salt for home consumption whose container does not have a spout and that does not pour easily. A vertically integrated firm changed what consumers expected, and demanded.

[40] Haynes, *American Chemical Industry*, says that "bromine was first produced from native salt brines . . . in 1845" (p. 324), but earlier in the same volume, he reports experiments in bromine production in 1829 and says that J. Q. Dickinson, a Kanawha salt manufacturer, made bromine in 1832 (p. xliii). J. E. Stealey, historian of the Kanawha salt industry, questions the earlier date, which preceded J. Q. Dickinson's entry into his grandfather's (William Dickinson) salt business (personal correspondence with the author).

[41] By 1870 American bromine was exported abroad, and by 1875 American bromine dominated the world market (*Oil, Paint and Drug Reporter*, 1880, p. 655).

TABLE 2
THE BROMINE INDUSTRY, 1880–1914

Year	Number of Firms	Output (pounds bromine)	Output ($ bromine)	Potassium Bromide Price (¢ per pound)
1880	12[a]	404,690[a]	—	28.0
1881	—	—	—	31.1
1882	—	—	—	31.5
1883	11	301,100	—	30.7
1884	—	281,100	67,464	29.3
1885	—	310,000	89,900	33.6
1886	—	428,334	141,350	34.5
1887	—	199,087	61,717	36.3
1888	—	307,386	95,290	33.8
1889	—	418,891	125,667	33.0
1890	—	387,847	104,719	33.0
1891	—	343,000	54,880	28.7
1892	—	379,480	64,502	22.5
1893	—	348,339	104,520	31.8
1894	—	379,444	102,450	36.8
1895	—	394,854	134,343	37.0
1896	—	559,285	144,501	38.6
1897	—	487,149	129,094	41.4
1898	—	486,978	126,614	44.0
1899	—	433,003	108,251	45.9
1900	—	521,444	140,790	46.0
1901	—	552,043	154,572	46.0
1902	13	513,890	128,472	42.3
1903	—	598,500	167,580	26.3
1904	—	897,100	269,130	30.0
1905	—	1,192,758	178,914	15.0
1906	—	1,283,250	165,204	16.1
1907	—	1,379,496	195,281	14.0
1908	9[b]	1,055,636	73,783	10.0
1909	—	569,725	57,600	19.0
1910	7	245,437	31,684	20.6
1911	—	651,541	110,902	30.2
1912	—	647,200	136,174	33.3
1913	—	572,400	115,436	39.0
1914	—	576,991	203,094	51.4

[a] U.S. Department of Commerce, *Census* 1880, pp. 1011–12.
[b] PSA file #080048, letter from W. R. Shields to Herbert Dow, 8 January 1908. Of these, only Dow was producing.
Notes: The prices presented here are *potassium bromide prices*. After the formation of the pool in 1885, almost all liquid bromine sales were at prices in pools contracts. Thus published bromine prices are not transaction prices. Almost all bromine consumed in the United States during this period was consumed as potassium bromide. Prices presented here are annual averages of weekly prices. Dash indicates information is unavailable.
Sources: Prices are annual averages of weekly quotations in the *Oil, Paint and Drug Reporter*. See the Appendix for sources for output and number of firms.

decline in bromine prices ended in the early 1880s (Figure 2). Although there were periods of low prices (as a result of several price wars) and increases in productivity (because of technological innovation), the average price of bromine between 1885 and 1914 was actually 24 percent

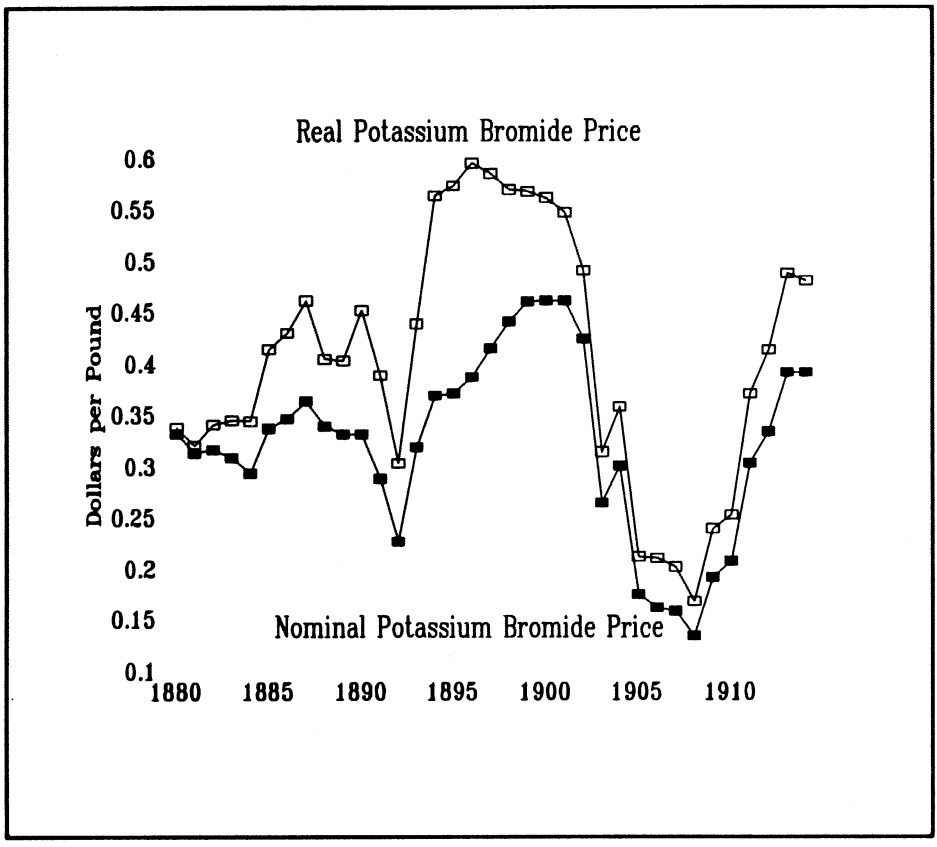

FIGURE 2

POTASSIUM BROMIDE PRICES: NOMINAL AND REAL PRICES, 1880–1914

Note: Prices are annual averages of weekly prices. As in Table 2, these are potassium bromide prices, not bromine prices. Real prices are deflated using U.S. Department of Commerce, *Historical Statistics*, Chemical and Allied Products Price Index, Series E61 and E49, pp. 200–02.
Source: *Oil, Paint and Drug Reporter*.

higher than the 1880 price. Collusion was able to stem the decline in bromine prices despite only limited barriers to entry in production. Entry into bromine production was more difficult than salt; there were fewer known locations with the necessary natural endowment. But the important barrier to entry was in bromine distribution. Bromine distributors had specialized knowledge and skills that put them in a position to help bromine producers both reach new markets and stem the decline in prices.

As in salt, before 1890, American bromine manufacturers were small, family-owned enterprises.[42] There were fewer of them—between 10 and

[42] Credit reports on these firms in 1909 gave a maximum of $85,000 in assets in bromine and salt manufacture, with an average of about $50,000. Most firms had a paid-in capital stock of somewhat less, ranging from $10,000 to $50,000. The credit reports estimated the net worth of most of these

15 (Table 2)—and they were more geographically concentrated than salt producers, because most salt-producing areas did not have sufficient bromine in their raw material to make its extraction worthwhile. The bromine producers were not primarily chemical companies. In addition to producing salt, most of the bromine-producing families, if not the firms themselves, had interests in local coal mines, real estate, and in one case, the local bank.

As with salt, bromine technology was stable through most of the century. Until Dow's entry in the 1890s, declines in cost had been associated with the discovery of new sources of supply rather than with new production technologies. No bromine producer is known to have had managers with formal training in chemistry or engineering, though in 1868 one Ohio River manufacturer was a former student of Julius von Liebig, a well-known German chemist, and another, Herman Lerner—referred to as "an enterprising German"—may have brought some chemical expertise to the region.[43]

Bromine producers reached their customers, headache sufferers and nervous Nellies in the United States and abroad, by relying on the distribution networks and technical skills of older, well-established, technologically sophisticated firms known as "fine chemical manufacturers." These firms purchased liquid bromine, converted it to bromide salts, and distributed it through their networks of salesmen to pharmaceutical jobbers and patent medicine producers around the country and world. These firms specialized in pharmaceutical products, but because of the small size of the U.S. chemical industry in this period, produced and distributed a wide variety of other chemicals.

The first fine chemical manufacturer to interest itself in bromine was Rosengarten & Sons of Philadelphia, founded in 1822 and one of the nation's oldest chemical firms. In 1866 it helped to finance a Pennsylvania bromine plant, and two years later it invested in one of the first plants in Pomeroy, Ohio.[44] Shortly thereafter Powers & Weightman, also of Philadelphia, entered the bromine market. Powers & Weightman (P&W), founded in 1818 by an English pharmacist, imported pharmaceutical materials from all over the world, as well as from remote regions of the United States like Michigan and Louisiana, for inclusion in "its extensive line of fine chemicals."[45] P&W and Rosengarten had "maintained a dominating national position in fine chemicals" for much

families at between $50,000 and $100,000, except for the owner of the Kanawha Valley Bank, who was reported to be worth over a million dollars (PSA file #090022, credit reports on Ohio River firms, 2 August 1909).

[43] Haynes, *American Chemical Industry*, p. 326; and Hale "Salt Manufacturing," quoted in Grimsley, *Iron Ores*, pp. 307–13. These two individuals may well have been one and the same man.

[44] Haynes, *American Chemical Industry*, p. 324.

[45] Sturchio, *Values*, p. 20.

of the antebellum period.[46] The city of Philadelphia was itself the center of the chemical and pharmaceutical industries during this period.[47]

In 1873 another important distributor entered the bromine market. Three German immigrant brothers founded Mallinckrodt Chemical Company in St. Louis in 1867. Like Rosengarten and P&W, it sold a variety of chemical and pharmaceutical products, including ether, acetic acid, and chloroform. The company's own history emphasizes the importance of marketing and reputation in its early success. Goods of "a superior quality, sold as Gilt Label . . . helped establish the reputation of the Mallinckrodt trademark." Great attention was paid to packaging and the appearance of products. "All these products were put up in bottles and small packages with the greatest care. . . . A crooked label had to be replaced.[48] In 1873, Edward Mallinckrodt toured the Ohio River area and contracted to purchase liquid bromine from manufacturers there. Three years later Mallinckrodt Chemical Works helped finance the construction of a new Ohio River bromine manufacturing venture.[49] Mallinckrodt quickly became the largest seller of bromide salts in the United States.[50] There is also some indication that the Liebig student and the "enterprising German" mentioned above were affiliated with Rosengarten and Mallinckrodt, so that these distributors may have facilitated the flow of human as well as financial capital into the industry.[51]

These well-established, technologically sophisticated fine chemical manufacturers made it possible for small bromine producers in southern Ohio and West Virginia to reach worldwide markets by providing distribution services, high-quality reprocessing of their bromine into bromide salts, and, in some cases, financial and human capital for bromine production. The output of bromine grew rapidly as a result, and the Ohio and Kanawha River salt producers gained a competitive edge relative to salt producers in nonbromine producing regions.[52]

National distributors also played an important role in the bromine pools that were organized to stem the postbellum decline in bromine prices. Both the producing and distributing firms in the bromine industry had previously participated in attempts to cooperate with

[46] These firms were so important that their foundings, changes in ownership, and so on, are included in a chronology of events in the chemical industry between 1609 and 1911 (Haynes, *American Chemical Industry*, pp. xxii–lxxvii). The two companies merged to become Powers-Weightman-Rosengarten in 1905 and merged with the Merck Company in 1927.

[47] Haynes, *American Chemical Industry*, p. 215; and Mahoney, *Merchants*, pp. 30–31.

[48] Stout, *Edward Mallinckrodt*, p. 53.

[49] Grimsley, *Iron Ores*, pp. 307–13.

[50] Haynes, *American Chemical Industry*, p. 325.

[51] Stout, *Edward Mallinckrodt*, p. 54.

[52] This last point is repeatedly emphasized in U.S. Geological Survey's *Mineral Resources*. For example, USGS1885 reported that "bromine has been a valuable by-product in the manufacture of salt, and if enough is found in Michigan to supply the trade it will be a severe blow to the salt works on the Ohio river" (p. 486).

competitors in other product markets. P&W was a founding member of the Manufacturing Chemists' Association, formed in 1872. The members of this organization "tried . . . 'gentlemen's agreements' and pools in attempts to control prices and divide markets."[53] The bromine producers were also experienced colluders: the West Virginia salt producers had formed the first salt pool, and reportedly the first formal cartel, in the United States early in the century.[54]

In the 1880s Mallinckrodt helped in the first attempt to establish a bromine pool. In 1882 Herman Lerner, whose bromine factory had been financed in part by Mallinckrodt, gained control of the U.S. Chemical Company. By 1884 U.S. Chemical controlled "about two-thirds of the Ohio product," but little West Virginia bromine.[55] This output was probably sold to the Mallinckrodt Company. Although prices did start to increase in 1884 (Table 2 and Figure 2), the *Oil, Paint and Drug Reporter*—the leading industry publication—suggested that the limited extent of the output that U.S. Chemical controlled also limited its market power.[56]

The following year, the more successful National Bromine Company (NBC) was established, with the cooperation of both Mallinckrodt and P&W. "[N]early all the producers of bromine throughout the United States . . . pooled [their output] and sold through the agency of Mr. D. G. Hildt, of New Philadelphia, Ohio."[57] NBC contracted with the bromine producers in the Ohio and Kanawha River Valleys to purchase their entire bromine output over the next five years. The National Bromine Company "also had an understanding with [Mallinckrodt and P&W] concerning the sale of bromine."[58] This "understanding" was a contract to sell them virtually all the bromine it purchased.[59] As a result, "by 1890 the Mallinckrodt Works, together with Powers-Weightman &

[53] Rosengarten & Sons joined the association, which then had 16 members, the following year (Haynes, *American Chemical Industry*, p. 251). Mallinckrodt Chemical Company, although not known to be a member of this association, was convicted of antitrust violations unrelated to bromine under Missouri law in 1913 (PSA file #130011, letter from H. E. Hackenberg to Herbert Dow, 4 November 1913).

[54] The Kanawha Salt Company, formed in 1817, is usually reported to be the first salt pool (Haynes, *American Chemical Industry*, p. xxxviii; and Eskew, *Salt*, pp. 88–90). Stealey, *Antebellum Kanawha Salt Industry*, claims that a predecessor firm, Steele, Donnally & Steeles was actually the first effective pool in the Kanawha Valley (pp. 22–26).

[55] *USGS1884*, pp. 851–53.

[56] Market reports in the *Oil, Paint and Drug Reporter* suggest that there were even earlier attempts to collude. "It is supposed temporarily there exists no combination on bromide potash and it is now obtainable at 33@34 cents" (16 February 1881, p. 215). Unfortunately we have no information about the "combination" that presumably was in suspense.

[57] *USGS1885*, pp. 486–87.

[58] *Oil, Paint and Drug Reporter* Anniversary Supplement, 8 March 1897.

[59] There were two aniline dye producers in the United States who used liquid bromine. They purchased directly from the National Bromine Company and did not play a pivotal role in the pool's organization.

Company, controlled the bulk of bromine produced in this country."[60] The declining trend in prices reversed. The average price of potassium bromide, the product sold by the distributors, was almost 10 percent higher during the NBC contracts than during the previous five-year period (Table 2).[61]

The contractual structure of the NBC was similar to that used in salt, but the economic relationship between the producers and the pool was different. As in salt, bromine manufacturers contracted to sell their entire output to the pool. NBC, however, was not owned by the producers, but by an individual, D. G. Hildt, who had the confidence of, and contracts with, both distributors and producers.[62] The internal bargaining problems that overwhelmed some salt pools were more manageable in the bromine pool because of the presence of a third-party mediator. NBC contracts were for a specified price and duration. The contracts did not limit the output of any bromine producer, but they did prohibit them from selling to anyone but the pool. The NBC also had long-term contracts to sell this bromine to Mallinckrodt and P&W. Mallinckrodt and P&W jointly set the market price, announced weekly in the *Oil, Paint and Drug Reporter*, of bromide salts. As diversified firms with substantial financial resources, Mallinckrodt and P&W were in a position to weather declines in demand that undermined many salt pools: they could hold inventories rather than lower prices. With the financial backing of large firms, NBC was a more appealing intermediary than were the short-lived salt pools.

Most important, a contract with NBC offered the producer superior distribution services—an established name with a reputation for quality. Competition from other distributors or potential distributors did not draw bromine producers away from the pool, because other distributors could not offer the same services that the pool did. Pool distributors could pay producers a higher price for bromine out of the rents earned from cartelizing the industry. They could sustain the cartel in the face of potential entry because their superior distribution networks gave them a competitive advantage and created a barrier against potential competition.

NBC dissolved in 1891 and was replaced the following year by a new pool organized by W. R. Shields. Shields had similar contracts with the bromine manufacturers for the exclusive purchase of their entire

[60] Stout, *Edward Mallinckrodt*, p. 54.

[61] The average price of potassium bromide between 18 February 1880 and 11 February 1885 was 31.07 cents. The comparable price during the NBC, 18 February 1885 to March 1991, was 34.09 cents. The average price during the "Shields Pool," from 11 March 1891 to 3 October 1892, was 40.88 cents. See Levenstein, "Price Wars," for further discussion of measures of success of the bromine pool.

[62] Hildt, and the subsequent organizer of the bromine pool, W. R. Shields, both resided in Ohio. Shields, at least, had personal and financial connections to both the manufacturing chemists and the bromine producers.

bromine output. Mallinckrodt and P&W contracted to purchase Shields's bromine.[63] Prices increased steadily during the Shields pool (Table 2).[64] These contracts remained in effect until 1902, when the withdrawal of the eight-year-long cooperation of the Dow Chemical Company led to the pool's demise.

The small bromine manufacturers of the Ohio River were able to compete successfully, and profitably, in national and international chemical markets because they cooperated with each other and with their distributors. Their contracts with distributors gave them access to these markets while limiting price competition. Without the pool, prices had fallen over 80 percent during the preceding decade.[65] The bromine manufacturers escaped from the prisoner's dilemma in which many industries found themselves trapped when markets became more integrated, but they sacrificed a share of the profits of monopoly, which went to their distributors. In the short run, this arrangement was profitable for both manufacturers and distributors. In the longer run, it created incentives for entry, and by keeping the bromine manufacturers at arms length from their final customers, limited their ability to respond creatively to that entry.

THE FLEETING NET BENEFITS OF THE POOL FOR THE MASS PRODUCING ENTRANT

Where collusion was successful, as in bromine, that success created incentives for entry. But the successful entrant had to overcome barriers to entry. Because the most important barriers to entry were in distribution, entry was easier if the producing firm was able to obtain the cooperation of pool distributors. But pool distributors did not want to encourage entry. The entering producer had to be able to offer the distributor something unobtainable from existing producers. Thus the successful entrant usually introduced lower-cost production techniques.[66] Not surprisingly, these innovative techniques usually had larger fixed costs and were more continuous process than older production techniques. The new production techniques were more "science-

[63] Shields's contracts with the bromine manufacturers specified an increasing price for their liquid bromine, assuming cooperation continued, to avoid tensions that had arisen during the earlier pool. During the NBC contracts, the price of potassium bromide increased, but the price the pool paid for liquid bromine did not. Thus the increasing profits were retained by the distributors and not shared with the bromine manufacturers (Levenstein, "Vertical Restraints").

[64] As a result of the lack of output constraints on the bromine manufacturers, the bromide distributors accumulated large stocks of inventories (Levenstein, "Vertical Restraints").

[65] Haynes, *American Chemical Industry*, p. 429.

[66] In the two cases I will consider, bleach and bromine, new entrants were the source of innovation. Incumbent firms may have been enjoying the quiet life offered by monopoly power. But in many cases they simply did not have within their firms the technical or scientific capabilities necessary to innovate.

based'' than older production technologies, requiring scientific training both in their development and in their use.

In the two cases I will discuss—bleach and bromine—an entrant, the Dow Chemical Company, introduced a new production technology into industries in which incumbent producers and distributors had successfully limited competition. In each case, Dow's successful entry depended on its use of the services of distributors who also served Dow's competitors. These distributors offered access to customers and established reputations. They also offered to fix prices with competitors. In the period immediately following entry, the benefits of working with an established distributor—and the threat of a decline in price if they did not—made cooperation with incumbent producers an appealing strategy. But Dow did not use the profits earned during this period to finance the quiet life of the monopolist. Rather, retained earnings provided the basis for investment in the firm's capability to produce and market a high-quality product. As Dow matured, the cost of restricting and pooling output increased. At the same time, the benefits of relying on an outside distributor decreased, and Dow integrated forward into the distribution of its output. In redrawing the lines of its internal organization, Dow had to withdraw its cooperation from the pools in which it had participated, and in so doing, redrew as well the organization of the markets controlled by those pools.

The Entrant and the Distributor in Bleach

As in salt and bromine, falling prices and increasing competition led bleach producers to cooperate to stabilize prices.[67] But unlike the salt and bromine cases, these producers were, until 1897, exclusively British firms. There were no American bleach producers; American consumers relied entirely on British imports.[68] In response to falling prices, British bleach producers formed the Lancashire Bleaching Powder Manufacturers' Association in 1883. The Association pooled its exports to the United States, using a single American distributor to sell its output in the American market.[69] The Association dissolved in 1889. Two years later, British bleach manufacturers merged into the United Alkali Company, Ltd. (now ICI).[70] Like the Association it replaced, United Alkali chose a well-known New York-based, heavy chemical distributor

[67] The price of bleach fell from $3.50 per hundred pounds in 1871 to $1.07 in 1881, two years before the first combination of British bleach producers. It had increased to $2.25 by 1891, when United Alkali was formed. Prices declined to $1.75 in 1901, despite the imposition of an import duty in 1897, and to $1.50 in 1911 (Haynes, *American Chemical Industry*, pp. 427, 432).

[68] In 1890, the United States consumed about $100,000 worth of bromine and about 14 times that much of bleach (Haynes, *American Chemical Industry*, pp. 403, 409).

[69] The Bleaching Powder Association was represented by James Lee and Company of New York (Hardie, *History*, pp. 143–44).

[70] Reader, *Imperial Chemical Industries*, pp. 102–06; Haber, *Chemical Industry*, pp. 224–30; and Haynes, *American Chemical Industry*, pp. 269–83.

(Edward Hill's Son & Company) as its representative in the United States.[71] Thus prior to 1897, United Alkali enjoyed a monopoly in the American bleach market.

The exercise of that market power created incentives for entry into the production of bleach.[72] In 1897 two new firms, the Dow Chemical Company of Midland, Michigan, and the Mathieson Alkali Company of Niagara Falls, New York, entered the industry.[73] Two other firms entered over the next decade, Pennsylvania Salt Company of Wyandotte, Michigan, and the Development and Funding Company, predecessor of the Hooker Chemical Company, of Niagara Falls, New York.[74] United Alkali also built its own bleach plant in Bay City, Michigan, operated by a wholly owned subsidiary, the North American Chemical Company.[75] All the American entrants introduced innovative production technologies that used electricity to separate chlorine from salt water solutions.[76] In each case the introduction of the new technology required experimentation after the construction of the first plant, and in three cases—Dow, Mathieson, and Hooker—production

[71] Haynes, *American Chemical Industry*, describes Edward Hill's Son & Company as an "old and important chemical importing house" (p. 115). Hill also distributed United Alkali's soda ash as well as its bleach.

[72] Congress imposed a tariff on bleach in 1897 of 20 cents per hundred pounds (about 10 percent of the selling price). Although the tariff surely benefitted domestic manufacturers, it does not appear to have directly influenced the entering firms. There is no suggestion in the records of the Dow Chemical Company that the tariff was expected. Dow began preparing to enter the bleach market at least four years before the tariff was passed. Similarly, the Mathieson Alkali Company had purchased the rights to the Castner chlorine-caustic cell, used in the production of bleach, in 1894. Technical problems and the relocation of production from Saltville, Virginia, to Niagara Falls, New York, delayed entry until 1897 (Haynes, *American Chemical Industry*, pp. 274–78).

[73] The Dow Chemical Company was formed in 1897. The Mathieson Alkali Company was formed in 1892. Mathieson's owners were Edward Arnold, a chemical importer and distributor, W. R. and F. C. Sayles, textile and paper manufacturers, and the family that owned the old Saltville, Virginia salt works where the plant was first located. Arnold had distributed the alkali of a British producer, Neil Mathieson. The Virginia plant was built by his son, Thomas T. Mathieson (Haynes, *American Chemical Industry*, p. 274).

[74] Pennsylvania Salt began construction of its Wyandotte plant in 1898, but did not make its first chlorine sale until 1908. Most of their chlorine output was sold as liquid chlorine, rather than bleach (Leavitt, *Prologue*, pp. 49–65).

[75] Haynes, *American Chemical Industry*, says that United Alkali built the Bay City plant in 1898 to manufacture chlorates (p. 282). Like the other American manufacturers, North American Chemical used the new electrolytic production methods. Haynes does not specifically say that North American Chemical produced bleach (chlorinated lime). That North American Chemical was in the bleach market by 1906 is clear from correspondence between Herbert Dow and M. L. Davies, manager of the North American Chemical Company (PSA file #060117, February 1906).

[76] In chemistry, the harnessing of the power of electricity gave rise to a wide range of new process innovations. The proportion of U.S. chemical output manufactured with the aid of electricity increased from 3 percent in 1899 to 15 percent in 1919 (Clark, *History*, p. 824). Because they relied on electrolytic technologies, the bleach firms were much larger than the older bromine and salt firms already discussed. The capitalizations of the Hooker, Penn Salt, Mathieson, and United Alkali Companies were $3.75 million, $5 million, $1.7 million (Haynes, *American Chemical Industry*, pp. 274–78), and £8.5 million (Haber, *Chemical Industry*, p. 184), respectively.

was set back by explosions that destroyed the plant.[77] In contrast, United Alkali's bleach imports were made using the LeBlanc process, which produced chlorine as a by-product in the production of soda ash. The LeBlanc process had been developed in the late eighteenth century.[78]

During the years in which United Alkali had no competition in the U.S. market, distributors probably did not play a significant role in maintaining market power. To the contrary, distributors who had developed reputations and networks of customers prior to the consolidation of the British manufacturers were in a position to facilitate entry. In at least one case, an American distributor did just that. Following in a long tradition of American import-export firms, the principals of the firm of Arnold, Hoffman & Company of Providence, Rhode Island, financed the formation of the Mathieson Alkali Company, using technology borrowed from the British firm of Neil Mathieson and Company, Ltd. Arnold, Hoffman had been Mathieson's importer before Mathieson sold out to United Alkali in 1893.[79]

As a result of their relationships with both United Alkali and the new entrants, certain distributors were in a position to negotiate between the incumbent and the entrants to forestall the price competition that might otherwise emerge. The agreements negotiated and implemented by distributors were apparently less formal—and less successful—than those in bromine.[80] During this period most bleach was consumed by paper and textile manufacturers. These manufacturers contracted for a year's requirements of bleach during the fall months.[81] The agreements among bleach producers, negotiated and implemented by their distributors, fixed the price on those annual contracts. There was also at least one multiyear agreement that set market shares.[82] But in most cases,

[77] Whitehead, *Dow Story*, p. 35; Haynes, *American Chemical Industry*, p. 278; and Thomas, *Salt*, p. 31.

[78] Haber, *Chemical Industry*, pp. 7–8.

[79] Haynes, *American Chemical Industry*, p. 274; and Reader, *Imperial Chemical Industries*, p. 108. Mathieson Ltd. did not produce bleach; it produced soda using the Solvay ammonia-soda method. In order to produce bleach, Mathieson Alkali purchased licenses from another British firm, Castner-Kellner, which used an electrolytic cell.

[80] Lamoreaux, *Great Merger Movement*, argues that the simultaneous entry of mass producers in a variety of industries, including tinplate, wire nails, and newspaper made collusion impossible to sustain. The bleach industry faced a similar situation during this period.

[81] As Herbert Dow wrote to E. E. Keller, "the bleaching powder business has followed the custom established by the United Alkali Company of Great Britain so rigorously that all sales were made by contract in the fall" (PSA file #090049, 16 November 1909).

[82] H. E. Hackenberg, Secretary of the Dow Chemical Company, refers to this contract and its provisions in a letter to Dow's distributor at the time, Edward Hill's Son & Company. It reads in part:

> The agreement . . . in the fourth paragraph . . . stipulated just how and in what proportion sales shall be made . . . in the fifth paragraph . . . comparisons must be made not later than the 15th of each month . . . with the object of keeping the sales to the proportions agreed upon. . . . In the second paragraph, the agreement stipulates that in the years 1904 and 1905

producers simply agreed to a price, to be adhered to by cooperating distributors. For example, Herbert Dow reported that there "had [been] a conference in New York at which the biggest German firm and also the biggest English firm had representatives [and] fixed the price for the coming year."[83]

From the perspective of the entering producers, established distributors offered the new firms access to customers, a reputation for quality, and, on occasion, technical feedback about the quality of product. As Dow wrote to the representative of a northern Michigan development company, issues of quality and reputation were particularly important in marketing chemicals. Impurities or fluctuations in the potency of a chemical used as an input in production could cost the consuming firm dearly.

> It is far more necessary to make proper connections to dispose of a chemical product than it is of the products of other manufacture, as the purchaser in a great many cases buys entirely on faith. Most buyers of lumber can judge for themselves the quality of the same, and if an outsider would offer him a better quality at the same price he would be very likely to get the business. This, however, is not so with a chemical product as the consumer usually takes it for granted that if the price is cut the quality is off, and it is consequently an extremely difficult matter to dispose of a new brand of any chemical. . . . We went through a similar experience with our Bleaching Powder, and it was years before we could get any prominent Paper Company to give our Bleach a trial as they were afraid it might ruin a whole batch of pulp or paper and interfere with their regular method of operation that they had developed through years of effort.[84]

The Dow Chemical Company made its first bleach sales directly—to a chemical jobber and a paper company, both in Cleveland. But Dow quickly gave up direct selling. It decided instead to rely on "some good company who would take our entire output of bleach."[85] Dow's primary reason for turning to an agent was not to restrain price competition, but because a distributor's information and reputation would be valuable to Dow as it entered a new product market.[86] As Herbert Dow wrote, a

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the total deliveries of bleaching powder in each year shall be apportioned on a certain basis (PSA file #030029, 18 November 1903).

It should be noted that Hackenberg was not appraising Hill's Son & Company of the provisions of this contract, but reminding them of provisions that he believed had not been implemented fully. The implementation of the agreement was Hill's responsibility.

[83] Letter from Herbert Dow to Dr. Cady Staley, member of Dow's Board of Directors, PSA, file #030041, 4 November 1903.

[84] PSA file #050039, Herbert Dow to F. G. Trimble, 20 September 1905.

[85] Herbert Dow to Charles A. Post, Dow Treasurer, PSA file #970056, 27 December 1897. Unlike the bromine industry, distributors in bleach were agents, not wholesalers, as they did not take title to the output.

[86] Another entrant into the bleach market, the Pennsylvania Salt Company reported similar problems in selling bleach in competition with United Alkali because "paper manufacturers . . . did not think highly of American-made bleach. It had required a deal of powerful selling for Pennsalt to get its powder into American paper mills" (Leavitt, *Prologue*, p. 62).

good distributor who "knows the consumers and the consumer knows that he handles nothing but first-class materials makes . . . an easy way to get into the market, and would prevent a great deal of labor at this office that would be advisable not to have until we get down to a system of producing a regular out-put."[87] A national distributor gave Dow the reputation, established distribution network, and economies of scope that would not have been available had it chosen vertically integrated entry.[88]

After only four years experience in the market, Dow's view of the benefits offered by a distributor changed. Use of a distributor helped avoid competition, but it also restricted direct contact with customers, limiting the flow of information from them, the ability to provide them service, and the development of customer-specific products. Dow continued its relationship with its distributor, F. G. Clarke, but tried to increase its contact with customers within the framework of that relationship in order to avoid a price war. Dow's president wrote:

> Arnold, Hoffman & Co. dispose of all of the product of the [Mathieson] works. . . . [F. G. Clarke has] been the agents of Arnold, Hoffman & Co. for . . . quite a number of years. . . . Mr. Arnold states that if we can come to an arrangement with Clark [sic], quotations will be arranged so that they will not compete with us in the Western District, nor we with them in the Eastern district. . . . On the other hand, if we cannot, . . . it would result in considerable competition with its attendant price cutting. . . . In order to get the most information, it would be preferable for us to bill the goods and settle the commission monthly, or any other way, so that we knew exactly where the goods went.[89]

Similar concerns were central to Dow's decision in 1902 to appoint a new distributor, Edward Hill's Son & Company.[90] Dow was searching for an arrangement that would give it the benefits of both a distributor who was in a position to facilitate price collusion and a close customer relationship that allowed it to obtain information about customer satisfaction and to develop a brand reputation. Hill promised to "keep our brand advertised, and the name of Dow prominently before the trade." Hill also expressed confidence in "their ability to make some arrangement with the United Alkali Works to prevent competition." Under this arrangement Dow would ship directly to its customers and

[87] PSA file #980056, Herbert Dow to Charles Post, 27 December 1897.

[88] The agent Dow selected, the Fred G. Clarke Company was intimately connected to Dow's bleach competitors. The Clarke Company was also the agent of the Arnold, Hoffman Company, who was in turn the agent (and principal financial backer) of the Mathieson Alkali Company, soon to be Dow's largest domestic competitor. Details of the terms of the Dow Chemical Company's contract with the Fred G. Clarke Company can be found in letters from Herbert Dow to C. A. Post, PSA file #980032, 18 April and 23 April 1898.

[89] Letter from A. E. Convers, Dow president, to H. E. Hackenberg, Dow secretary, PSA file #010054, 9 September 1901.

[90] Edward Hill's Son & Company became the Dow Chemical Company's exclusive agent for the sale of its bleach on 1 January 1903 (PSA file #020029, "Minutes of Midland Conference," 18 August 1902).

therefore know their identities and be able to contact them directly.[91] Hill's confidence in its ability to negotiate with United Alkali reflected its long-standing relationship with United Alkali; it had been United Alkali's distributor in 1892.[92]

Despite Dow's hopes, this arrangement failed to prevent price cutting. Edward Hill's Son & Company had, like the Clarke Company, significant latitude in setting the price of Dow bleach. In response to low quotations by United Alkali, Hill sold all Dow's bleach for the coming year at a very low figure. United Alkali then proceeded to raise the price on its own bleach. Problems regarding the quality of Dow bleach arose, and Dow felt constrained in its ability to accommodate its customers.[93] Instead of looking for another distributor, Dow decided to integrate forward into the sale and distribution of its own bleach. In 1904 Dow terminated its relationship with Hill and established its own sales office. As Dow's secretary wrote to Herbert Dow:

> I welcome the day when we will make all sales directly. We won't have any more controversies than we now have, the difference being that we will have them directly with our customers, with whom we can always treat better than through a third party. Personally, therefore, I would favor settling up all disputes with Hill . . . and then arrange to sell bleach directly to the consumers.[94]

The use of a national distributor with connections to other bleach producers facilitated Dow's entry into the bleach market. Dow turned to a distributor because it limited the demands on scarce managerial resources in the new company and because distributors had specialized knowledge of market demand that Dow did not.[95] Dow continued to use a distributor for several years, even as managerial resources became less scarce and the costs of an arms-length relationship with customers became apparent, because distributors also had specialized knowledge about other producers. This knowledge meant that their representation of Dow to competing manufacturers could help to restrain price competition. For Dow, whose strategy increasingly depended on product diversification and technological innovation, the net benefits of

[91] PSA file #020028, "Minutes of the Executive Committee of the Dow Chemical Company," 14 July 1902.

[92] *Oil, Paint and Drug Reporter*, vol. 7, 30 May 1892, p. 38; and Haynes, *American Chemical Industry*, p. 276.

[93] These complaints focused on the strength of Dow bleach. Dow suggested to Hill's Son & Company that "[i]f you have had any recent complaints in regard to the quality of our bleach . . . it would be a good plan for us to send a chemist to investigate the specific cases" (PSA file #030050, 22 September 1903).

[94] PSA file #040036, letter from H. E. Hackenberg to Herbert Dow, 31 March 1904.

[95] Penrose, *Theory*, argues that expansion into new activities increases the utilization of a firm's scarce managerial human capital. As new activities become routine, the firm finds itself with managerial slack and is ready to take on new activities again. When Dow first entered the bleach market, tackling the production problems consumed all the energies of its small managerial team. Only after the new process had become routine did the firm have the resources to devote to marketing its product.

cooperating with a collusive distributor, although positive when first entering the market, became negative after several years. So Dow turned to vertical integration. With the experience acquired from eight years of producing bleach, Dow was in a position to sell directly to its consumers. As newer entrants became a factor in the bleach industry, formal collusion became impossible to sustain. But with its own network of customers loyal to Dow bleach, Dow was able to maintain its prices and sales.[96] By then, Dow also knew its competitors well enough to negotiate price-setting agreements without the aid of an outsider. By 1909, Dow's sales manager reported that although "competition has been keener [than] in the past . . . we have . . . maintain[ed] our prices in the West [that is, west of Cleveland] . . . and have been successful also in booking practically the same tonnage as contracted for 1909. . . . [W]e have been able to work harmoniously with the Pennsylvania Salt Company, and thereby avoid needless competition from this quarter."[97] Innovative, mass-producing entrants relied on established distributors to reach customers and negotiate with competitors. But with incentives to increase rather than restrict output, and a need to develop direct contact with customers, these firms, once established, had an incentive to integrate forward. They developed within their own organizations the capability to serve customers and to negotiate with competitors.

The Entrant and the Distributor in Bromine

The pattern in the bromine industry was remarkably similar to that in bleach. Collusive prices charged by the bromine pool created an incentive for entry. In the 1890s a new firm, the Midland Chemical Company, introduced an electrolytic technology that made possible the continuous-process mass production of bromide salts. In order to reach customers, who could not be enticed by lower prices, Midland contracted to sell all of its bromides through the two pool distributors, Mallinckrodt and Powers & Weightman. The company prospered, and after its merger with the Dow Chemical Company in 1900, used the profits earned to increase its output capacity and improve its product quality.[98] As the firm became more established, the restrictions on output and contact with customers in its contracts with Mallinckrodt and P&W imposed more costs than the benefits offered by their

[96] Dow also responded to increasing competition in bleach by integrating forward into the production of chlorine-using products, primarily chloroform and carbon tetrachloride, where the market was growing faster and competition was not as great as in bleach. The Pennsylvania Salt Company apparently followed a similar strategy, using its own sales office to promote the use of liquid chlorine by paper manufacturers (as a bleaching agent) and municipalities (for water purification), Leavitt, *Prologue*, p. 62.

[97] PSA file #090043, Report by W. H. Van Winckel, Sales Manager of the Dow Chemical Company, 15 December 1909.

[98] Bromide quality is measured in terms of the percent bromide in the final product. All bromide salts contain trace amounts of chloride salts, and occasionally iodide and bromate, that detract from quality.

reputations or their ability to restrain price competition. As in bleach, Dow turned first to other distributors who it hoped would offer some of the same benefits with fewer costs. As in bleach, that strategy failed, and price cutting ensued. And also as in bleach, that price cutting led to Dow's decision to distribute its product through its own sales office. As argued by Alfred Chandler, the introduction of a lower-cost technology, in and of itself, was not sufficient for a new mass producer to dominate an industry.[99] Dow had also to develop an internal organization capable of supporting vertically integrated entry. This was not because of weaknesses in existing distribution channels. Rather, Dow had to develop an internal organization capable of transforming the existing market organization. It had to develop the capability to compete directly with existing distributors as well as manufacturers using the older technology. This vertical capability then allowed Dow to use its high-fixed-, low-marginal-cost technology in an integrated international market without either facing uncontrolled price competition or participating in a pool that set its prices.

But the road from an innovative technology to a successful, integrated firm was a long one. As an undergraduate chemistry student at the Case School of Applied Science in Cleveland, Ohio, in the 1880s, Herbert Dow began experimenting with a new, electrolytic process for separating bromine from brine. Dow's patented process was continuous (rather than batch), integrated the production of liquid bromine and bromide salts, and avoided the necessity of extracting marginally profitable sodium chloride salt. Dow's process had economies of scale through the size of the existing domestic market. In 1890, Dow got the financial backing of a family friend, John Osborn, and formed the Midland Chemical Company in 1890. The partnership floundered, even after two other investors were brought in. In 1891 the little firm failed, without ever having sold any bromine. Not to be discouraged, Dow and Osborn refounded the Midland Chemical Company in 1892 as a corporation with greater, if still modest, financial backing from several other Cleveland businessmen.

The new Midland Chemical Company had more success at producing than selling its bromides. Its costs were less than half those of the pool producers.[100] Despite "offering it at about 60 percent of the recognized market value," Midland could not sell its bromides without the imprimatur of the leading distributors, who only distributed the output of

[99] According to Chandler, "in order to benefit from the cost advantages of these new, high-volume technologies of production, entrepreneurs had to make three sets of interrelated investments . . . in production facilities, . . . in a national and international marketing and distribution network, . . . [and] in management" (*Scale and Scope*, p. 8).

[100] Dow's continuous-process technology produced potassium bromide at a cost of 8 cents per pound (PSA file #010070, "Midland Chemical Co. factory report"). The cost of producing potassium bromide using liquid bromine was approximately 16.6 cents per pound (Levenstein, "Price Wars," p. 35).

members of the bromine pool. As Dow wrote, "the wholesale Drug houses told us they had no demand for [potassium bromide] of an unknown make."[101] Despite threats of an impending price war, Dow believed that his little company could sell outside the bromine pool, bypassing existing distribution channels because of its lower average costs and integrated technology. He was wrong. Midland tried for two fairly desperate years (1892 to 1894) to avoid the pool (during which time, Dow lost his job as general manager). In 1894 Midland signed a contract agreeing to sell all its output to Mallinckrodt and P&W. The contract limited Midland's output to 100,000 pounds a year. This contract was renewed, with modifications, until 1902.

Although cooperation with the pool does not appear to have been Herbert Dow's first choice, the Midland Chemical Company prospered during this period. It paid dividends to its increasingly impatient stockholders for the first time immediately after signing its contract to sell to Mallinckrodt and P&W. Between 1894 and 1900 (when it was purchased by the Dow Chemical Company for more than three times the value of its paid-in capital stock), the Midland Chemical Company paid dividends at an annual rate of between 12 and 40 percent on the par value of its stock. More important, it accumulated experience with its own technology, knowledge of alternative sources of demand for its output, and a reputation—not with its final consumers, with whom it had little or no contact, but with other distributors (potential competitors to Mallinckrodt and P&W)—as a high-quality, low-cost producer.[102] During the period of its cooperation with the pool, Dow built a new plant that produced bromides at lower cost and greater purity than had previously been achieved. Dow hired chemists from the Case School in Cleveland to develop new methods for the final stages of its production process, which further lowered production costs, and began research on a variety of new bromine-based products, including mining salts, water purifiers, and bromine dyes.

In 1897 Dow attempted to contract with distributors outside the pool but was only able to attract the interest of small, unknown pharmaceutical distributors. By 1902 Dow was able to attract an old, established, and reputable distributor, Rosengarten and Sons, to distribute its product. Dow chose to work with Rosengarten and Sons because this firm had a reputation as one that did not undercut prices. As reported in

[101] PSA file #050039, letter from Herbert Dow to F. G. Trimble, 20 September 1905.

[102] In 1897 the Midland Chemical Company negotiated with George Merck to distribute its bromides. Merck rejected the proposal. Midland turned to a small St. Louis firm, Herf & Frerichs, formed a decade before by a former Mallinckrodt employee (PSA file #970080, letter from B. E. Helman to H. S. Cooper, 8 March 1897; and Haynes, *American Chemical Industry*, p. 330). By 1902 Merck's attitude had altered. "Mr. Dow has just received a letter from Merck & Co., of N.Y. asking him if he can come East to see them with reference to Bromid, and Mr. Dow will arrange to do so the first part of April" (PSA file #020027, "Minutes of Midland Conference," 17 March 1902).

the minutes of a conference of the Executive Committee of the Dow Board of Directors, "Mr. Shields telephoned Mr. Dow the other day from Saginaw and wanted to know what we would do. Mr. Dow told him that we had made arrangements with Rosengarten. . . . The idea was that he knew that Rosengarten would not cut prices."[103] In contrast to 1897, Dow was able in 1902 to convince Rosengarten to distribute Dow bromides. The improvements Dow had made in its process meant that its bromides were not only cheaper but also significantly purer than those made from Ohio River bromine. With an established record of producing large quantities of high-quality bromides at low cost, Dow could offer Rosengarten something that the latter could not have gained through contracts with an Ohio River bromine producer.[104] Dow's new contracts required it to accept some of the risk of price fluctuations, from which it had been protected under its old contracts.[105] As a larger, more diversified company than it had been ten years before, Dow was in a position to assume this risk.

Escape from output restrictions was not Dow's sole motivation for breaking from the pool. It had increased its output quota from 100,000 to 225,000 pounds a year between 1894 and 1902 and could have increased it further if it had been willing to renew its contracts, as requested by Mallinckrodt and P&W. But the agreements also limited Dow's ability to expand its bromine-based product line and build its own reputation. Two years into an international price war, Herbert Dow defended the decision to break with the pool to his Board of Directors, even though "we might possibly have sold as much as 500,000 pounds at 24 cents per pound" through Mallinckrodt and P&W. The break was necessary "unless we wanted to play the part of second fiddle to Mallinckrodt and Powers-Weightman."[106] Of course, by then Dow was selling a million pounds a year. But selling more at lower prices gave Dow "a standing all over the world, so that we are not dependent upon Powers-Weightman-Rosengarten and Mallinckrodt to sell our goods."[107] Dow's worldwide standing was based on the capabilities it

[103] PSA file #020028, 19 May 1902.

[104] Dow reported that Rosengarten had higher quality standards than Mallinckrodt. Dow wrote to H. E. Hackenberg, Dow secretary, "Mr. Rosengarten . . . is much more particular about the quality of his bromide than Mr. Mallinckrodt is, and I do not fear that we will lose him as a customer, under any circumstance" (PSA file #050014, 1 April 1905).

[105] Dow's new contracts specified that it would receive a percentage of the price at which Rosengarten sold potassium bromide. Under the old contracts, Mallinckrodt and P&W guaranteed that they would purchase a fixed amount at a fixed price over the period of the contract.

[106] PSA file #070001, letter from Herbert Dow, 28 December 1907. Despite the enactment of the Sherman antitrust law over a decade before, there is absolutely no evidence of concern about antitrust prosecution in the Dow correspondence during this period. Antitrust concerns arose for the first time in 1908. Dow's concerns at that point were solely in regard to Michigan's antitrust laws. These concerns had no significant effect on Dow's participation in collusive agreements until 1910 (Levenstein, Determinants).

[107] PSA file #060073, letter from Herbert Dow to J. H. Osborn, 1 August 1906.

had developed during its years in the pool. As Herbert Dow wrote to Dow Director, Dr. A. W. Smith:

> We never before were so able to meet competition and hold our own. Partly because our equipment is better than ever before, partly because our Sales Department is better organized than ever before, and partly because we have a large number of customers of our own and are not dependent upon the fickleness of two or three people the way we were when we were not selling directly to the consumer.[108]

The high prices Dow enjoyed during its cooperation with the pool made possible its internal growth and protected the small firm as it learned about its own production technology and developed the marketing capability to sell its own goods as well as the closely related technological capability to develop new products for its customers. After ten years, Dow was in a position to withdraw from the pool because it had developed the capability to dominate its market—not simply by using lower costs to charge lower prices, but through more restrained, nonprice competition based on quality, service, and reputation.

In deciding how to market its first two products, bromide salts and chlorine bleach, Dow chose first to use the services of distributors who negotiated cooperative agreements with competing producers. But those agreements placed limits on Dow's ability to make profitable use of its technological capability and its natural resources. Vertical restraints forced Dow to develop the capability to market its products in order to escape from the restrictions imposed by cooperative agreements. And it had to develop that capability sufficiently to capture a large market share without lowering prices so much that it could not cover its fixed costs, which were much greater than those of its older competitors.[109] In order to capture the potential profit from its technology, the mass producer had to create an organization that could compete in other dimensions than price.

To ensure its long-run dominance of the industry, Dow pursued a strategy of developing new markets for its products, markets that only it had the technological capability to supply. Dow developed bromine-based products for nonpharmaceutical consumers and customer-specific products for its patent medicine customers. It began selling bromates to the Telluride Reduction Company for gold extraction and then developed a worldwide customer base for a variety of bromate mining salts. Its contract with the Emerson Drug Company, manufacturers of BromoSeltzer, called for a much finer grain of potassium bromide granules than Dow had previously produced. Its sales to the

[108] PSA file #050007, 11 November 1905.

[109] Lazonick, *Business Organizations*, discusses the impact of the increase in fixed costs on firm strategy more generally. He does not address the effect of preexisting cooperative agreements on the strategies pursued by high-fixed-cost firms.

patent medicine producer Meyer Brothers required that it develop the capability to produce potassium bromide crystals, rather than the granular consumed by most of the U.S. market. It also began manufacturing sodium and ammonium bromides and worked with Kodak to develop bromine-based film. After World War I, Dow and General Motors developed ethylene dibromide for antiknock gasoline.

Dow developed its chlorine-based product line as well. It developed a new, low-cost method to manufacture chloroform. That process made carbon tetrachloride as an intermediate stage. Dow discovered a growing market for carbon tetrachloride as a solvent and cleanser, and its production and sales increased rapidly. Dow also began to produce sodium benzoate and zinc chloride, both of which used chlorine in their manufacture, for sale to canneries. As in bromine, Dow used the flexibility provided by vertical integration to develop customer-specific products; for example, it provided Merck with liquid chlorine piped into a plant adjacent to Dow's, built for the manufacture of chloryl hydrate.[110] Dow's sales agents were specifically compensated with part of the profits of any new products that the company developed as a result of contact with customers, to encourage them to bring ideas back to the factory and laboratory.

Dow attempted to achieve, and eventually did achieve, dominance in the American bromine market. It replaced the pool because it developed a continuous-process, mass-production technology that could make bromides at lower cost and higher quality. After its break with the pool, It protected its dominant position in the bromide market through the establishment of exclusive dealing and market-division agreements, as well as the strategic use of quality standards.[111] But Dow only *could* replace the pool when it understood that it had to do more than produce the same thing that the pool did. In bleach, where several other firms had also adopted mass-production technologies, the challenge was even greater, and Dow could not achieve the national dominance it did in bromine. Instead, as with bromine, it used its sales office to locate and develop other sources of demand for its chlorine. Successful entry required that Dow discover and sell new ideas in order to produce and sell new products.

[110] Levenstein, "Information Systems," pp. 86–94.

[111] Dow's ability to produce purer bromides than its competitors meant that high-quality standards, both public and private, favored Dow. For example, Dow expected the Pure Food law to give it an advantage by "shut[ting] out all impure Bromides made from Ohio River Bromine without repurification" (PSA file #060012, letter from Herbert Dow to A. E. Convers, 15 March 1906). It also intervened to change the national pharmacopeia, a private standard, to make competition from the Ohio River manufacturers more difficult (PSA file #090105, letter from Edward Mallinckrodt to Herbert Dow, 5 November 1908).

CONCLUSION

As late nineteenth-century manufacturers attempted to take advantage of the new opportunities presented by the decline of transportation costs and the opening up of new markets, they were confronted with a new problem—real price competition, and often dramatic declines in price. They responded to this challenge by attempting to fix prices and limit output. Where their access to broad markets had been facilitated by national distributors, they turned to those distributors to help monitor and enforce their collusive agreements. Where, as in salt, producers had relied on many local distributors to market their product, colluding producers attempted to create a common distributor through the creation of a pool. Despite this creative response, salt producers found their attempts to collude continually stymied by a lack of unanimity among producers, cheating, and entry. In contrast, bromine producers were able to sustain collusion because of the ability of their distributors to enforce participation and limit entry.

Distributors could not forestall entry permanently, especially when challenged by new, continuous-process, mass-production technologies. In cases where important distributors were excluded from collusive agreements, they could even be a source of support for new entrants, as Rosengarten was when Dow left the bromine pool and Arnold was after Mathieson sold out to United Alkali. But the existence of collusion did shape the strategy and structure of these new producers. In both bleach and bromine, Herbert Dow introduced new production technologies through his fledgling companies, the Midland Chemical Company and then the Dow Chemical Company. In both cases the companies cooperated with their competitors and their distributors when first entering the industry. The services provided by established distributors—access to customers, reputation, technical advice—were valuable. The threat of a price war if Dow did not cooperate was a serious threat to a financially fragile firm learning about its own new technology. During the years of cooperation, Dow was able to earn, and reinvest, high profits, giving it the financial stability, and more importantly, the capability to challenge the pool. A break with the pool was necessary not just to increase output and take advantage of the economies of scale in Dow's technology, but also to eliminate the requirement that it sell through the pool distributor. Although in Dow's early years, and in markets in which customers were small and dispersed, the distributor's service had real economic value to the mass producer, increasingly it needed direct contact with its own customers. Once it ended its cooperation with its competitors and established its own sales office, it developed a wide variety of bromine- and chlorine-based products to satisfy specific customer needs. Product differentiation and quality

improvements in turn provided Dow a much more secure protection from price competition than was ever afforded by a pool.

This article has examined three closely related questions about the role of national distributors in the late nineteenth and early twentieth centuries. First, it has argued that, at least in some industries, national distributors played a central role in creating integrated national and international markets by providing access to those markets for small, locally oriented manufacturers. Second, where these distributors existed, they also were in a position to facilitate collusion among manufacturers. Finally, with the entry of mass producers at the end of the century, national distributors provided the protection of a collusive price and access to large numbers of customers, allowing the mass-producing entrant to take advantage of its scale economies without having to locate large numbers of customers and without having to lower price. But in the long run, output restrictions and a lack of contact with customers came to outweigh the benefits of collusion. Vertical integration and product differentiation provided the basis for sustainable competitive advantage for the mass producer and left the national distributors of the previous century with a much more circumscribed role.

Appendix: Data Sources and Official Publications

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