THE CONSOLIDATION OF AMERICAN INDUSTRY:
A NEW PERSPECTIVE ON THE TRUST ERA

DISSERTATION

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By

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To my two sons, John and Mike, who are, and always will be, my finest accomplishments.
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INTRODUCTION:

The consolidation of American industry began in 1882 when ninety percent of the petroleum refining capacity of the United States was brought under central management by the formation of the Standard Oil Trust. Prior to the 1880s, with the exception of transportation, virtually all industrial production in this country had been carried on by single plant firms. But, in the years immediately following the creation of the Standard Oil Trust, several other very large consolidations, measured by both market share and size of capitalization, took place. This was the beginning of a merger wave that was to have a profound effect on American industrial structure and for which we still have no good explanation. The purpose of this paper is to show that the 1880s saw the emergence of the multiple plant firm because the supply and demand conditions facing some industries at that time made multiple plant organization more efficient than single plant firms of any size.

1. The Standard Oil Trust was capitalized at over $90,000,000. The Sugar Refineries Company represented over eighty percent of refined sugar output and was capitalized at over $40,000,000. The American Cotton Oil Trust, also capitalized at over $40,000,000, controlled about eighty percent of its market and the Distillers' and Cattle Feeders' Trust, manufacturers of over eighty-five percent of all alcohol and spirits produced in this country, was capitalized at $30,000,000. Andrews (1989) pp. 128-31.
I apply the theory of the core associated with small numbers situations \(^2\) to the long standing questions about the motives behind the formation of the great industrial trusts and conclude that restricting competition was necessary in the trust industries to support an equilibrium set of firms that could most efficiently (at least cost) respond to the cyclical nature of the markets involved. Unstable demand had become particularly troublesome in these industries when technological change led to new cost structures.

The period from 1860 to 1880 had been a time of rapid innovation in many industries. The earlier discovery of large deposits of coal in Pennsylvania and the adaptation of steam as an energy source led to many technological changes that were adopted in growing industries. In many industries, these technological changes resulted in production processes that required high sunk costs, as well as costs that were fixed for any positive level of output but could be avoided by shutting down. These avoidable fixed costs, like the sunk costs, varied directly with the capacity of the plant. Large plants had higher sunk and avoidable fixed costs, but lower minimum average total costs than those of small plants.

Since high fixed costs were associated with low average variable cost, and vice versa, firms of different sizes could coexist. The industry supply curve was therefore a function of the mix of firms that chose to operate. A single, self-interested firm looked only at the private benefits of the decision to operate or shut down. But, one

\[\text{Telser (1972) and (1978). Bittlingmayer (1981) defines the core of a market as "those allocations that the procedure of recontracting could not, from the point of view of some set of participants, improve upon."} \]
firm's operating decision altered the industry supply curve, thereby affecting the profitability of the remaining firms.

In industries with these costs structures and uncertain or cyclical demand, competition led to the "wrong" mix of plants operating. During periods of high demand, both large, efficient plants and smaller, higher cost plants could be supported. But, in periods of low demand, industry-wide cost minimization required that only very large, efficient plants produce and smaller, higher cost plants be shut down to economize on avoidable costs. Instead the small plants continued to produce as long as they could cover their variable costs. Because of the "lumpy" nature of costs, the large plants could not force the smaller plants to close during periods of low demand. The result was that all the plants produced at a loss.

As a consequence of these frequent periods of ruinous competition, firms elected to install smaller than optimal plants to minimize the risk associated with unavoidable fixed costs. This meant that, with no very large plants available to take full advantage of scale economies, average cost in these industries was higher than necessary. Only by bringing all production under the control of a single agent, could optimal size plants be assembled and operated for all levels of demand. Therefore, although the trusts reduced competition, they had the potential to increase social welfare by coordinating output decisions in the face of demand fluctuations.

This dissertation is organized as follows. Chapter I is a critique of the standard explanations of the turn-of-the-century consolidations.
These include economies of large scale production, high sunk costs, the closing of the frontier, the development of a national rail system, the emergence of the professional manager and monopolization. I point out why none of these explanations adequately explains the emergence and success of the multiple plant firm. Chapter II contains background material.

Chapter III offers an efficiency explanation for the formation of the trusts. I use a model from Sharkey (1982) to show why multiple plant organization is more efficient than single plant in industries with increasing returns and uncertain demand. I then show why, under the same conditions, competition will be "ruinous". Next, I use a simple game to show why firms fearing ruinous competition would choose to install globally suboptimal capacity. Building on Telser's 1985 example of a market for which the core is empty, I show that a suboptimal configuration of firms in a market will reduce the firms' risk but at the same time decrease the surplus available in the market. I conclude that the trusts, by restricting competition, solved the empty core problem, thus allowing the firms to assemble and operate optimal size plants.

Chapter IV is a case study of the sugar industry. A history of the technological changes that resulted in new cost structures in the sugar industry is interwoven with a description of the sugar refining process. The rationalization of production in the industry following the formation of the Sugar Trust is also included. Chapter V summarizes the new perspective this paper lends to the trust era.
CHAPTER I: LITERATURE REVIEW

There are a number of explanations that are commonly given for the consolidations that occurred in the final years of the nineteenth century. None of them has been completely satisfactory because none has been able to incorporate both the timing and the method of consolidation into a model that demonstrates the desirability of consolidation. A brief review and critique of the standard theories will demonstrate their weaknesses and clarify the need for a better explanation.

One of the earliest explanations of the consolidation movement was that it was a natural extension of the increasing size of industrial plants. According to this theory, a mere increase in size resulted in increased efficiency. This argument seems to come from a confusion between the efficiency of large scale production and the efficiency of large scale organization. While it is true that technological changes that increased the efficient size of plants in many industries following the Civil War preceded the merger movement, it does not follow that grouping large plants into large firms would result in further increases in efficiency.

Technological changes that led to increasing returns to scale in production should have been exploitable by expanding the size of a

3. For example, see: Collier (1900), Ely (1900), Giddings (1901), Swift (1888), von Halle (1899), Van Hise (1914).
plant. Exploitable efficiencies that are mentioned (spreading fixed charges over larger output, specializing in the use of machinery and management, utilizing by-products, investing in research and development, and monopsony power in purchasing inputs) could have been achieved by increasing the size of plants and would not have required the consolidation of existing plants. To explain why efficiency required the centralized control of all the existing plants, it is necessary to show that the combinations were able to achieve some additional economy that was not attainable without multiple plant organization.

Another theory is that the introduction of capital-intensive production methods that resulted in cost structures dominated by high sunk costs were responsible for the necessity to consolidate. According to this theory, during periods of slack demand, firms would continue to produce and sell at prices that did not cover their full costs of production rather than shutting down. The only way for the firms to control this overproduction was to consolidate. This is an incomplete explanation of the consolidation movement, explaining only the difficulty of retiring capacity when there are high sunk costs.

High sunk costs do not explain why competition did not result in the "correct" firms, i.e., those with higher costs, being forced to close and eventually exit the market leaving optimal size firms. As a

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4. For early references, see Clark (1902), Hadley (1886), Jenks (1903). For one of the first formal presentations, see Jones (1920). In her 1985 book, Lamoreaux brings together a wealth of data and an interesting historical perspective, but unfortunately uses the same sunk cost model that has become standard since Jones (1920).
consequence of this deficiency, this theory cannot explain the superiority of the multiple plant form of organization. Admitting that this theory of high fixed costs would not predict consolidation as a general outcome, Lamoreaux suggests that it was the particular conjunction of events that occurred in the 1890s (unusually rapid growth in industries with high fixed costs followed by an economic depression in 1893) that led industries to seek consolidation, ignoring the fact that the consolidation movement began fifteen years earlier.  

The closing of the frontier has also been used to explain the merger movement. This theory says the closing of the American frontier led to economic retardation and forced producers to band together to protect their margins when there were no longer any new opportunities to exploit. The theory was tested by Nelson who found that mergers were positively related to growth rather than decline as this theory would suggest.  

Another theory tested by Nelson is that the mergers were the result of the development of the national rail system. According to this theory, firms merged to avoid the increased competition that came with the creation of a national market. This suggests that decreases in transportation costs destroyed regional monopolies and created competition between firms that had previously been isolated. Nelson found

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that, although industries with high transportation costs were represented in the turn-of-the-century merger wave, the lowering of transportation costs could not be supported as a cause of those mergers. First, industries with high transportation costs were already geographically concentrated so that there was not much to gain from the lowering of transportation costs and second, Nelson found a positive relationship between merger activity and geographical concentration not the negative relationship that this theory would suggest. This evidence supports a natural scepticism of this theory that comes with the realization that if creation of a larger market was the cause of the merger wave, we should have seen some similar activity when the canal system was built earlier in the nineteenth century.

Chandler suggests that the emergence of the professional manager in the late 1800s led to the consolidation movement. According to this theory, the multunit firm emerged as managers learned to co-ordinate production at dispersed locations and the cost of doing so internally became lower than the cost of market transactions. This is consistent with Coase (1937) but does not identify the change in property rights that allowed managers to capture efficiencies in the 1880s that they had not been able to capture before, i.e., what it was they "learned" that enabled them to take advantage of economies of large scale organization and how the information was made available to so many firms in such a

short time span. Also, this theory does not explain why the multiunit firm emerged from consolidation rather than from internal expansion.

Stigler has suggested that the consolidations were formed to capture easily extractable monopoly profits.\textsuperscript{10} If this is true, he needs to explain the timing of the movement, because, as he points out, the mergers should have been profitable "well before" they occurred. Stigler suggests that the consolidations were held up by the backwardness of corporation laws and capital markets, specifically, "In a regime of individual proprietorships and partnerships, the capital requirements were a major obstacle to buying up the firms in an industry, and unlimited liability was a major obstacle to the formation of partnerships."\textsuperscript{11} This is not a fair representation of nineteenth century industrial America.

Corporations were not unusual even early in the 1800s. The New England states alone granted 1700 charters to manufacturing firms between 1800 and 1830.\textsuperscript{12} The general acceptance of limited liability by 1830 made incorporation even more popular and between 1830 and 1875, these same states chartered over 9000 corporations.\textsuperscript{13} Dodd found that, contrary to Stigler's notion, incorporations of small, not large, firms increased after the general acceptance of limited liability. Adding the

\textsuperscript{10} Stigler (1968), pp. 95-107.
\textsuperscript{11} Ibid., p. 101.
\textsuperscript{12} Kessler (1948) p. 46.
\textsuperscript{13} Ibid.
benefit of limited liability lowered the relative price of incorporation and made it affordable for small firms.\textsuperscript{14}

There also was no lack of capital available as evidenced by the investment in railroads. Over \$1,100 million in railroad securities had been issued by 1859.\textsuperscript{15} The largest railroads were capitalized at \$17 to \$35 million,\textsuperscript{16} while even the largest industrial firms were rarely capitalized at over \$1 million.\textsuperscript{17}

Another problem with the theory that the trusts were formed simply to extract monopoly rents is that this would imply that the trusts restricted output and produced below pre-consolidation levels (after controlling for increased demand). There is evidence to the contrary. If we look at the output of the trust industries over a period of several years following the formation of the trusts, we find that, rather than producing less, the trusts actually increased output at a rate that often exceeded that of manufacturing in general (see Appendix E). This is an indication that, although they had monopoly power and could produce at a price greater than marginal cost, through consolidation the trusts had captured an efficiency that outweighed the negative effects of monopolization.

Stigler's theory that the mergers were formed merely to extract monopoly rents that had previously been unextractible because of the

\textsuperscript{14} Dodd (1954) p. 383.
\textsuperscript{15} Chandler (1977) p. 90.
\textsuperscript{16} Chandler (1965) p. 16.
\textsuperscript{17} Chandler (1977) p. 90.
immaturity of American corporation laws and capital markets is not supported by simple empirical evidence and ignores the fact that the consolidation of industry in the late nineteenth century was not unique to this country. Similar consolidation was taking place in England, Germany, Austria and Belgium and to a lesser extent in Bulgaria, Egypt, Italy, Portugal, Romania, Spain, Switzerland and Russia.  

If profitable mergers were held up by the state legislatures (the charter-granting bodies), as Stigler's theory suggests, it would be hard to justify their action. By allowing these mergers, the legislatures could have expected to extract some of the profits that were created. Some legislatures did just this when, in the 1890s, they passed liberal corporation laws to attract firms that wanted to legalize existing cooperative agreements by merging. If such opportunities had existed earlier in the century, surely the legislatures would have taken advantage of them earlier just as they did later.

More recently there has been some attention paid to the importance of avoidable as well as unavoidable fixed costs and cyclical demand in explaining early consolidations. Bittlingmayer (1981, 1982 and 1983), in a detailed study of the cast iron pipe industry at the turn of the century, presents a strong case for the incompatibility of such supply and demand conditions and competition. His work is particularly valuable because he was able to obtain cost data for plants in the industry at the turn of the century and could, therefore, demonstrate that costs were indeed similar to those of the model of empty core markets in Sharkey's (1977) theoretical piece.

In the 1982 paper, Bittlingmayer traces some of the intellectual history of the issue, an intuitive understanding of which may explain the accepting attitude of the contemporary economists for the trusts. It is clear that some of the contemporary economists did have such an intuitive understanding of both the nature of the problem and the necessity of a solution. For instance, when discussing the effects of the trusts on prices one wrote "It would seem that in such an industry the real rate under competition, if the almost inevitable combination were not made, would be first below cost, then far above it, then below again, and thus continuously in cycles."\(^{19}\) Further evidence that he understood the incompatibility of competition and the demand and supply conditions facing these industries is found in his statement that "One ought not to fail to note that in industries of this class, under present methods of doing business, one can scarcely with propriety speak of a competitive rate that is in any sense normally uniform."\(^{20}\)

While Bittlingmayer offers strong evidence to support the necessity of consolidation to solve an empty core problem in an industry similar to the trust industries, he does not address the issue that leads to my new perspective on the trust era. The issue is: if the supply and demand conditions facing the trust industries were incompatible with competition in the short run, how did this affect the long run capacity choice decisions of the firms? By showing that the empty core problem

20. Ibid.
would have lead to a nonoptimal configuration of plants in the industries, I introduce an additional efficiency enhancement motivation for the formation of the trusts.
CHAPTER II: BACKGROUND

The trust industries were similar in many respects, leading them to seek similar solutions to common problems. Each produced a homogeneous product using a process that had recently undergone technological change that led to a more energy-intensive, capital-intensive mode of production that greatly increased the volume and speed of throughput but resulted in inflexible production capabilities. The trusts that were to have any success were formed in processing industries. This branch of industry was the earliest to develop large scale, high speed, continuous production processes that required high sunk and avoidable fixed costs. Economies of large scale production at the plant level were being realized by many firms in the industries and some smaller, less efficient plants were being closed, but plants which varied considerably in size remained. Demand was periodic (depending on the season of the year) in some industries, inherently uncertain in others. There were almost continuous attempts to stabilize the markets through price agreements, output agreements, industrial pools, or joint sales agencies but these were unsuccessful because the incentives to cheat were too strong and the costs of monitoring too great.

21. The singulary unsuccessful Cattle Trust was the exception.
23. See Appendix B for a description of these market control mechanisms.
When these efforts at market stabilization proved futile, the men actively involved in the industries searched for a way out of their predicament. John D. Rockefeller found one: simultaneously consolidate all the firms in an industry and control production so that supply could be adjusted to demand using capacity correctly to minimize costs industry-wide and share the profits resulting from this efficiency-enhancement among all the firms in the industry to eliminate the incentive to cheat.

The Standard Oil Trust, a consolidation of oil refining companies, was the culmination of J. D. Rockefeller's campaign to control the industry. Rockefeller's company, Standard Oil of Ohio, was incorporated in June, 1870 with a capital stock of $1,000,000. The largest oil refinery in the country, it accounted for about ten percent of the industry's output.

In the 1870s the introduction of new refining techniques resulted in economies of scale. Several of the leading oil refining firms, including Standard Oil, expanded the size of their plants and some smaller plants were absorbed. In 1874, a pool, The Central Alliance of Refiners, was organized. The pool represented a large percentage of the refining capacity of the country. By 1879, over ninety percent of the refining capacity in the U.S. was loosely linked to Standard Oil of Ohio by stock ownership or trust agreements, but the need for centralized control of production was still apparent. In 1882, the Standard Oil Trust was formed.

When Rockefeller and his associates consolidated the petroleum refining industry, they centralized control of the constituent firms through the formation of a trust. "A trust is a fiduciary relationship concerning property in which one person, known as the trustee, holds the legal title to property for the benefit of another, known as the beneficiary." To form an industrial trust, the stock of the constituent firms was turned over to a group of trustees who, through the legal title, gained the voting rights of all the stocks, effectively establishing centralized control. In return for the firms' stocks, the previous stockholders received shares in the trust, retaining their right to the proceeds of the business.

Standard Oil's legal counsel, S. C. T. Dodd, advised the use of the trustee device because it allowed the consolidating firms to achieve several objectives. They could centralize control without prior legislative approval, without the necessity of forming partnerships between the joining firms and without relinquishing secrecy. This use of the trustee device was an innovative step in the evolution of the corporation, necessary because contemporary corporation law did not allow an easy route to consolidation. No general corporation laws of the time allowed one corporation to hold the stock of another and common law forbade corporations to form partnerships. Application to a state legislature, expensive in both time and money, would have been required to seek a special charter to accomplish what was accomplished through the trust agreement.

Over ninety percent of the petroleum refining capacity in the U. S. came under the control of the trustees of the Standard Oil Trust in 1882. Even though the trust reduced the number of refineries it operated from fifty-three to twenty-two in the next three years,27 the need to serve consumers in a fluctuating market required that Standard Oil keep some smaller refineries open while dismantling or expanding others.28 This reorganization of productive capacity enabled the trust to earn an average return of nineteen percent on its investment between 1882 and 1896.29

The stability of the Standard Oil Trust proved the feasibility of Rockefeller's solution and the profitability of the Trust demonstrated its success. Other industries quickly followed suit and in these early consolidations, unlike many of the later ones, the impetus to bring all the firms in an industry under one management came from within. And, like Standard Oil, they all originally took the form of trusts before later reorganizing as single corporations or holding companies.30

The Cotton Oil Trust was a consolidation of cottonseed oil producers, an industry that was very small and primitive until the 1870s. In 1876 industry output was only 4,500,000 gallons. When new uses for the product increased demand, output increased to 7,800,000

29. Seager and Gulick (1929) p. 121.
gallons by 1880. In 1880 there were 41 cottonseed-oil mills in the south, but by 1885 the number had increased to 131.

During the early eighteen eighties, the mill owners in Arkansas and Texas formed a pool to control overproduction in the industry. Early in 1884 the refiners in Memphis also banded together temporarily. A need for firmer control over the market lead to the formation of a trust later that year. Comprised of over seventy firms, the trust controlled about eighty percent of industry capacity. Immediately after forming, the trust closed more than a dozen refineries and by 1889 it had consolidated production into seven refineries and fifty-two crude oil mills. Although capitalized at more than twice the market value of the constituent firms, the trust earned a return of not less than twelve percent and was one the largest and most successful of the trusts.

The Linseed Oil Trust was a consolidation of linseed (flaxseed) oil producers. This industry dated back to 1793 when production was concentrated on the Eastern Seaboard because most of the flaxseed had to be imported from Europe. As American farmers began to grow flaxseed in the Middle West, refineries were built in inland areas, becoming concentrated in Ohio by the 1850s and moving west as the farming population moved west. As the production of flaxseed moved further west, the Ohio refineries found it hard to compete with newer, more efficient firms but were able to remain open, depressing the margins of all the mills.

In 1885, when the Linseed Oil Trust was formed, there were seventy linseed oil processing plants still in existence. The trust included only about two thirds of the processing capacity of the country and was forced to dismantle twenty-one of its refineries to reduce losses. The never, more efficient firms chose to stay outside the consolidation and new mills were built to take advantage of temporarily higher prices. With the trust unable to control enough of the market to effectively adjust production to demand, its failure was assured. The result of this failure was that instability continued to be a problem for the industry. Because of this, National Lead built its own refinery to process the linseed oil needed in the production of white lead. Eventually synthetic substitutes were developed for linseed oil and the industry's largest single consumer, Sherwin-Williams, also built its own linseed oil refinery.34

The Distillers' and Cattle Feeders' Trust was a consolidation of distillers who produced spirits and alcohol for immediate consumption, rather than aged Kentucky Whiskey. Following the Civil War, there were over eighty spirits distilleries in operation and competition was fierce. Changes in excise tax laws were responsible for wide swings in the demand for alcohol by industrial users. By 1870, the independent distillers were entering into agreements to limit production, sometimes cutting back production by as much as sixty percent. Any excess production that still remained was exported. By 1880, however, there were restrictions on the import of American spirits into Europe. Good corn

34. Eastman (1968).
crops in Europe so lowered the demand for American alcohol that exports could only be sold at a loss. The distillers were willing to sell at a loss in order to keep their distilleries operating, because it was difficult for them to close down as long as they had cattle to feed (slop from the distilleries was used to raise cattle).

In November, 1881, the first pool was formed in the industry. In May 1882, the pool was dissolved to be reorganized in September of the same year. That there were economies of scale in production was evidenced by the fact that the pool organizers found it profitable to pay some of the smaller plants to close so that the larger ones could be run at full capacity. The pool was organized and broken up nearly once a year from 1881 to 1887. In the spring of 1887, the leading distillers decided that a stronger form of organization was necessary and they elected to form a trust. All but twenty of the more than eighty distilleries were closed after formation of the trust and only twelve of these twenty were operated on a regular basis. That the trust was successful in the short run can not be denied. The twenty distilleries were able to earn "good dividends" (on the capital of over eighty distilleries) for the member firms and to accumulate a surplus as well. The phenomenal success of the trust, however, invited entry and the inability to control entry led to the eventual failure of this trust. 35

The lead Trust was a consolidation of firms that concentrated on processing (smelting and refining) rather than fabricating lead. From 1870 on, various devices to control competition in the industry were

tried but failed and in 1887 several large producers formed the National Lead Trust. The trust did not control enough of the capacity in the industry to be an immediate success and in 1889 it was reorganized to include eight more large concerns. By the end of 1889, the trust was producing eighty percent of the country’s white lead, seventy percent of its red lead and sixty percent of its lead acetate, but less than ten percent of fabricated lead products. The increase in market control made the reorganized firm much more successful.  

The Sugar Trust was a consolidation of sugar refining firms. Following the Civil War, there was a general expansion of the sugar refining industry, including new entry and expansion of existing plants. Capacity increased very rapidly, as did demand, but demand remained periodic, being much lower in the winter months when there was little to can or preserve. Some refiners closed their plants during periods of slack demand, but this was not enough to keep margins from falling to unprecedentedly low levels in the 1870s. Agreements to limit output brought only temporary relief because the incentives to cheat on such agreements were so high. This was because the capital invested in the industry could not be easily transferred to another industry because the equipment it was tied up in was of use in sugar refining only and scale economies required producing at full capacity to minimize costs. Firms left the industry (from 1867 to 1887 the number of refineries declined from sixty to twenty-seven) but output continued to increase (from about

.54 million tons a year to 1 million tons) as the average size of plants increased about five-fold.\(^{37}\)

In June 1880 a pool was organized in the sugar refining industry but it brought little relief. Then, in 1886 the refiners in New York, Boston and Philadelphia agreed to cease production for ten days but only a few actually shut down. In the winter of 1887 one of the most modern refineries, the Brooklyn Sugar Refinery, lost $200,000. All the refineries reportedly suffered similar losses and the refiners decided that something had to be done to save the industry. In 1887 eighteen of the remaining twenty-three firms entered into a trust agreement, creating the American Sugar Refineries' Company. An attempt was made to include all firms, including two that were not currently operating. The trust originally controlled eighty-four percent of production east of the Rockies. Of the original twenty plants, seven were closed and dismantled, three were used only during periods of peak demand (one that had burned down was rebuilt to be used only occasionally) and eight were combined, in sets of two, into four larger plants.\(^{38}\) These four large plants were expanded further, resulting in a total capacity for the trust that was greater than the combined capacity of the independent firms had been.\(^{39}\) The remaining ten plants were able to pay a ten percent per annum dividend on total capitalization (of twenty plants), plus

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an eight percent bonus dividend in 1889, plus accumulate $7 in surplus by 1891 (equivalent to an additional fourteen percent dividend). 40

The Cordage Trust was a consolidation of the producers of twine and rope. This industry had a long history of failed attempts at market control. The first trade agreement was consummated on February 23, 1866 to be rewritten in July 1874. Still not successful, it was strengthened in 1875 and, finally, replaced by a pool in January 1878. This pool was abolished in 1881 to be reorganized in 1882 and again in 1885. In 1887 four of the largest producers of twine and rope entered into a more permanent arrangement by forming a trust, the National Cordage Association. 41

Although formed as a trust, like the other trust industries, this company took a different route to centralized control. It set up a joint sales agency, but unfortunately, was never able to gain control over more than about thirty percent of its market and its spectacular failure, in May 1893, helped to precipitate the panic of 1893. 42

The Cattle Trust, patterned after the Standard Oil Trust, was a consolidation of Western cattle producers. Following the dismal winter of 1886-1887, several large cattle firms were forced to liquidate and some of those remaining in the industry blamed their misfortune on the low prices paid by the large meat packing firms. To prevent future exploitation, some of the large producers proposed the formation of a firm

large enough to counterbalance the monopsony power of the processors. The plan put before the cattlemen was grandiose indeed, calling for a capitalization of $100,000,000 and complete control over the production, processing and distribution of beef.

The trust that was actually created in May, 1887 was much more modest, having approximately $8,000,000 in resources at its height in 1888. This trust was not based on any expectation of increasing efficiency, but instead was meant as a protest against the methods of the Eastern meat packing firms. By late 1888 it was clear that the trust would never achieve anything near a monopoly in the production of cattle. Having been plagued with financial trouble from the start, the Cattle Trust was dissolved in the spring of 1890.43

Other "trusts" are mentioned in contemporary literature but their designation as trusts represents misuse of the word. Because they were conspicuously successful, the trusts had aroused suspicion and alarm. Popular literature was full of accounts of the monopolistic nature of the trusts, causing people to confuse trusts with monopolies and leading to the popular use of the word to signify any large firm with (often imaginary) market power. Many of the "trusts" mentioned in contemporary literature were price-fixing agreements, pools or joint sales agencies. The salt "trust" (a joint sales agency), the steel rail "trust", the beef "trust" and the gunpowder "trust" (pools) are examples of this

misuse.\textsuperscript{44} These and other similar arrangements were not actually consolidations in the sense that they did not represent centralized control, although they were often early signs that consolidation would be attempted later.\textsuperscript{45}

Once consolidated, the trusts moved to restructure production by dismantling some plants, keeping some plants closed but in operating order, and combining or expanding others. The restructuring resulted in a different size distribution of plants for the trust industries. The largest plants became larger and the smaller plants became fewer in number, but a range of plant sizes was kept in inventory.\textsuperscript{46}

The common nature of the production processes and the similar routes taken to consolidation lead to the conclusion that the nature of the production process was responsible for, and the route taken indicative of, the problem faced by the trust industries. One of the most striking similarity of the trusts was the manner of consolidation. In all cases an attempt was made to bring all production under central control simultaneously and to prevent future entry.\textsuperscript{47} This suggests that, either the trusts were formed to create monopolies and extract monopoly rents or they were formed to capture an efficiency that could be exploited only through multiple plant organization. I offer an efficiency

\textsuperscript{44} Jones (1924), pp. 9-14.

\textsuperscript{45} See Appendix B for a description of these other forms of market control.

\textsuperscript{46} See Appendix C for statistics on the structural change in the trust industries.

\textsuperscript{47} Where this was not accomplished (the Cordage Trust, the Cattle Trust, the Whiskey Trust and the Linseed Oil Trust), the trusts eventually failed.
explanation that incorporates the necessity of multiple plant organization and the elimination of competition. Previous explanations are less satisfactory because they fail to show either why the consolidation of existing plants was necessary or why the consolidations occurred when they did.
CHAPTER III: AN EFFICIENCY EXPLANATION

Introduction

The extent to which other industries followed the initiative of the trusts (it has been estimated that as much as one-half of U.S. manufacturing capacity took part in the turn-of-the-century merger wave) and multiple plant firms came to dominate American industry, is evidence that some very real efficiency was captured by those first consolidations, an efficiency that could be captured only through multiple plant organization and restriction of competition. In this section I show that multiple plant organization was necessary to allow firms to adjust operating capacity to fluctuating demand and restriction of competition was necessary to allow firms to install optimal capacity.

When looking at the optimal plant size for an industry, the starting point is generally to assume a level of demand, then to look at cost structures and entry conditions and finally to derive the size and number of plants that will exist in equilibrium. The problem with this methodology is that, in the present context, there will be no competitive equilibrium and we do not, yet, know how to characterize

what does exist. Further, there is no one optimal plant size, because, in fact, full efficiency requires an inventory of plants of different sizes. 49

The Efficiency of Multiple Plant Organization

The following model from Sharkey (1982) shows why having plants of various sizes increases welfare in markets characterized by unstable demand and "lumpy" cost structures. 50 Suppose there is a collection of identical consumers, each willing to purchase one unit of a homogeneous product at a price $b$. Assume the total number of buyers is uncertain. Let $t$ denote the actual number of buyers that results from a drawing from the underlying distribution, and assume that the distribution is uniform over $[0,1]$. Then, the density function of $t$ is

$$f(t) = \begin{cases} 1 & \text{if } t \in [0,1] \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

Entry is free, but to enter, a firm must commit itself to a capacity $q < 1$. Let the cost of a plant of size $q$ be $f + cq$, where $f$ is a fixed cost of entry that must be incurred before production takes place and $cq$ is a fixed, but avoidable, cost of production. If a plant of size $q$ is used in production, then any output $t$, $0 \leq t \leq q$, can be


produced at a cost $cq$. If the plant is shut down, the cost $cq$ is not incurred.

How does the firm choose an optimal $q$? Assume the firm chooses $q$ to maximize total expected surplus. The expected surplus is shown as the shaded area in Figure 1, Appendix A.\textsuperscript{51} For $t < cq/b$, surplus is zero because the firm will not produce, preferring to minimize its losses by avoiding the cost $cq$. For $t > q$, surplus is $(b-c)q$ with the plant operating at full capacity. Total expected surplus is

$$S(q) = \int_{cq/b}^{q} (bt-cq)dt + (1-q)(b-c)q$$

which is maximized at $q^* = b/(b + c)$.

Now suppose that, instead of one plant, the firm decides to operate two plants so that $q_1 + q_2 = q^*$. Then total surplus is increased by the darker shaded area in Figure 2, Appendix A. As long as this area is greater than $f$, the increase in fixed cost, the firm will prefer to operate two plants. With two plants, for $t < cq_1/b$, both plants are closed, for $cq_1/b < t < q'$, only plant 1 is operated and 2 is closed, for $q' < t < q''$, only plant 2 is operated and 1 is closed and for $t > q''$ both plants are operated.

The increase in surplus from operating two plants is due to increased flexibility. Having the appropriate combination of plants can reduce costs and excess capacity at low levels of demand and can reduce

\textsuperscript{51} Sharkey, (1982), p. 137.
excess demand at high levels of demand. Sharkey has shown that efficient production when demand is uncertain requires a set of plants of different size (to take advantage of scale economies and to allow flexibility) and that no optimal or minimum efficient scale of firm exists because only the collection of all plants is efficient. The difficulty is, as Sharkey points out, if it is optimal for a firm to have more than one plant, there is room in the industry for more than one firm. However, if there is more than one firm, given the supply and demand conditions we have assumed, there is no competitive equilibrium because the core of the market is empty. Competition will be, in the words of the late-nineteenth-century economists, ruinous.

The Empty Core Problem

To see why competition is ruinous under these conditions and how consolidation can eliminate the problem, consider the following example from Telser (1985). We have an industry where there are a small number of firms each producing an identical, homogeneous product. Let $k_i$ denote the capacity of firm $i$, $i=1, 2, 3, 4$. Each firm incurs a cost, $a_i$, if it operates but no cost if it does not operate. This avoidable cost, $a_i$, depends on capacity but not the actual level of production. Variable costs are constant and are assumed to be zero. Sunk costs do

52. Telser (1978) p.77.
not affect the firms' decisions in the short run because the level of capacity has already been chosen and installed. The following table describes one possible industry configuration:

<table>
<thead>
<tr>
<th>Firm</th>
<th>k_i</th>
<th>a_i</th>
<th>a_i/k_i</th>
</tr>
</thead>
<tbody>
<tr>
<td>A_1</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>A_2</td>
<td>2</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>A_3</td>
<td>4</td>
<td>12</td>
<td>3</td>
</tr>
<tr>
<td>A_4</td>
<td>8</td>
<td>16</td>
<td>2</td>
</tr>
</tbody>
</table>

The table shows that Firm 1 has a capacity of 1 and avoidable costs of 5, so it will not operate unless its receipts are at least 5. Firm 2 has a capacity of 2 and avoidable costs of 8 and therefore will not operate unless its receipts are at least 8. The same reasoning applies to Firms 3 and 4. Average avoidable cost is a decreasing function of capacity.

Let \( r_i \) represent the gain to firm \( A_1 \). This short run return will be equal to the total revenue of the firm minus the avoidable cost of production. Because a firm can close down, sell nothing, and incur no production cost, it can guarantee that its short run return will never be less than zero. Therefore, \( r_i \) will be nonnegative.

Assume there are identical buyers, each willing to purchase one unit of the good at a limit price of 5. Demand is unstable so the actual number of buyers in any period is uncertain. Denote the actual
number of buyers $m$ and denote the gain to a consumer $s$ for consumer surplus. Since all consumers are identical, $s$ (the difference between the reservation price and the actual price) must be the same for all consumers and of course will be nonnegative.

The maximum available surplus in the market will be the reservation price, $P$, times the actual number of buyers, $m$, minus the minimum cost of producing $m$ units of the good, i.e.,

$$ Pm - \min C(m). $$

Coalitions (temporary alliances of independent parties for joint action) of buyers and firms may form. A coalition will consist of a group of buyers and a firm, $A_1$, where the number of buyers will be $\leq k_1$. Each coalition can assure itself of a combined net gain given by the maximum total amount the buyers are willing to pay minus the avoidable cost of the firm. If we denote the surpluses for coalitions of buyers with firms which are operating at their respective capacities as $\pi$, we have the following possible surpluses:

$$ \pi(1b, A_1) = \max < 0, 5-5 > = 0, $$

$$ \pi(2b, A_2) = \max < 0, 10-8 > = 2, $$

$$ \pi(4b, A_3) = \max < 0, 20-12 > = 8, $$

$$ \pi(8b, A_4) = \max < 0, 40-16 > = 24. $$
For example, firm $A_3$ has a capacity of 4 and an avoidable cost of 12. It can satisfy the demand of 4 consumers who will each pay up to 5. The maximum available surplus is then $4 \times 5$ minus the firm's avoidable cost of 12 which equals 8.

Now assume that firms and buyers are free to form any coalitions that they choose. The individual firms and buyers act in their own behalf to find the most favorable terms possible. The minimum gain acceptable to any coalition will be:

$$sm + \sum_{i=1}^{n} r_i,$$

where $s$ is the consumer surplus, $m$ is the number of buyers, $n$ is the number of firms, and $r_i$ is the short run return of firm $i$. This means that any coalition that forms would have to guarantee its members at least as much as the maximum gain available to the coalition as shown above in 2. That is, the gains of the individual buyers and sellers must satisfy the following inequalities:

$$s + r_1 \geq \pi(1b, A_1) = 0, \quad (6.1)$$
$$2s + r_2 \geq \pi(2b, A_2) = 2, \quad (6.2)$$
$$4s + r_3 \geq \pi(4b, A_3) = 8, \quad (6.3)$$
$$8s + r_4 \geq \pi(8b, A_4) = 24. \quad (6.4)$$

A competitive equilibrium will not exist for such a market if the constraints imposed by the lower bounds on gains attainable by the
coalitions can not be satisfied by an outcome that also achieves the globally maximal consumer surplus. An equilibrium requires that the maximum available surplus be at least as great as the minimum acceptable gain required by any coalition, i.e.,

$$\max \{ P_m - \min C(m) \} \geq \min \{ s_m + \sum_{i=1}^{n} r_i \}. \quad (7)$$

Whether an equilibrium is possible or not depends on the number of potential buyers. As long as the minimum acceptable gain to a coalition is less than or equal to the maximum consumer surplus available (condition number 5 is satisfied), there will be a competitive equilibrium which is contained in the core of the market. It is not always possible to satisfy all the constraints within the bounds set by the the maximum available consumer surplus, however. When the minimum acceptable gain exceeds the maximum consumer surplus, the core of the market is empty and therefore no competitive equilibrium is possible.

To understand why there is no equilibrium for some levels of demand, a simple verbal explanation of what occurs for some arbitrary level of demand is helpful. For instance, suppose there are 10 buyers. The globally optimal (cost minimizing) solution calls for $A_2$ and $A_4$ to produce and for $A_1$ and $A_3$ to be idle. The maximum total surplus available is 26 (10 times 5 minus 24). But, $A_3$ is a competitive alternative. $A_3$ can offer any set of four buyers a price of 3 which would result in a gain of 2 for each. Therefore, the highest price that can be charged is 3 and each consumer will demand a consumer surplus of 2. The gain to
the group must be 10 times 2 (the total gain to the buyers) plus 6 (the short run return to firm $A_4$ when selling at 3). The gain the group requires (28) exceeds the maximum total surplus available (26), therefore no equilibrium is possible (condition number 5 is violated).

With $A_3$ and $A_4$ both producing, supply exceeds demand, but $A_3$ cannot be forced from the market by $A_2$ because $A_2$ will not produce at a price below 4. $A_4$ can not force $A_3$ from the market by charging a price lower than 3, either, because $A_4$ can not satisfy all the demand. The two buyers not able to purchase from $A_4$ will bid the price up to 3 by forming a coalition with $A_3$ and 2 other buyers. As long as $A_3$ is allowed to act independently there can be no competitive equilibrium with ten buyers.

With 10 buyers (or 9, 11, or 13) the globally optimal solution requires that a less efficient firm (one with higher minimum average cost) produce while a more efficient one (with lower minimum average cost) stands idle. Since this is not in the best interest of the more efficient firm if it is acting independently, the globally optimal solution requires that some restriction be placed on it. Telser concludes that, in such industries, sales quotas would allow an efficient equilibrium to obtain because the quotas would give each firm some property rights over the output rates of the other firms.

This is the solution the trust industries attempted to obtain by forming pools and joint sales agencies. Only when these attempts at market control had failed because the agreements were unenforceable, did they consolidate and finally achieve the degree of control necessary to
obtain an efficient solution. The formation of a trust effectively eliminated the market failure by giving the individual firms a property right to a share of the return of the entire industry, making it in each firm's best interest to maximize that return. Global rather than local maximization became the goal of all the firms.

A more serious consequence of the market failure in the short run was that it affected the long run decisions of the firms. The possibility that "all hell would break loose" and cause the failure of firms and the loss of the entire investment that had been made in the plants resulted in the wrong size distribution of plants in these industries. Even though technological change had led to production processes that were characterized by considerable scale economies, the individual, independent plant owners dared not risk the capital required to build very large plants because of the frequent episodes of ruinous competition. When choosing a plant capacity to install, the owners had to take into consideration the possibility that there would be frequent periods in which the market price of their product might stay below the total cost of production. This led the owners to choose smaller plants with lower sunk costs.
Capacity Choice

A simple noncooperative game can be used to show why independent firms would choose to install globally nonoptimal capacity under the given conditions. In this game, each firm will choose the course of action that maximizes its individual expected return given the currently available information.

Consider an industry characterized by rigid supply which is a result of the production process requiring the use of large discrete units of capital with fixed capacities. The cost of installing capacity varies directly with size and once capacity is installed the high cost entailed is sunk. There are also high avoidable fixed costs which vary directly with capacity. Variable costs are fairly constant and small relative to the other costs and will, therefore, be set to zero. Because there are capacity constraints and all costs come in lumps that depend on capacity but not the level of output, average cost declines up to full capacity and then increases at an infinite rate. The following notation will be used:

$q_i$ is the output of a firm of size $i$, $i=1, s$.

$k_i$ is the capacity of a firm of size $i$.

$K_i$ is the cost of installing capacity of size $i$.

$F_i$ is the avoidable cost of using capacity of size $i$. 
The industry is also characterized by unstable demand. Quantity demanded is a function of total industry output and a random variable. At any given time, demand may be either high or low, either level occurring with equal probability, so that the inverse demand function is:

\[ P(Q, \varepsilon) = E - bQ + \varepsilon, \]  

(8)

where \( Q \) is \( \Xi q_i \) and \( \varepsilon \) can either of two values, \( \varepsilon = 0 \) when demand is low and \( \varepsilon > 0 \) when demand is high.

Assuming demand will support at most two plants, we have two firms each of which must decide first the level of capacity to install and then, once capacity is installed, whether to produce or remain idle. Assume, for the sake of simplicity, that there are only two possible sizes of capacity, large and small, the capacity of a large plant being twice the capacity of a small plant.\(^54\) Due to scale economies, the minimum average avoidable cost of a large plant is lower than the minimum average avoidable cost of a small plant, while the sunk and avoidable fixed costs of a large plant are greater than those of a small plant, that is

\[ F_L / q_L < F_S / q_S. \]  

(9)

---

\(^54\) Sharkey (1977) shows that, under these conditions, the capacities of the other plants in the industry will be powers of two of the capacity of the small plant.
In general, because of the nature of the production costs, a plant will produce at full capacity, so that \( q_1 = k_1 \), or not at all, so that \( q_1 = 0 \). Therefore, assuming \( q_1 = k_1 \), we have the following relationships:

\[
q_1 = 2q_s \quad \text{by assumption.} \tag{10}
\]

\[
P(Q, \varepsilon) = B + bQ + \varepsilon \quad \text{if demand is low.} \tag{11}
\]

\[
P(q_s, \varepsilon) > \frac{F_s}{q_s}. \tag{12}
\]

\[
P(q_1, \varepsilon) > \frac{F_s}{q_s} > \frac{F_1}{q_1}. \tag{13}
\]

\[
P(2q_s, \varepsilon) > \frac{F_s}{q_s}. \tag{14}
\]

\[
P(q_s + q_1, \varepsilon) < \frac{F_1}{q_1} < \frac{F_s}{q_s}. \tag{15}
\]

\[
P(2q_1, \varepsilon) < \frac{F_1}{q_1}. \tag{16}
\]

\[
P(q_s, \varepsilon) > P(q_1, \varepsilon) = P(2q_s, \varepsilon) > P(q_1 + q_s, \varepsilon) > P(2q_1, \varepsilon). \tag{17}
\]

\[
P(0, \varepsilon) = B + bQ + \bar{\varepsilon} \quad \text{if demand is high.} \tag{18}
\]

\[
P(q_s, \bar{\varepsilon}) > \frac{(K_s + F_s)}{q_s}. \tag{19}
\]

\[
P(q_1, \bar{\varepsilon}) > \frac{(K_1 + F_1)}{q_1}. \tag{20}
\]

\[
P(2q_s, \bar{\varepsilon}) > 2(K_s + F_s)/q_s. \tag{21}
\]

\[
P(q_s + q_1, \bar{\varepsilon}) > \frac{(K_s + F_s + K_1 + F_1)}{(q_s + q_1)}. \tag{22}
\]

\[
2(K_1 + F_1)/q_1 > P(2q_1, \bar{\varepsilon}) > \frac{F_1}{q_1}. \tag{23}
\]

\[
P(q_s, \bar{\varepsilon}) > P(q_1, \bar{\varepsilon}) = P(2q_s, \bar{\varepsilon}) > P(q_1 + q_s, \bar{\varepsilon}) > P(2q_1, \bar{\varepsilon}). \tag{24}
\]
When making its capacity choice decision, a firm would first calculate the expected return for each plant size. Assuming a one period horizon, the expected profits under competition would be:

\[ E[ \pi^S(q_s, q_s)] = 0.5[P(2q_s, \bar{c})]q_s + 0.5[P(2q_s, \bar{c})]q_s - K_s - F_s. \]  
\[ E[ \pi^S(q_s, q_1)] = 0.5[P(q_s + q_1, \bar{c})]q_s + 0.5[P(q_s + q_1, \bar{c})]q_s - K_s - F_s. \]  
\[ E[ \pi^L(q_s, q_1)] = 0.5[P(q_s + q_1, \bar{c})]q_1 + 0.5[P(q_s + q_1, \bar{c})]q_1 - K_l - F_l. \]  
\[ E[ \pi^L(q_1, q_1)] = 0.5[P(2q_1, \bar{c})]q_1 + 0.5[P(2q_1, \bar{c})]q_1 - K_l - F_l. \]

To determine the level of these expected profits, a firm would first consider the expected return to producing once a given size of plant has been installed. A firm knows that if demand were low, \( P = B - bQ + \bar{c} \). From (16) we can see that, if there were two large plants in the industry, neither would produce because \( P(2q_1, \bar{c}) < \) minimum average avoidable cost of a large plant. Hence, \( q_1 \), and therefore revenues, would equal zero during periods of low demand if there were two large plants in the industry. On the other hand, if there were two small plants, both would be able to produce because \( P(2q_s, \bar{c}) \) is \( \geq \) the minimum average avoidable cost of a small plant (relationship 14).

If demand were high, \( P = B - bQ + \bar{c} \). From (23) we know that, if there were two large plants in the industry, both would produce because \( P(2q_1, \bar{c}) \geq \) minimum average avoidable cost, but less than twice the average total costs so that total expected revenue would not be great
enough to cover entirely the sunk costs of a large plant. If there were two small plants, both would produce and total revenue would cover the sunk cost of a small plant (relationship 21).

Each firm would make its capacity choice decision based on the above information. Since each would know the return to it for each of the two possible levels of demand with each of the two possible sizes of capacity, its optimizing choice would be that level of capacity that would maximize its expected return. The following shows the game in strategic form, where the outcomes are the expected profits of the firms (the boxes for s, l and 1, s being empty because with simultaneous entry and symmetric information it is impossible for the firms to arrive at different optimal choices):

\[
\begin{array}{c|c|c}
 & s & l \\
\hline
s & \{ E[\pi^S], E[\pi^S] \} & \ \\
\hline
l & \{ E[\pi^L], E[\pi^L] \} & \ \\
\end{array}
\]

The Nash equilibrium for this game is for both firms to install the small capacity plant, because, from (14) and (21) we have that

\[
E[\pi^S(q_s, q_s)] = .5[P(q_s + q_s, \bar{c})]q_s + .5[P(q_s + q_s, \bar{c})]q_s > 0, \quad (29)
\]
while, from (16) and (23) we have that

$$E\left[ n(q_1', q_1) \right] = 0.5[P(q_1 + q_1', \varepsilon)] \cdot 0 + 0.5[P(q_1 + q_1', \varepsilon)]q_1 < 0. \quad (30)$$

Uncertainty on the demand side would make the expected return of a large plant negative under a competitive regime. Therefore, with each firm making its capacity choice decision based on its individual expected return, neither firm would choose to install a large capacity plant if entry were simultaneous and information symmetric.

The same result holds under the more realistic assumption that entry is not simultaneous, as long as the first plant in the industry is a small plant. This is an intuitively appealing assumption since demand might have been low originally and only later have increased to the point where more capacity was needed. The second firm would then have to choose the optimal capacity to install, given uncertain demand and the presence of a competitive small plant. Once again its choice would depend on its expected return.

If demand were low, from (12) we have that $P(q_s, \varepsilon)$ would be greater than the minimum average avoidable cost of a small plant, from (13) that $P(q_1, \varepsilon)$ would be greater than the minimum average avoidable cost of a large plant and greater than or equal to the minimum average avoidable cost of a small plant, and from (15) that $P(q_1 + q_s, \varepsilon)$ would be less than the minimum average avoidable cost of either size plant.

During a period of low demand, then, if there was a large plant and it produced and charged $P(q_1, \varepsilon)$, the small plant would also produce
since at \( P(q_1, \xi) \) it could cover its avoidable costs. But, as long as the small plant produced, the large plant could not, because if both produced at full capacity, price will fall below the average avoidable cost of both plants. If the large plant produced and charged a price less than \( P(q_1, \xi) \), there would be excess demand which would drive the price up to \( P(q_1, \xi) \), allowing the small plant to produce.

If the large plant accommodated the production of the small plant by producing at \( q_s \), it could not cover its avoidable costs. But, with the large plant not operating, price would equal \( P(q_s, \xi) \). At this price, the large firm would have an incentive to form a coalition with \( q_1 \) buyers offering them a price less than \( P(q_s, \xi) \). At a price less than \( P(q_s, \xi) \), the small plant would not produce because it could not cover its avoidable costs. There would be more buyers than the large plant could service at a price less than \( P(q_s, \xi) \), however. Excess demand would force the price back up to \( P(q_s, \xi) \) and once again allow the small plant to produce.

With low demand, there would be no equilibrium price or quantity of output with both a large and a small plant in the industry. If both plants were small, there would be no such problem. With two small plants, both would operate at full capacity, price would equal the minimum average avoidable cost of the plants and there would be no excess demand.

If demand were high, and there was both a large and a small plant, from (22) we have that \( P(q_s + q_1, \xi) \) would be greater than the average avoidable cost of both plants, allowing both to produce. For a
large plant, total revenue would not be high enough to cover the costs of installing capacity, however. If both plants were small, from (21) we have that \( P(2q_s, \bar{e}) \) would be greater than the plants' avoidable costs and total revenue would be high enough to cover the cost of installing a small capacity plant.

From the above, we have that the optimal choice for an entrant, given that the incumbent plant is small, is to install a small capacity plant also. This is because competition from the incumbent plant would result in a large plant not being able to cover its sunk costs of installation. So, whether entry is simultaneous or sequential with a small plant entering first, the Nash equilibrium is for both plants to be small.

If the firms were able to collude however, there would be a small and a large plant, resulting in the following expected return for the multi-plant firm:

\[
E[ u^M(q_s, q_1) ] = .5E[ P(q_1, \bar{e}) ]q_1 + .5E[ P(q_s + q_1, \bar{e}) ]q_s + [ P(q_s + q_1, \bar{e}) ]q_1 - K_s - K_1 - F_s - F_1,
\]

which is greater than the sum of the returns to the two small independent firms. With a mixed size configuration multi-plant firm, only the large plant would be operated if demand was low, resulting in a lower minimum average fixed cost than two small plants. If demand was high, both plants could be operated. This would result in greater output.
lower price, and lower average total cost than operating two small plants. Even though having a large plant as well as a small plant in the industry would decrease the cost of producing over the entire range of demand, a mixed configuration could only be obtained in an industry where one firm controlled both plants.

As long as competition reigned, a small plant could block production by a large plant during periods of low demand simply because a small plant had lower avoidable costs. This would prevent the large plant from covering the cost of installing capacity and, therefore, large capacity would never be installed. A firm could risk the high cost of installing a large capacity plant only if it knew the other plant would be a small plant and if it could ensure that the small plant would not be operated during periods of low demand.

In an industry characterized by both rigid supply and unstable demand, the optimal configuration of plants could be obtained only if competition were restricted. Restricting competition would be efficiency enhancing because it would allow global (industry wide) cost minimization to obtain.
Conclusions

To return to the Telser example used earlier, if the firms were unable to restrict competition, they would be forced to build nonoptimal size plants to minimize their risks. These small plants would not be able to take advantage of scale economies, however. Instead of the socially optimal industry configuration assumed earlier, the actual configuration that evolved might look like the following:

<table>
<thead>
<tr>
<th>Firm</th>
<th>( k_1 )</th>
<th>( a_1 )</th>
<th>( a_1/k_1 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_1 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_2 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_3 )</td>
<td>2</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>( A_4 )</td>
<td>2</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>( A_5 )</td>
<td>4</td>
<td>12</td>
<td>3</td>
</tr>
</tbody>
</table>

This distribution of plant sizes would make an equilibrium more likely and lower the probability that the market price would fall below cost. At the same time, the individual firms would be risking less sunk costs because these costs are directly related to capacity. This distribution is not optimal from the standpoint of society, however, because it would result in higher costs. Consider the case of 10 consumers again. With the first distribution of plant sizes, there was no equilibrium with 10 buyers, but the minimum cost of producing 10 units was \( 16 + 8 = 24 \). The maximum possible surplus in the market was \( (5 \cdot 10) - 24 \) = 26.
With the second distribution of plant sizes, there is an equilibrium with all the firms producing at full capacity, but the total cost of producing the 10 units has increased to 38. The maximum possible surplus is only \( (5 \cdot 10) - 38 \) = 12. The decrease in surplus (increase in cost) of 14 is the cost to society of lowering the risk of ruinous competition.

To carry this exercise one step further, consider the affect of having an industry configuration made up of only the smallest plants. The following describes this extreme configuration:

<table>
<thead>
<tr>
<th>Firm</th>
<th>( k_i )</th>
<th>( a_i )</th>
<th>( \frac{a_i}{k_i} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>( A_1 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_2 )</td>
<td>2</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_3 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_4 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_5 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_6 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_7 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_8 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_9 )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>( A_{10} )</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

With this configuration, there will always be a nonempty core, but there will never be any surplus in the market. The cost of producing each
unit of output will just equal the reservation price of the buyers for any level of output. The price will never be less than 5 and there will be no consumer nor producer surplus. The minimum cost of producing ten units of output with this configuration of firms is 50. Again, the increase in cost (higher by 26 than the first configuration for ten units of output) is a real cost to society of reducing the risk to the independent firms.
CHAPTER IV: INDUSTRY STUDY

In 1887 twenty sugar refining plants joined together to form the Sugar Trust. Prior to the formation of the trust, many technological changes had taken place in the industry and most of the advances had been widely adopted by 1880. The refining of sugar required three basic steps; melting, filtration and crystallization. These were carried on in horse-powered refineries as far back as 1689. Prior to the mid-nineteenth century, melting took place in large copper kettles over an open fire. The liquid was then filtered through blankets and returned to the cleaned kettles to be boiled until the substance was thick enough to crystallize. The sugar was then ready to be placed in molds and baked in large ovens. The entire process took up to two weeks to complete for the highest grade of sugar.

In the 1830s, some firms began to introduce innovations from Europe. One of these was the use of steam power. The process of creating a partial vacuum allowed sugar to be boiled at much lower temperatures, eliminating much of the discoloration caused by boiling at high temperatures.\(^\text{55}\) The steam vacuum pan was first used by the Stuart brothers in their New York refinery. The vacuum pan was a cylindrical copper vessel enclosed by an iron or copper jacket, the operation of

\(^{55}\) Vogt (1908), pp. 6-15. According to Chandler (1977), the use of superheated steam distillation was borrowed by the petroleum industry in the 1860s.
which required an attendant. One attendant and a sufficient amount of power was necessary to produce any output, so the per unit cost of operating a pan decreased up to full capacity but the cost of operating the pan could be avoided by shutting down production. The capacity of a pan could be increased by increasing its diameter and, while costs would go up by less than the proportional increase in diameter, the capacity would go up by more than the proportional increase in diameter (the surface area to be heated would increase by \( \pi r^2 \) and the volume by \( \pi nr^2 \)). This stage of the process, then, exhibited both economies of scale and avoidable fixed costs that depended on the size of the pan used.

In the 1860s a method was devised to clean the animal charcoal filters that were used to remove impurities from the syrup. This was an important cost saving to the industry. As the industry's production of sugar increased, bone black (animal charcoal) became more expensive. The use of chemicals to clean the bone black allowed it to be used many times.\(^{56}\) The necessity of cleaning filters daily represented another cost that was avoidable and probably did not increase in proportion to increases in output but did depend on the size of filters used.

In 1851 a patent was awarded for a machine that revolutionized the crystallization process. Until this time, crystallization had taken up to two weeks to complete and had limited the amount of sugar a refinery could produce. The new machine used centrifugal force to separate the molasses from the crystallized sugar. Boiled syrup was pumped into a

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large sieve that revolved at a velocity of up to two thousand revolutions a minute, forcing the liquid molasses out through small holes and leaving the larger sugar crystals behind. The time necessary to produce high grade sugar was reduced to less than twenty-four hours.57 This process, which came into general use after 1860, also used steam as a motive force and resulted in economies of scale and avoidable costs similar to the other two processes.

Following the Civil War, there was a general expansion of the sugar refining industry, including new entry and expansion of existing plants. Capacity increased very rapidly, as did demand, but demand was still periodic, being much lower in the winter months when there was little to can or preserve. Some refiners closed during periods of slack demand, but there was still enough overproduction to force margins to unprecedentedly low levels in the 1870s. Agreements to limit output brought only temporary relief because the incentives to cheat on such agreements were very high. The capital invested in the industry could not easily be transferred to another industry because the equipment it was tied up in was of use in sugar refining only. This encouraged firms to operate as long as they could cover variable costs and to delay exit from the industry. Some firms did choose to leave the industry (from 1867 to 1887 the number of refineries declined from sixty to twenty-seven) but output continued to increase (from about .54 million ton a year to 1 million ton) as the average size of plants increased about

five-fold. 58

In the 1870s, during the seasonal low demand periods, refining margins fell below total cost and the refiners began to look for a way to control output. In June 1880 a pool was organized, but it brought little relief to the refiners. In 1886 the refiners in New York, Boston and Philadelphia agreed to cease production for ten days but only a few actually shut down. In the winter of 1887 one of the most modern of the refineries, the Brooklyn Sugar Refinery, lost $200,000. All the refineries reportedly suffered similar losses and it was evident that something had to be done to save the industry. In 1887 eighteen of the remaining twenty-three firms entered into a trust agreement, creating the American Sugar Refineries' Company. An attempt was made to include all the plants in the industry, including two that were not currently operating, resulting in a consolidation that originally controlled eighty-four percent of the production of refined sugar east of the Rockies.

At the time of the forming of the Sugar Trust, twenty plants owned by eighteen firms were included. Immediately following the consolidation, two refineries were closed and dismantled. An unsuccessful attempt was made to continue operating two small refineries that had to be closed a few months after the consolidation. One refinery burned down and was not rebuilt. One refinery, which had burned down during the negotiations that preceded the formal consolidation, was rebuilt and equipped with the latest technology to be operated only during

periods of peak demand. Two other refineries were also kept in operating order only to be used to adjust to unusually high or low demand or when another refinery was closed for repairs. In four locations where two large refineries had been built very close to each other, the two refineries were joined by pipes and effectively became one plant. In this way, for the first time, plants large enough to take advantage of all possible scale economies were created. Three remaining refineries were operated at their pre-consolidation capacity. 59

By limiting production to seven plants, those plants could be run continuously at full capacity and the avoidable costs of the remaining three plants could be avoided unless demand deviated widely. The restriction of wasteful competition eliminated the necessity of closing or running at less than capacity all plants during periods of slack demand. With the assurance that price would not be forced below total cost, came the confidence that allowed very large plants to be assembled. After this rationalization of production, the ten remaining plants had a daily capacity that was 1700 barrels greater than the capacity of the original twenty plants at a cost that was approximately 1/8 cent per pound lower. 60

The technological changes that occurred in refining resulted in cost structures that included sunk costs that varied directly with the level of capacity chosen, avoidable fixed costs which also depended on capacity and constant input prices. Given these cost structures, the

60. Ibid.
behavior of the firms in the industry, both prior to the consolidation and immediately after it, are understandable. The high fixed costs of the firms explain the difficulty of retiring capacity and the incentive to agree to production limitations. The presence of avoidable costs explains the method chosen to limit production under the early agreements. These agreements called for shutting down the refineries for short periods of time (saving avoidable costs) rather than producing at a lower rate. The need to adjust capacity quickly to changing (periodic or uncertain) demand explains the necessity of the trust keeping in inventory smaller plants with lower fixed costs as well as large plants that could take advantage of scale economies. The combining, at four locations, of two large plants into one after the formation of the trust is evidence that there were scale economies that had not previously been captured and the frequent episodes of ruinous competition explain the reluctance of any individual firm to invest in plants as large as those that resulted from the combination of two plants.61

61. See Table 10, Appendix D for sugar refining industry statistics.
CHAPTER V: SUMMARY

I have examined the circumstances surrounding the first large consolidations, all of which took place in processing industries. I argue that the introduction of large scale, high speed, continuous processing techniques employed in these industries created scale economies, capacity constraints and cost structures characterized by high avoidable fixed costs. Since high avoidable fixed costs were associated with low average variable cost, and vice versa, firms of different sizes could coexist in these industries. The industry supply curve was therefore a function of the mix of firms that chose to operate. In industries where this supply situation was complicated by widely fluctuating demand, a competitive equilibrium was not viable.

A single, self-interested firm looked only at the private benefits of the decision to shut down or operate. But, one firm’s decision altered the industry supply curve, thereby affecting the profitability of the remaining firms. Competition often resulted in the "wrong" mix of firms choosing to operate. During periods of high demand, price was high enough to support both very large, efficient plants and smaller, higher cost plants. But, in periods of low demand, industry-wide cost minimization required that only very large, efficient plants produce and smaller, higher cost plants be shut down to economize on avoidable costs. Instead the small plants continued to produce, driving the
market price of the product so low that none of the plants could cover their full costs. Because of the "lumpy" nature of costs in these industries, the large plants could not force the smaller plants out and plants of all sizes were hurt by ruinous competition.

The most serious consequence of the frequent periods of ruinous competition was that it prevented firms from building plants large enough to take full advantage of scale economies. Firms elected, instead, to install smaller than optimal plants to minimize the risk associated with unavoidable fixed costs. This resulted in average costs that were higher than necessary. Once competition was eliminated and production controlled by a single agent, firms could assemble very large plants and achieve real cost savings. 62

The increase in efficiency came from the multiple plant firm's ability to adjust production to fluctuating demand by installing and using the combination of plants that maximized total surplus in the market. Therefore, although the trusts reduced competition, they had the potential to increase social welfare by coordinating output decisions in the face of demand fluctuations.

This explanation of the consolidation movement differs from earlier efficiency-enhancing explanations because it demonstrates the necessity of multiple plant organization to support an equilibrium set of firms that could most efficiently respond to cyclical demand. Also, it centers on the beginning of the consolidation movement and shows that the

62. See Appendix F for a comparison of the size distribution of plants in the trust industries relative to all manufacturing industries.
new cost structures that resulted from technological change were responsible for the timing of the movement.
Figure 1
Figure 2
Market Control Mechanisms

The loosest form of arrangement that the industries used to gain market control was the gentlemen's agreement. As the name implies, these were merely agreements between men in the same industry to limit output or to maintain an agreed-upon price. No attempt was made to centralize management and no performance contracts were signed. Such agreements would have been difficult to monitor and were unenforceable under the common law.

When gentlemen's agreements failed to mitigate the deleterious effects of competition, industries often adopted a tighter form of organization, the pool. These arrangements encouraged compliance with agreed-upon terms by providing a penalty for cheating. Each firm was allotted an amount of production based on its capacity and total expected market demand. Each producer was charged a per unit fine for any output in excess of his allotment, the proceeds to be used to compensate those producers who sold less than their allotment. These arrangements were a step toward firmer control, but still did not provide for any type of central management and did not effectively eliminate the incentive to cheat. Like the gentlemen's agreement, pools were unenforceable under the common law.

Another means of gaining market control that was used in some industries was the joint sales agency. Under these arrangements, the
independent firms turned all of their output over to a single sales agency that had been established to sell the output of all the firms. The sales agency either gave the firms an advance on the output at the time it took title or returned the proceeds at the time of sale. The use of a joint sales agency, as they were generally set up in this country, eliminated the opportunity to shave prices on output sold through the agency, but still did not achieve centralized control over production or eliminate the incentive to cheat on the agreement by selling directly to consumers. Again, as with the cruder types of control, these agreements were unenforceable.

A trust differed from these looser forms of organization in that it made possible centralized control over production. The firms that sought to establish such control in their industry, set up a trust and elected a group of trustees. The stockholders of all the combining firms then transferred their stock to the trustees who became the legal owners of the stock. The previous stockholders retained the right to the proceeds of the firms and were issued shares in the trust in exchange for their stock. As legal owners of the stock, the trustees held the voting power of all the stock and could elect the directors of each firm. This effectively centralized the control of all the constituent firms. All stock dividends were paid to the trust and these proceeds were then distributed to the holders of the trust shares. This effectively eliminated any incentive to cheat by giving all the shareholders
a property right in the return to the entire industry, making global optimization rather than local optimization the goal of all the firms.

It is likely that the trust form of organization was used to establish combinations in this country because it seemed to circumvent the common law prohibition of agreements between firms in restraint of trade. The previous stockholders maintained that the trust agreement was between the shareholders and did not directly involve the firms. The trust arrangement eliminated the necessity of output restriction agreements that were unsuccessful because they were unenforceable in American courts. In countries where there was no strong common or judicial law precedent against industrial consolidation, other means of combination were used. In Germany, France and Austria joint sales agencies were commonly used, while in England mergers were more common. In these and other European countries there was strong sentiment in favor of recognizing and regulating rather than restricting combinations. It is clear that the existing laws of a country affected the form that combinations took, but did not materially alter the course of consolidation.

63. Jenks (1903), pp. 228-54.
APPENDIX C
Statistics on Industrial Structure

The following pages contain tables of statistics that describe the change in industrial structure of the trust industries. Included are the number of establishments, amount of capital invested, total wages and salaries, miscellaneous expenses, cost of materials used and value of product produced from the 1870 and 1900 Census of Manufacturing. From these I calculated average product, value added and average value added. All dollar values were adjusted from nominal to real terms using Warren-Pearson wholesale price index numbers from Wholesale Prices for 213 Years, 1720-1932.

It is best to keep in mind that the census bureau was not always consistent in assigning establishments to a particular industry. For instance, in the 1880 and 1890 censuses, establishments that processed sugar cane into raw sugar (the raw material for the sugar refiners) were included in the refining industry statistics. Furthermore, it is not always possible to determine whether or not one year's statistics are comparable to another year's.
Table 1
Cordage Industry

<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>201</td>
<td>165</td>
<td>150</td>
<td>105</td>
</tr>
<tr>
<td>Capital($)</td>
<td>2,615,163</td>
<td>7,140,475</td>
<td>28,351,883</td>
<td>35,701,793</td>
</tr>
<tr>
<td>Salaried employees</td>
<td>*</td>
<td>*</td>
<td>414</td>
<td>436</td>
</tr>
<tr>
<td>Wage earners</td>
<td>3,698</td>
<td>5,435</td>
<td>12,385</td>
<td>13,114</td>
</tr>
<tr>
<td>Wages and salaries($)</td>
<td>914,276</td>
<td>1,558,676</td>
<td>5,532,770</td>
<td>5,532,770</td>
</tr>
<tr>
<td>Miscellaneous expense($)</td>
<td>*</td>
<td>*</td>
<td>1,020,697</td>
<td>2,092,933</td>
</tr>
<tr>
<td>Cost of materials($)</td>
<td>4,251,561</td>
<td>9,330,261</td>
<td>29,331,300</td>
<td>32,478,056</td>
</tr>
<tr>
<td>Value of product($)</td>
<td>6,651,394</td>
<td>12,492,171</td>
<td>40,625,072</td>
<td>46,158,111</td>
</tr>
<tr>
<td>Average product($)</td>
<td>33,092</td>
<td>75,710</td>
<td>270,834</td>
<td>439,601</td>
</tr>
<tr>
<td>Value added($)</td>
<td>2,399,833</td>
<td>3,161,910</td>
<td>11,293,772</td>
<td>13,680,055</td>
</tr>
<tr>
<td>Average value added($)</td>
<td>11,939</td>
<td>19,163</td>
<td>75,292</td>
<td>130,286</td>
</tr>
</tbody>
</table>

* No data reported for this variable in this year.

Sources: U. S. Bureau of the Census, 1870 and 1900 Census of Manufacturing. Warren-Pearson wholesale price index numbers from Wholesale Prices for 213 Years, 1720 to 1932, p.9, were used to adjust nominal prices.
Table 2
Cottonseed Oil Industry

<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>26</td>
<td>45</td>
<td>119</td>
<td>369</td>
</tr>
<tr>
<td>Capital($)</td>
<td>907,667</td>
<td>3,862,300</td>
<td>15,620,727</td>
<td>42,013,977</td>
</tr>
<tr>
<td>Salaried employees</td>
<td>*</td>
<td>*</td>
<td>395</td>
<td>1,569</td>
</tr>
<tr>
<td>Wage earners</td>
<td>664</td>
<td>3,319</td>
<td>5,906</td>
<td>11,007</td>
</tr>
<tr>
<td>Wages and salaries($)</td>
<td>216,320</td>
<td>880,836</td>
<td>2,326,618</td>
<td>5,759,404</td>
</tr>
<tr>
<td>Miscellaneous expense($)</td>
<td>*</td>
<td>*</td>
<td>1,419,007</td>
<td>2,968,185</td>
</tr>
<tr>
<td>Cost of materials($)</td>
<td>987,875</td>
<td>5,091,251</td>
<td>17,516,007</td>
<td>55,165,823</td>
</tr>
<tr>
<td>Value of product($)</td>
<td>1,633,785</td>
<td>7,690,921</td>
<td>23,580,423</td>
<td>71,617,844</td>
</tr>
<tr>
<td>Average product($)</td>
<td>62,838</td>
<td>170,909</td>
<td>198,155</td>
<td>194,086</td>
</tr>
<tr>
<td>Value added($)</td>
<td>645,910</td>
<td>2,599,670</td>
<td>6,064,416</td>
<td>16,452,021</td>
</tr>
<tr>
<td>Average value added($)</td>
<td>24,843</td>
<td>57,770</td>
<td>50,961</td>
<td>44,585</td>
</tr>
</tbody>
</table>

* No data reported for this variable in this year.

Sources: U. S. Bureau of the Census, 1870 and 1900 Census of Manufacturing. Warren-Pearson wholesale price index numbers from Wholesale Prices for 213 Years, 1720 to 1932., p.9, were used to adjust nominal prices.
Table 3
Lead Refining Industry

<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>*</td>
<td>57</td>
<td>*</td>
<td>39</td>
</tr>
<tr>
<td>Capital($)</td>
<td>*</td>
<td>1,310,594</td>
<td>*</td>
<td>87,986,504</td>
</tr>
<tr>
<td>Salaried employees</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>425</td>
</tr>
<tr>
<td>Wage earners</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>8,319</td>
</tr>
<tr>
<td>Wages and salaries($)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>7,126,338</td>
</tr>
<tr>
<td>Miscellaneous expense($)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>1,422,207</td>
</tr>
<tr>
<td>Cost of materials($)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>175,847,760</td>
</tr>
<tr>
<td>Value of product($)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>213,983,298</td>
</tr>
<tr>
<td>Average product($)</td>
<td></td>
<td></td>
<td></td>
<td>5,486,751</td>
</tr>
<tr>
<td>Value added($)</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>38,135,538</td>
</tr>
<tr>
<td>Average value added($)</td>
<td></td>
<td></td>
<td></td>
<td>977,834</td>
</tr>
</tbody>
</table>

* No data reported for this variable in this year.

Sources: U. S. Bureau of the Census, 1880 Report on Mining Industries of the U. S. and U. S. Bureau of the Census, 1900 Census of Manufacturing. Warren-Pearson Wholesale price index numbers from Wholesale Prices for 213 Years, 1720 to 1932, p. 9, were used to adjust nominal prices.
### Table 4

**Linseed Oil Industry**

<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>77</td>
<td>81</td>
<td>62</td>
<td>48</td>
</tr>
<tr>
<td>Capital($)</td>
<td>2,861,449</td>
<td>5,872,750</td>
<td>17,077,266</td>
<td>18,854,283</td>
</tr>
<tr>
<td>Salaried</td>
<td>*</td>
<td>*</td>
<td>187</td>
<td>285</td>
</tr>
<tr>
<td>employees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage earners</td>
<td>945</td>
<td>1,416</td>
<td>1,886</td>
<td>1,328</td>
</tr>
<tr>
<td>Wages and</td>
<td>339,546</td>
<td>681,677</td>
<td>1,207,799</td>
<td>1,389,705</td>
</tr>
<tr>
<td>salaries($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>*</td>
<td>*</td>
<td>1,611,538</td>
<td>804,398</td>
</tr>
<tr>
<td>expense($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of</td>
<td>5,345,492</td>
<td>12,874,294</td>
<td>23,627,491</td>
<td>29,750,945</td>
</tr>
<tr>
<td>materials($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of</td>
<td>6,579,231</td>
<td>15,393,812</td>
<td>28,700,373</td>
<td>33,151,623</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>85,445</td>
<td>190,047</td>
<td>462,909</td>
<td>690,659</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value added($)</td>
<td>1,233,739</td>
<td>2,519,518</td>
<td>5,072,882</td>
<td>3,400,678</td>
</tr>
<tr>
<td>Average</td>
<td>16,023</td>
<td>31,105</td>
<td>81,821</td>
<td>70,847</td>
</tr>
<tr>
<td>value added($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* No data reported for this variable in this year.

**Sources:** U. S. Bureau of the Census, 1870 and 1900 Census of Manufacturing. Warren-Pearson wholesale price index numbers from *Wholesale Prices for 213 Years, 1720 to 1932*, p. 9, were used to adjust nominal prices.
<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>170</td>
<td>86</td>
<td>94</td>
<td>67</td>
</tr>
<tr>
<td>Capital ($)</td>
<td>*</td>
<td>27,325,746</td>
<td>94,410,117</td>
<td>116,253,527</td>
</tr>
<tr>
<td>Salaried employees</td>
<td>*</td>
<td>*</td>
<td>1,068</td>
<td>1,201</td>
</tr>
<tr>
<td>Wage earners</td>
<td>1,870</td>
<td>9,869</td>
<td>11,403</td>
<td>12,199</td>
</tr>
<tr>
<td>Wages and salaries ($)</td>
<td>877,451</td>
<td>4,381,572</td>
<td>8,523,754</td>
<td>10,400,594</td>
</tr>
<tr>
<td>Miscellaneous expense ($)</td>
<td>*</td>
<td>*</td>
<td>2,523,498</td>
<td>4,062,013</td>
</tr>
<tr>
<td>Cost of materials ($)</td>
<td>15,889,029</td>
<td>34,999,101</td>
<td>82,827,711</td>
<td>125,438,221</td>
</tr>
<tr>
<td>Value of product ($)</td>
<td>19,957,250</td>
<td>43,705,218</td>
<td>103,659,998</td>
<td>151,133,395</td>
</tr>
<tr>
<td>Average product ($)</td>
<td>117,396</td>
<td>508,200</td>
<td>1,102,766</td>
<td>2,255,722</td>
</tr>
<tr>
<td>Value added ($)</td>
<td>4,068,221</td>
<td>8,706,117</td>
<td>20,832,287</td>
<td>25,695,174</td>
</tr>
<tr>
<td>Average value added ($)</td>
<td>23,931</td>
<td>101,234</td>
<td>221,620</td>
<td>383,510</td>
</tr>
</tbody>
</table>

* No data reported for this variable in this year.

Sources: U.S. Bureau of the Census, 1870 and 1900 Census of Manufacturing. Warren-Pearson wholesale price index numbers from Wholesale Prices for 213 Years, 1720 to 1932, p. 9, were used to adjust nominal prices.
Table 6
Distilled Spirits Industry

<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>719</td>
<td>844</td>
<td>440</td>
<td>967</td>
</tr>
<tr>
<td>Capital($)</td>
<td>11,514,901</td>
<td>24,247,595</td>
<td>37,812,410</td>
<td>39,697,078</td>
</tr>
<tr>
<td>Salaried</td>
<td></td>
<td></td>
<td>581</td>
<td>661</td>
</tr>
<tr>
<td>employees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage earners</td>
<td>5,131</td>
<td>6,502</td>
<td>4,762</td>
<td>3,722</td>
</tr>
<tr>
<td>Wages and</td>
<td>1,496,156</td>
<td>2,663,967</td>
<td>3,432,791</td>
<td>3,198,566</td>
</tr>
<tr>
<td>salaries($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td></td>
<td>79,487,716</td>
<td>89,290,520</td>
</tr>
<tr>
<td>expense($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of</td>
<td>14,614,394</td>
<td>27,744,245</td>
<td>18,181,918</td>
<td>18,472,907</td>
</tr>
<tr>
<td>materials($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of</td>
<td>26,808,469</td>
<td>41,063,663</td>
<td>127,070,572</td>
<td>118,046,882</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>37,286</td>
<td>48,654</td>
<td>288,797</td>
<td>122,075</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value added($)</td>
<td>12,194,075</td>
<td>13,319,418</td>
<td>108,888,654</td>
<td>99,573,975</td>
</tr>
<tr>
<td>Average</td>
<td>16,960</td>
<td>15,781</td>
<td>247,474</td>
<td>102,972</td>
</tr>
<tr>
<td>value added($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* No data reported for this variable in this year.

Sources: U. S. Bureau of the Census, 1870 and 1900 Census of Manufacturing. Warren-Pearson wholesale price index numbers from Wholesale Prices for 213 Years, 1720 to 1932, p. 9, were used to adjust nominal prices.
Table 7
Cane Sugar Refining Industry

<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1910&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>59</td>
<td>49</td>
<td>19</td>
</tr>
<tr>
<td>Capital($)</td>
<td>15,218,681</td>
<td>27,432,500</td>
<td>115,240,791</td>
</tr>
<tr>
<td>Salaried</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>employees</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wage earners</td>
<td>4,597</td>
<td>5,857</td>
<td>*</td>
</tr>
<tr>
<td>Wages and</td>
<td>2,353,547</td>
<td>2,875,032</td>
<td>*</td>
</tr>
<tr>
<td>salaries($)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>*</td>
<td>*</td>
<td>7,749,389</td>
</tr>
<tr>
<td>expense($)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of</td>
<td>71,777,356</td>
<td>144,698,499</td>
<td>226,287,960</td>
</tr>
<tr>
<td>material($)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of</td>
<td>80,697,712</td>
<td>155,484,915</td>
<td>248,628,659</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>1,367,758</td>
<td>3,173,161</td>
<td>13,085,719</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value added($)</td>
<td>8,920,356</td>
<td>10,786,416</td>
<td>22,340,699</td>
</tr>
<tr>
<td>average</td>
<td>151,192</td>
<td>220,131</td>
<td>1,175,826</td>
</tr>
<tr>
<td>value added($)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> No data from the 1890 and 1900 census are recorded because, according to the 1910 census, in those years the statistics that were reported included raw sugar processors as well as sugar refiners.

* No data reported for this variable in this year.

Sources: U.S. Bureau of the Census, 1870, 1900 and 1910 Census of Manufacturing. Warren-Pearson wholesale price index numbers from Wholesale Prices for 213 Years, 1720 to 1932, p. 9, were used to adjust nominal prices.
Table 8
All Industries

<table>
<thead>
<tr>
<th></th>
<th>1870</th>
<th>1880</th>
<th>1890</th>
<th>1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Establishments</td>
<td>252,148</td>
<td>253,852</td>
<td>355,415</td>
<td>512,254</td>
</tr>
<tr>
<td>Capital($)</td>
<td>1,569,043,533</td>
<td>2,790,272,606</td>
<td>7,957,507,910</td>
<td>11,972,481,000</td>
</tr>
<tr>
<td>Wage earners</td>
<td>2,053,996</td>
<td>2,732,595</td>
<td>4,251,613</td>
<td>5,308,406</td>
</tr>
<tr>
<td>Salaried</td>
<td>*</td>
<td>*</td>
<td>461,009</td>
<td>396,759</td>
</tr>
<tr>
<td>employees</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wages and</td>
<td>574,506,921</td>
<td>947,953,795</td>
<td>2,784,410,401</td>
<td>3,324,445,256</td>
</tr>
<tr>
<td>salaries($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>*</td>
<td>*</td>
<td>769,786,628</td>
<td>1,253,360,705</td>
</tr>
<tr>
<td>expenses($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost of</td>
<td>1,843,279,439</td>
<td>3,396,823,549</td>
<td>6,295,175,702</td>
<td>8,957,821,526</td>
</tr>
<tr>
<td>Material($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value of</td>
<td>3,135,053,883</td>
<td>5,369,579,191</td>
<td>11,429,801,000</td>
<td>15,859,258,000</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>12,433</td>
<td>21,152</td>
<td>32,159</td>
<td>30,960</td>
</tr>
<tr>
<td>product($)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Value added($)</td>
<td>1,291,776,444</td>
<td>1,972,755,642</td>
<td>5,134,625,862</td>
<td>6,901,203,039</td>
</tr>
<tr>
<td>Average value</td>
<td>5,123</td>
<td>7,771</td>
<td>14,446</td>
<td>13,472</td>
</tr>
<tr>
<td>added</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* No data reported for this variable in this year.

Sources: U.S. Bureau of the Census Bulletin Nos. 55-62, 1906. Warren-Pearson wholesale price index numbers from Wholesale Prices for 213 Years, 1720 to 1932, p. 9, were used to adjust nominal prices.
Table 9

Percentage Change Over Time
(1870–1900)

<table>
<thead>
<tr>
<th>Industry</th>
<th>Establishments</th>
<th>Capital</th>
<th>Value of product</th>
<th>Average product</th>
<th>Value added</th>
<th>Average value added</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cordage</td>
<td>-48</td>
<td>+1265</td>
<td>+594</td>
<td>+1228</td>
<td>+470</td>
<td>+991</td>
</tr>
<tr>
<td>Cottonseed Oil</td>
<td>+1391</td>
<td>+4529</td>
<td>+4284</td>
<td>+209</td>
<td>+2447</td>
<td>+79</td>
</tr>
<tr>
<td>Refined Lead</td>
<td>-32</td>
<td>+6613</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td>Linseed Oil</td>
<td>-38</td>
<td>+559</td>
<td>+404</td>
<td>+708</td>
<td>+176</td>
<td>+342</td>
</tr>
<tr>
<td>Petroleum Refining</td>
<td>-61</td>
<td>+325(^a)</td>
<td>+657</td>
<td>+1821</td>
<td>+532</td>
<td>+1503</td>
</tr>
<tr>
<td>Distilled Spirits</td>
<td>+35</td>
<td>+245</td>
<td>+340</td>
<td>+227</td>
<td>+717</td>
<td>+507</td>
</tr>
<tr>
<td>Cane Sugar Refining</td>
<td>-68</td>
<td>+657</td>
<td>+208</td>
<td>+857</td>
<td>+150</td>
<td>+678</td>
</tr>
<tr>
<td>All Industries</td>
<td>+103</td>
<td>+640</td>
<td>+406</td>
<td>+149</td>
<td>+434</td>
<td>+163</td>
</tr>
</tbody>
</table>

\(^a\) Because no data was available for 1870, this increase represents the increase from 1880 to 1900.

* no data available to compute changes.
Table 10

Refined Sugar Statistics

<table>
<thead>
<tr>
<th>Year</th>
<th>Quantity Produced (million pounds)</th>
<th>Price (nominal)</th>
<th>Margin</th>
<th>Consumption (per capita)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1884</td>
<td>2712</td>
<td>6.780c</td>
<td>.923c</td>
<td>53.41 lbs.</td>
</tr>
<tr>
<td>1885</td>
<td>2912</td>
<td>6.441</td>
<td>.712</td>
<td>51.8</td>
</tr>
<tr>
<td>1886</td>
<td>2949</td>
<td>6.117</td>
<td>.781</td>
<td>56.9</td>
</tr>
<tr>
<td>1887*</td>
<td>3014</td>
<td>6.013</td>
<td>.768</td>
<td>52.7</td>
</tr>
<tr>
<td>1888</td>
<td>3048</td>
<td>7.007</td>
<td>1.256</td>
<td>56.7</td>
</tr>
<tr>
<td>1889</td>
<td>3170</td>
<td>7.640</td>
<td>1.207</td>
<td>51.8</td>
</tr>
<tr>
<td>1890</td>
<td>3233</td>
<td>6.171</td>
<td>.720</td>
<td>52.8</td>
</tr>
<tr>
<td>1891</td>
<td>4069</td>
<td>4.691</td>
<td>.828</td>
<td>66.1</td>
</tr>
<tr>
<td>1892</td>
<td>3896</td>
<td>4.346</td>
<td>1.035</td>
<td>63.5</td>
</tr>
<tr>
<td>1893</td>
<td>4050</td>
<td>4.842</td>
<td>1.153</td>
<td>63.9</td>
</tr>
<tr>
<td>1894</td>
<td>4281</td>
<td>4.120</td>
<td>.880</td>
<td>66.0</td>
</tr>
<tr>
<td>1895</td>
<td>3961</td>
<td>4.152</td>
<td>.882</td>
<td>62.6</td>
</tr>
<tr>
<td>1896</td>
<td>3957</td>
<td>4.532</td>
<td>.908</td>
<td>61.6</td>
</tr>
<tr>
<td>1897</td>
<td>4241</td>
<td>4.503</td>
<td>.946</td>
<td>64.5</td>
</tr>
<tr>
<td>1898</td>
<td>4107</td>
<td>4.965</td>
<td>.730</td>
<td>...</td>
</tr>
</tbody>
</table>

Production Indices

The following pages contain graphs of the production index for each of the trust industries compared to an index of general manufacturing. These were constructed by first calculating index numbers for the quantity of output in an industry using the first year of available data as the base year (the first year necessarily varies across industries due to the vagaries of reporting such information). Warren Person’s index of physical production for manufacturing industries was then adjusted so that the base year was the same as that of the industry. Each industry was then graphed separately to show how its output increased relative to manufacturing in general. A vertical line in each graph separates the pre and post-trust eras, except in the case of cottonseed oil, where no pre-trust yearly output data was available.

Quantity of output data by year was used for all industries except linseed oil. Because no comparable data was available for this industry, dollar value of output for the census years 1870, 1880, 1890 and 1900 was used. This data was adjusted using Warren-Pearson price index numbers and the four data points were then splined.

The raw data came from the following sources. The quantity of output data for the cordage industry is from Depew (1895), the quantity of output data for refined petroleum in from Oil City Derrick (1901), the quantity of output data for cottonseed oil is from Statistical
Abstracts (1915), the dollar value of output of linseed oil data is from
The Census of Manufacturing (1900), and the quantity of output data for
the remaining industries is from Historical Statistics of the U. S.
Warren Person's index is from Historical Statistics of the U. S. and
the Warren-Pearson price indices are from Cornell University
Agricultural Experiment Station (1932).
Cordage Production
relative to all manufacturing

Figure 3
Cottonseed Oil Production relative to all manufacturing

Figure 4
Refined Lead Production relative to all manufacturing

Figure 5
Refined Petroleum Production relative to all manufacturing

Figure 6
Linseed Oil Production relative to all manufacturing

Figure 7
Refined Sugar Production
relative to all manufacturing

Figure 8
Distilled Spirits Production relative to all manufacturing

Figure 9
Table 11

Size of Establishments in 1909

Per Cent Distribution Among Establishments With Specified Product

<table>
<thead>
<tr>
<th></th>
<th>$5,000</th>
<th>$5,000 - 19,999</th>
<th>$20,000 - 99,999</th>
<th>$100,000 - 999,999</th>
<th>$1,000,000 and over</th>
</tr>
</thead>
<tbody>
<tr>
<td>All industries</td>
<td>34.8</td>
<td>32.4</td>
<td>21.3</td>
<td>10.4</td>
<td>1.1</td>
</tr>
<tr>
<td>Average for the trust industries</td>
<td>6.1</td>
<td>7.5</td>
<td>16.4</td>
<td>35.9</td>
<td>34.1</td>
</tr>
<tr>
<td>Cordage, twine, jute and linen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Liquors, distilled</td>
<td>31.2</td>
<td>22.2</td>
<td>15.0</td>
<td>25.3</td>
<td>6.4</td>
</tr>
<tr>
<td>Oil, cottonseed</td>
<td>0.2</td>
<td>4.4</td>
<td>43.0</td>
<td>50.3</td>
<td>2.1</td>
</tr>
<tr>
<td>Oil, linseed</td>
<td>0.0</td>
<td>3.4</td>
<td>0.0</td>
<td>62.1</td>
<td>34.5</td>
</tr>
<tr>
<td>Petroleum, refining</td>
<td>0.7</td>
<td>10.2</td>
<td>17.0</td>
<td>48.3</td>
<td>23.8</td>
</tr>
<tr>
<td>Smelting and refining, lead</td>
<td>3.6</td>
<td>0.0</td>
<td>10.7</td>
<td>10.7</td>
<td>75.0</td>
</tr>
<tr>
<td>Sugar, refining</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
<td>10.5</td>
<td>89.5</td>
</tr>
</tbody>
</table>

Source: 1910 Census of Manufacturing, pp. 196-199.
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