Invention, Markets, and the Scope of the Firm: The Nineteenth Century U.S. Shoe Machinery Industry

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Consider two opposing expectations about the connection of the scope of the firm to the evolution of an industry. According to George Stigler, as an industry's market grows a scale is achieved at which specialized firms can emerge; economic growth thus results in vertical disintegration, new industries, and growing decentralization of the economy. According to Alfred Chandler, the growth of the firm-- and of the market-- is limited by the structure of firms. Innovations that extend the scope of the firm's activities overcome this limit and therefore account for both firm and market growth [2, 16].[1]

These opposing expectations are tied to differing treatments of the sources of change. For Stigler, market growth is given to the firm, and vertical disintegration is a response. For Chandler, the firm does more; its internal restructuring leads both to its own growth and to the expansion of the market.

The difference can be put another way. Stigler interprets Smith's dictum that the division of labor is limited by the extent of the market to mean that firms decrease in scope as markets grow, so that the invisible hand of market interaction expands as a way of organizing economic activity. Chandler highlights the efficacy of the firm's innovation in determining market growth, and the visible hand of organization within the firm increases as an economic organizing force. Clearly, the issue extends beyond the expected trend of firm scope to the process and role of innovation in a capitalist economy.

This paper adds a third term to the relation of firm scope and market size: the process of invention. For many industries (including the U.S. shoe machinery industry on which the paper focuses), the growth of firms and the process of technical change so interrelated that neither can be understood in isolation. The form taken by technical change was a critical determinant of firm scope and industry growth.

New Machines, New Markets, and New Firms

Shoes were produced by a system of dozens of machines by 1900, but four sewing machines most influenced the reduction of labor time, the birth of large shoe machinery firms, and the generation of other shoe machines.

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[1] While focusing on vertical disintegration, Stigler recognizes that the scope of the firm also can decrease through the specialization of the firm's product line [16, p. 189n]. Chandler explicitly rejects Stigler's decentralization contention for many sectors of the post-1850 U.S. economy [2, p. 490].

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The earliest (practical by 1855) was the standard dry-thread sewing machine. It sewed cloth and, with minor changes, the light upper pieces of shoes. The waxed-thread sewing machine, practical soon after, stitched heavier uppers. The McKay machine, spreading rapidly by 1865, sewed the upper to the two soles with a single thread. By the early 1890s Goodyear sewing machines duplicated the construction of the hand-bottomed shoe [19].

Let us begin with three characteristics of the processes through which all shoe-sewing machines originated. First, these machines diffused as new commodities rather than by the movement of workers trained in their use. Second, they typically were produced and sold by new firms: I.M. Singer, Grover and Baker, and other dry-thread firms, Elmer Townsend's waxed-thread companies, and the sole-stitching machine firms of Gordon McKay and Charles Goodyear.[2] Third, each firm vertically integrated in order to produce, market, and service their commodities. The well-known marketing innovations of Singer were copied by other sewing machine firms. McKay added a leasing arrangement in which machines were not sold but let out for a royalty payment per pair of shoes. Goodyear copied this arrangement but extended it beyond the expiration of basic patents and added a series of other machines leased as a system. Unsatisfied to license production rights, leading firms also organized their own factories [8, 15].

These characteristics had direct bearing on the relation between industry growth and firm structure. The first two support Stigler's expectations. Compared to the possibility that techniques were developed by shoe manufacturers for their own use, sale by new capital goods firms entailed vertical disintegration. That new firms developed these machines, rather than diversification by existing machinery companies, also reduced firm scope.

Vertical integration by sewing machine firms supports Chandler's expectation that-- perhaps particularly when new firms begin the industry--as the industry expands, firm scope grows, especially through integration forward into sales. This clearly was the case for shoe-sewing machines early in their product cycles. The focus on marketing captures a critical reality: to sell commodities, the firm must discover the need its product is to fulfill, identify potential consumers, and organize a means to reach these consumers. Each was a problem; solutions governed the growth of industry sales and the concentration of sales among firms.

More to the point of this paper, these characteristics also informed the process of technical change in a way that in turn influenced the scale and scope of firms and the scale of the market. Most basically, the process generating practical machines was structured by the commodity form of sewing machine diffusion. Marketing spread not only machines, but also technological knowledge of their mechanisms and limits. Such knowledge was frequently employed by those who held it-- especially among the machinists, shoemakers, and tailors who came into contact with the machines-- to

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[2] A partial exception is Wheeler and Wilson, a small metalwares manufacturer that brought the inventor Allen Wilson into the firm and produced his dry-thread sewing machines.

undertake further invention. Through this process, which I have called learning by selling, sales led to ongoing technical progress [18, 19, 20].

Shoe-sewing machines originated through such market-mediated learning. None of the companies that introduced practical machines had first invented them. In the case of the dry-thread sewing machine, the technological sequence leading from Elias Howe's machine to the practical machine of the mid-1850s was socially structured by the communication coming through marketing efforts; in this way, failing firms contributed to later success. Other firms made waxed-thread machines prior to Townsend's entry. The basic patents for the two bottom-sewing machines were marketed to others before their purchase by McKay and Goodyear.

Once begun, the mutual support of sales and invention became cumulative. The first modest successes of major dry-thread companies expanded sales, and thus learning and invention. We can see this by relating sales of the three dominant companies-- Singer, Wheeler and Wilson, and Grover and Baker-- to patenting, the latter interpreted as a measure of inventive activity. Sales by these firms doubled from 1,800 machines in 1852 to 3,700 machines in 1854. Sewing machine patents increased from annual averages of 4 from 1849 through 1851 to 8 in 1852 and 1853 and then surged to 38 in 1854 and 1855. Moreover, invention increased where sales grew. The three states in which the major companies were located-- New York, Connecticut, and Massachusetts-- had 82 percent of sewing machine agencies listed in commercial directories in 1852 and 1853 and took out 75 percent of sewing machine patents from 1853 through 1855. The product cycle and secondary invention progressed together.[3]

Market-mediated interactions among firms and inventors fostered invention and sales in two ways. On the one hand, inventors multiplied; they or others formed new firms that added to industry sales. In this way the very integration of major firms into marketing, by increasing the growth of machine usage and related invention, supported the formation of new firms.

Marketing also supported invention by established firms. From their integration into marketing, firms learned about the limits of their products and the requirements of adequate machines; this knowledge directed their continuing invention. Major firms were decisive in developing each type of sewing machine. All began with important patents and continued to invent. Through partners (Allen Wilson, Isaac Singer, Gordon McKay) or employees, major firms conceived and perfected virtually all of the basic improvements needed for practicality, including Wilson's four-motion feed, Singer's foot treadle, and McKay's rotating horn. They also formulated important alternate solutions to technical problems. Their patenting shares were particularly high early in the product cycle. The three major dry-thread firms took out 21% of all sewing machine patents from 1851 through 1855 and 40% of repeat

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[3]Sewing machine patents were identified from [21] and were then individually examined. For sales, see [3]. Sewing machine agencies were identified from a survey of 69 U. S. city and business directories. On the methodology and interpretation of this procedure, see [19]. Locational data are used to argue that invention resulted from learning by selling rather than from increased incentives associated with market growth.

sewing machine patents (those issued to inventors with previous patents). McKay and Goodyear were even more dominant. They received at least 40 percent of all identifiable sole-sewing patents between 1862 and 1871.

It was thus the leading firms that developed practical machines, adequate marketing systems, and vertically integrated organization. Indeed, it was such innovation and the resulting output concentration in a few firms (or, for each waxed-thread line, a single firm) that constituted leadership. Patent control further strengthened their competitive positions via pooling for the three major dry-thread firms (in conjunction with Elias Howe) and through internal invention and patent purchasing by each of the three waxed-thread companies. The success of major firms in turn supported industry growth. Increased sales revenues deepened the marketing and product development systems and set the stage for rapid market penetration.

Market Penetration, Ongoing Invention, and Firm Scope

Once established, vertical integration need not persist. By the logic of Stigler's argument, integration that fostered rapid market growth might lead to disintegration. The increasing scale of the industry would allow firms to specialize in fewer functions, leaving vertically connected functions to others. To extend the argument, market-led invention might form the basis for entry, and new firms might lead the reduction of scope. Firms with smaller shares of narrower markets would then result.

Elements of this argument were met. Once product design and marketing mechanisms were adequate, sewing machine sales and use increased rapidly. Even with the stagnation of the Civil War, dry-thread sales growth rose from 1855 through 1872. From an annual average of 1,900 machines in the 1851-1853 period, the major three dry-thread companies increased annual sales to 4,500 machines in 1854-1856, 23,700 in 1857-1859, 139,700 in 1868-1871, and 365,000 in 1872-1874. Adequate sales data do not exist for all sewing machine firms, but a survey of business directories for 48 U.S. cities indicated that total sewing machine agencies increased from 11 in the 1852-1853 period to 154 in 1857-1859, 330 in 1868-1871, and 621 in 1872-1874. Similarly, the number of pairs of shoes bottomed on McKay machines grew from 5 million in 1864 to 32 million in 1871, a rise from 16% to 40% of national shoe output. Goodyear shoes expanded more slowly, from 3 million pairs in 1880 to 12 million in 1890 and 50 million in 1899 [3, 15].

As sales increased so did learning and invention. For all sewing machines, annual patenting rose from 33.6 in the 1853-1857 period to 74.4 in 1858-1862 and 184.3 in 1872-1874. Likewise, waxed-thread sewing machine patents grew from 6.4 annually from in 1862-1866 to 13.0 in 1872-1876 and 27.4 in 1892-1896.

Invention grew especially rapidly outside the major firms. From 21% of sewing machine patents from 1851 through 1855, the share of the three major dry-thread companies fell to 6% from 1856 through 1862 and to about 3% afterwards. From their 40% share of bottom-sewing patents in the 1862-1871 period, McKay and Goodyear fell to 21% in the next decade and to 13% from 1882 through 1901.

Yet far from diminishing, firm scope extended among new firms and old. From the many new entrants in dry-thread sewing and the few in waxed-thread, the successful were the most vertically integrated. They typically entered after having patented distinctive products and commonly took out many further patents. They often competed by selling less expensive machines (for example, chainstitch dry-thread machines) or better machines (lockstitch leather-sewing machines). New firms also integrated forward. Among dry-thread machines, only the three major firms had 10 or more agencies in surveyed cities in 1862, but 6 firms achieved this level by 1866, 18 by 1872, and 24 by 1882. As a result, major firms' share of surveyed agencies fell from one-half in 1855 to one-fifth in 1872.

Major companies increased their scope. Marketing systems deepened. Backward linkages grew; major dry-thread companies organized product development and came to produce accessories and cabinets. Led by Singer, they also spread internationally [1, 2, 4, 7]. Nor did major firms lose much of their sewing machine market shares. From about half of the machines reported in the 1860 census, the share of the major three firms fell modestly to about 47% of output in 1870 and grew again in the industry stagnation after 1872. Advantages of an early start-- notably adequate (and for leather-sewing machines superior) products, high profit margins, and well-formed marketing networks and systems of technological communication-- were built upon in the market penetration phase by extending ranges of attachments, improving credit terms, and, for all but Goodyear, maintaining patent control. Major firms maintained (and some improved) their positions even after basic patents ran out.

Vertical disintegration did occur in one way. The largest firms reaped advantages of large-scale production by organizing many of the most advanced metalworking factories of the day. As Stigler would expect, disintegration was a means; many of the most important new machine tools were invented in sewing machine factories but were then made and sold by specialized machine tool producers. Still, many machines were made in shop with advantages accruing to innovating firms [6, 7, 13, 14].

For each machine, domestic sales growth slowed or ended a decade or two after practicality had been reached. Largely for competitive reasons, major firms integrated even more. Singer increased its U.S. agencies from 200 in 1876 to 1,700 at the beginning of the 20th century and bought an iron mill and timberlands by the 1890s. Still, a problem of market limitations to growth remained to be overcome.

Diversification

Most shoemaking operations other than sewing also were mechanized by 1900. Especially in bottoming and heeling, mechanization was not only bound up with the sewing machine, but also with the diversification of sewing machine firms. Technical change again influenced the scope of the firm.

Diversification was not the only way that existing machines influenced the birth of new ones. Learning through existing machines (in their invention, sale, servicing, production, or use) augmented incentives to develop new machines, directed attention to technically convergent or complementary operations, and thus led inventors unconnected to shoe and sewing machine firms to develop new machines. This was evidenced among shoe-sewing machines, each of which fostered its followers. Shoe-sewing machines similarly aided invention of other shoemaking machinery. When shoe-sewing machines were introduced in the 1860s and early 1870s, shoe manufacturing patents quadrupled from 27 annually from 1862 through 1866 to 102 a decade later. That Massachusetts inventors took out half of both shoe manufacturing and shoe-sewing patents and that a third of shoe-sewing machine inventors also took out shoemaking patents further indicate their integration [19].

New shoe machines to heel, last, channel, mold, and polish were almost all the products of new firms. The number of shoe machinery firms listed in the Boston business directory increased from 8 in the early 1860s to 88 three decades later, and 101 of these firms received shoe manufacturing patents from 1860 through 1901. By creating incentives and knowledge for invention and new firm formation, sewing machine firms indirectly bolstered their own growth to the extent that new products were complementary. The McKay machine, for example, occasioned the invention of channeling, molding, and leveling machines that increased McKay usability and hence revenues [10, 19].

Established firms also developed new shoe machines. Such intraindustry diversification had two rationales: to overcome limits of the slowing market growth for mature products and to allow sale of the primary product. The first applied to Singer, Wheeler and Wilson, Townsend, and McKay; the second pertained principally to Goodyear. To develop new machines, firms put to work the legacy of past innovation: sales revenue, knowledge of techniques and needs embedded in their staff and communications network, and their production and marketing facilities. Diversification could and did occur during the phase of rapid growth; like entering the family market or adding marketing outlets, developing new products added to the firm's growth prospects. But the need for new products became pressing when market growth slowed for existing products.

Major dry-thread firms focused their inventive efforts on the standard machine and the family market. They received three percent of standard sewing machine patents from 1868 through 1882 but only one percent of specialized machine patents (or two percent of nonleather-sewing specialized machines). But they did diversify. Wheeler and Wilson purchased patents, hired inventors, and developed its own buttonhole machine in the 1860s. Singer first diversified by buying out other firms. It made and sold the Union Buttonhole machine in the mid-1860s and bought the company in 1867. It then developed and sold machines to sew carpet pieces, gloves, belting, and books [5, 10].

From its basis in waxed-thread sewing machines, Townsend diversified into a number of shoe machines. Most importantly, Townsend developed a practical machine to peg shoes, at mid-century the dominant mode of uniting soles with uppers. He bought several of the major patents in the 1850s, hired the patentees, and marketed a practical machine by the mid-1860s. He also developed an eyeletting machine, an edge-setting machine, and an alternative means to bottom shoes using nails [10].

The great success of the McKay machine underpinned Gordon McKay's leadership in new product development. He began in the 1860s by developing two machines to complement his bottom sewer, one to cut the channel in which sewing took place and the other to rewind the thread in the stitcher's horn. The purpose was to increase McKay machine royalties; largely in pursuit of this end, McKay was issued 13 sewing-related shoe patents from 1860 through 1871, 81% of all shoe patents he received in this period.

From 1870, about the time he no longer needed to reinvest sewing machine royalties to make and sell these machines, McKay diversified in four directions. In each, he began by taking out or buying patents, formed a firm to improve and sell the new machines, and then consolidated with other firms. Two adapted technical principles of his sewing machine to other types of bottoming. Based on Lyman Blake's turn shoe patents, McKay joined with Goodyear in 1875 but soon left, discouraged by the slow progress of Goodyear machines. Discovering the convergence of his sewing mechanisms with pegging, McKay took out pegging and metallic fastening patents and in 1877 merged with a Townsend interest to form the McKay Metallic Fastening Association [10].

McKay also entered two operations little connected to his sewing machine. The first was heeling, which included steps to make, attach, and trim heels. Around 1870 McKay bought patents and hired inventors who took out over 120 heeling patents in the next three decades. His 14 heeling patents from 1872 to 1879 formed 61% of his shoemaking patents. Patent overlaps brought McKay into conflict with Horace Bigelow, a conflict resolved in 1875 with the formation of the McKay and Bigelow Heeling Machine Association. Success came quickly; by 1876 the machines of this association heeled about 30% of American shoes. Invention continued; from 1887 through 1896 over half of the McKay's 82 patents were issued for heel-trimming machines.

In the 1870s McKay entered lasting, a critical operation that temporarily united the upper and the inner sole in preparation for permanent sewing or pegging. He began patenting in the 1870s; the 25 lasting patents issued to his firm from 1880 through 1886 were over half of the patents issued to McKay firms in this period. He consolidated with two major firms but did not last 10% of U.S. shoe output until the mid-1890s. Unlike McKay's other interests, lasting would be led by a different company, and this firm set the terms for the formation of the Consolidated and McKay Lasting Machine Company in 1897.

Past innovation bolstered present. McKay's diversification efforts made use of revenues from earlier machines and economies of scope associated with production and marketing facilities and with the firm's technological and marketing knowledge. Revenues, facilities, and inventors were all redirected to new products.[4] Just as Blake moved from sewing to channeling and metallic fastening machines, so others moved between sewing, heeling, and

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[4]Market limits and economies of scope are two widely employed explanations of diversification [11, 17]. Chandler uses both in discussing 20th century diversification [2, p. 473].

lasting. McKay inventors (along with Goodyear inventors) averaged three times as many repeat patents as other inventors who gained use, and they were more likely to invent more than one kind of machine. McKay used his advantages to induce others to combine and so reduced later potential competition.

Diversification was propelled for Goodyear by an absence rather than an abundance of profits. Goodyear machines did not bottom one-tenth of all shoes until the early 1890s. Goodyear faced technological difficulties arising from the complexity of its sewing machines and the need to design complementary bottoming machines. The prolonged product development introduced competitive difficulties; basic patents ran out prior to market penetration so that others entered the field.

Goodyear responded to both difficulties by diversifying into other bottoming machinery. Its most important invention, the rough rounder and channeler, removed the possibility that the outsole stitch could cross and cut the insole stitch. It employed sewing and shoe inventors to design machines to channel, level soles, assemble soles, separate stitches, and last [15].

By 1897 Goodyear had diversified into 25 bottoming machines. It added one other product innovation: it leased machines as a system in which welt- or turn-sewing machines had to be used in order to use other bottoming machinery. By these means Goodyear fostered use of welt-sewing machines but also provided a key competitive advantage over other welt-sewing firms.

Product Cycles, Invention, and the Scope of the Firm

The case of shoe machinery clearly supports Chandler's expectation that the scope of the firm grew as the market expanded. Of course, general conclusions cannot be drawn from a single case, particularly when vertical disintegration occurred in associated machine tool production. But we can examine the concepts used to understand the factors at work in this case.

The key factor was that shoe machines were new commodities. As such, they followed a logic of market penetration in which market limitations appeared that only further innovation could overcome. Chandler's focus on marketing innovations recognizes that these limits existed but could be overcome by the firm; he can therefore understand how vertical integration and market growth coexisted, the latter fostered by the former. The logic of market penetration also informed the behavior of firms later in the product cycle. Firms retained and deepened their marketing networks both to penetrate the potential market and to protect and extend market shares.[5] When penetration was well advanced, market limits led to further scope-extension through diversification and internationalization.

Like many economic theorists, Stigler ignores the market penetration process by assuming that market growth is given to firms and hence that all potential markets have been realized. This assumption makes it difficult to

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[5]Stigler acknowledges the possibility of vertical integration as a competitive strategy aimed at limiting entry and, by implication, the growth of competitors [16, p. 191].

account for such penetration-related phenomena as technical change and vertical integration. It might seem that Stigler's notion would better apply when the market had been penetrated, but it was in response to market limitations of this period that firms diversified.[6]

The market was not the only limit to overcome: a practical machine also was required. The process of technical change was inseparable from the product cycle; it influenced progress through this cycle and was shaped by that progress. Adequate new machines were not formed prior to sale. They emerged instead from an interaction of firms structured by efforts-- whether successful or not-- to sell or lease machines. The invisible hand, with its unplanned form and unexpected effects, remained fundamental to the process of technical change.

To argue that technical change was interactive is not to deny that firms organized their own invention processes, just as they organized marketing efforts. The visible hand of intrafirm planning helped bring all machines to practicality. Integration into marketing supported learning and ongoing technical change within the firm. Over time the role of such planning increased. Whereas the dry-thread sewing machine was the outcome of many new firms, Townsend, McKay, and Goodyear machines were each, after initial patent purchases, developed by a single firm.

Moreover, the time prior to extensive market penetration lengthened for such products as Goodyear stitchers and the lasting machine, and invention was concentrated earlier in the product cycle. Thus, lasting machines patents, which averaged 11 annually from 1877 to 1891, only grew to 13 per year during the next decade. By contrast, heeling followed a pattern more like dry-thread sewing; from 2 annually in the decade prior to practicality, heeling machine patents rose to 5 per year when market penetration occurred in the 1872-1881 decade, and 10 for the rest of the century.

The intrafirm organization of technical change deepened when firms diversified into other shoe machinery. Earlier product cycles supported new ones; reinvested profits and technical and marketing staffs formed the means, and the complementarity among machines and financial imbalances between retained earnings and investment outlets for existing machines provided the aims. The growth of the firm and its ongoing invention were intertwined.

Technical change in turn shaped innovating firms in size and scope. Not only were they vertically integrated, they also took advantage of their early technical leadership and patent control to grow rapidly, force consolidations, gain large (at times monopolistic) market shares, and diversify widely among sewing and shoe machines. The ties of technical change, market control, integration, and diversification were exemplified by the successor to

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[6]It might be thought that the choice of shoe machinery biases the question against Stigler, because, after all, it was an industry in which market growth clearly depended upon innovation. But in another sense, shoe machinery was the best kind of industry, because it grew very rapidly and thus should have manifested tendencies to specialize more strikingly than slowly growing industries. In any case, rapidly growing industries often, perhaps typically, were innovative. Moreover, shoe machinery experienced much less backward integration into earlier stages of production than did many other industries.

Goodyear and McKay-- United Shoe Machinery-- which was formed to reduce servicing costs, eliminate risks associated with lasting patent overlaps, and, perhaps more importantly, avert the threat to Goodyear when Consolidated and McKay Lasting Machine combined with a minor welt-sewing machine firm and thus could market a more inclusive line of machinery [9; 12; also see 2, p. 405]. New techniques, when they diffused as new commodities, required both technological and marketing innovations. These innovations jointly shaped the scope of firms and the scale of markets.

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