Some Evidence on the Scale of the Antebellum Farm Implement Industry

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> Virtually all new agricultural implements...required skill in manufacture, particularly of their metal parts, to a degree not possessed by the traditional source of supply--the local blacksmith.... Over the period there was a marked trend toward the manufacture of implements in fewer but larger establishments. [4, p. 182]

Changes in antebellum American agriculture were so profound that some writers speak of an "agricultural revolution." Most economic historians believe that the developments in agriculture, in turn, were of paramount importance in America's pronounced economic growth in the 19th century. Perhaps no change was more important than the substitution of man-made capital in the form of machines for natural capital in the form of animals and human beings. The industry responsible for providing the machines and tools of the agricultural revolution was the farm implement industry, and this paper explores some aspects of its development in the three decades preceding the Civil War. I do not attempt to add anything to standard accounts of American agricultural history by Percy W. Bidwell and John I. Falconer [2], L. C. Gray [7], Paul Gates [6], Fred Shannon [12], Clarence Danhof [4], and especially Leo Rogin [11], that discuss the forms of farm mechanization. Rather I wish to look briefly at evidence pertaining to the size of individual firms.

We all know of dramatic improvements in implement technology before the Civil War. The mechanical reaper often receives the most attention in textbooks but dramatic improvements occurred elsewhere as well, especially in plows where John Deere and other innovators were responsible for major improvements. Still progress was uneven in implement development. Rogin notes [11], for example, "that it was not until the late sixties or early seventies that the harrow ceased to be a relatively crude and unsatisfactory implement, made in large part on the farm with the aid of the local blacksmith." This quotation raises an interesting question:

to what extent were farm implements in, say, 1860 produced on the farm or on a very small scale by blacksmiths, and to what extent had large firms evolved that produced machinery for more than a local market? Also, how does the scale of manufactures in 1860 compare with that of a generation earlier, before the invention or adoption of such important implements as the mechanical reaper and self-scouring plow?

There is little question that immediately before the innovations of McCormick, Hussey, Deere, and others in the 1830s, production of agricultural implements was carried out on an extremely small scale on the farm or in blacksmith shops. Some perspective on the question of scale is provided by the McLane report of 1833 [20], the most comprehensive study of manufactures at that time. With a number of assumptions, one can even estimate the magnitude of farm implement output in 1830. The returns for New Hampshire appear to be particularly complete and explicit detail on blacksmithing is provided [20, p. 588]. They suggest that some 282 men and boys were engaged in blacksmithing in that state in 1830 producing some $151,000 in output. If one were to subtract the $56,000 in raw materials used, $95,000 remains as the value added by manufacture. Blacksmithing was highly localized and the returns indicate little exporting of output to other states. Slightly less than 2 percent of the American rural population in 1830 lived in New Hampshire [17]. If we assume that the level of blacksmithing activity per person living in rural areas in New Hampshire equaled the national average, then the overall magnitude of blacksmithing in the United States can be estimated. Under this assumption, some 14,241 persons would have been involved in blacksmithing, with value added by manufacture approaching $4.8 million, perhaps one-half of one percent of the GNP at that time.[1] In New Hampshire, the only industries larger than blacksmithing were cotton textiles, shoemaking, and possibly ironmaking [17, pp. 588-89 and 686-87]. In the United States as a whole, it is hard to imagine 10 industries that might have been larger. Not all the output of the blacksmith was in the form of farm implements, of course. Still, Victor S. Clark once stated [3, p. 477] that "the principal function of the cross-roads blacksmith was to make and repair his neighbors' implements of tillage." If one assumes that half of blacksmith shop value added was in the form of constructed implements, the estimated value of blacksmith-produced implements for 1830 is $3.8 million, with the value added by manufacture being $2.0 million.[2]

As to the question of the size of blacksmith operations, most were very small. Some 27 individual shops on the state of Maine listed in the McLane Report indicated that one-half or more of output was for agricultural implements or tools of some kind [20, pp. 1-65]. Of the 27 shops, 17 employed only one man, 7 employed two men (or one man and a boy), and 3 employed three. Even the larger shops looked small in comparison with many farming

operations. George Hight, who started blacksmithing in 1815, was perhaps typical. In 1830, he used some $500 in capital, of which $200 was in real estate, $150 in tools and machinery, and $150 in inventories and goods in process. With this and three men, along with $650 in raw materials (mostly imported iron and steel), he made some $1,200 of farm tools and $600 of other tools. After paying $930 in wages and $650 for materials, he was left with $220 [17, p. 32].

The preceding discussion, however, ignores specialized production of implements *outside* of blacksmith shops. There was already some activity outside shops. Clark, for example, notes three firms in Massachusetts that manufactured some 7,000 plows in 1830 [3, p. 471]. The McLane report reveals an iron-casting firm in Columbus, Ohio, made some 1,500 plows a year, while the Cincinnati firm of Mills and Williams made some 10,800 axes, 400 plows, and other items totaling some $25,000 [20, p. 862 and pp. 870-71]. The firm of A. Peacock manufactured plows in Cincinnati as early as 1823 [4, p. 194]. While standard accounts note still other examples of early specialized manufacture, it is interesting to note that not one single firm discussed by R. L. Ardrey in his important study [1] of implement manufacturing was in existence in 1830. After looking at the sources, it seems unlikely that more than perhaps 20 percent of farm implements were manufactured by specialized firms in 1830.

As already indicated, there were profound developments in the types of implements manufactured after 1830. This led to a significant increase in production. Any estimate of the precise magnitude of the increase is highly speculative. If one assumes that 80 percent of implement output was produced by blacksmith shops in 1830 and that the previous estimate of national output for that year was correct, and further assuming that by 1850 some 50 percent of output was produced by specialized firms, output grew from $4.8 million in 1830 to $13.7 million in 1850. The 1850 result is based on the Seventh Census [18, p. lxxxii]. This is an annual growth in output of 5.4 percent. Using the Towne and Rasmussen implement price index to correct for falling implement prices, real implement output is estimated to have risen by 5.88 percent a year, or 2.8 percent a year per capita, which is probably double the per capita growth in total output [12, p. 276].

Output grew rapidly after 1850, even though some innovations such as the reaper were not yet universally adopted [5 and 10]. The 1860 Census was correct in stating that "as a branch of manufacture, this class of machinery has been wonderfully extended within the last ten or fifteen years" [15, pp. xii-xiii]. Output of specialized implement makers in 1859 was 155.6 percent greater than a decade earlier -- an astounding annual output increase of 9.8 percent a year [16, p. xi]. Correcting for price changes alters the conclusion but slightly, as prices remained nearly constant in the 1850s; given qualitative improvements in implements,

in a real sense they probably declined and output growth was given greater than previously stated. Adding in implements produced in blacksmith shops, the observed growth rate for implements in the 1850s falls to "only" 5.5 percent. By 1860, it is estimated that 75 percent of implements were manufactured by specialized firms. Blacksmithing was clearly declining in relative importance. If the earlier estimates on blacksmithing in 1830 are correct, value added by blacksmithing grew only 71 percent in the 30 years after 1830, or about 1.8 percent a year (compared with a population increase of 3.0 percent).

FIRM SIZE IN IMPLEMENT MANUFACTURE

The specialized farm implement firms of 1860 were typically larger and also more capital-intensive than the traditional blacksmith shops, but much smaller than firms in some other forms of manufacture (Table 1). The average firm specializing in implement manufacture had seven or eight employees, nearly $6,000 in capital, and value-added output of also $6,000, implying a capital-output ratio of one. The average size of implement makers was not markedly at variance from that of all manufacturing firms, with the implement manufacturers using about 20 percent less of both labor and capital inputs but producing only 2 percent less value-added output than the average firm in all forms of manufacturing.

Within the farm equipment industry, there were wide variations in firm size between different types of products. Among the major products, the evolution to large-scale production had seemed to have gone farthest in the manufacture of reapers and mowers, where the average firm employed 33 men and used about $28,000 in capital. Also, the reaper firms were a bit more capital intensive in that there was about $842 in capital per worker compared with $730 for the remainder of the industry. By contrast, the average firm producing plows was much smaller, employing only five or six men and being only modestly larger than a typical blacksmith shop. Still, the amount of capital per worker among plow manufacturers was more than double that in blacksmithing, suggesting that the specialized firms used more capital-intensive production techniques. Most other forms of farming equipment were produced in relatively small shops, although firms making threshing machines tended to be somewhat larger, averaging more than 10 employees and nearly $10,000 in capital.

Compared with some other industries, notably cotton goods manufacture, implement firms were small. Indeed, when one considers that within the state of Louisiana alone there were 1,640 plantations with 50 or more slaves in 1860, the farm implement industry does seem to be characterized by small operations even by standards of the day [9]. Still, the move from a norm in 1830 of production of implements on a *custom* basis by blacksmiths in

Table 1
AVERAGE FIRM SIZE, FARM IMPLEMENT MAKERS, 1860

Product	Number of firms	Average capital	Average number of workers	Average value added output
Fanning mills	47	$ 3,076	3.77	$ 2,330
Grain cradles and scythes	47	2,998	4.66	3,010
Handles, plows, and other	83	2,669	3.86	2,628
Hoes	5	23,500	32.60	27,468
Mowing and reaping machines	73	27,932	33.16	33,151
Plows, harrows, and cultivators	423	4,478	5.43	4,475
Rakes	83	1,272	2.64	1,231
Straw cutters	2	17,000	22.50	18,925
Threshers and separators	163	9,414	10.68	8,037
Miscellaneous implements	1,046	4,972	6.79	5,205
All implement firms	1,982	5,791	7.47	5,985
All manufacturing firms	140,433	7,191	9.34	6,083
Blacksmithing	7,504	658	2.09	1,096

Source: [16, pp. 733-42].

a two-man shop to production in *specialized* shops employing *three* times as much labor and *eight* or more times as much capital was a very significant development.

SOME ADDITIONAL EVIDENCE

The foregoing references to average firm size ignore the fact that there were deviations from the average; these deviations may have been considerable. Accordingly, a sample of 126 farm implement firms in the states of New York, Ohio, Indiana, and Illinois was selected for examination; these firms produced plows, reapers, threshing machines, and "miscellaneous implements," as indicated in the Eighth Census [16].[3]

A frequency distribution of firms according to value-added output, capital, and number of employees is presented in Table 2. The striking fact that emerges from the table is that firms varied substantially in size, however measured. Though more than 60 percent of the firms employed five or fewer workers, three companies employed over 100. Though nearly half the firms had less than $2,500 in capital, three had over $100,000. Indeed, the largest implement firm in the country, McCormick in Chicago, which is included in the sample, employed some 200 men and had some $414,000 in capital. Still, even that firm was fairly small compared with establishments in some other branches of manufacturing, and even small compared with the largest cotton and sugar plantations. If it were assumed that, among the firms for which the census did not state the specific type of product produced, that *none* made any reapers and mowers, the McCormick firm produced only 15 percent of the output of the United States. Among the 73 reaper producers, the McCormick firm used 21 percent of the capital and only 8 percent of the labor. Since it is possible that some reapers were produced by firms listed by the census as making "miscellaneous implements," 15 percent represents an upper-bound estimate of McCormick's share of the output of reapers in the country in 1860. Moreover, unlike some other companies, it did not license other firms to manufacture the McCormick design after 1851 [8, p. 274]. The small share of the national market claimed by McCormick does not reflect a practice of selling reapers only in a limited geographic area. William T. Hutchinson has demonstrated that McCormick's reaper was marketed over a very extensive geographic area long before 1860 [8, especially ch. 15]. Therefore, on the basis of the data it seems reasonable to conclude that in reaper production the industry was either perfectly competitive or monopolistically competitive in nature, not characterized by strong oligopoly or monopoly elements; that conclusion is tempered somewhat by the fact that licensing agreements instilled an element of monopoly power. Moreover, firms could differentiate their product somewhat and obtain at least some control over price.

Table 2
VARIATIONS IN SIZE, SAMPLE OF 126 FARM IMPLEMENT FIRMS, 1860

Number of employees	Number of firms
1	14
2-3	39
4-5	24
6-9	17
10-24	15
25-49	11
50-99	3
100 or more	3
Coefficient of variation:	2.148
Capital in firm	
Less than $1,000	20
$1,000 to $2,499	37
$2,500 to $4,999	27
$5,000 to $9,999	19
$10,000 to $49,999	19
$50,000 to $99,999	1
$100,000 or more	3
Coefficient of variation:	3.878
Value added output	
Less than $1,000	24
$1,000 to $2,499	33
$2,500 to $4,999	25
$5,000 to $9,999	19
$10,000 to $49,999	21
$50,000 to $99,999	3
$100,000 or more	1
Coefficient of variation:	2.849

Source: Sample of 126 firms derived from [16].

The conclusions just reached generally hold if one disaggregates the sample into different types of implements. Variation in firm size (as measured by the coefficient of variation) was greatest in the production of reapers, followed closely by plows; variation was less in thresher production (where the average size firm was nonetheless relatively large) and in miscellaneous implements.

FIRM SIZE AND LONG-RUN EQUILIBRIUM

The standard theorizing of economists suggests that after long-run adjustments are made, firms of different size in a competitive market should compete on roughly an equal basis or, put differently, that average costs of production should be about the same. In other words, once the relevance range of alternative scales of production has been determined, no economies or diseconomies of scale should exist. Since the implement business was in a period of great innovation and growth, it may seem plausible that the process of attrition had not provided the long-run adjustments envisioned by the theorists and that industry was characterized by something other than constant returns to scale. It is possible using so-called cliometric techniques to test this proposition. Any statistical test, of course, is only as good as the data on which it is based, and the census data on firms are far from ideal, particularly regarding the measurement of capital. Moreover, statistical problems often cloud the results still further. Nonetheless it would seem desirable to test the presence of scale economies, keeping in mind that any results should be accepted with caution. Accordingly, the parameters of a two-variable input unconstrained Cobb-Douglas production function were estimated for the sample of 126 firms as well as for four subgroups of firms within the sample (threshers, reapers and mowers, plows, and miscellaneous implements). If the output elasticity of the labor and capital input variables sum to greater than one, it suggests that a 1 percent infusion of inputs leads to a greater than 1 percent increase in output, and that larger firms are more efficient. If the elasticities sum to less than 1, the reverse is true. The results of the statistical estimation (using ordinary-least squares regression analysis) are presented in Table 3.[4]

In no case were there indications of economies or diseconomies of scale sufficiently strong to make assertions with much confidence. In the case of plow manufacturers, the estimated coefficient suggests that large firms may have been more efficient, although the results are significant at only the 15 percent level. Whether better data and/or a larger sample might have increased or decreased the evidence on economies of scale is conjectural. It is probably best to observe that the evidence is weak that the

Table 3

SCALE PARAMETERS, FARM IMPLEMENTS, 1860

Class of firm	Number of firms	Scale parameters[a]
Miscellaneous implements	35	1.00795
Plows	53	1.07412
Reapers and mowers	15	0.93581
Threshing machines	23	1.00794
All implements	126	1.05644

Source: See text.

[a] None of the scale parameters is significantly different from 1.0 at the 5 percent level. A coefficient of greater than 1.0 denotes economies of scale; less than 1.0, decreasing returns to scale.

industry was in a disequilibrium situation; we cannot reject the hypothesis that constant returns to scale existed, and that small firms seemed to compete on roughly equal terms with larger ones. Variations in firm size, then, are not explained by differences in production costs but rather by differences in marketing or financing the firm's output, factors which in turn probably to a considerable extent reflect different entrepreneurial skills.

CONCLUSIONS

The obvious advances in technology and in the use of farm implements in the late antebellum period was accompanied by a less obvious but perhaps equally important shift in production from predominantly small shops engaged in the manufacture of custom-made implements along with other items to larger, more capital-intensive shops specializing in the manufacture of relatively few implements made with standardized parts. Still, on the eve of the Civil War small shops and medium-sized shops competed on fairly equal terms; it is possible but no means certain that larger firms had some advantages in some forms of implement manufacture. The first phase of the transition of the industry had occurred, namely the move from the blacksmith shop to small firms specializing in implement manufacture. The second phase, which involved larger-

scale factory operation, did not become prevalent until the Civil War.[5]

NOTES

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1. If gross national product per capita were $80 to $85 at this time, which is consistent with some estimates for 1840, GNP for the United States approximated $1 billion.

2. The assumption that one-half of the output of blacksmiths was newly constructed agricultural implements may be reasonable. For a sampling of 40 blacksmith firms listed in the McLane report for which details on output were available, 64.3 percent was in the form of agricultural goods. To be sure, some of this probably was maintenance on existing agricultural capital.

3. The sample included all firms in those states that could be individually identified from the published volumes. Excluded were firms clustered together in a single county which produced the same product. It seems unlikely that exclusion of firms on this basis should impart any substantial bias. The firms in the sample produced approximately 10 percent of the total implement output of the United States, and averaged somewhat larger than the national average, in part because of the chance inclusion of the McCormick works in the sample.

4. Any statistical estimation of this type is not without its difficulties. For example, possible errors in the capital figures reported in the census might distort the results. Generally, firms stated the value of capital at original cost. This causes distortion to the extent that the rate of capital depreciation varied between firms. Also, multicollinearity was strong enough in two of the disaggregated groupings of firms to diminish the reliability of the estimators.

5. The scale of operations grew steadily after 1860. For example, the average number of employees per firm grew from slightly more than 8 in 1860 to 12 in 1870, 20 in 1880, and 42 in 1890 [19, p. 344]. The number of implement firms declined slightly from 1860 to 1880, then fell by more than 50 percent in the 1880s.

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