Gallman Revisited: Blacksmithing and American Manufacturing, 1850-1880

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“Under a spreading chestnut tree
The village smithy stands;
The smith, a mighty man is he,
With large and sinewy hands;
And the muscles of his brawny arms
Are strong as iron bands”

-Henry Wadsworth Longfellow

1. Introduction

Outside of the home, most manufacturing in early nineteenth century America took place in artisan shops. In the typical shop an artisan made a product using little more than hand tools, working alone or with one or more helpers or a partner or two. If laboring alone, the artisan obviously performed all of the tasks involved in fashioning the good from start to finish. If others were involved, there might be some division of labor, but that division would be incomplete because the number of different tasks in making a product would almost always exceed the number of different workers available to perform them. Complete specialization in production-- one worker per task -- was thus impossible.

Although complete specialization in production might be impossible in a typical artisan shop, there could be specialization in the choice of product, because some artisans crafted a single type of good-*cum*-variations. Shoemaking is an iconic example. Shoes were a custom product, varying with the customer’s needs – size as a minimum but also gender, style, and so on and the successful shoemaker had the talent, experience, tools, and raw materials to meet these various demands. However, the typical shoemaker would not combine this core business with another, unrelated branch of manufacturing – flour milling, for example. The artisan’s occupational title clearly defined what he did to earn his daily bread.

However, there were other artisans who were far less specialized on the product side. They were, instead, "jack(s)-of-all-trades" producing many kinds of goods from a more or less common set of raw materials. For example, jewelers worked with precious metals and stones to fashion a variety of products. So too did the cabinet maker producing household furniture such as tables, chairs, bedsteads, cupboards and chests. However, by far the important example quantitatively, and the focus of this paper, were blacksmiths. They created products by forging wrought iron or steel, using heat and tools to shape, bend, and otherwise work the metal. The goods produced by nineteenth century smithy ranged from agricultural implements to pots and pans, grilles, weapons, tools, carriage wheels and anything and everything iron- and-steel in-between. To be sure, workers in many other industries used metal as a raw material but the blacksmiths were distinguished by their ability to craft very different kinds of goods from start to finish, and repair them as need arose.

Blacksmithing was an important enough activity economically to qualify as a separate "industry" of manufactures in the nineteenth century manufacturing censuses, alongside more familiar industries as boots and shoes, flour milling, textiles, and clock making. In the 1860 manufacturing census, for example, enumerated 7,504 blacksmith shops employing 15,720 workers, producing an aggregate gross product of $11,641,213 (current dollars; see Walker 1872, p. 399)—in terms of the number of establishments, the 4th most common activity behind lumber milling, flour milling and shoemaking.[1] Although the absolute number of blacksmith shops continued to increase for some time after the Civil War, the number declined relative to manufacturing as a whole and, more importantly, relative to industries such as agricultural implements and carriage-making whose goods competed with those produced by traditional

[1]The 1900 census combined blacksmithing with wheelwrighting.

blacksmiths. By the early 1900s, blacksmiths were no longer a separate industry in the Census of Manufactures.

This paper uses the Atack and Bateman (1999) manufacturing census samples for 1850, 1860, and 1870 to study three aspects of historical blacksmithing.[2] The first concerns the distribution of blacksmith gross output between manufactured goods and services such as repair work and horse shoeing. This is important because in a classic paper Gallman (1960) presented estimates of manufacturing value-added over the period 1839 to 1899 but those estimates exclude blacksmithing and other so-called "hand trades". As explained in a later paper (Gallman and Weiss 1969) this was because Gallman was unable to determine from the published volumes of the manufacturing censuses how much of their output consisted of manufactures – plows, for example -- versus services, such as repairing broken tools or shoeing horses. However, the questionnaires for the 1850-70 manufacturing censuses asked a series of questions about the types of products that the establishment produced, as well as their quantity (if relevant) and value. This information was never tabulated in the published census but is a part of the original handwritten manuscripts returned by the enumerators and most of it was encoded in the Atack-Bateman manufacturing samples.

We use these output product codes for three purposes in this paper. First, we provide lower and upper bound estimates of the fraction of the gross value of blacksmith output that should be classified as manufacturing for the census years 1850-70. We are conservative in our interpretation of the product codes data and for reasons described more fully in the paper this

[2] Collection of sample data from the extant manuscripts of the nineteenth century censuses of manufacturing was begun by Thomas Weiss (see Bateman and Weiss 2002) and completed by Atack and Batemen, We do not use the Atack-Bateman sample from the 1880 census because, as explained in the text, we rely heavily on census information regarding the specific products that blacksmith shops produced. The 1880 census made no inquiry into the specific types of products produced by manufacturing establishments.

produces a fairly large range between the lower and upper bound estimates – for example, in 1850, the lower bound estimate of the manufactures share is about 29 percent whereas the upper bound is 65 percent. However, a robust finding is that manufacturing's share of blacksmith gross value was declining over time despite growth in the number of establishments, which supports a conjecture made by Potter (1960).[3]

Second, we use the manufactures share as an explanatory variable in a regression analysis of of productivity. It is well known that, in nineteenth century US manufacturing, measured value added per worker tended to be relatively high in the smallest establishments. This makes it difficult to accurately assess the role of economies of scale in manufacturing productivity. In a classic paper, Sokoloff (1984) attributed this (very) "small firm effect" to alleged under-reporting of the so-called "entrepreneurial labor" input which biased upwards labor productivity in small establishments relative to large. Sokoloff proposed a simple correction for the alleged bias; once this was implemented, there was strong evidence of economies of scale, even in non-mechanized establishments, which Sokoloff attributed to division of labor. However, in a recent paper Margo (2015) argues that there is no evidentiary basis for Sokoloff's correction and, as a result, the small firm effect remains a puzzle. Here, we show that, relative to larger establishments, the smallest blacksmith shops had a product mix that favored services; and that, other factors held constant, the higher the share of services in the product mix, the higher was output per worker. That said, controlling for the product mix explains only a small portion of the small firm effect.

[3] Potter (1960) also alleged that, because Gallman omitted blacksmith (and related hand trades) from manufacturing, his estimates biased upwards the growth rate of manufacturing over time. Our results support Potter's critique, but the bias turns out to be very small.

Third, we use the product codes to study the differences in gross output per worker between those blacksmith shops that produced, for example, plows versus establishments that also produced plows but reported their industry to be "agricultural implements" rather than blacksmithing. We show that, holding the type of good produced constant, the self-identified specialized producer of the good – agricultural implements, to continue the example - had higher productivity, on average, than when made by blacksmiths. And, in fact, consistent with such a productivity difference, over the course of the century production of manufactured goods did shift away from blacksmiths towards industries that specialized on the goods side. The village smithy could and did produce rakes and hoes, but the village smithy eventually and increasingly gave way to businesses like (John) Deere & Company who did it better.

1. Blacksmithing and Nineteenth Century Manufacturing: Background

The village blacksmith was common sight in early nineteenth century American communities, along with cobblers, shoemakers, grist mill operators, and other artisans. Blacksmiths made goods from wrought iron or steel. The metal is heated until pliant enough to be worked with hand tools, such as a hammer, chisel, and an anvil. Blacksmiths were distinguished from others who worked metal by their abilities to fashion a wide range of products, as well as fix broken tools or objects. Over time, blacksmithing went into decline, displaced by manufacturing establishments that specialized in individual products once produced by blacksmiths.

Given what blacksmiths did with their hands for a living, one might think that blacksmithing is a natural activity to categorize as "manufacturing". Indeed, as noted in section 1, the nineteen century manufacturing censuses listed blacksmithing as a separate industry. Economic historians, however, have had other ideas.

In particular, in two celebrated articles Robert Gallman (1960, 1966) provided the first credible estimates of GNP and its structure for the nineteenth century United States. In the first article Gallman (1960) presents series of value added, employment, and labor productivity in the "commodity-producing" sectors, namely agriculture, mining and manufacturing, and construction. The time series cover the period from 1839 to 1899, with benchmark estimates at five-year intervals (e.g. 1854, 1859).[4]

In the course of fashioning these estimates Gallman made various adjustments to the published census data. One of his decisions was to exclude industries that the Census had deemed to be "manufacturing" but which he did not. The excluded industries eventually would appear elsewhere in Gallman's national accounts, just not in manufacturing. For example, the Census considered carpentry to be a manufacturing activity, but Gallman disagreed, and he re-classified it as construction. The point of departure for this paper is Gallman's (1960, p. 58) decision to exclude the so-called "independent hand trades" from manufacturing, of which there were six.[5] By far the most important quantitatively was blacksmithing.

To the extent that Gallman (1960) justified his exclusion restriction, the logic seems to have been that blacksmiths and the other hand trades were (mostly) employed in "independent shops" rather than the factories that already made up the bulk of employment in manufacturing in 1850 and which would grow to overwhelming importance by the end of the century. We would also argue that the vast majority of manufacturing establishments and most manufacturing output before 1880 did not take place in what we would call factories anyway. We discuss this

[4] Gallman's (1960) appendix gives the details of his estimation procedure. In the case of manufacturing, the basic sources are the federal censuses, starting in 1839. These were supplemented by various state censuses, which were used to interpolate to mid-points (e.g. 1854) between federal census dates.
[5] The six are blacksmithing, locksmithing, coppersmithing, whitesmithing, gunsmithing, and carraigesmithing; see Gallman (1960).

logic in the next section. Here, we note that, Potter (1960, p. 67), in his discussion of Gallman's article, pointed out that the hand trades did, in fact, make physical products which, in principle, were part of manufacturing; hence, Gallman's value-added estimates, which excluded these workers, were biased downwards. But in a nod to Gallman's logic, Potter also asserted that the hand trades "were in considerable part displaced by manufacturing during the period 1839-99[.]" As a result, the downward bias was greater earlier (eg. 1839) in the period than later (1899), and therefore, the growth rate of manufacturing, as estimated by Gallman, was biased upwards.

About a decade later matters were clarified when Gallman published a co-authored paper with Thomas Weiss on the service sector (Gallman and Weiss 1969). Gallman and Weiss (1969, p. 347) recognized that workers in the hand trades could be "employees of manufacturing establishments" or they could have been laboring "in small, independent shops". Workers in "independent" shops might be crafting goods or they might be performing services, such as a blacksmith fixing a carriage wheel. Gallman and Weiss agreed that the former activity should be included in manufacturing while the latter was clearly a service. The published census, however, did not divide up gross value in the hand trades into physical goods versus services. Therefore, because Gallman had previously excluded the hand trades from commodity output, the practical solution at the time was to put them in the service sector "so that their contribution does not go unrecorded" (Gallman and Weiss 1969, p. 347).

After the publication of the Gallman and Weiss article, the issue lay dormant for three decades until the appearance of the paper by Jeremy Atack and Fred Bateman announcing their samples from the surviving manuscripts of the nineteenth century manufacturing censuses (Atack and Bateman 1999). In a brief discussion towards the end of the paper, Atack and Bateman (1999, p. 187) pointed out that that blacksmiths "produced a wide range of goods that fully deserve to be called 'manufactured products'" such as "pots and pans … plows, fanning mills, hoes, scythes, knives, and wagons[.]" thereby agreeing with Potter (1960). Atack and Bateman used the product codes in the census manuscripts (see below) to provide illustrative calculations of the contribution of blacksmiths to goods production – for example, Atack and Bateman attribute 25 percent of the gross value of production of agricultural implements in the South in 1850 to blacksmith shops. Below we elaborate on those pioneering calculations.

The historical evolution of blacksmithing may also be helpful in assessing the role of economies of scale in nineteenth century manufacturing. There is now a long literature making use of establishment-level data from the manuscripts of the nineteenth century manufacturing censuses to estimate the parameters of production functions econometrically, from which the extent of economies of scale can be calculated. Early work, for example, Atack (1978) or Sokoloff (1984) found evidence of economies scale, based on production function estimates. But a recent re-evaluation of this earlier literature by Margo (2015) suggests that a finding of scale economies is not robust to commonly-made but unjustifiable adjustments to the original census data. The fundamental problem is that very small manufacturing establishments have high value added per worker relative to larger establishments (Sokoloff 1984). As we show later in the paper, this (very much) smaller firm effect is clearly present among blacksmiths. Sokoloff (1984) argued that the small firm effect on productivity reflected measurement error resulting from under-reporting of the labor input in the smallest establishments relative to larger ones. Margo (2015), however, assesses Sokoloff's claim and finds it wanting on a variety of textual and statistical grounds. This calls into question the sort of adjustment that, for example, Sokoloff made for 1850 (adding one to the count of workers to proxy for the "missing" entrepreneurial labor input). However, without such an adjustment, the small firm effect is large enough to render conventional economies of scale estimates entirely non-robust (Margo 2015).

We use the product codes to make two points previously unremarked upon in this literature. First, we show that the very smallest blacksmith shops had a different product mix from larger shops – the smallest shops derived a smaller share of gross output from products that qualify as manufactures. We also show that, among blacksmith shops, the share of manufactures in gross value is negatively associated with output per worker. That said, controlling for the manufactures share, explains relatively little of the small firm effect among blacksmiths – because the majority of blacksmith shops were, in fact, very small. However, the general point we are making remains – conventional estimates of economies of scale using the 19th century manufacturing censuses have generally failed to control for the product mix, which may bias the results.

Second, we compare output per worker in blacksmith shops that produced agricultural implements as their primary activity with output per worker in the establishments that labeled themselves as in the agricultural implements industry (as opposed to blacksmithing). We find that, ceteris paribus, labor productivity was lower in the blacksmith shops. We call this the "John Deere" effect, in a nod to the famous entrepreneur. We nod in his direction because Deere began his career as an "independent" blacksmith, to use Gallman's term. In the late 1830s he invented a plow that proved remarkably useful to Midwestern pioneer farmers. He formed a partnership with Leonard Andrus in 1843 to build enough plows to meet robust demand for his plows. The partnership was dissolved in 1848 and Deere moved his company to Moline, Illinois where it prospered and grew in size (Broehl 1984).[6]

Putting the two results together, we suggest that the small firm effect present in the census data may be due in part to selection bias. In the case of blacksmiths, over the course of the nineteenth century, most either exited the industry, or men with the talent and strength to work metal ended up as employees ("mechanics") in factories that made iron and steel products. Blacksmiths who remained in the "industry" either were engaged in high value services that required special skills – repairing a specific tool or product, for example – or else worked within remote isolated markets with limited "market access" to the specialized industries and their products that replaced blacksmithing elsewhere.

2. Data and Empirical Analysis

Our empirical analysis makes use of the national samples of establishments collected by Atack and Bateman (1999) from the 1850-70 federal censuses of manufacturing. To begin the analysis, Panel A of Table 1 shows statistics on blacksmiths derived from the published 1850-70 censuses of manufacturing. The analogous statistics are shown in Panel B for blacksmiths in the Atack-Bateman national samples, assuming that observations meet the standard sample screens used in our previous work (e.g. Atack, Bateman, and Margo 2008).

Panel A shows that blacksmith establishments made up a significant share of total manufacturing establishments in the 1850-70 period.   According to the published census,

[6] There are many other anecdotes of well-known industrial firms that had their start as independent blacksmith shops, for example, Studebaker Brothers, which began as a blacksmith shop in the early 1850s, but soon specialized in wagons and carriages. The company grew dramatically during the Civil War as a consequence of military contracts with the Union Army (see Erskine 1918).

blacksmith shops were 8 percent of manufacturing establishments in 1850, 5 percent in 1860, and nearly 10 percent in 1870.

The zig-zag pattern in the time series led Gallman and Weiss (1969) to argue that blacksmiths were under-enumerated in 1850 and 1860 which, in turn, caused upward adjustments in their estimates of service sector output before the Civil War. Allegedly, the under-enumeration was concentrated in the left tail – the smallest blacksmith shops whose annual gross output was close to the census cutoff of $500. The census claimed to make a better effort at enumerating small manufacturing establishments in 1870 (Walker 1872), which Gallman and Weiss believe accounts for the increase in the blacksmith share of total establishments between the 1860 and 1870 censuses. . However, the census cutoff of $500 was never adjusted for changes in the price level; because the Civil War inflation persisted into the late 1860s we would expect that the blacksmith share would be higher in 1870, even if no changes in enumeration policy had been made. As shown in Panel B, when we impose a real, as opposed to nominal, $500 cutoff on the Atack-Bateman sample data, the share of blacksmiths in 1870 is below the level observed in 1850, which is consistent with the long-run (1850-1900) trend but there is still a rise in the between 1860 and 1870. This is concentrated in the South, where it may reflect a temporary response to transportation and other economic dislocations associated with the Civil War (Atack and Bateman 1999).

Although blacksmith shops made up a non-trivial share of all manufacturing establishments, they constituted a much smaller share of gross value, factor use (employment, capital, and raw materials), and value added. For example, in 1850, when blacksmith shops made up a little more than 8 percent of establishments reported in published census, their share of employment was far smaller, 2.6 percent. However they are measured, blacksmith shops were, on average, small and their size distribution was heavily skewed to the left. As we show in Panel C, where we compare the distribution of establishments by the number of workers, this was true relative to the overall distribution – in each of the three census years--a larger share of blacksmith shops had 1 or 2 workers than in manufacturing as a whole.

Not only were blacksmith shops smaller than the norm in manufacturing, they were less productive. This is shown in Panel A or B, by comparing the blacksmith share of total value-added, which is always less than the blacksmith share of employment, implying that output per worker was lower on average in blacksmith shops than the average in manufacturing. That said, it is clear that, when Gallman excluded blacksmiths from manufacturing, he reduced the total size of the sector, measured in terms of gross value, and that effect was larger in 1850 than in 1870.

Panel C illustrates a basic conceptual problem with Gallman's (1960) original exclusion of the "independent" hand trades from manufacturing. If true "manufacturing" only took place in larger establishments as opposed to "independent shops" – defined as a sole proprietor, or a proprietor plus an assistant – then the vast majority of establishments should have been dropped, even in industries such as flour milling where there is no question whether the work force was providing a service or making a product for sale. However, the published census volumes for the earlier years of Gallman's estimates never included size distributions of establishments, so there was simply no way for Gallman to exclude "independent" shops, except wholesale by industry (such as blacksmiths). But, as Panel C shows, size alone cannot be the criterion for exclusion. We turn now to how one can use the product codes in the census manuscripts to distinguish service activity from manufacturing, and also to explore some of the consequences of variations in this product mix.

3. Analysis of Product Codes: the Mix of Services and Manufacturing among Blacksmiths

A unique feature of the Atack-Bateman manufacturing samples is the inclusion of information reported in the manuscript schedules of the 1850, 1860, and 1870 censuses regarding the types of inputs used and outputs produced by each establishment. This information was not compiled at the time and therefore did not appear in the published census volumes. Moreover, with the minor exception of a section of Atack and Bateman (1999) these data have not been used in previous research.

The instructions to enumerators called for each establishments to be asked to list up to six products or services provided by the establishment, along with the same number of raw materials, both in order of their importance. Along with the name of the product or raw material, information was also collected on quantity (and the units of measurement) and the total value.[7] When there were more than four, the values of the less important raw material inputs and outputs were aggregated and coded as "miscellaneous" as the fourth input or output. A similar practice must also have been adopted by the enumerators as they sometimes listed a "miscellaneous" category as the last input or output in their enumeration. Input and outputs were typically named along with their units of measurement. These were converted to numeric codes and are identified in the codebook to the Atack and Bateman samples. There are 1,395 separate

[7] Not all of this information made it into the Atack-Bateman samples since the data were encoded on 80-column Hollerith punch cards which were able to accommodate up to four inputs and output values, quantities and codes. In the vast majority of cases, there were, at most, no more than three outputs or inputs given so these are reported separately in the Atack and Bateman samples.

product codes and 1,295 raw materials codes. [8] From census year to census year, these codes grew more numerous and specific.

There were 83 separate final product codes used for blacksmiths. We have collapsed these into a set of six broad product categories – general blacksmithing (such as jobbing and including horse shoeing); hardware (harness fittings, nails, hinges, latches and the like); implements (such as hoes, plows, rakes and tools); iron work (like fencing and generic "iron work"); repair services; and carriages, wagons, and wheels. Many blacksmith shops still produced more than one of these broadly defined products.

Panel A of Table 2 shows the fraction of the gross value of the primary activity (this is the first product listed) as distributed across the product category, along with the distribution of establishments. A sound majority – two thirds, for example, in 1850 – of total blacksmith gross value or, for that matter, of blacksmith shops, were engaged in what we call "general blacksmithing" or repair services. Moreover, by 1870, the share of blacksmith gross value so classified had increased to 85 percent, that is to say blacksmith shops became less specialized in specific product production and more service-oriented over time.

Our general blacksmithing category is an amalgam of specific listed activities, some of which were (mostly) services, such as shoeing horses, while others were vaguely worded, such as "jobbing," "custom work", or simply (but unrevealing) "blacksmith". Because of this, we construct two estimates of the share of blacksmith gross value that can be attributed to manufacturing activity, a lower bound and (plausibly) an upper bound. The lower bound

[8]A few products have multiple codes that survived the data cleaning process so that the number of different products or raw materials is slightly less than reported in the text. The multiple codes are allowed for in assigning broad product categories.

assumes that, unless a specific good is mentioned, such as a plow or an axe, the blacksmith was engaged entirely in services. The upper bound excludes from the calculation any activities which are too vaguely worded to be plausibly allocated either to services or manufactures. To calculate the lower and upper bounds, we use all of the activities listed (up to four), not just the first, as shown in Panel A.

Panel B shows our lower and upper bound estimates of the share of blacksmith gross value attributable to manufactures, by census year. In any given year, the range is obviously wide, a reflection of the fact that many blacksmiths reported their primary, secondary, and so activities as "blacksmith". However, both the lower bound and upper bounds are decreasing over time – robustly so, indicating that the blacksmith "industry" was shifting strongly away from production of manufactured goods towards services.

In the previous section, we noted that blacksmith shops, always small on average, were becoming even smaller over time, counter to the general trend in manufacturing. The fact that the shrinking in size was occurring when blacksmiths were shifting towards services suggest that the two features of behavior – size and product mix – might be related. Panel C demonstrates that this is so; it shows the coefficient of the manufactures share of value added (lower bound estimate) and the probability that a blacksmith shop had at most two workers. The coefficient is negative and statistically significant, regardless of whether we control for geographic location – urban status and state – which also might matter for the size distribution. Larger blacksmith shops, in other words, had a product mix more tilted towards goods production, while the shops that specialized in services were smaller. The next section explores how size and product mix affected labor productivity in blacksmithing.

4. **Labor Productivity in Blacksmithing: The Small Firm Effect, Product Mix, and Industry Endogeneity**

The defining feature of nineteenth century industrialization in the United States was the growth of large scale production. At the start of the century the vast majority of manufacturing took place in artisan shops but by century's end, output and factors of production had shifted towards factories (Atack 2014). The shifts toward large scale production was driven by improvements in internal transportation and changes in technology that created incentives for division of labor, and by greater access to financial markets which provided the monetary grease so that firms could grow in size.

It is a truism that economic historians believe that the shift towards large scale production contributed to the growth of labor productivity in manufacturing through the exploitation of economies of scale. But using the primary source of data on nineteenth century American manufacturing – the censuses of manufacturing – to document the existence of and measure the extent of economies of scale has proven to be surprisingly elusive. The basic problem is what we call a type of "small firm effect" – the smallest establishments, measured in terms of workers, have higher labor productivity than larger establishments (Sokoloff 1984). The presence of this small firm effect on productivity has made it very difficult to use conventional production function techniques to establish economies of scale.

One well-known explanation of the small firm effect is to attribute it to asymmetric measurement error. This is the argument made in a well-known paper by Sokoloff (1984) who, following a previous argument by Atack (1977), claimed that the nineteenth century census routinely ignored the "entrepreneurial" labor input – that is, the census data on employment in manufacturing refers to employees, not any labor input provided by the employer. In a large-scale manufacturing establishment, this was arguably unimportant, because the owner of the establishment was not working on the shop floor. But in a sole proprietorship or a small artisan shop, the omission of such labor input would obviously bias labor productivity upward, relative to labor productivity in larger establishments. In his analysis of the 1820 census data, Sokoloff proposed a fix for this alleged problem that allocated additional workers based on whether an establishment was a sole proprietorship, a partnership, incorporated, and so on. For his analysis of 1850 census data, however, such information was not available to him, so Sokoloff simply added one to the reported count of workers.[9] With the fix in place, Sokoloff was able to show the existence of fairly sizeable economies of scale, even in non-mechanized establishments, which he attributed to pure division of labor.

In a recent re-evaluation of the arguments, Margo (2015) shows that the evidence does not favor adjustments to the labor input like those proposed by Sokoloff. Margo makes five points. First, the evidence of favor for economies of scale, for example, in 1860 is knife-edge with respect to Sokoloff's adjustment – if the adjustment is made, the evidence is strong as is the extent of economies of scale, but if the adjustment is not made there are diseconomies of scale in the data. Second, the instructions to census enumerators were clear that the labor input of owners was to be counted, as long as it contributed materially to production. Third, if Sokoloff were correct, there should be large numbers of establishments in the census manuscripts with zero reported workers (or the relevant column left blank) because sole proprietorships were ubiquitous (such as blacksmiths). However, in the Atack-Bateman samples there are, in fact, very few establishments with zero workers. Fourth, using 1820 data, Sokoloff showed that

[9] Subsequently Atack reviewed the original worksheets for the Atack-Bateman sample and was able to classify establishments as sole proprietors, partnerships, and corporations. This information was used by Margo (2015) to replicate Sokoloff's analysis for the Atack-Bateman samples, as described in the text. See also Atack (2014).

partnerships had higher output than sole proprietorships, controlling for the reported number of workers, which he interpreted as evidence that the labor input was higher in partnerships, although not recorded. Margo was able to replicate Sokoloff's analysis for the later census years using a version of the Atack-Bateman samples that identified partnerships, and showed that the productivity difference disappears once other factors, such as capital intensity, are controlled for, which Sokoloff did not do in his analysis. Lastly, Margo argues that there was some under-reporting of the labor input in small establishments relative to large for an entirely different reason than Sokoloff alleged, but correcting for it does not eliminate the small firm effect and, therefore, does not produce more robust evidence of economies of scale.

A small firm effect is clearly present among blacksmiths. Column 1 of Panel A of Table 3 reports the coefficients of a dummy variable equal to one if the number of workers was one or two from a panel regression of the log of value added per worker. The regression also includes fixed effects for census year (1860 and 1870), urban status, and the state in which the establishment was located. The coefficient of the dummy variable is positive and highly significant – even among blacksmiths, where there were relatively few large-scale establishments, the smallest shops were significantly more productive.

Use of the product code information in the samples provides fresh insight into what may be going on. Specifically, the overall product mix between services and goods manufacturing may be lurking behind the small firm effect. In the aggregate nineteenth century economy, output per worker was highest in services, and this differential may have carried over within industries. As we showed in the previous, the smallest blacksmith shops had a product mix tilted towards services than towards good production.

We can test whether this was the case by adding our estimated manufactures share to the regression specification. As can be seen in column 2, the manufactures share is negatively related to output per worker, consistent with the hypothesis just suggested; the "small firm" dummy is smaller in magnitude, but still positive and highly significant. The last column adds the log of the capital-labor ratio to the regression; this reduces the effect of the small firm dummy as well, but again the coefficient is positive and highly significant.

Moreover, the product codes can be used to compare the productivity of blacksmith shops and establishments with that in other industries that produced the same good. One of the most important examples involves agricultural implements. In the first half of the nineteenth century blacksmiths in rural areas everywhere made hoes, rakes, plows and many other tools for use on farms. By the end of the century, however, the vast majority of this production took place in factories whose owners considered themselves to be in the "agricultural implements" industry. In the Atack-Bateman sample, such establishments are given the (modern) SIC code 352.

To make this productivity comparison, we limit the sample to blacksmith shops (SIC 769) whose primary activity was the production of a specific agricultural implement, such as a plow and to agricultural implements establishments (SIC 352) who did the same. Thus, in effect, we are holding constant what the establishments in both industries considered to be their primary economic activity. We have two dependent variables, the log of the gross value of the primary product, and the log of the gross value of total output. Our interest is in the coefficient of a dummy variable taking the value one if the observation pertains to a blacksmith shop (SIC 769). All of the regressions include fixed effects for the census year and the product code of the primary activity, and continuous variables in factor inputs (see the notes to Panel B of Table 3).

Our narrative of change over time in agricultural implements production implies that the coefficient of the dummy variable for blacksmith shops should be negative – that is, blacksmith shops were less productive than establishments in the specialized industry. We are calling this the "John Deere" effect since he was a blacksmith before establishing his famous company. As can be seen in columns 1 and 2 of Table 4, the hypothesis is strongly borne out, whether or not we include fixed effects for urban status and state in the regression.

Although the regressions in columns 1 and 2 control for factor inputs, these controls are not specific to the goods in question. Thus it may be that blacksmith shops that were specialized in agricultural implements production allocated less labor, capital, and raw materials to producing such implements, relative to other activities. In columns 3 and 4, the dependent variable is the total value of gross output; the difference between the columns is that the regression in column 4 includes our estimate of the overall share of manufactures while column 3 does not. The coefficient of the dummy variable for blacksmith shops is negative in column 3, but not significant. However, once we control for the manufactures good share, the blacksmith shop coefficient is negative, larger in magnitude, and significant at the 5 percent level.

We believe that these results for blacksmiths suggest a plausible explanation for why it has been so difficult for economic historians to generate robust estimates of economies of scale from the nineteenth century census data. Consider the goods produced historically by blacksmiths, such as plows. Over time, blacksmiths produced fewer and fewer of these, concentrating instead on services like shoeing horses or repairs. But even controlling for this, only the most productive of blacksmiths (or else those with a market protected from competition in some way) survived – a selection effect. On the goods side of the market, production shifted towards establishments that were sufficiently productive that they could specialize in a particular “industry,” such as John Deere in the agricultural implements industry. As this industry grew, it drew in workers some of whom, in an earlier era, might have opened blacksmith shops but most of whom worked on the factory floor perhaps doing some of the same tasks by hand that blacksmiths had done earlier but otherwise performing entirely novel tasks, because production process was increasingly mechanized. On average, workers in the specialized industry were more productive than the “jack-of-all-trades,” the blacksmith, had been formerly.

5. Concluding Remarks

During the first half of the nineteenth century blacksmiths were ubiquitous in the United States but by the end of the century they were no longer sufficiently numerous or important goods producers to qualify as a separate industry in the manufacturing census. Blacksmiths are interesting to study because they were “jacks-of-all-trades,” capable of producing manufactured goods like pots and pans, hoes and rakes, from scratch but also capable of repairing a broken tool or carriage wheel. They were “gateways” to more specialized (and highly skilled) activities. In a famous paper, Robert Gallman (1960) treated blacksmiths as a precursor to modern manufacturing—proto-industry—and therefore excluded them and their output from his estimates of manufacturing value added. While even at the time this was recognized as incorrect because blacksmiths did produce manufactured goods, there was no way for Gallman to measure the importance of manufacturing in blacksmith activity.

In this paper we have used the product codes in the Atack and Bateman (1999) samples of the manuscript censuses of manufacturing to measure the share of manufactures in blacksmith gross output for the census years 1850 to 1870, and we also explore the relationship of the product mix to labor productivity. Over time the product mix among blacksmiths shifted towards services and the typical shop becoming smaller, opposite the general trend in establishment size in manufacturing. The product mix and size were also related in cross-section – the smaller the blacksmith shop, the higher was the share of output devoted to services. The product mix also helps to explain some of the “small firm effect” present in nineteenth century US manufacturing census data, the tendency for the smallest establishments to have the highest value added per worker. However, much of the small firm effect remains even after controlling for the product mix.

We also compare labor productivity of blacksmiths and in establishments in a related industry, agricultural implements, controlling for the specific type of implement that the establishment considered to be its primary output. We show that blacksmiths were less productive the specialized establishments, even if we control for the overall product mix. Taken together the two productivity results help explain why blacksmith production of manufactured goods was displaced over time, but also why some shops were able to survive.

Table 1: Blacksmiths in American Manufacturing, 1850-1870

A. Published Census\

Year	Number of Blacksmith Shops	Blacksmith Percent of: Total Establishments	% Gross Value of Output	% Employment	% Capital	% Raw Materials	% Value Added
1850	10,373	8.4	1.0	2.6	1.1	0.9	1.1
1860	7,504	5.3	0.6	1.2	0.5	0.3	1.0
1870	26,364	10.5%	1.0	2.6	0.8	0.5	1.6

Source: Walker (1872). 1850: p. 406; 1860: p. 399; 1870: p. p. 394.

B. Atack-Bateman National Samples: With Sample Screens

Year	Number of Blacksmith Shops	Blacksmith Percent of: Total Establishments	% Gross Value of Output	% Employment	% Capital	% Raw Materials	% Value Added
1850	430	8.7%	1.5%	2.6%	1.0%	0.9%	2.1%
1860	339 [336]	6.8 [6.7]	1.1 [1.1]	2.0 [2.0]	1.0 [1.0]	0.7 [0.7]	1.8 [1.7]
1870	346 [290]	9.0 [8.0]	0.7 [0.6]	1.6 [1.4]	0.5 [0.5]	0.4 [0.4]	1.1 [1.1]

Source: Atack and Bateman (1999). Establishments must be in the national samples to be included in the table. One blacksmith observation in the 1850 national sample is dropped as an outlier. All establishments have positive values of reported employment, capital, inputs, and value added, and $500 in gross output measured in current dollars; in addition, establishments with very high or low estimated rates of return are dropped. [ ]: to be included observations must have $500 of real gross output, measured in 1850 dollars; 1860 cutoff is $518; 1870 cutoff, $826.

C. Distribution of Establishments by Reported Employment: Blacksmith Shops, Atack-Bateman National Samples with Sample Screens

	1-2 workers	3-5	6-15	16 or more
1850				
Blacksmiths	67.5%	28.8%	3.5%	0.2%
All	45.6	28.4	16.5	9.5
1860				
Blacksmiths	77.1	18.2	3.9	0.8
All	45.6	27.4	16.8	10.3

1870				
Blacksmiths	77.2	21.0	1.7	0
All	37.2	28.9	19.5	14.4

Source: see Panel B. Sample screens are the same as in Panel B.

Table 2: The Product Mix in Blacksmith Shops

Panel A: Distribution of Primary Product Code by Product Category: Blacksmith Shops, 1850-70

	General Blacksmithing	Hardware	Implements	Iron Work	Repair Services	Carriages, Wagons, and Wheels	Number of Observations
1850	63.1% [63.3]	11.9% [2.3]	11.5% [16.9]	1.7% [1.8]	2.9% [2.3]	9.0% [13.5]	444 {84.2%}
1860	66.2 [66.2]	2.4 [1.8]	11.8 [13.2]	0 [0]	4.2 [3.0]	14.5 [25.5]	333 {54.3}
1870	62.5 [63.3]	0 [0]	3.6 [5.1]	1.0 [1.5]	21.4 [15.6]	11.6 [14.6]	275 {74.4}

Source: computed from Atack and Bateman (1999) national samples, 1850-70 manuscript censuses of manufacturing. To be included in the table an establishment must be a blacksmith shop (SIC code 769) and also meet standard sample screens (see chapter 3). Columns 2-6, outside parentheses: fraction of gross value of output of primary product; [ ]: fraction of blacksmith shops listing the good or service as primary product. { }: fraction of total gross value of output accounted for by primary product.

Panel B: Blacksmith Value of Gross Output Attributable to Goods Manufacturing: Lower and Upper Bound Estimates, 1850-70

Year	Lower	Upper
1850	28.9%	65.4%
1860	24.1	53.9
1870	15.4	30.1

Based on classification of primary, secondary, etc. output. Lower bound assumes that if the output is “jobbing”, “miscellaneous”, or “blacksmithing” that the blacksmith produced no manufactured goods. Upper bound assumes that if the listed good is one of these three, the blacksmith produced manufactured goods in the same proportion of gross value of the other blacksmiths in the sample who identified specific products (e.g. plows) or services (e.g. repair). Horseshoeing is treated as a service in both columns.

Panel C: Regression Estimates, Probability that Blacksmith Shop Has 1 or 2 workers

Dependent variable	= 1 if one or two workers	=1 if one or two workers
% manufactures of gross value	-0.110 (0.039)	-0.099 (0.043)

Year dummies	Yes	Yes
Urban status and state dummies	No	Yes
Adjusted R-2	0.014	0.047

Source: see text. Standard errors in parentheses. N = 1,052 establishments.

Table 3: Productivity Analysis: Blacksmiths, 1850-70

Panel A: Regression: Log of value added per worker: Blacksmith Shops, Atack-Bateman samples, 1850-70

Dependent variable	Log (value added per worker)	Log (value added per worker)	Log (value added per worker)
% manufactures of gross value		-0.127 (0.047)	-0.132 (0.048)
1 or 2 workers?	0.111 (0.036)	0.105 (0.036)	0.097 (0.035)
Log K/L included?	No	No	Yes
Urban and state dummies included	Yes	Yes	Yes
Year dummies included	Yes	Yes	Yes
Adjusted R-2	0.295	0.300	0.365

Source: see text. N = 1,052 establishments.

Panel B: Regressions of Ln (Gross Value of Output): Blacksmith Shops vs. Agricultural Implements Establishments

Dependent Variable	Ln (Gross Value of Output, Primary Activity)	Ln (Gross Value of Output, Primary Activity)	Ln (Gross Value of Output, Aggregate)	Ln (Gross Value of Output, Aggregate)
Blacksmith = 1	-0.589 (0.139)	-0.605 (0.154)	-0.120 (0.083)	-0.151 (0.083)
Urban status and state dummies?	No	Yes	Yes	Yes
Manufactures share of gross value of output included?	NA	NA	No	Yes
Adjusted R-Square	0.758	0.767	0.915	0.916

To be included in the regressions, an establishment must be either a blacksmith shop (SIC code 969) or agricultural implements establishment (SIC code 352) producing an identifiable agricultural implement(s) as the primary activity. Standard sample criteria also apply. All regressions include fixed effects for year, product code of primary activity, and the following continuous variables: ln (workers), ln (capital), ln (value of raw materials). Factor inputs (e.g. ln (capital)) are aggregate, not specific to primary activity. N = 225. Standard errors in parentheses. NA: not applicable.

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