# Technological Unemployment in Historical Perspective: A Task Level Analysis

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Did technological unemployment sweep across England in the wake of the British Industrial Revolution?  We don't know. The extent to which the new machines replaced workers, leaving them temporarily unemployed, has never been quantified. Recent scholarship refers to the technological unemployment which caused devastating short-term harm to workers during the Industrial Revolution (Frey 2019), while other scholars doubt the scale of the impact (Mokyr et al, 2015). This lack of agreement reflects the paucity of existing data on labour displacement and reinstatement in historical context.

## Introduction
Two decades of research on skills-biased technological change has provided considerable evidence that the impact of new technologies is often visible at the "task" level of occupation (Acemoglu & Autor, 2011).  English census data currently tracks occupation only at the industry level, which obscures shifts in the occupational structure taking place at more granular levels.

I therefore develop a new method to produce a more finely grained occupational categorization structure, using text recorded in individual level English census observations, as digitized by the Integrated Census Microdata project (ICEM), as data. I apply this to the English bootmaking industry, and link 1.29 million English bootmakers (97.2%) to the sub-industry level "tasks" they performed. This illuminates the impact of mechanization on the occupational structure within the industry, revealing that 152,000 jobs were lost as certain skills became obsolete, and another 145,000 jobs, demanding new skills, were created. Incumbent English bootmakers were not able to keep up with the shifting demands of the industry. They did not transition out of obsolete "tasks" and into the newly generated ones, and so were left behind.

## Historical Context
The mechanisation of the English bootmaking industry was precipitated by the adoption of the sewing machine. This enabled the task of "binding", the sewing together of leather pieces which form the upper part of the shoe, to be mechanized. The sewing machine had been modified to do the heavy work of sewing together boot leather by 1852 (Thompson 1989), and the machine was promptly adopted in America.  English manufacturers attempted to introduce the bootmaking sewing machines in 1855, but faced effective and concerted resistance from organised labour, and were delayed for several years.

Nonetheless, by the 1860s the sewing machine revolution was well underway across the United Kingdom. Starting with sales of a few thousand machines per year in the early 1860s, extremely rapid uptake resulted in sales of nearly 50 000 machines per year only a decade later. By the 1890s around 150 000 sewing machines of all types were being sold in England every year. In total, a minimum of 4.3 million sewing machines would have been sold in the UK between 1865-1911 (Godley 1996).  To understand the impact of the technological shock on labour displacement and reinstatement I turn to the occupational data recorded in the British census.

## Data Construction of a "Task" Variable for Occupation
Every British census between 1851 to 1911 asked individuals to describe their occupation. William Farr, the superintendent of the statistical department at the general register office (GRO) at the time, advised that the description of occupation was meant to reflect five key aspects of work: "skill, talent, or intelligence; tools, instruments, machinery or structures; materials; processes; products", and indeed these elements of the work are often present in the responses householders provided to the occupation question. The

responses ranged from terse one-word summaries through to detailed descriptions. See the variable for "Occupation", given in table 1, below, for an example.

Table 1: Example data

| Industry Code | Occupation (Original response as written in the Census data records) | New Variable: "Task" |
|---|---|---|
| 663 (Bootmaker) | CORDWAINER | Cordwainer |
| 663 (Bootmaker) | BOOT & SHOE MAKER (MASTER EMPLOYING 4 MEN 4 WOMEN & 5 APPS) | Maker |
| 663 (Bootmaker) | BOOT AND SHOE BINDER | Binder |
| 663 (Bootmaker) | BOOT & SHOE RIVETTER | Rivetter |
| 663 (Bootmaker) | SEWING MACHINIST | Machinist |

*Note: Example of Individual-level observations, first two columns as in ICEM digitized data, third column showing the newly constructed "task" variable.*

When the General Registers Office received the census enumerators' books for the decennial census taken in 1851, these contained hundreds of thousands of unique character strings describing occupation. The GRO realized that managing the data at this level of granularity was untenable, and devised a taxonomy of occupations. This limited the formal records to tracking employment at industry level, for approximately 800 different industries. Clerks employed by the GRO were responsible for assigning each individual observation to the correct industry. Social science research and analysis based on English and Welsh census data has predominantly been conducted at the industry level of occupation from that point onwards.

The Integrated Census Microdata project (ICEM) has recently digitized the original English Census data for the decades between 1851-1911, excluding census year 1871. The new ICEM dataset makes individual level census observations digitally available for the first time (Schurer & Higgs 2014), and this has opened up the frontiers of research on the transformation of the United Kingdom's occupational structure during the second half of the 19th century. However, information on occupation has remained categorized at the industry level. This leaves encrypted the more granular information on occupation which has been available – if all but hermetically sealed into the text by the constraints of processing big data - for nearly 200 years.

I construct a sub-industry level "task" classification scheme by extracting information from the original textual description of employment. An example of this is given above in

Table 1: the final column contains the new "task" variable, which indicates what type of work the individual did within the bootmaking industry. The process of constructing the "task-level" classification proceeds in three steps: all unique strings are collected, then tokenized, and a set of categories is constructed from the most frequent "task" terms.

**Results**

Net employment remained roughly constant as the industry mechanized - analysis conducted at industry level shows minimal change in the total number of bootmakers over the course of the second half of the 19th century. However, analysis at the newly constructed, and more granular, "task" level of occupation reveals that 145 248 jobs were created, and 152 235 lost, as the new technology was adopted. See Figure 1, below, for the kinds of "tasks" bootmakers employed in the industry performed, and the evolution of employment in those tasks over time.

Figure 1: Selected English Bootmaking Tasks, 1851-1911
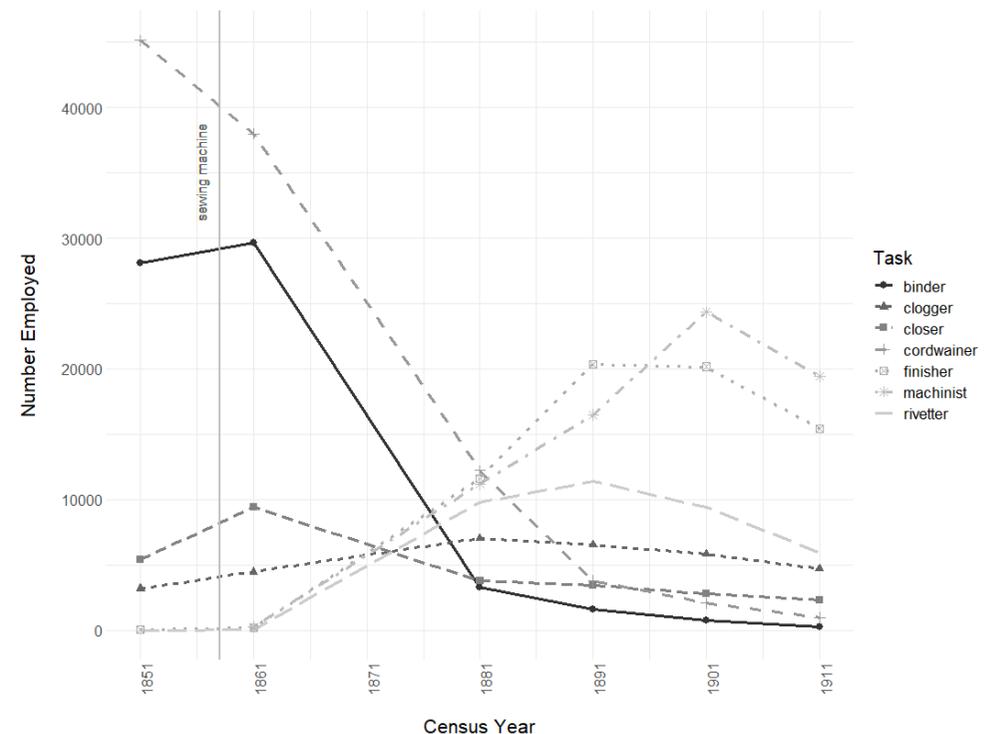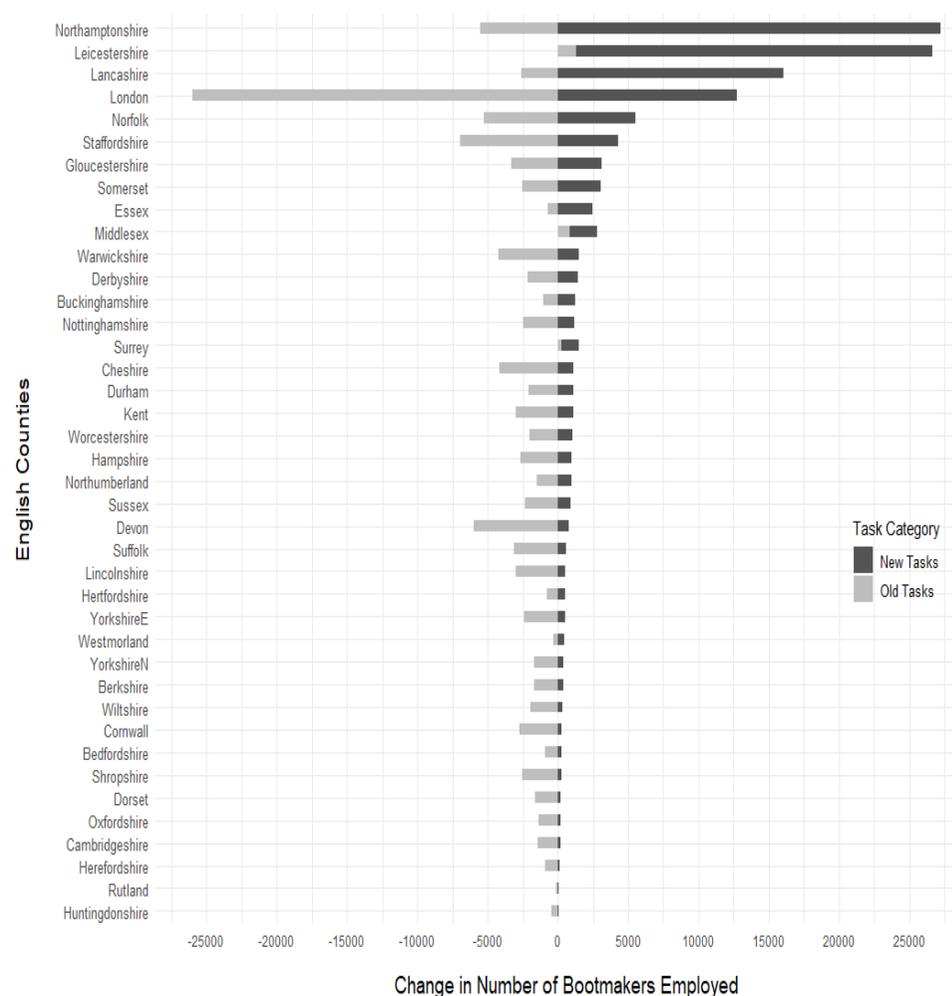


Data Source: Derived by Author

The most rapid decline in employment was experienced by "binders" and "cordwainers", while new jobs were generated for "(sewing) machinists" and "finishers". As mentioned above, "binders" manually sewed together the leather pieces which form the upper part of the boot. Following the adoption of the bootmaking sewing machine in 1858, the number of "binders" in England dropped precipitously, with very nearly 90% disappearing from every county in England. Simultaneously, a new occupation – the "sewing machinist" – emerged in the census records. This sharp expression of labour displacement and reinstatement [1] had ramifications in terms of access to employment by gender, geographical location, and age.

The technological shock, however profound, did not alter the gendered division of labour within the industry. Prior to the introduction of the sewing machine, 98% of binders were women. When the work was mechanized, it remained the task of women: 91% of the new sewing machinists were women. However, this persistence of the gendered division of labour within the industry endured despite the considerable social resistance to young women working in factories. The disapprobation may have been felt by the young workers involved, and had selection effects in terms of take-up of the new jobs.

The task level analysis of the geography of employment in the bootmaking industry reveals that the newly generated employment opportunities were heavily concentrated in only a few counties, whilst the decline in employment in the "old" tasks took place across the nation. Figure 2, below, illustrates the absolute change in the number of bootmakers employed in "new" and "old" tasks in each English county between 1851-1911. The old tasks are those which, together, were responsible for the employment of 97% of bootmakers in 1851 and 1861, prior to mechanization. These include: "binders", "cloggers", "closers", "makers", and "cordwainers" and "dealers". The set of new tasks encompasses all tasks which first appear in the census data following the technological shock. This is a much larger set of tasks, as specialization set in alongside mechanization.

The result of these countervailing forces of job loss and job creation, interpreted geographically, was a tectonic shift in the location of the industry. Northamptonshire and Leicestershire became the enclaves of the English bootmaking industry during this period, and the industry contracted substantially in other counties across the country. The new employment opportunities were heavily concentrated geographically, with 44% of the new jobs being generated in Leicestershire and Northamptonshire alone.



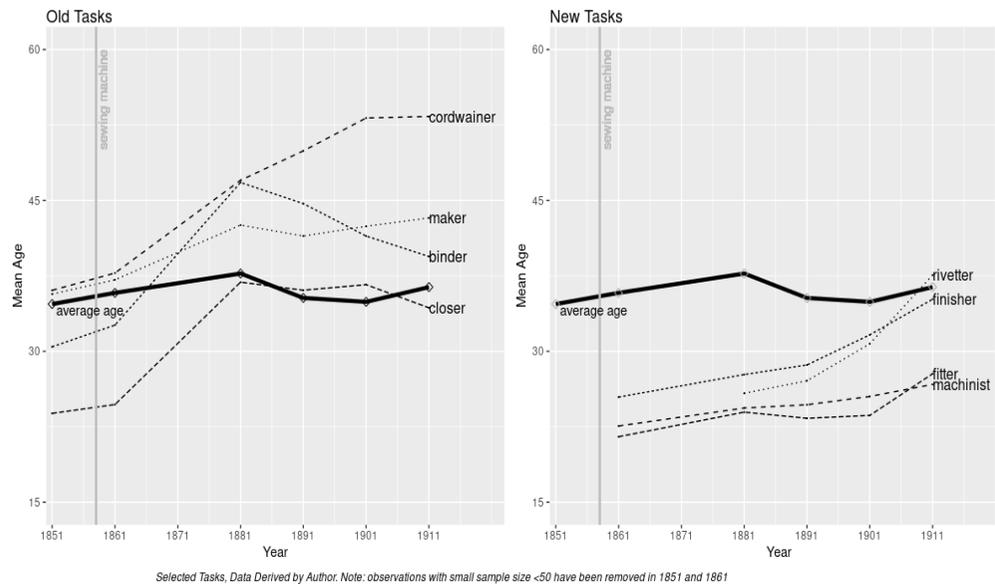Figure 2: Change in Number of Bootmakers Employed between 1851-1911, by Task

Data Derived by Author

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[1] Please see Acemoglu, D. & Restrepo, P. (2019) for a model of labour displacement and reinstatement

A task level analysis of access to employment by age reveals that the older workers, whose skills were rendered obsolete by the new technology, were not able to take up the new employment opportunities generated by the creation of the "new" bootmaking tasks. Those new jobs went predominantly to young people. See Figure 3, below.



Figure 3: Mean Age by Task, 1851-1911

Selected Tasks, Data Derived by Author. Note: observations with small sample size <50 have been removed in 1851 and 1861

Between 1851-1911, the population mean age of bootmakers stayed fairly constant, at around 35 years of age. Prior to the technological shock, the mean age in most of the "tasks" bootmakers performed hovered fairly close to this, with the exception of "closers", who seemed to be a bit younger. Following the introduction of the new technology, a sharp polarization is observed. The mean age of bookmakers working in "old" tasks soared, increasing by 10 years or more. In contrast, the "new" tasks

were taken up by young people, and the mean age in those tasks is well below the population mean age.

Since employment opportunities in the "old" tasks contracted substantially following mechanization, with 152 000 jobs in these tasks disappearing, the older bootmakers would have had to transition into the newly generated opportunities in the "new" tasks to remain within the industry. They did not do so. I conclude that, as creative destruction swept through the English bootmaking industry, incumbents were not able to follow. Instead, they were left behind, and would have had to seek employment in other industries.

**Robustness**
The findings above hinge on whether the original textual descriptions of occupation recorded by the census enumerators accurately represent the type of work bootmakers were performing. If the descriptions were quasi-random, then the data offers little useful information. There are three reasons to believe the descriptions do track the quotidian employment of English bootmakers.

Firstly, a range of narrative evidence confirms that the type of tasks comprising the production of boots evolved along the same lines as found in textual descriptions of occupation in the census records. Secondly, there is a reassuring consistency in the data. Between 1861 and 1881, when the sewing machine was first introduced, the task of "binder" disappeared. Every county and sub-district lost very close to 90% of their binders. That this disappearance coincided with the arrival of the new technology, and then was visible in every county and sub-region of England, is highly suggestive that events taking place in the world were being reflected in the nomenclature by which people described their occupations in the census.

Finally, and perhaps most importantly, I census link English bootmakers between 1851-1861[2]. This is prior to the technological shock, and the task level occupational structure within the industry remained static between the two decades. If this panel data had revealed a great deal of discontinuity between the "tasks" an individual performed in each time period, then that would have provided evidence that the textual descriptions

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[2] The matching programme is my own code. However, I rely on ABE code (https://ranabr.people.stanford.edu/sites/g/files/sbiybj5391/f/abe_algorithm_code_july2020_0_0.zip) for cleaning names (Abramitzky, Boustan, & Eriksson 2019)

were somewhat haphazard, and therefore do not accurately reflect the type of work individuals performed. However, approximately 70% of the individuals in the linked dataset are recorded as having the same task in 1851 and 1861. That is, people who described themselves as "clog makers" in 1851 tended to describe themselves as "clog makers" in 1861, and people who described themselves as "binders" in 1851 tended to describe themselves as "binders" in 1861. This continuity over time provides evidence that the nomenclature is meaningful.

## Conclusion

My paper employs a methodology which makes available the sub-industry, "task", level of occupation for English census data. This illuminates the impact of mechanization on occupational structure for the first time. While analysis at the industry level captures no effect of the shock, analysis at the new "task" level reveals extensive labour displacement and reinstatement. In the bootmaking industry, 152 000 jobs were lost, and 145 000 created, as mechanization set in. The "task" level analysis also shows that, as the industry transformed, and shifted both in terms of geographical location and skillsets required, existing workers were not able to follow.

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