Classification of occupations for economically active:  
Factor analysis of Registration Sub-Districts (RSDs) in 1891

Robert J. Bennett, Harry Smith and Dragana Radicic

rjb7@cam.ac.uk  hjs57@cam.ac.uk  DRadicic@lincoln.ac.uk

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University of Cambridge, Department of Geography and Cambridge Group for the History of Population and Social Structure, Downing Place, Cambridge, CB2 3EN, UK.

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Classification of occupations for economically active: Factor analysis of RSDs in 1891

Harry Smith, Robert J. Bennett and Dragana Radicic

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1. Introduction.

This paper discusses how census data for 1851-1911 can be used to classify the occupations of the economically active population within Registration Sub-Districts (RSDs) for England and Wales using a factor analysis methodology applied to all occupations. This first analysis is based on 1891 as a pilot for the other census years. The paper uses the database for Entrepreneurs 1851-1911 referred to in this and other project Working Papers developed by ESRC project ES/M010953 Drivers of Entrepreneurship and Small Businesses. For this paper the I-CeM source for 1891 is used.

The original population census returns for individuals/householders in the 1891 census are derived from the original Census Enumerators Books (CEBs). Individuals followed a census instruction to give their main occupation. This information provides the basis of the assessments in this paper which seek to identify groups of occupations in different RSDs. It is recognised that the population census was not perfect in the design of questions about occupations, or in the classification and processing of the householder’s returns. This constrains the data and the interpretations possible. A fuller discussion of the nature of the data, and their limitations, is given in the ESRC project WP 2: Employers and the self-employed in the censuses 1851-1911: The census as a source for identifying entrepreneurs, business numbers and size distribution.

This paper first discusses the methodology (Section 2). Section 3 applies the method to classification of the entire economically active population (all workers, employers and own account). Section 4 compares the RSDs for loadings on each factor using their mapped outputs. Section 5 compares then develops the same analysis solely for females occupied. Section 6 classifies the RSDs using their factor scores to produce a classification of each RSD. The paper forms a stepping stone towards the classification of entrepreneurs using a similar methodology.
The results in this working paper are used as a base against which to compare specific classifications of entrepreneurs reported in subsequent research.

2. Methodology.

2.1. Method of factor analysis used

The purpose of factor analysis is reveal patterns in a set of variables by grouping them into a limited number of groups based on shared variance (Yong and Pearce, 2013). Factor analysis relies on the correlation coefficients between pair-wise variables. To examine whether variables have common features, either the correlation or covariance matrices can be used. The former is a commonly used matrix because it is usually easier to interpret relative to the covariance matrix.

Among the two main factor analysis techniques, Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA), we apply the former, specifically PCA (principal component analysis). Although there is no consensus in the literature whether principle components analysis is preferred to factor analysis (Osborne and Costello, 2005), in most cases both procedures will produce similar results, especially when the number of variables per factor is large (Goldberg and Velicer, 2006) and in large datasets (Osborne and Costello, 2005), both of which are pertinent to our analysis.

An important decision in EFA is determining the optimal number of factors (Goldberg and Velicer, 2006; Osborne and Costello, 2005), where factors represent substantially independent (uncorrelated) patterns of relationships between variables (Rummel, 1967, 1970). The most commonly applied method is to retain those factors that have eigenvalues greater than one, although this is among the least accurate methods (Osborne and Costello, 2005). We opted to retain two different numbers of factors in the analysis here, 12 and 25, as well as using guidance in the automatic cut-offs in Stata. These selections help to examine various possibilities for possible explanatory factors. A final choice is made by noting that extracting too many factors may result in a large error variance deriving from spurious and small sample effects, while extracting too few factors may omit important valuable common variance (Yong and Pearce, 2013).
After a first stage of component-factor analysis is conducted, the result is the original, unrotated factor matrix. This is difficult to interpret and usually has little scientific utility (Goldberg and Velicer, 2006). Instead, we apply the commonly used method of “orthogonal” factor rotation to achieve an outcome where each factor has a correlation of exactly zero with all the other factors. The alternative is to use “oblique” factor rotation whereby factors are permitted to have some correlation with each other. The decision between the two rotational algorithms entails a trade-off between lower-level factors within a single domain (i.e. a large number of factors at the lower level of the trait hierarchy) and broad factors at the highest level of the structure (Goldberg and Velicer, 2006). In addition, we applied the “varimax” algorithm (Kaiser, 1958), which is the most commonly used procedure for “orthogonal” factor rotation (Goldberg and Velicer, 2006; Osborne and Costello, 2005). The resulting factor loadings determine how much the variable has contributed to the corresponding factor, whereby a larger factor loading implies that the variable’s contribution is larger and vice versa (Rummel, 1967, 1970; Yong and Pearce, 2013). All calculations were undertaken in Stata.

Some robustness testing of the results of the 12 and 25 factors was undertaken by comparing against earlier stages of the analysis. In these stages, an initial exploration of the factors using only those sectors with the main entrepreneur categories was used. This was 43 sectors, excluding Public admin, clergy; Clerks, weighers, telegraph, non-theological students and apprentices; Domestic and service staff, cooks; Labourers & transport staff (including family on farms). A further stage was to subdivide mining into coal and other mining, and subdividing public administration etc. by extracting military personnel. The resulting factor analysis of the intermediate stages of 43 and 48 occupational variables are very similar to those for the full 50 sectors reported here suggesting that the results are stable for the 1891 data.

2.2. Spatial level and Census data used

The purpose of the analysis is to classify spatial areas to common occupational characteristics. The spatial basis chosen is census Registration Sub-Districts (SRDs) in England and Wales. There were 2110 of these in 1891. This base is used as it aggregates small units, thus smoothing potential errors and noise in the data. It also brings residential locations together with workplace for most of the population. Some employers and workers will still be located a long way from their residence, but for most small businesses and their workers the location of employment and residence will be in the same RSD; this would not be the case if parishes were used.
The Census data extracted had careful pre-screening and cleaning to ensure that the subsequent analysis used consistent definitions and was not distorted by spurious entries, or occupationally inactive population. Hence, although many younger people were engaged in occupations, this was often inconsistently recorded by enumerators and may not properly separate full and part-time activity. To ensure consistency, the data used excluded everyone under 15. Also excluded was anyone who was retired, listed only as ‘pensioner’ or ‘former’, living on own means, unemployed, and students, scholars, or pupils.

Because the aim is a classification of locations it was important to focus on those that were permanent or longer-term residents. As a result boarders, visitors and lodgers were excluded, as were those in institutions or ships. Whilst some boarders and institutional inmates will have been long-term residents with full-time occupations in that locality, these categories include many for whom the relationship to the locality was unclear.

Because the focus of this analysis is subsequently on entrepreneurs, for consistency anyone who gave no answer to the employment status question as to whether they were employer, own account, or worker was also excluded. This means that the workforce covered in this paper is only those who explicitly acknowledged their status as workers, employers, or own account. Similarly excluded were all with nil or illegible answers to the employment status question.

2.3. **Aggregation of occupations into 50 occupational groups**

The occupational categories used are based on aggregations to 50 occupational groups. These groups are described in detail Working Paper 5. Aggregation is essential for the factor analysis to converge. The original I-CeM coding offers two categories for c. 400 and c.750 occupational categories. Both of these levels contain many occupations with very small numbers of people. When disaggregated around the 2110 RSDs this results in many RSDs having zero entries or very small numbers than can distort the analysis. Aggregating to 50 occupational categories overcomes most of these difficulties, though it is accepted that this approach imposes an order and grouping on the occupations from the outset.
3. Classification of entire economically active population.

This Working Paper assesses factor analysis as a method for classifying RSDs using the information on all occupational groups. It is likely that many groups do not have specific differences from the general occupational norm; i.e. there are similar shares of entrepreneurs in many occupations, and groups of occupations, to those across other the entire working population. In such cases the occupations reflect the general character of entrepreneurship in the whole economy. Hence an analysis of all economically active provides a base for our main concern here (reported in other working papers), to identify occupations and locations that differ significantly from that norm in terms of entrepreneurial location. As noted, this is undertaken with 12-factor and 25-factor analyses. As summarised above, this is for all census respondents who were household residents, with a stated occupation, aged 15 and over, and excluding institutions, the unemployed, retired, students, etc. The focus on residents of that locality also excludes boarders, visitors and lodgers (even though some of these may be long-term residents).

3.1 12-Factor study.

The 12-factor analysis of the entire economically active is given in Table 1 for the factor variance, and Table 2 for the factor loadings. In this and subsequent factor loading tables the potentially significant loadings above a value of 0.2 are identified (marked in yellow) and where they are the highest loading for all factors for that occupation they are marked brown. Negative loadings are highlighted in blue where their value is smaller than -0.5.

As shown in Table 1 the explanatory power of the factor analysis tails off after 6 or seven factors: 53% of the explained variance is accounted for by the first four factors, and 80% by the first eight. Overall the explanatory power for 12 factors is 59% of the total variance, which is highly significant, but indicates that there is considerable variation not explained by the factor analysis. This can be compared with an automatic cut-off proved by Stata which had 13 factors.

The characteristics of the first group of factors draw out useful distinctions. The discussion here focuses exclusively on the occupational group loadings on a factor where they are the highest for that occupational group (i.e. highlighted in brown in Table 2).
<table>
<thead>
<tr>
<th>Factor</th>
<th>Variance</th>
<th>Difference</th>
<th>Proportion</th>
<th>Cumulative</th>
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</tbody>
</table>

**Table 1**: Factor analysis for all economically active (for workers, employers and OA jointly), 12-factor variance.

- Number of obs = 2,110
- Method: principal-component factors
- Rotation: orthogonal varimax (Kaiser off)  Number of params = 534
- LR test: independent vs. saturated: chi2 (1225)= 6.2e+04  Prob>chi2 = 0.0000

Note that farming has only one marginally significant positive loading (0.1959 on Factor 9 – rural industries); its loadings are mainly negative, and its highest loading in this analysis is -0.60. This indicates that it is widespread across all areas, and where it plays a role it is loaded in the opposite direction to many other occupations (especially heavy industry and coal). In fact it is negatively loaded on all factors except Factor 9; its highest negative loading is on Factor 2 (-0.60) and next highest on Factor 1 (-0.36).

‘Other Mining’ also has no significant positive loading, with a high negative on factor 11 (-0.53) for clothing and agricultural produce. Mining and quarrying, like farming, is thus usually too widespread in distribution to have significant RSD loadings.
Table 2 12-Factor loadings for each of the 50 aggregated occupational variables.

The different factor loadings can be summarised and interpreted as below:

**Factor 1 (Commercial and professional)** identifies a group of commercial and professional occupations where the analysis of RSDs evidences a clear grouping into the major business and professional centres:

- Merchants, banks, insurers and brokers
- Other commerce (accountants, solicitors, travellers, officers of Cos.)
- Construction management (builders and contractors)
- Professions (barristers, solicitors, scientific pursuits)
- Professions (doctors, dentists, artists, performers, education)

As well as occupations associated with these groups in leading business centres:

- Stationary dealing (stationers, publishers, newsagents)
- Public admin, clergy
- Clerks, weavers, telegraph, non-theological students and apprentices
- Domestic and service staff, cooks
- Labourers & transport staff (excluding family on farms)
- Peers of property and unoccupied

ESRC project ESM010953: WP 8: Bennett et al.: Factor analysis of RSDs in 1891: All occupied, Cambridge University.
All these occupational groups have factor loadings above 0.5, mostly above 0.7. Apart from stationary dealing this factor excludes retail (although there is a close but smaller relation to chemists and druggists who are more strongly linked to Factor 3). Stationary dealing in this case is primarily wholesale and includes leading media activities as well as some retailing. Clerks, weighers etc. indicate a worker group strongly associated with commerce: they were the bookkeepers and human resource infrastructure of the commercial centres. Public administration and the clergy, however, indicate a different type of clustering: the co-location of the state’s administrative functions in the main commercial centres.

Factor 2 (Heavy manufacturing and coal) identifies heavy manufacturing, metals manufacture, chemicals and coal mining:
- Coal mining
- Machinery manufacture
- Iron & steel manufacture, bolts and nails
- Other metal manufacture (copper, tin, brass, whitesmiths, etc.)
- Gas, coke and chemical manufacture
- General manufacture (manufacturers, mechanic, artisan, machinist)

Of these gas, coke and chemical manufacture has a relative low loading (only 0.28) but this factor is the only one where it has any potentially significant relationship, and is an industry often closely associated with heavy industries. This factor also has two of only three high negative loadings in the whole factor analysis, in this case on:
- Farming, fishing, market gardeners, horse breeding and keeping (loading -0.60)
- Labourers & transport staff (including family on farms) (loading -0.56)

This indicates a strong negative association between heavy manufactures and coal compared with agriculture and general labourers (since most specific labourers are identified to their industry, these are general or undefined labourers who are mostly agricultural). (q.v. Factor 9).

Factor 3 (Retail and lodging) identifies the prime retail sectors focused on personal and household needs as well as lodging:
- Clothing and dress dealing (drapers, hosiers, haberdashers)
- Food sales (butchers, fishmongers, cheesemongers, milk sellers, grocers)
- Lodging & drink sales (wine & spirits, hotels, inns, coffee houses)
- Ironmongers
- Chemists, druggists
**Factor 4 (Wood, leather, furnishing and printing manufacture)** is chiefly a factor grouping manufacturers of leather, wood, wood-using industries (other than building), and printing which all have loadings of 0.5 or greater:

- Leather, fur, hair & bone manufacture
- Wood manufacture (sawyers, coopers, cane workers)
- Furnishing manufacture (cabinet makers, french polishers, undertakers)
- Printing & paper manufacture (paper, cardboard, printers, bookbinders)

Lesser loadings (all at 0.4 or greater) are for:

- Drink & tobacco manufacture (maltsters, brewers, distillers, tobacco & pipes)
- Road & rail transport (which includes small carriers)
- Other retail (general shopkeeper, huckster, hawker)

Other retail, which is mainly market stall and street traders, has potentially significant loadings also on Factors 3 and 7. It is clearly a fairly widespread activity with Factor 4 producing the strongest association, but this fits less well than a possibly more natural grouping with Factor 3.

**Factor 5 (Building and personal service industries)** combines three occupational groups:

- Construction operatives (masons, bricklayers, thatcher, plumbers etc.)
- Construction management (builders and contractors)
- Personal services (washing & bathing, hairdressing, chimney sweeps)

This is essentially a building factor, but also loads strongly on personal services. Personal services also loads positively on 3, 1 and 4 (in that rank order), which are all consumption goods industries in urban centres. There is not a strong relationship to dirty occupations needing a lot of laundry, like mining and heavy industries (Factor 2). Its close relation to building draws from the relation of building to major urban consumer centres, but may also indicate some relation to a dirty industry needing lots of laundry. There is a secondary and less significant association of these sectors with food sales and ironmongery, which are much more strongly grouped into Factor 3, as well as the more personally-related professions (doctors, dentists, artists etc.) and public administration which are strongly loaded on Factor 1. But these associations indicate that construction, like personal services are strongly clustered around consumer users. However, it is clear that Factor 5 is quite similar in many respects to elements of Factors 1 and 3.

**Factor 6 (Major transport, transport manufacture and military)** is an association largely based on ports and major transport hubs, which are also usually the main location for related
manufactures. The military enter this factor because of the large proportion of their personnel who are naval, also concentrated in a few ports.

- Ship, road & rail vehicle mf
- Ocean, inland and dock transport
- Military

**Factor 7 (Textiles manufacture)** is a highly concentrated grouping of the main large-scale textile industries:

- Woollen manufacture (woollen goods, carpets, blanket, flannel)
- Cotton & silk manufacture (including ribbon, weaving, dyeing, bleaching etc.)
- Other textile manufacture (flax, hemp, rope, jute, lace, tape, thread)

**Factor 8 (Tools, instruments and household goods):**

- Tool & weapons manufacture
- Watch & instrument manufacture
- Household & personal goods dealer (earthenware, glass, jewellers)

This is a fairly heterogeneous group but with a focus on generally highly skilled craft manufactures with a low level of mechanisation.

**Factor 9 (Rural trades)** combines three groups that are ubiquitous in rural areas related to agricultural needs and agricultural manufacture:

- Blacksmiths
- Agricultural produce manufacture (millers, refiners, bakers, confectioners)
- Labourers & transport staff (including family on farms)

*Possible: [Farming, fishing, market gardeners, horse breeding and keeping]*

These are mostly maker-dealers. Among these, some such as bakers and confectioners, also occur frequently in urban areas, but are less frequently concentrated in them to the exclusion of other trades. It is noteworthy that agricultural produce manufacturers otherwise only loads strongly on Factor 4. As noted under the strong negative loadings on Factor 4 (wood, leather, furnishing and printing manufacture), which are often related industries. As noted for Factor 2, agriculture and general labourers are mostly agricultural, and hence their grouping with blacksmiths and agricultural produce is consistent, and their negative loading on Factor 2. Farming has its only positive loading on this factor, but only at 0.1959, just at the level used to cut-off identification of other loadings; but it could be added to this factor as its closest link.
**Factor 10 (Apparel and textile maker dealers)**

Clothing manufacture (tailors, milliners, hosiery, hats, gloves, umbrellas, buttons, leather)

Shoe, boot, clog manufacture

Waterproof goods manufacture (floor & oil cloth, rubber etc.)

Generally closely linked industries that are widespread at low densities across many RSDs, but also concentrated into some centres of hand and mechanised manufacture.

**Factor 11 (Dealers with a strong basis in the carrying trade)**

Coal dealing

Agricultural produce dealing, and dealers in timber, hay, corn

The main distribution industries at both a wholesale and retail level where heavier loads need dedicated carriers. Often focused on railway stations (large and small) and/or canal and ports mainly across rural areas, but also in some urban areas. This factor also has the only significant loading for other mining and quarrying, but it is negative (-0.53). The different sign shows the polar relation with the coal dealing and other dealing sectors, but is a very clear identifier of almost all the main mine and quarry areas: in the SW, Wales, limestone and clay ears of the Midlands, Derbys., S and W. Yorks., N. Yorks., Durham, Northumberland, Cumberland and Westmorland, as well as small quarry owners elsewhere such as N. Kent and Isle of Purbeck.

**Factor 12 (Earthenware and glass manufacture)** has only one occupational group loading, but that at a high level (0.8). This group includes all Pottery, brick and tile manufacture, within which Pottery, brick and tile manufacture is a major element. This is fairly widespread in addition to the concentrated centres such as Staffs. It indicates a concentration of this industry in a group of RSDs, but its emergence as the last factor indicates its localisation to a few RSDs.

### 3.2 25-Factor Study.

The results for a factor analysis allowing the method to run to 25 factors are shown in Tables 3 and 4. This is primarily used as a guide for two purposes: first, to assess the robustness of the factors identified in the 12-factor study; and second, to check on the presence of significant groupings, like that in earthenware and glass manufacture, which are highly clustered but only in a limited range of locations so that the total variance that they can explain is limited.
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**Table 3:** Factor analysis for all economically active (for workers, employers and OA jointly), 25-factor variance.

Number of obs = 2,110  
Method: principal-component factors  
Retained factors = 25  
Rotation: orthogonal varimax (Kaiser off)  
Number of params = 950  
LR test: independent vs. saturated: chi2 (1225) = 6.2e+04  
Prob>chi2 = 0.0000

ESRC project ES/M010953: WP 8: Bennett et al.: Factor analysis of RSDs in 1891: All occupied, Cambridge University.
In general the patterns are very similar, although because the variance is now spread between a large number of factors the loadings in most cases are lower. Table 3 indicates the variance is again chiefly explained by the first 7 or 8 factors, but the larger number of factors allows increases the overall explanatory power considerably, up to 81% for the full 25 factors. The level of variance explained by the first 12 factors is comparable, though slightly lower than shown than in Table 1.

Table 4 indicates similar factor loadings and structure of factors for the 25-factor as the 12-factor study. Factor 1 is still the main commercial and professional grouping, but now has many dealers and small manufacturers added into it; somewhat combining the 12-factor groups for Factors 1, 3, 4, 5, 10, and 11. There is a notable high negative loading of farming and agricultural labourers on Factor 1. Factor 2 now combines heavy manufactures and textiles (Factors 2 and 7 of the 12-factor study). This has a notably high negative loading of farming, agricultural labourers and domestic staff. Factor 3 combines Factors 2, 6 and 9 of the 12-factor study generally related to metal trades. Factor 4 groups wood, agricultural produce and other retail. From Factor 5 onwards there is generally only one lead occupation associated with the factor.
Table 25-Factor loadings for each of the 50 aggregated occupational variables.

Table 25 brings out the spatial concentrations in a few RSDs of tools and household goods (Factor 5), agricultural labourers, but at a low level (Factor 7), shoe manufacture (Factor 9), woolen manufacture (Factor 10), earthenware & glass (Factor 12), waterproof goods (Factor 15), other mining and coal dealing (Factor 16), persons of property (Factor 17), gas, coke and chemicals (Factor 18), drink & tobacco (Factor 20), domestics (Factor 21), clothing manufacture (Factor 22), and leather, fur etc. (Factor 23).

Overall, although the variance explained by this extended 25-factor analysis is much greater, the structure of factors is less interpretable. Indeed the automatic cut-off of the statistic estimates in the factor analysis for the economically active is 13 factors. The added insight from the 25-factors over the 12-factors is the dominance of large commercial and manufacturing-dealing locations, and the possible significance of spatial concentrations in less frequent occupational categories (notably shoe manufacture, woolens, waterproof goods) as well as the common finding of earthenware and glass as the 12th factor. The 25-factor study also brings out some of the sectors

ESRC project ESM010953: WP 8: Bennett et al.: Factor analysis of RSDs in 1891: All occupied, Cambridge University.
with high concentrations of non-entrepreneurs (especially agricultural labourers, domestics) as well as the ambiguous category of persons of property. The overall conclusion is that the 25 factor study is less useful for interpreting because it combines too many occupational groups in complex ways. The rest of the analysis here therefore uses the 12-factor results.

4. Comparisons of RSDs using mapping

The rest of the analysis here uses the 12-factor results which are summarised in Table 5.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description and occupation variables</th>
<th>Factor</th>
<th>Description and occupation variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Commerce &amp; professions</td>
<td>7</td>
<td>Textiles manufacture</td>
</tr>
<tr>
<td></td>
<td>Merchants etc.</td>
<td></td>
<td>Woollen mf</td>
</tr>
<tr>
<td></td>
<td>Other commerce</td>
<td></td>
<td>Cotton &amp; silk mf</td>
</tr>
<tr>
<td></td>
<td>Construction management</td>
<td></td>
<td>Other textile mf</td>
</tr>
<tr>
<td></td>
<td>Professions (law etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Professions (doctors etc.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stationary dealing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Public admin, clergy</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Clerks etc.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Mining &amp; heavy metals</td>
<td>8</td>
<td>Tools, instruments &amp; Hhd goods</td>
</tr>
<tr>
<td></td>
<td>Coal mining</td>
<td></td>
<td>Tool &amp; weapons mf</td>
</tr>
<tr>
<td></td>
<td>Machinery mf</td>
<td></td>
<td>Watch &amp; instrument mf</td>
</tr>
<tr>
<td></td>
<td>Iron &amp; steel mf</td>
<td></td>
<td>Hhd goods dealer</td>
</tr>
<tr>
<td></td>
<td>Other metal mf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gas and chemical mf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>General mf</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Retail and lodging</td>
<td>9</td>
<td>Rural trades</td>
</tr>
<tr>
<td></td>
<td>Clothing &amp; dress dealing</td>
<td></td>
<td>Blacksmiths</td>
</tr>
<tr>
<td></td>
<td>Food sales</td>
<td></td>
<td>Agricultural produce mf</td>
</tr>
<tr>
<td></td>
<td>Lodging &amp; drink sales</td>
<td></td>
<td>Labourers &amp; transport staff</td>
</tr>
<tr>
<td></td>
<td>Ironmongers</td>
<td></td>
<td>Possible: Farming, etc.</td>
</tr>
<tr>
<td></td>
<td>Chemists, druggists</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Small mf &amp; transport</td>
<td>10</td>
<td>Apparel and textile maker dealers</td>
</tr>
<tr>
<td></td>
<td>Leather mf</td>
<td></td>
<td>Clothing manufacture</td>
</tr>
<tr>
<td></td>
<td>Wood mf</td>
<td></td>
<td>Shoe, boot, clog manufacture</td>
</tr>
<tr>
<td></td>
<td>Furnishing mf</td>
<td></td>
<td>Waterproof goods manufacture</td>
</tr>
<tr>
<td></td>
<td>Printing &amp; paper mf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Drink &amp; tobacco mf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Road &amp; rail transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Other retail</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Building and washing</td>
<td>11</td>
<td>Dealers-carriers</td>
</tr>
<tr>
<td></td>
<td>Construction operatives</td>
<td></td>
<td>Coal dealing</td>
</tr>
<tr>
<td></td>
<td>Personal services</td>
<td></td>
<td>Agric. deal. &amp; timber dealing</td>
</tr>
<tr>
<td>6</td>
<td>Transport &amp; military</td>
<td>12</td>
<td>Earthenware &amp; glass mf</td>
</tr>
<tr>
<td></td>
<td>Ship, road &amp; rail vehicle mf</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ocean &amp; dock transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Military</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Farming; other mining; labourers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>Negative</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>31 (plus 3 negative)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 5: Summary of the Factors for the 12-factor analysis, with the loadings that are the highest for that occupation category.
In all the following maps the scales are chosen to indicate the four quartiles for positive loadings (red to yellow), and the 50% point for negative loadings, those above 50%, and additionally all those with the largest negatives of less than -0.5 shown separately (shades of blue).

The spatial distribution of Factor 1 (commerce and professions) shown in Figure 1 is heavily focused in the main urban centres, and those areas like Carlisle or Ulverston that are distant from other main centres. This Factor also brings out the role of some major commercial centres which are also resorts (e.g. Brighton and Southport).

Factor 2 (heavy manufacturing and coal), Figure 2, very closely mirrors the coalfields and related industries concentrated in these for heavy manufacturing, metals manufacture and chemicals. Rural areas in general heavily load negatively on this factor.

Factor 3 (retail and lodging). Figure 3, identifies the areas where their main focus is retail for personal and household needs and lodging, but where there is little commercial or professional development. The spatial distribution covers many small towns and centres in otherwise rural areas, as well as the smaller resorts not captured in Factor 1.

Factor 4 (wood, leather, furnishing and printing manufacture), Figure 4, is a relatively diversified set of occupations which are in fringe urban areas and locations with a local timber industry (such as Herefordshire and Westmorland), or with a high degree of local specialisation wood, timber and printing: such as parts of London, Buckinghamshire and Suffolk.

Factor 5 (building and personal service industries), Figure 5, combines construction operatives and management with personal services (washing & bathing, hairdressing, chimney sweeps). It has a surprisingly strong orientation to the south rather than the north of the country, which may be indicative of the stage of urban development in 1891 and the high level of suburban development associated with rail expansion into wider commuter zones.

Factor 6 (transport, transport manufacture and military mainly naval personnel), Figure 6, is heavily concentrated on ports around most coasts, and in major transport hubs, which are also the main location for related manufactures (such as Crewe, Swindon, Doncaster, and the W. Midlands – especially Coventry). However, there are some concretions that seem difficult to
interpret, such as in Bedfordshire and Buckinghamshire suggesting this factor is picking up a variety of loadings at the margins.

Factor 7 (textiles manufacture), Figure 7, is a highly concentrated grouping in Lancashire and Yorkshire, but with other smaller concentrations in Bedford, Bucks., Wiltshire/Somerset, Devon, Suffolk, rural Wales and scattered rural centres elsewhere.

Factor 8 (tools, instruments and household goods dealers), Figure 8, is a heterogeneous group but with strong concentrations in the W. Midlands Black Country, Sheffield. S. Wales and a few smaller centres and a few parts of London. It seems to be picking out the highly skilled craft metal manufactures with a low level of mechanisation.

Factor 9 (rural trades), Figure 9, combines three groups that are ubiquitous in rural areas but not generally in the south of the country, where they are replaced mainly by Factor 5 for building. Factors 5 and 9 are thus somewhat complimentary. The low loading on farming (the only factor where farming appears) is also indicative of its lack of spatial focus in specific areas.

Factor 10 (apparel and textile maker dealers), Figure 10, shows remarkable concentration in the areas with high levels of concentration in clothing manufacture: hats in Bedford and Hertford; hosiery in Leicester, Nottingham and Northants; shoes in Nottingham and Kendal; and gloves in Somerset, Wilts and Dorset. Many of these sectors had a high level of outworkers, and in many ways this Factor brings out areas of outworking very clearly.

Factor 11 (dealers in coal and agricultural produce, timber, hay & corn), Figure 11, brings out the concentration of these sectors in centres with railway stations and/or canal and ports. However, the very large concentrations in Lancashire and Teesside suggest that this factor is also picking up some fringe urban elements.

Factor 12 (earthenware, pottery, bricks, tiles, and glass manufacture), Figure 12, has only one occupational group loading. It shows the expected concentration in Staffordshire, but is also much more widespread. It appears to be linked to coal areas, S. Wales, Lancs., Cheshire, and Durham; and to major cement production facilities in places like N. Kent and Warwickshire or stone quarrying as in W. Yorkshire and parts of the South West.
Figure 1. Spatial distribution of Factor 1.
Figure 2. Spatial distribution of Factor 2.
Figure 3. Spatial distribution of Factor 3.
Figure 4. Spatial distribution of Factor 4.
Figure 5. Spatial distribution of Factor 5.
Figure 6. Spatial distribution of Factor 6.
Figure 7. Spatial distribution of Factor 7.
Figure 8. Spatial distribution of Factor 8.
Figure 9. Spatial distribution of Factor 9.
Figure 10. Spatial distribution of Factor 10.
Figure 11. Spatial distribution of Factor 11.
**Figure 12.** Spatial distribution of Factor 12.
5. Females all occupied

It is important to assess if there are gender differences among the occupations of the economically active. This section examines female occupations. Taking a comparable 12-factor study, Table 6 shows that the first 3-5 Factors are dominant, with Factor 1 well ahead in loading, and Factors 2 and 3 almost identical, after which potential breaks after Factors 5 and 7.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Variance</th>
<th>Difference</th>
<th>Proportion</th>
<th>Cumulative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Factor 1</td>
<td>2.51953</td>
<td>0.33217</td>
<td>0.0681</td>
<td>0.0681</td>
</tr>
<tr>
<td>Factor 2</td>
<td>2.18737</td>
<td>0.00156</td>
<td>0.0591</td>
<td>0.1272</td>
</tr>
<tr>
<td>Factor 3</td>
<td>2.18581</td>
<td>0.32835</td>
<td>0.0591</td>
<td>0.1863</td>
</tr>
<tr>
<td>Factor 4</td>
<td>1.85746</td>
<td>0.02057</td>
<td>0.0502</td>
<td>0.2365</td>
</tr>
<tr>
<td>Factor 5</td>
<td>1.83689</td>
<td>0.30667</td>
<td>0.0496</td>
<td>0.2861</td>
</tr>
<tr>
<td>Factor 6</td>
<td>1.53023</td>
<td>0.02144</td>
<td>0.0414</td>
<td>0.3275</td>
</tr>
<tr>
<td>Factor 7</td>
<td>1.50878</td>
<td>0.18422</td>
<td>0.0408</td>
<td>0.3683</td>
</tr>
<tr>
<td>Factor 8</td>
<td>1.32456</td>
<td>0.00947</td>
<td>0.0358</td>
<td>0.4041</td>
</tr>
<tr>
<td>Factor 9</td>
<td>1.31509</td>
<td>0.09568</td>
<td>0.0355</td>
<td>0.4396</td>
</tr>
<tr>
<td>Factor 10</td>
<td>1.21941</td>
<td>0.04060</td>
<td>0.0330</td>
<td>0.4726</td>
</tr>
<tr>
<td>Factor 11</td>
<td>1.17880</td>
<td>0.05473</td>
<td>0.0319</td>
<td>0.5044</td>
</tr>
<tr>
<td>Factor 12</td>
<td>1.12407</td>
<td>0.04399</td>
<td>0.0304</td>
<td>0.5348</td>
</tr>
<tr>
<td>Factor 13</td>
<td>1.08008</td>
<td>0.0292</td>
<td>0.0292</td>
<td>0.5640</td>
</tr>
</tbody>
</table>

Table 6: Factor analysis for female economically active: 13 factors

| Number of obs | 2,110 |
| Method | principal-component factors |
| Retained factors | 13 |
| Rotation | orthogonal varimax (Kaiser off) |
| Number of params | 403 |
| LR test: independent vs. saturated: chi2 (666) | 2.0e+04 |
| Prob > chi2 | 0.0000 |

The factor loadings are shown in Table 7.
Table 7: 12-Factor loadings for each of the aggregated female occupational code.

No factor has any significant loading on coal mining. Only 37 of the 50 occupational groups are of significance and loaded in the analysis. This includes all the rural-related such as agricultural produce, and farming enters only as strongly negative (on Factor 2). The loadings can be summarised as follows:

1: Factor 1 (Leather & wood mf., printing drink & tobacco & transport) Captures the main female sectors of cane, fur, hair and tobacco pipe workers; transport loading may result from lockkeepers etc.

Leather, fur & bone mf
Wood mf (sawyers, cooper, cane workers)
Printing & paper mf (paper, cardboard, printers, bookbinders)
Drink & tobacco mf (maltsters, brewers, distillers, tobacco & pipes)
Ocean, inland and dock transport

2: Factor 2 (Stationers, professions, washing, professionals & clerks) Probably stationers relate with post mistresses

Stationary dealing (stationers, publishers, newsagents)
Professions (doctors, dentists, artists, performers, education): mainly teachers
Personal services (washing & bathing, hairdressing, chimney sweeps)
Clerks, weighers, telegraph, non-theological students and apprentices

High negative loading for:
Farming, fishing, market gardeners, horse breeding and keeping (-0.64)

3: **Factor 3 (Tools & furniture mf., household goods dealers merchants)** Merchants etc. may be spurious

- Tool & weapons mf
- Furnishing mf (cabinet makers, french polishers, undertakers)
- H/h & personal goods dealer (earthenware, glass, jewellers)
- Merchants, banks, insurers and brokers

4: **Factor 4 (Clothing and food dealing)** An expected female sector concentration, but quite distinct from the domestic servants showing a clear distinction of locational differences in residential concentration

- Clothing and dress dealing (drapers, hosiers, haberdashers)
- Food sales (butchers, fishmongers, cheesemongers, milksellers, grocers)

  High negative loading on:
  Domestic and service staff, cooks (-0.48)

5: **Factor 5 (Domestic service & clerical)** Another expected female sector concentration, notably distinct from clothing and retail (Factor 4), but also distinct from cotton and silk mf which has no high positive loadings

- Public admin, clergy
- Domestic and service staff, cooks

  High negative loading on:
  Cotton & silk mf (incl ribbon, weaving, dyeing, bleaching etc.) (-0.83)

6: **Factor 6 (Clothing and shoe mf.).** Also an expected female sector concentration

- Clothing mf (tailors, milliners, hosiery, hats, gloves, umbrellas, buttons, leather)
- Shoe, boot, clog mf

7: **Factor 7 (Wool, other textiles, small retail)**

- Woollen mf (woollen goods, carpets, blanket, flannel)
- Other textile mf (flax, hemp, rope, jute, lace, tape, thread)
Other retail (general shopkeeper, huckster, hawker)

This marks the point where the factors become difficult to interpret and may be spurious, except for Factors 10, 11 and 13.

**[Factor 8]** No highest loaded for any occupation; two most highly loaded are same as Factor 3. This factor removed and reallocated.

- H/h & personal goods dealer (earthenware, glass, jewellers) (0.52)
- Merchants, banks, insurers and brokers (0.24)

**8: Factor 9 (Gas, chemical, explosives & waterproof goods)**
- Gas, coke and chemical mf
- Waterproof goods mf (floor & oil cloth, rubber etc.)

**9: Factor 10 (lodging & drink sales, other commerce)** An expected female sector concentration for lodgings, but not for other commerce

- Lodging & drink sales (wine & spirits, hotels, inns, coffee ho.)
- Other commerce (accountants, salesmen, travellers, officers of cos.)

**10: Factor 11 (Tin plate and watch mf.)** Similar to Factor 3, but focusing on other small metal manufactures

- Other metal mf (copper, tin, brass, whitesmiths, etc.)
- Watch & instrument mf

**11: Factor 12 (Transport and general mf.)**

- Ship, road & rail vehicle mf
- General mf (manufacturers, mechanic, artisan, machinist)

**12: Factor 13 (Bolts and nail mf)** Although not strong female presence in heavy iron and steel, this factor appears to be picking up the female concentrations in small metals.

- Iron & steel mf, bolts and nails

The mapping of the female classification for RSDs is shown in Figure 13 after cleaning for small sample sizes, and reallocating Factor 8.
Figure 13. Spatial distribution of factors for females only all occupied: final allocation.
6. Factor scores

As clear from the mapping discussed above, many RSDs have high scores on several factors. To obtain a more general classification of RSDs it is necessary to assess how far any RSD is primarily loaded on one factor rather than others. This can be achieved by calculating the factor scores for each RSD by summing the loadings attributed to each factor. Only those groups with the highest loadings on that factor are used. It is then necessary to decide to which factor a specific RSD is primarily classified. This classification can be largely automated, and there is advantage in using an objective statistical approach throughout.

The judgement on the groupings of RSDs is made by reference to the scores on each of the 12 factors in the 12-factor study, in three stages:

1. Each RSD was classified to the factor on which it had the highest score. This gave a first classification of each RSD which were then scrutinised in stages:
   2. Those where the highest score on any factor was below 0.5 were re-allocated to a separate group with ‘no strong loadings’.
   3. Those RSDs which had scores over 0.5 were scrutinised to check that none had a strong alternative classification to different factor(s) for which their scores were close to that on the highest factor to which they had been classified. These were candidates for possible reallocation or grouping across factors.

The group of RSDs that did not score highly on any of the factors are allocated to a separate group, termed ‘no strong loadings’ to indicate that they have no high concentrations on any of the occupational variables: they are close to the general average occupational distribution across the country, or have no spatial concentrations high enough on any occupation to give them a high factor loading.

To help in interpretation, there was first a direct mapping of the RSD with their highest scores following the above methodology (‘original’ map). This is shown in Figure 14.
Figure 14. ‘Original’ mapping of RSD factor scores.

This map produces a fairly clear picture, but it is apparent that there is a number of potential confusions or ambiguities that make the map difficult to interpret. To overcome this a ‘directed’
approach was undertaken for each RSD for each factor. This combines aspects of the standard approaches of ‘exploratory’ and ‘confirmatory’ factor analysis; where the exploratory approach has been used to inspect the first 12 factors, and the confirmatory approach is used to ensure interpretation meets criteria of interpretability against know patterns: a ‘reality check’. The starting point is the automatic ‘original’ classification, but this was tensioned against alternatives as under step 3 above, and against the known patterns of different locations derived from secondary literature.

The results are summarised below. The method followed was to reallocate all of Factor 5, which is the most difficult to interpret, ‘building and washing’. When examined in detail the RSDs loading highly on this factor mostly have strong alternative similarly high loadings which appear at least as appropriate and: reassigned to second significant factors – mainly Factors 3, 9 and 11, and no strong. Similarly Factors 3 and 4 were often alternates for any RSD, with small differences in loadings between the two. It appears that these, largely rural, areas had close similarities and whilst orthogonal, they could take a high load on either of these factors. Because of this a decision was made to combine them as a joint classification (Factors 3 + 4). Similarly Factors 9 and 11 were also close alternatives and these two factors were combined as one classification. For all Factors, but especially Factors 6 and 9, a check was also made on the sample sizes in each RSD contributing to the factors cores. In Factors 6 and 9 a number of RSDs had very small samples on these critical factors. Whilst geographically distinctive, this often relied on very small numbers of people to distinguish the locality from more general patterns. Where the sample size was small these RSDs were reassigned to no strong loading. The reassignment of the areas with small samples contributes to a general ‘cleaning up’ of the map and the underlying classification removing anomalies.

**Summary of 12-factor analysis 1891 all occupied:** highest occupation loading on each factor and changes made to the ‘original’ automated classification using a ‘directed’ methodology:

**I: Factor 1 (Commercial and professional)**
- Merchants, banks, insurers and brokers
- Other commerce (accountants, salesmen, travellers, officers of Cos.)
- Professions (barristers, solicitors, scientific pursuits)
- Professions (doctors, dentists, artists, performers, education)

Also occupations associated with these groups
Stationary dealing (stationers, publishers, newsagents)
Public admin, clergy
Clerks, weighers, telegraph, non-theological students and apprentices

2: Factor 2 (Coal mining and heavy manufacturing)
Coal mining
Machinery manufacture
Iron & steel manufacture, bolts and nails
Other metal manufacture (copper, tin, brass, whitesmiths, etc.)
Gas, coke and chemical manufacture
General manufacture (manufacturers, mechanic, artisan, machinist)

High negative loadings on:
Farming, fishing, market gardeners, horse breeding and keeping (loading -0.60)
Labourers & transport staff (including family on farms) (loading -0.56)

3: Factor 3 (Retail, small manufactures and lodging)
Clothing and dress dealing (drapers, hosiers, haberdashers)
Food sales (butchers, fishmongers, cheesemongers, milksellers, grocers)
Lodging & drink sales (wine & spirits, hotels, inns, coffee houses)
Ironmongers
Chemists, druggists

Combined with Factor 4

[Original Factor 4 (Wood, leather, furnishing and printing manufacture)]
Leather, fur, hair & bone manufacture
Wood manufacture (sawyers, coopers, cane workers)
Furnishing manufacture (cabinet makers, french polishers, undertakers)
Printing & paper manufacture (paper, cardboard, printers, bookbinders)

Combined with Factor 3

[Reallocated: Factor 5 (Building and personal service industries) combines three occupational groups]:
Construction operatives (masons, bricklayers, thatcher, plumbers etc.)
Construction management (builders and contractors)
Personal services (washing & bathing, hairdressing, chimney sweeps)

Rationale unclear and mostly strong alternatives: reassigned to second significant factors – mainly Factors 3, 9 and 11, and no strong

4: Factor 9 (Rural trades, building, coal and timber dealing)
   Blacksmiths
   Agricultural produce manufacture (millers, refiners, bakers, confectioners)
   Labourers & transport staff (including family on farms)
   0.1959 [Farming, fishing, market gardeners, horse breeding and keeping]
   Combined with Factor 11
   Also some small numbers reassigned

[Original Factor 11 (Dealers with a strong basis in the carrying trade)]
   Coal dealing
   Agricultural produce dealing, and dealers in timber, hay, corn
   High negative loading on:
   Other mining and quarrying (-0.53)
   Combined with Factor 9

5: Factor 6 (Major transport, transport manufacture and military)
   Ship, road & rail vehicle mf
   Ocean, inland and dock transport
   Military
   Retained, but those with small numbers re-assigned

6: Factor 7 (Textiles manufacture)
   Woollen manufacture (woollen goods, carpets, blanket, flannel)
   Cotton & silk manufacture (including ribbon, weaving, dyeing, bleaching etc.)
   Other textile manufacture (flax, hemp, rope, jute, lace, tape, thread)

7: Factor 8 (Tools, instruments and household goods):
   Tool & weapons manufacture
   Watch & instrument manufacture
   Household & personal goods dealer (earthenware, glass, jewellers)
8: **Factor 10 (Apparel and textile maker-dealers)**
   Clothing manufacture (tailors, milliners, hosiery, hats, gloves, umbrellas, buttons, leather)
   Shoe, boot, clog manufacture
   Waterproof goods manufacture (floor & oil cloth, rubber etc.)

9: **Factor 12 (Earthenware and glass manufacture)** one occupational group

10: **No strong loading**

The mapping of the directed 12-Factor study is now reduced to 10 categories, as summarised above, and shown in Figure 15.
Figure 15. Final mapping of RSD factor scores for all occupied.
7. Conclusion

This Working Paper has developed a classification of RSDs for 1891 based on an aggregation of occupational categories into 50 groups. The final results for all occupied (Figure 15) and female all occupied (Figure 13) appear to fit closely to patterns that are well understood from the literature, and in most cases also develop spatial groups without imposition of any contiguity controls, such as could be used for urban areas. These results are a pilot for the application of similar methods to other census years and for the development of the classification for use for a range of analytical purposes, including a classification of the different employment status categories of employers, own account and workers. These developments are summarised in subsequent Working Papers.

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The census database used derives from K. Schürer, E. Higgs, A.M. Reid, E.M Garrett, Integrated Census Microdata, 1851-1911, version V. 2 (I-CeM.2), (2016) [data collection]. UK Data Service, SN: 7481, http://dx.doi.org/10.5255/UKDA-SN-7481-1; enhanced; E. Higgs, C. Jones, K. Schürer and A. Wilkinson, Integrated Census Microdata (I-CeM) Guide, 2nd ed. (Colchester: Department of History, University of Essex, 2015). A special acknowledgement of thanks is made to Kevin Schürer for advice and all his help in developing improved versions of I-CeM, and to Alice Reid, Eilidh Garrett, Joe Day, Hanna Jaadla, Xuesheng You, Leigh Shaw-Taylor and other members of the Campop I-CeM group who, with the authors, have collectively worked on the new versions of I-CeM.

The GIS boundary files for RSDs were constructed by Joe Day for the ESRC fertility project directed by Alice Reid:

http://www.geog.cam.ac.uk/research/projects/victorianfertilitydecline/publications.html


References


**Other Working Papers:**


WP 2: Bennett, Robert J., Smith Harry J. and van Lieshout, Carry (2017) *Employers and the self-employed in the censuses 1851-1911: The census as a source for identifying entrepreneurs, business numbers and size distribution*.


WP 6: Smith, Harry J. and Bennett, Robert J. (2017) *Urban-Rural Classification using Census data, 1851-1911*.


WP 8: Bennett, Robert J., Smith, Harry, and Radicic, Dragana (2017) *Classification of occupations for economically active: Factor analysis of Registration Sub-Districts (RSDs) in 1891*.

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