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Evidence on the within-industry agglomeration of R&D, production, and administrative occupations

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Abstract

To date, most empirical studies of industrial agglomeration rely on data where observations are assigned an industry code based on classification systems such as NAICS in North America and NACE in Europe. This study combines industry data with occupation data to show that there are important differences in the spatial patterns of occupation groups *within* the widely used industry definitions. We focus on workers in manufacturing industries, whose occupations almost always fit into three groups: production, administrative, or R&D. We then employ two approaches to document the spatial distributions of each group within an industry. First, we calculate the distribution of employment shares across local labor markets and second, we calculate a version of the Duranton and Overman (2005) agglomeration index. Both approaches reveal appreciable differences in the spatial distribution of occupation groups within most manufacturing industries. These differences have important implications for our understanding of the sources of industrial agglomeration, the spatial agglomeration of innovation, the effectiveness of local economic development initiatives, and the spatial properties of particular industries.

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1 Introduction

The geographic concentration of industries – such as high-tech in Silicon Valley and autos in Detroit – has fascinated researchers and practitioners going back at least to Alfred Marshall (1890). This is because industrial agglomeration plays an important role in a variety of research and practical fields, including economic growth, industrial organization, international trade, business strategy, local economic development, local public finance, and urban planning. While theories of industrial agglomeration have been well developed for some time, empirical studies that test the theories have been published only somewhat recently. To date, these studies have primarily relied on data where observations are assigned an industry code base on classification systems such as NAICS in North America and NACE in Europe.[1] This study shows that there are notable differences in the spatial patterns of occupation groups *within* these industry definitions, which can have important implications for our understanding of the nature and effects of industrial agglomeration.

We are able to look within the black box of industry definitions because we use worker-level data from the American Community Survey (ACS) rather than establishment-level data, such as County Business Patterns. The ACS asks workers to specify their place of work, industry, and occupation. We sort the Census occupation codes into twelve large groups based on the similarity of the tasks the occupation titles describe. Following the earlier literature on industrial agglomeration, and to simplify our analysis, we focus on manufacturing industries. In that sector, production functions are similar to the extent that over 80% of workers fall into either the production, administrative, or R&D[2] occupation groups.

We use two approaches to document the differences in the spatial distributions of occupation groups within an industry. First, for each group within an industry, we calculate the distribution of employment shares across local labor markets. The idea behind this approach is that since the industry classification systems delineate industries based on the similarity of establishments' production functions, we would expect the share of employment for an occupation group in any given local labor market to be close to that of the industry as a whole. That is, if 50% of all the workers in paper mills in the US are production workers, then we would expect to find that about 50% of the workers in paper mills in the Lake Winnebago, Wisconsin region are production workers. Overall, we find little evidence for that type of relationship. Instead, we find notable variation in employment shares for most occupation groups across local labor markets in most industries, with the largest variation typically for R&D shares.

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[1] These classification systems generally seek to delineate industries based on the similarity of the production functions of establishments, though some industry definitions are based on the similarity of the product produced (Economic Classification Policy Committee 1993).

[2] Note that because we are using occupation titles to identify R&D workers, our definition of R&D activity necessarily differs from the literature on R&D labs.

Our second approach is to calculate a worker-level (rather than establishment-level) version of the Duranton and Overman (2005) agglomeration index for each occupation group within an industry. The idea behind this approach is that if occupation groups have different agglomeration index values, their spatial distributions must be different. Here too, we find notable differences in occupation groups' index values. In particular, we find that in most industries, R&D employment is the most concentrated, followed by administrative employment, and then production employment.

The presence of agglomeration by occupation groups within industries is relevant to the many research fields where industrial agglomeration plays an important role. The most direct application is to the empirical literature on the sources of industrial agglomeration, which has made tangible progress in the past two decades (Combes and Gobillon 2015). The aim of this literature is to quantify the relative importance of the theories put forth by Marshall (1890) for what causes agglomeration economies. Marshall suggested that industries agglomerate and coagglomerate to reduce the costs of transporting goods, people, and ideas. Thus firms in the same industry cluster near customers or suppliers, cluster to share in the same local labor force, or to take advantage of intellectual spillovers. An additional explanation that has developed since Marshall is that industries cluster in areas with natural advantages, such as the wine industry in Napa Valley, where the soil and climate are particularly well suited to wine production. To distinguish between these explanations, empirical studies have constructed quantitative measures that aim to proxy for the possible sources of agglomeration economies and used these measures to try to explain the variation in the agglomeration or coagglomeration indexes of industries. Because it is likely that within-industry occupation groups cluster for different reasons, studies that incorporate such information may be able to obtain further precision in their estimates beyond what is in the current literature.

Our study also relates to the literature on the spatial agglomeration of innovation. This line of research documents the highly concentrated nature of innovation in space – which is consistent with our finding that R&D workers are the most concentrated within industries – and seeks to understand why this is the case (Carlino and Kerr 2015). The primary sources of data for the literature are the locations of R&D labs, R&D spending, and patents and citations. The results of our study suggest that the location of R&D workers could be an additional useful source of information on where innovation happens.

The results of this study are relevant for the literature on local economic development and place-based policies (Bartik 2012, Neumark and Simpson 2015). To the extent that such policies seek to support or develop an industrial cluster, it could be very important to account for the within-industry characteristics of the workforce needed for the cluster. For example, should a partnership between the firms in an industrial cluster and local educational institutions focus on developing engineers with 4-year degrees or developing skilled machine operators?

Finally, the results of our study can also be useful for the study of particular industries. For example, the declining share of motor vehicle production in the traditional Midwestern locations and the shift of the industry southward is well documented (see e.g. Klier and McMillen, 2008). Yet, this development does not seem to have affected the viability of the automotive R&D cluster, which remains centered in Detroit, and seems as strong today as it has been for quite some time (Hannigan, Cano-Kollmann and Mudambi 2015, Klier, Testa and Walstrum 2014, Walstrum and Testa 2013).

2 Data description

Most studies of industrial agglomeration in the US use establishment-level data such as the Annual Survey of Manufactures or County Business Patterns. Unfortunately, these sources provide little information on the types of work that takes place in the establishments, which we show can vary widely for manufacturers. For example, a firm can have separate R&D labs and production plants that are separate establishments, but that are treated as identical in establishment-based datasets. To look within the black box of the industry definitions that the establishment data rely on, we use worker-level data from the public 2010-14 ACS, as provided by IPUMS (Ruggles, et al. 2015). ACS respondents report their age, employment status, work location, industry, and, importantly, their occupation. We include in our analysis anyone over age 16 who reports being employed.

To delineate local labor markets, we use commuting zone definitions (year 2000 version) created by the US Department of Agriculture's Economic Research Service. Commuting zones (CZs) cover the entire United States, which is an advantage over the US Office of Management and Budget's Metropolitan Statistical Areas (MSAs), which cover only urban areas. Like MSAs, CZs are a set of adjacent counties. The ACS identifies a respondent's place of work as within the boundaries of a Public Use Microdata Area (PUMA), which are drawn by the Census Bureau to contain roughly 100,000 people. Thus PUMAs in urban areas can cover very small land areas, while PUMAs in rural areas can cover multiple counties. Because PUMA boundaries are not county-based, occasionally, a PUMA overlaps more than one commuting zone. In this case, we use a crosswalk between counties and PUMAs generated by the Missouri Census Data Center's MABLE/Geocorr14 geographic correspondence engine. We multiply the crosswalk's population weights by the individual sampling weights in the ACS, so that the observations for individuals in PUMAs that fall in more than on CZ are split across the CZ based on the share of the PUMA's population in each county.

Industry is defined by the 2012 Census industry classification system, which is based on the NAICS and at roughly the same aggregation level as the 4-digit NAICS.

We use the occupation codex created by IPUMS called *OCC1990* that is based on Census occupation codes, but consolidated so that they are consistent across Census years from the present back to 1950. We then sort workers into one of 12 occupation groups based on their occupation titles. Appendix table A1 lists the occupation codes, occupation titles, and the

groups we assign to them. Table 1 shows the distribution of workers by occupation for all industries and for manufacturing industries. Across all industries, administrative workers are the largest group (25.7%), followed by production (12.5%). The ranking switches for manufacturing industries, with 45.8% of workers in the production group and 22.8% in the administrative group. R&D workers are the next largest group in manufacturing, representing 12.6% of workers. This share is much larger than for all industries together, where only 6.4% of workers are in R&D occupations. Figure 1 shows the distribution of occupation group shares across manufacturing industries. Production shares vary the most, while administrative and R&D shares are more uniform.

Table 1 also shows that there are a number of occupation types that are closely tied to particular non-manufacturing industries. For example, educators largely serve in the education industry and farmers work almost exclusively in the farming industry. However, some ACS survey respondents say they are farmers working in a manufacturing industry. While it is possible that there are some food growers employed by manufacturing firms, it is likely that Census Bureau misclassified such workers' industries or occupations. That said, it appears that the number of misclassifications is small. Moreover, our subsequent analysis focuses on production, administrative, and R&D workers. It is possible that some of these workers' occupations are misclassified, but the measurement error is also likely to be small.

3 Methodology

We use two approaches to document the differences in the spatial distributions of occupation groups within a manufacturing industry. First, we calculate the distribution of employment shares by occupation group across local labor markets as defined by CZs. For example, for workers in the dairy product manufacturing industry, for each local labor market, we calculate the share of workers who are in the production group. We then compare the distribution of local labor market shares to the overall share of production workers in dairy product manufacturing. If there is a large variance in the distribution of shares, we can conclude that the spatial distributions of within-industry occupation group are unique. To assess the size of the variance, we calculate the absolute percentage distance of each CZ's occupation share from the overall industry share:

$$Absolute\ percentage\ distance = 100 \cdot \left| \frac{Occupation\ Share_{CZ}}{Occupation\ Share_{Ind}} - 1 \right|.$$

We then calculate for each occupation group the share of an industry's workers who live in commuting zones where the absolute percentage distance is greater than 25% and 50%. We focus on the 53 of 80 manufacturing industries that have at least 20 commuting zones with more than 50 observations.

To measure the agglomeration of the occupation groups, we use the index created by Duranton and Overman (Duranton and Overman 2005). The DO index was designed to be calculated at the establishment level and is based on a nonparametric estimate of the probability density function of the pairwise distances between establishments. Thus the distribution's mean is the mean distance between establishments. Our data are at the worker level and in calculating the index we treat each worker as an "establishment".

Calculating an agglomeration index requires a counterfactual distribution. The most common counterfactuals used in the literature to date are the distribution of overall employment and the distribution of overall manufacturing employment. Because we focus on manufacturing industries, we use the distribution of overall manufacturing employment as our counterfactual. An industry or occupation group exhibits agglomeration if the distribution of distances between its workers is more concentrated at smaller distances than the overall distribution of the distances between manufacturing workers.

A nonparametric estimate of the distribution of pairwise distances between n establishments is the summation of $\frac{n(n-1)}{2}$ Gaussian kernel functions, giving a kernel density function of:

$$\widehat{K} = \frac{2}{n(n-1)h}\sum_{r=1}^{n-1}\sum_{s=r+1}^{n} f\left(\frac{d-d_{rs}}{h}\right),$$

where $d_{r,s}$ is the distance between establishments r and s and $f(\cdot)$ is a Gaussian kernel function with bandwidth h.[3]

To calculate distances, we would ideally have the exact address of a worker's place of work. In this case, we only know that the place of work is somewhere within a PUMA, so we use the Euclidian distances between PUMA centroids as the measure of the distance between workers.

Because PUMAs contain multiple workers ("establishments") with identical distance profiles, we calculate $\widehat{K}$ at the PUMA level, weighting by employment levels in the PUMA:

$$\widehat{K} = \frac{2}{\sum_{r=1}^{n}\sum_{s=r}^{n} w_{rs}}\sum_{r=1}^{n}\sum_{s=r}^{n} w_{rs} f\left(\frac{d-d_{rs}}{h}\right),$$

where

$$w_{rs} = emp_r emp_s \; if \; r \neq s$$
$$w_{rs} = \binom{emp_r}{2} \; if \; r = s.$$

[3] For the bandwidth, we follow the standard approach in the literature, which is to use the optimal bandwidth derived by Silverman (1986), $1.06sn^{-0.2}$, where s is the standard deviation of the $n(n-1)$ distance.

We make a final adjustment so that $\widehat{K}$ does not have any positive density over negative distances. This problem arises because the kernels are symmetrical so that when individuals have very short distances between them, some of the affiliated kernel will be in negative territory. One solution, proposed by Silverman (1986), is to reflect the density for negative distances over the zero line. For example, any density at $d = -3$ is added to the density at $d = 3$. This adjustment results in the kernel density function

$$\widehat{K} = \frac{2}{\sum_{r=1}^{n}\sum_{s=r}^{n} w_{rs}} \sum_{r=1}^{n}\sum_{s=r}^{n} w_{rs}\left[f\left(\frac{d-d_{rs}}{h}\right) + f\left(\frac{-d-d_{rs}}{h}\right)\right] \; for\; d > 0,$$

$$\widehat{K} = 0 \; for\; d \leq 0.$$

The DO agglomeration index is the sum of the differences in densities from zero miles up to a selected threshold. This is equivalent to the difference in the CDFs of the kernel density functions at a given distance. Formally, the index is:

$$\Gamma_{ind} = \int_{0}^{threshold} \widehat{K}_{ind}(d) - \widehat{K}_{mfg}(d)\, dd$$

We also calculate an alternate version of the index, which is the ratio of the CDFs of the kernel density functions at a given distance. We believe this version is easier to interpret in the context of this paper as it tells us how many times greater the share of pairwise distances under a certain threshold is for an industry or occupation group. Formally, the alternative "ratio" version of the index is:

$$\mathrm{P}_{ind} = \int_{0}^{threshold} \frac{\widehat{K}_{ind}(d)}{\widehat{K}_{mfg}(d)} dd$$

The value of the index hinges critically on the choice of threshold. The literature provides some guidance on the choice. Duranton and Overman (2005) use the median establishment-to-establishment distance in their UK-based data, which is 112 miles (180 kilometers). Ellison, Glaeser, and Kerr (2010) estimate a median plant distance of around 1,000 miles in their US-based data, calculate the index using thresholds ranging from 100 to 1,000 miles, and use the 250-mile threshold for their primary results. Ellison, Glaeser, and Kerr (2010) note that the large geographic area of the lower 48 states in US makes it harder to pick a threshold and that to date there is no theory to dictate the threshold.

In this paper we report index values at the 100 and 250 mile threshold, and our preferred threshold is 100 miles. Our logic for the 100 mile preference is that a 100 mile diameter circle covers most metropolitan areas, but goes no further, so that the measure is not diluted by the relatively sparsely populated areas between metropolitan areas. Thus one way to think of the agglomeration index at this threshold is it that counts the number of metropolitan areas with a significant cluster: the lower the number, the greater the index. At 250 miles and greater

distances, the index has the advantage of capturing possible linkages between neighboring metropolitan areas, but at the expense of additional noise.

4 A case study of the auto industry

The auto industry is an archetype of the clustering of occupation groups within an industry and thus serves as a useful case study. In this section, we document the spatial distribution of the auto industry's R&D, production, and administrative occupation groups and show how their distributions differ using the methodology detailed in section 3.

Figure 2 shows a dot distribution of all auto workers in the continental US from the 2014 ACS, where there are 2,500 dots and one dot equals 0.04% of workers. While there is some employment in the heavily populated coastal areas, the auto industry is clearly concentrated in the middle of the country, starting in the Detroit area and extending south along what is known as Auto Alley. Figure 3 provides a picture inside the overall spatial distribution of auto workers, with a separate map for production, administrative, and R&D workers. While all types of workers are concentrated in the Detroit area, production workers appear to be the most spread out, with greater density in Auto Alley and the Appalachians. Administrative and R&D workers also appear to be more concentrated in urban areas.

Our first approach to quantitatively documenting these visual differences is to examine the distribution of employment shares by occupation group across local labor markets. The idea of this approach is that if the establishments within an industry have similar production functions, the employment shares of the occupation groups should be similar across local labor markets. Figure 4 shows maps for each of the occupation groups where we color-coded CZs based on how close they are to the occupation group's countrywide share of industry employment. For example, panel C shows R&D worker shares across CZs. R&D workers make up about 12% of all autoworkers, and we assign yellow to commuting zones whose shares are plus or minus 25% percent of 12% (i.e., shares that range from 9% to 15%). In red commuting zones, the share is more than 50% of the overall industry share (i.e., greater than 18%) and in dark green commuting zones, the share is less than 50% of the overall industry share (i.e., less than 6%). Of particular importance in the case of the auto industry, the Detroit CZ (where about 16% of all autoworkers work) is red. About 28% of autoworkers in the Detroit CZ are R&D workers, which is over twice the share of the auto industry as a whole.

We summarize the maps from figure 4 in figures 5 and 6. Figure 5 shows the distribution of employment shares by occupation groups across CZs as a histogram. Returning to the R&D distribution, panel C shows that around 75% of commuting zones have an R&D employment share that is less than the industrywide share and that around 60% of CZs have an R&D employment share that is 25% less than the industrywide share. This is strong evidence that auto R&D workers are not evenly distributed across local labor markets.

We also want to take into account that auto employment is not evenly distributed across the CZs that have auto employment. As we noted earlier, 16% of all autoworkers work in one CZ, Detroit. For this reason, we also calculate the distributions of occupation group shares across CZs weighted by the CZ's total auto industry employment. Again turning to the R&D group, figure 6 panel C shows that around 40% of all autoworkers work in a CZ whose share of R&D workers is at least 25% percent less than the overall industry share. In addition, 26% of autoworkers work in a CZ whose share of R&D workers is at least 25% more than the overall industry share (70% of those workers work in the Detroit CZ). This too is strong evidence that auto R&D workers are not evenly distributed across local labor markets.

We now apply our second approach for documenting differences in the spatial patterns of occupation groups within industries to the auto industry. We use the DO agglomeration index, which is based on the kernel density function (KDF) of pairwise distances between establishments, or in our case, workers. Figure 7 shows the KDFs for the occupation groups in the auto industry compared to the KDF for all manufacturing workers. All three occupation groups are clearly more concentrated than manufacturing as a whole (that is, they have a much larger share of pairwise distances at low mileages), but it is also clear that there are differences between the groups. R&D is far more concentrated than the other groups, and the distributions for administrative and R&D workers are slightly bimodal.

Table 2 shows values of the DO index for the auto industry as a whole and the occupation groups within it when calculated using either a 100- or 250-mile threshold. At the 100-mile threshold, the standard (0.176) and ratio (7.2) versions of the index confirm that R&D employment is the most concentrated. The ratio version of the index indicates that the share of pairwise distances that are less than 100 miles is 7.2 times larger for R&D autoworkers than for all manufacturing workers. Administrative and production autoworkers are still quite concentrated (with ratios of 3.6 and 2.5), but notably less so than R&D autoworkers. At the 250-mile threshold, R&D autoworkers are still much more concentrated than other autoworkers, but there is no difference in the concentration of administrative and production workers.

5 Results for all manufacturing industries

While the auto industry is an archetype for within-industry agglomeration by occupation group, we find that occupation groups have agglomerate within most other manufacturing industries as well. We first document the extent to which occupation group shares in CZs differ from their industry's overall share.

Figure 8 shows the distribution across industries and occupation groups of the share of workers living in CZs where the absolute percentage distance is greater than 25%. Summary statistics for the distributions are given in table 3. As in the auto industry, the variance of R&D shares across CZs is the largest for most industries. For any manufacturing industry, at least 24% of workers live in a CZ where the absolute percentage difference is greater than 25%. The average is 62%.

Figure 9 shows the distribution across industries and occupation groups of the share of workers living in CZs where the absolute percentage distance is greater than 50%. At this threshold, far fewer workers qualify, particularly in terms of production shares, where for nine industries, zero workers qualify. However, there are many industries where a large share of workers qualify in terms of R&D shares, where the average share of workers is 34% and goes as high as 78%.

We now turn to evidence on within-industry clustering of occupation groups based on DO agglomeration indexes. Table 4 shows summary statistics for the four versions of the index we calculate for across industries and occupation groups. (Note that the standard and ratio versions of the index inherently tell the same story because their formulas are closely related.) In line with the literature, the agglomeration indexes we calculate indicate that most manufacturing industries agglomerate, with an average standard version index value of 0.02 at the 100-mile threshold and 0.04 at the 250-mile threshold. The ratio versions of the indexes indicate that the average industry is 1.89 times more concentrated than manufacturing employment as a whole at the 100-mile threshold and 1.42 times more concentrated at the 250-mile threshold. Once again in line with the literature, the indexes we calculate indicate that there is a lot of variation across industries in their degree of concentration, with some industries not concentrated at all (standard version index values of less than zero, ratio version index values of less than 1) and some industries highly concentrated.

The agglomeration patterns of occupation groups within industries are quite similar to those of the auto industry. Administrative employment tends to be more concentrated than production employment at the 100-mile threshold, but not at the 250-mile threshold. R&D employment is the most concentrated, with an average 100-mile ratio index of 2.8, compared to an average production index of 1.9, and an average administrative index of 2.1. Figure 10 shows the full distributions of the 100-mile threshold ratio version index across industries and occupation groups. While index values for most industries fall between 1 and 2 for all occupation groups, it is clear that the R&D distribution is the widest and most skewed away from 1, followed by the administrative distribution, and, finally, the production distribution.

We explicitly compare the occupation group index values for all versions of the index in table 5. For the standard indexes, we calculate the *difference* between the R&D index and either the production or administrative index. For the ratio indexes, we calculate the *ratio* of the R&D index to either the production or administrative index. On average, at the 100-mile threshold, R&D employment is 56% more concentrated than production employment and 33% more concentrated than administrative employment. At the 250-mile threshold, R&D employment is about 20% more concentrated on average than both production and administrative employment.

It is also worth noting that there is some variation across industries in how different their occupation group indexes are. For a small minority of industries, R&D employment is less concentrated than production or administrative employment. There are also a handful of

industries where R&D is substantially more concentrated. Figure 11 presents the full distribution of the ratio of the R&D index to either the production or administrative index for the 100-mile ratio version of the index. Most of the ratios are greater than 1.25 and many are greater than 1.5, values that represent a notable difference in the degree of concentration. Figure 11 makes clear, then, that for most manufacturing industries, occupation groups have different spatial footprints.

6 Conclusion

This paper provides evidence that occupation groups within industries have unique spatial patterns. We show this using two approaches. First, we document variation across local labor markets in occupation groups' shares of employment. We find that for most manufacturing industries and most occupation groups, there are many local labor markets where an occupation group's share is much larger or smaller than its overall industry share. Our second approach is to calculate agglomeration indexes for occupation groups. This approach reveals notable differences for most manufacturing industries in the degree of concentration of occupation groups, particularly when comparing R&D to production occupations. These differences provide strong evidence for a broad-based pattern of different spatial footprints for occupation groups within manufacturing industries.

We hope that our finding will filter into the wide array of research topics where industrial agglomeration plays a role, including the literatures on the sources of industrial agglomeration, the spatial agglomeration of innovation, and local economic development. For example, R&D occupations likely cluster to take advantage of knowledge spillovers and labor market pooling, while production occupations likely cluster to take advantage of supplier linkages and proximity to customers. Because there are likely different forces behind the agglomeration of R&D and production occupation groups, the variation in their spatial patterns could help further clarify the relative importance of the sources of industrial agglomeration. The literature on the spatial agglomeration of innovation may benefit from the ability to identify the location of R&D workers within industries and possible knowledge sharing linkages across industries. Finally, the literature on local economic development could evaluate, for example, the payoff to subsidies to certain industrial clusters depends on the occupational composition of the cluster.

7 Tables and Figures

Table 1. Distribution of Occupation Types, 2010-14 ACS

	Employment (1000s)		Share	
	All Industries	Manufacturing	All Industries	Manufacturing
Total	144,377	14,967	100.0	100.0
Production	18,113	6,854	12.5	45.8
Administrative	37,164	3,407	25.7	22.8
R&D	9,188	1,887	6.4	12.6
Business Services	9,047	916	6.3	6.1
Transportation	5,982	683	4.1	4.6
Sales	15,718	637	10.9	4.3
Personal Services	15,339	355	10.6	2.4
Education	13,336	< 100	9.2	< 1
Entertainment	6,618	< 100	4.6	< 1
Farming	1,778	< 100	1.2	< 1
Government	10,022	< 100	6.9	< 1
Health	2,073	< 100	1.4	< 1

Table 2. Duranton and Overman Indexes for the Auto Industry

	Standard		Ratio	
	100-mile	250-mile	100-mile	250-mile
All Workers	0.054	0.171	2.9	2.7
Production	0.042	0.167	2.5	2.7
Administrative	0.074	0.169	3.6	2.7
R&D	0.176	0.296	7.2	4.0

Note: The standard version of the index is the share of pairwise distances under a certain mileage threshold for a given group *minus* the share of pairwise distance under the threshold for all manufacturing workers. The ratio version of the index is the share of a given group *divided by* the share for all manufacturing workers.

Table 3. Summary statistics of distribution across industries of share of workers in commuting zones with absolute percentage distance from overall industry share greater than 25% or 50%

	Mean	Std. Dev.	Minimum	Maximum
Share of workers > 25%				
Production	30	21	1	79
Administrative	41	17	13	82
R&D	62	17	24	100
Share of workers > 50%				
Production	7	8	0	31
Administrative	14	12	0	62
R&D	34	18	2	78

Note: Commuting zones with fewer than 50 observations are excluded. Industries with fewer than 20 commuting zones with fewer than 50 observations are excluded. Fifty-three of 80 manufacturing industries meet this requirement.

Table 4. Summary statistics of the Duranton and Overman agglomeration indexes across industries, by version, mileage threshold, and occupation group

	Mean	Std. Dev.	Minimum	Maximum
Standard, 100-mile				
Industry	0.02	0.05	-0.01	0.36
Production	0.02	0.05	-0.01	0.37
Administrative	0.03	0.05	0.00	0.37
R&D	0.05	0.06	0.00	0.36
Standard, 250-mile				
Industry	0.04	0.08	-0.02	0.49
Production	0.04	0.08	-0.02	0.52
Administrative	0.04	0.07	-0.01	0.44
R&D	0.07	0.10	-0.02	0.53
Ratio, 100-mile				
Industry	1.89	1.65	0.77	13.67
Production	1.85	1.73	0.79	14.11
Administrative	2.10	1.72	0.84	14.08
R&D	2.77	2.05	1.07	13.88
Ratio, 250-mile				
Industry	1.42	0.77	0.83	5.87
Production	1.43	0.83	0.82	6.23
Administrative	1.41	0.66	0.88	5.36
R&D	1.73	1.00	0.82	6.27

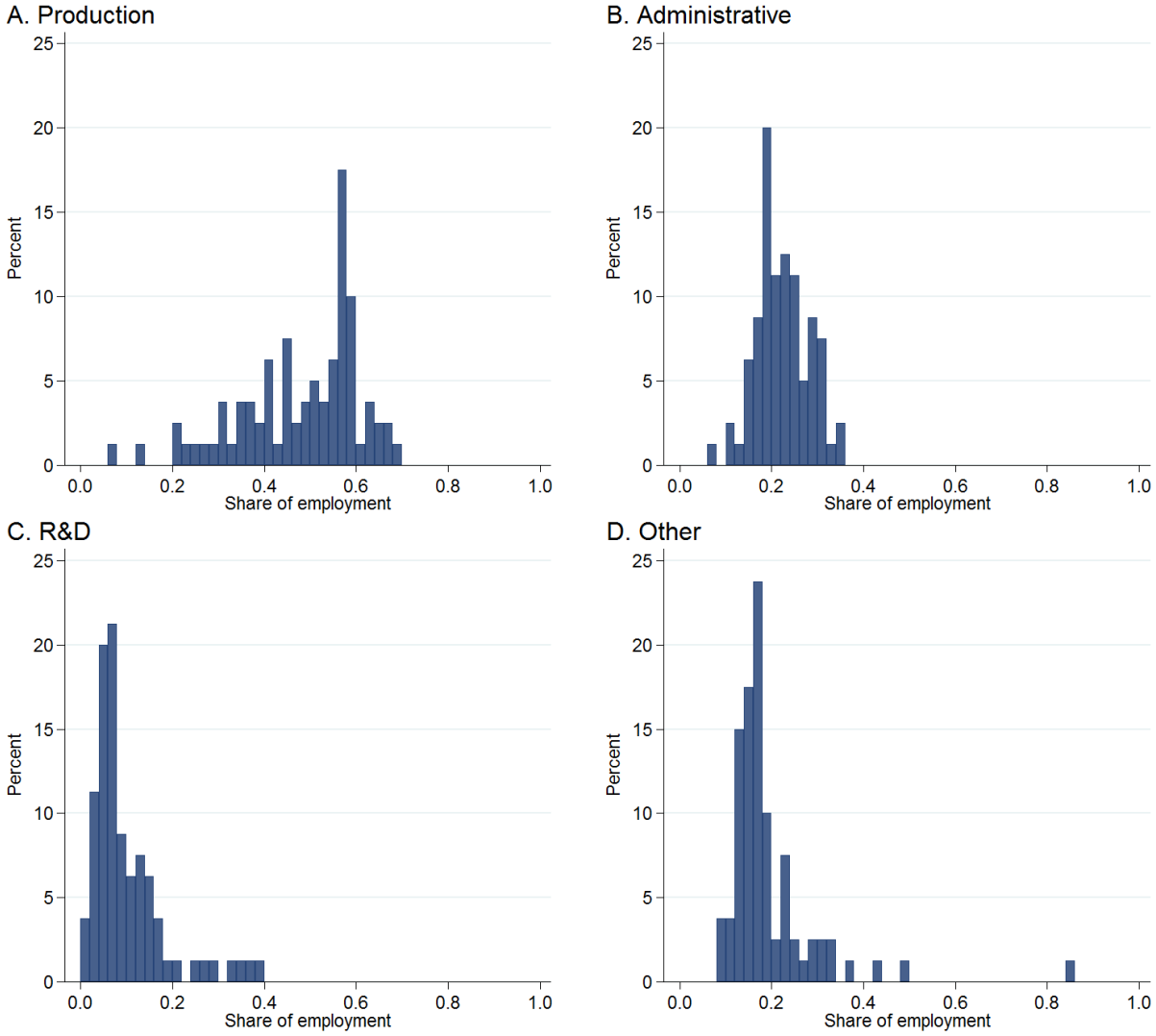
Note: There are 80 manufacturing industries. The standard version of the index is the share of pairwise distances under a certain mileage threshold for a given group minus the share of pairwise distance under the threshold for all manufacturing workers. The ratio version of the index is the share of a given group divided by the share for all manufacturing workers.

Table 5. Summary statistics of the differences between or ratios of the standard or ratio versions of the Duranton and Overman agglomeration index for occupation groups, by mileage threshold

	Mean	Std. Dev.	Minimum	Maximum
Standard, 100-mile				
R&D minus Production	0.03	0.03	-0.01	0.13
R&D minus Administrative	0.02	0.03	-0.05	0.16
Standard, 250-mile				
R&D minus Production	0.03	0.04	-0.02	0.14
R&D minus Administrative	0.03	0.05	-0.01	0.28
Ratio, 100-mile				
R&D divided by Production	1.56	0.52	0.79	3.70
R&D divided by Administrative	1.33	0.38	0.74	3.19
Ratio, 250-mile				
R&D divided by Production	1.21	0.25	0.80	1.89
R&D divided by Administrative	1.20	0.22	0.88	1.92

Note: There are 80 manufacturing industries. The standard version of the index is the share of pairwise distances under a certain mileage threshold for a given group minus the share of pairwise distance under the threshold for all manufacturing workers. The ratio version of the index is the share of a given group divided by the share for all manufacturing workers.

Figure 1. Distribution of of occupation group shares across manufacturing industries



Note: There are 80 manufacturing industries.

Figure 2. Distribution of auto employment, all occupation groups, 2014 ACS (2500 dots, 1 dot = 0.04% of workers)

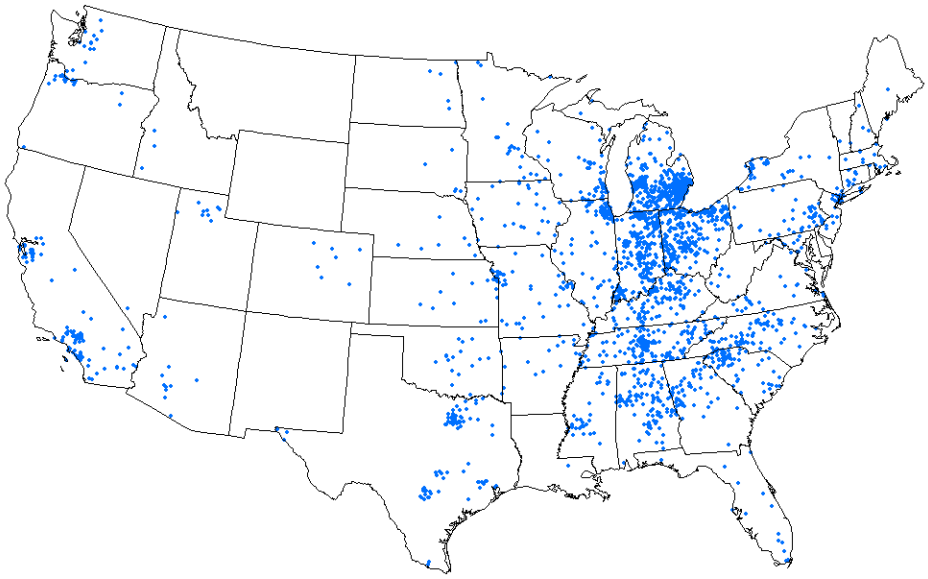
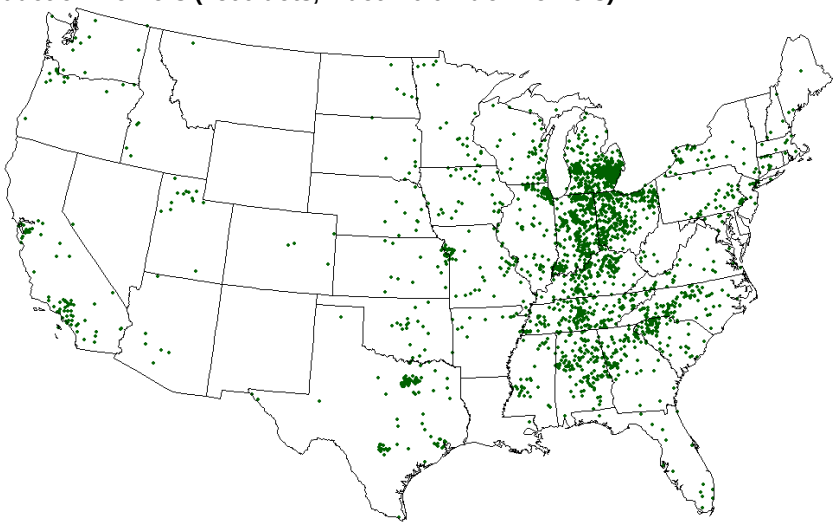
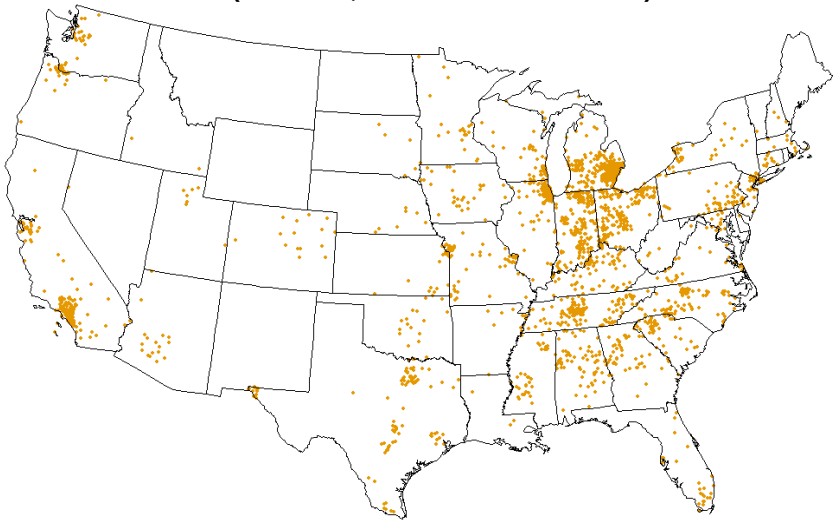


Figure 3. Distribution of auto employment by occupation group, 2014 ACS

A. Auto production workers (2500 dots, 1 dot = 0.04% of workers)



B. Auto administrative workers (2500 dots, 1 dot = 0.04% of workers)



C. Auto R&D workers (2500 dots, 1 dot = 0.04% of workers)

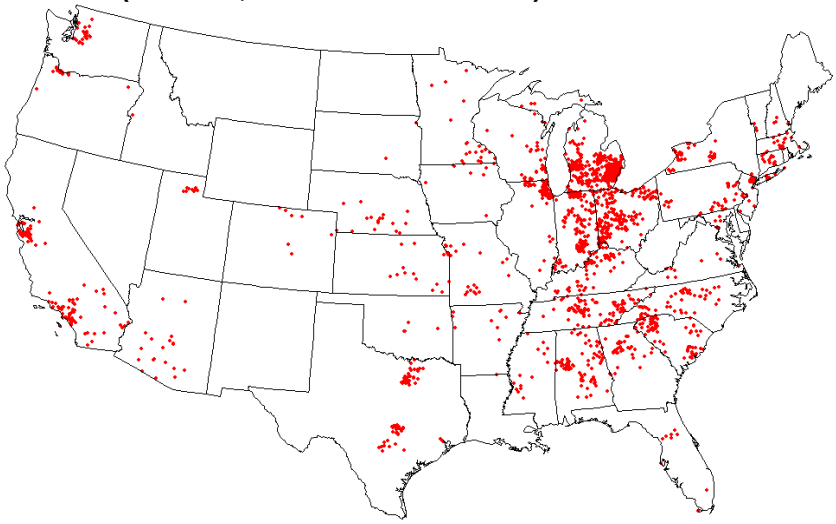
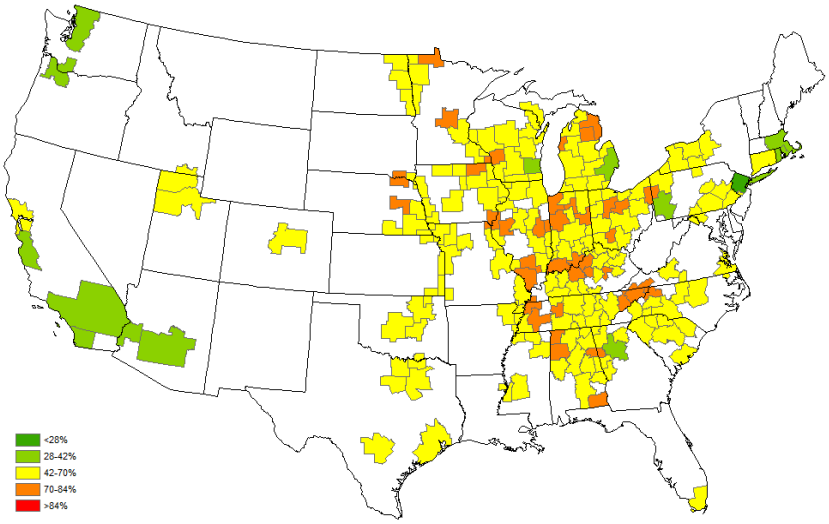
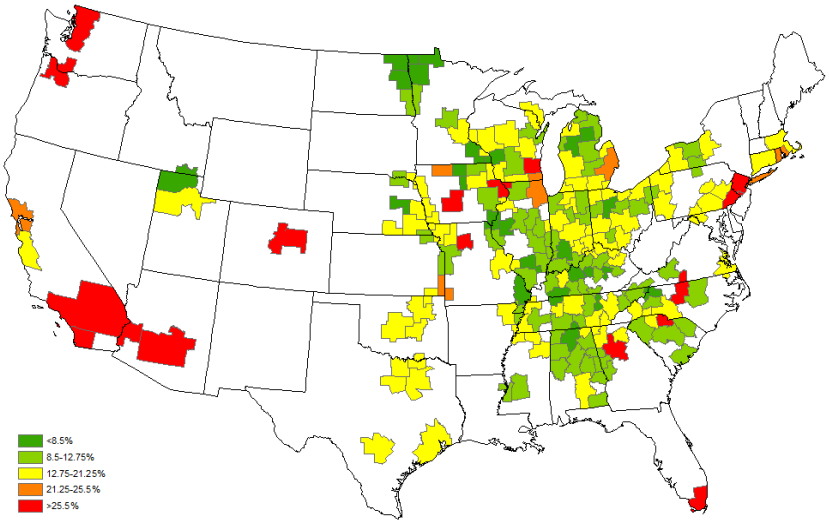


Figure 4. Distribution of auto employment shares by occupation group and commuting zone, 2010-14 ACS

A. Auto production workers



B. Auto administrative workers



C. Auto R&D workers

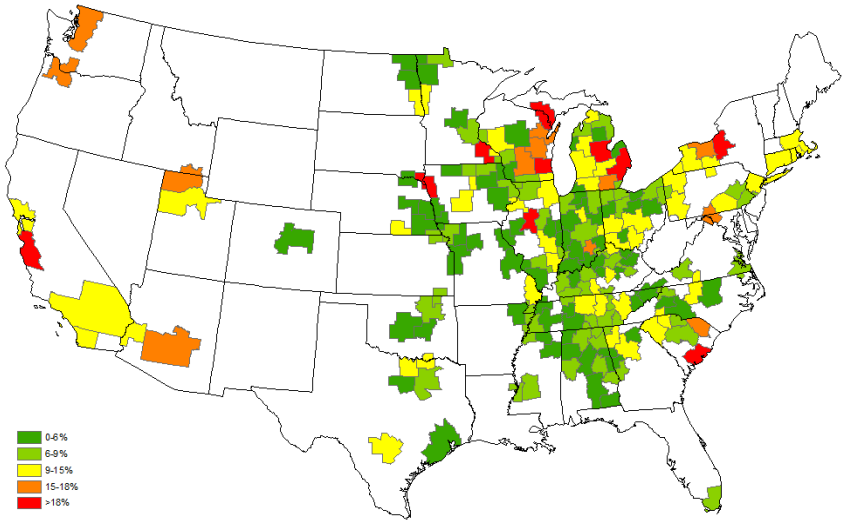


Figure 5. Distribution of auto employment shares by occupation group across commuting zones (solid red line is the industrywide share; dashed red lines are ±25% of the industrywide share), 2010-14 ACS

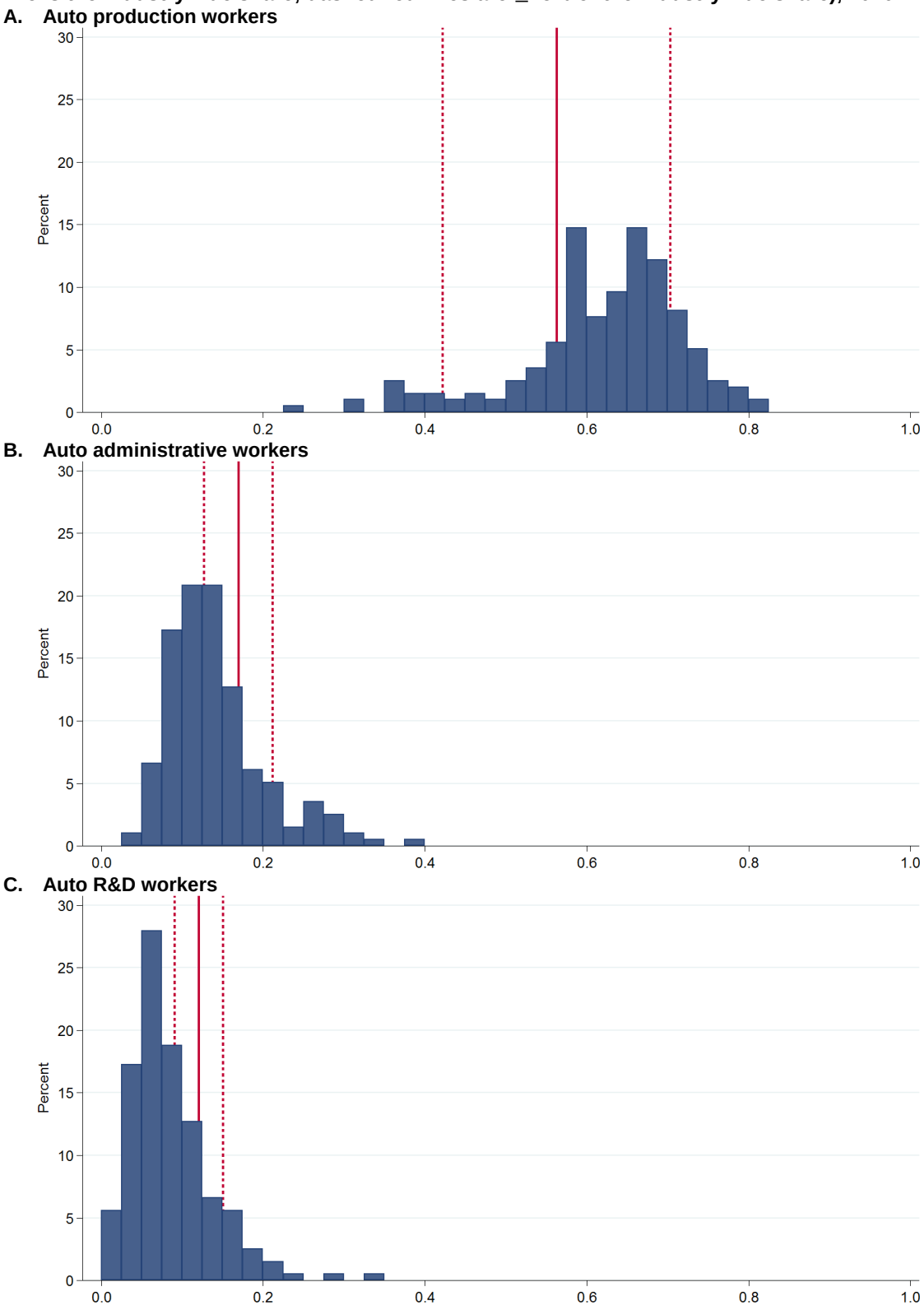


Figure 6. Distribution of auto employment shares by occupation group over commuting zones, weighted by employment

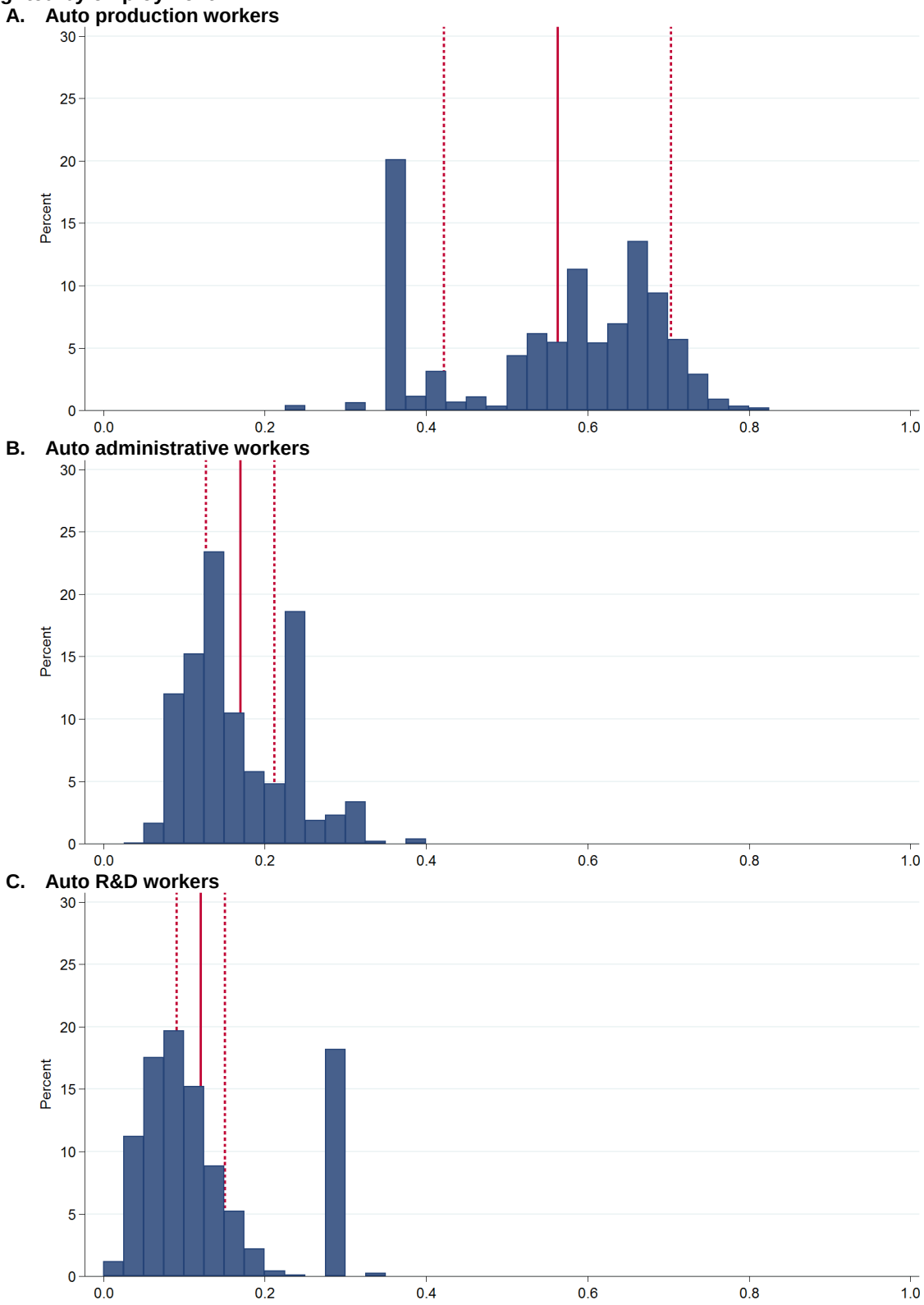
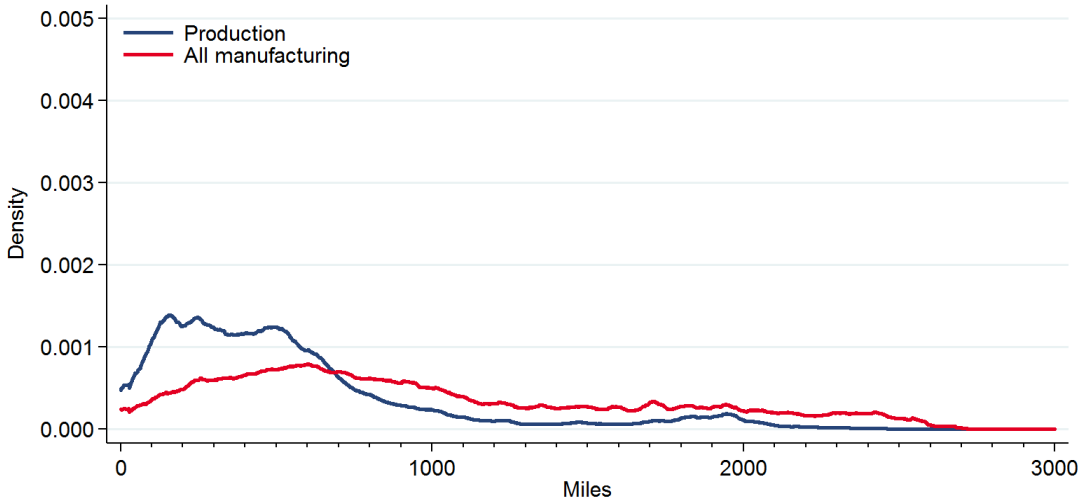
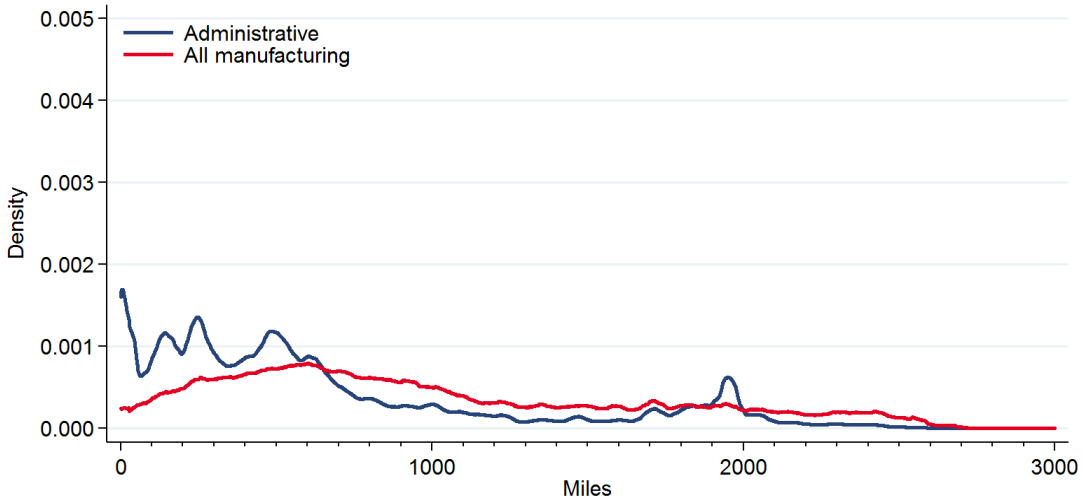


Figure 7. Kernel density function of pairwise distances between workers by occupation group (smoothed using a 25-mile lead, 25-mile lag moving average)

A. Production



B. Administrative



C. R&D

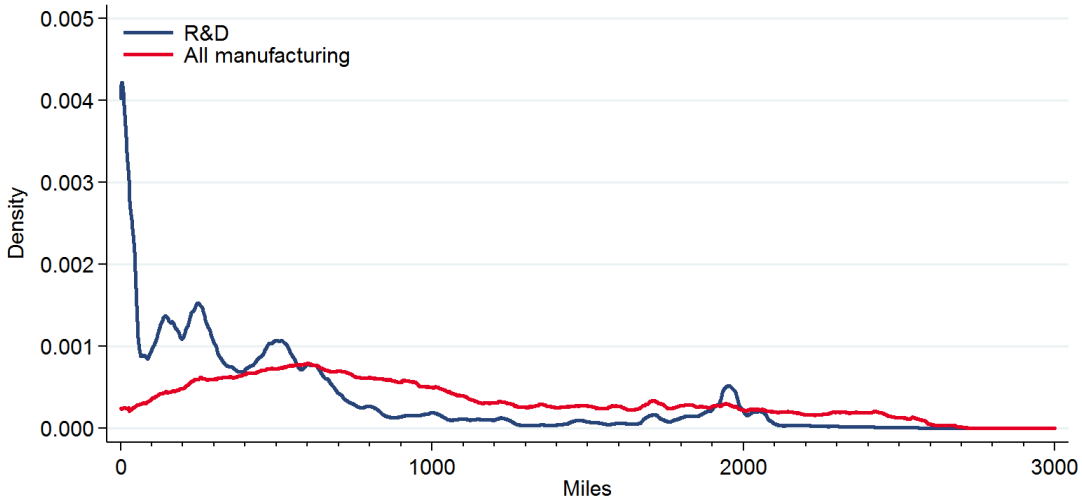
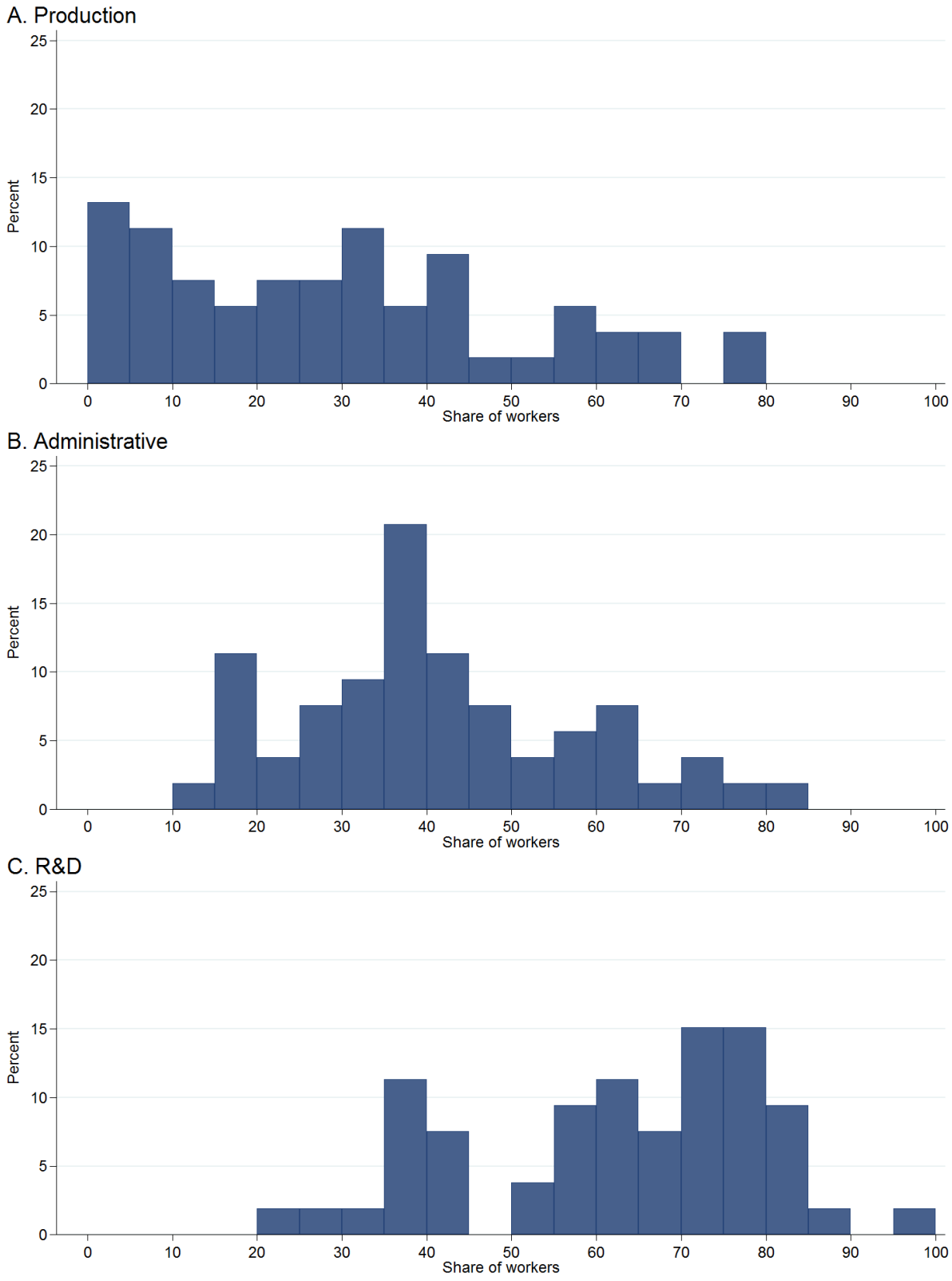
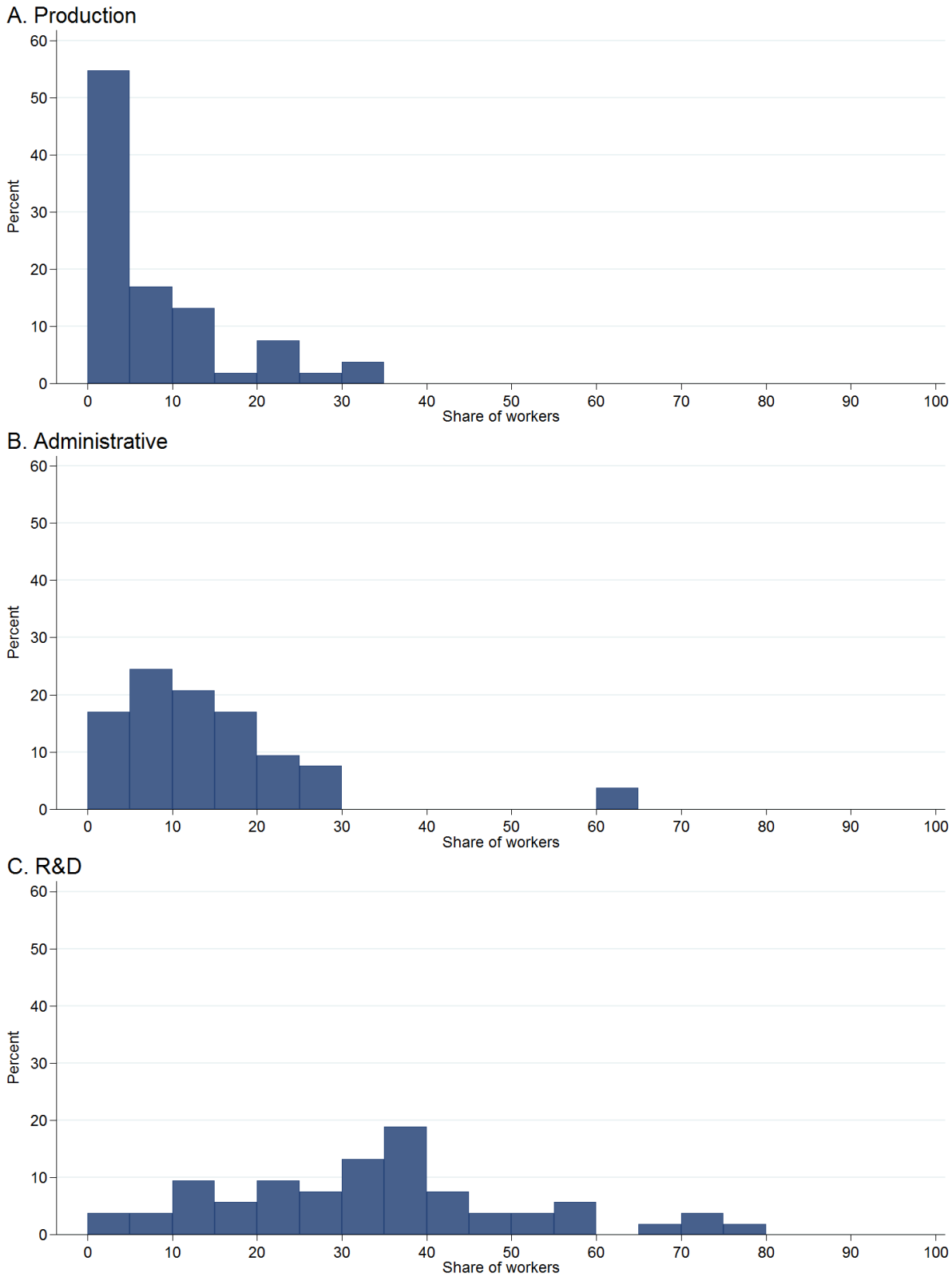


Figure 8. Distribution across industries of share of workers in commuting zones with absolute percentage distance from overall industry share greater than 25, by occupation group



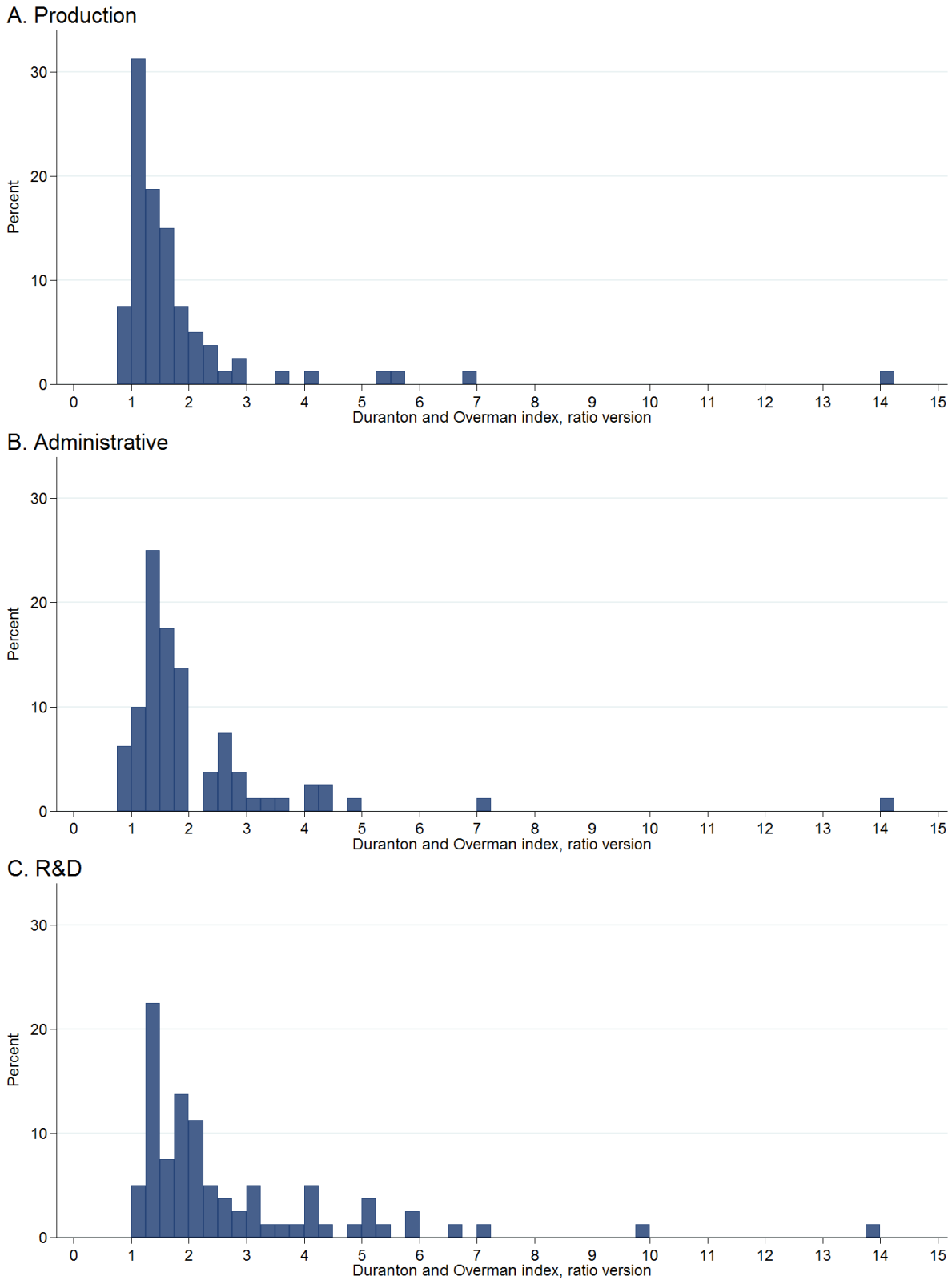
Note: Commuting zones with fewer than 50 observations are excluded. Industries with fewer than 20 commuting zones with fewer than 50 observations are excluded. Fifty-three of 80 manufacturing industries meet this requirement.

Figure 9. Distribution across industries of share of workers in commuting zones with absolute percentage distance from overall industry share greater than 50, by occupation group



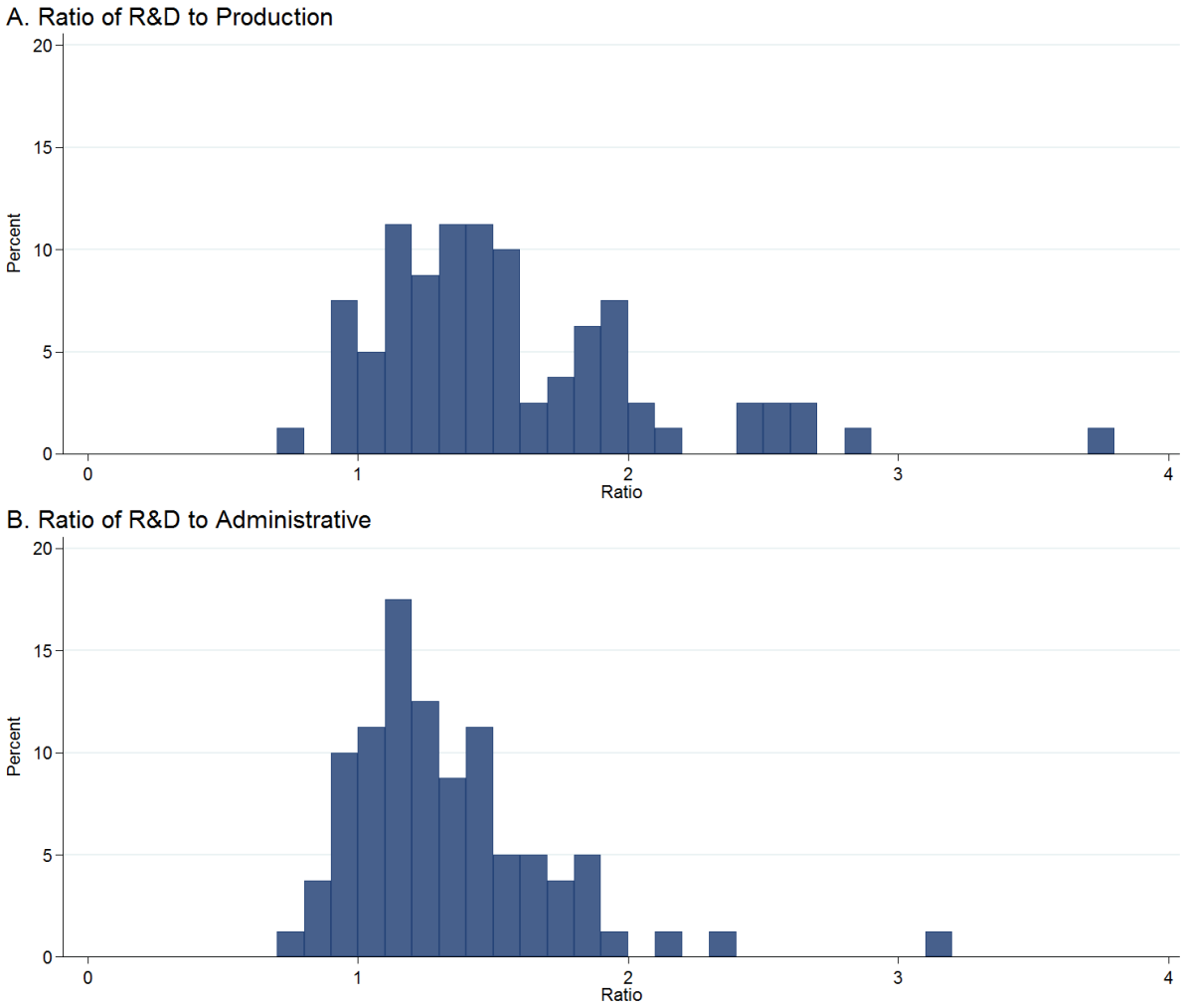
Note: Commuting zones with fewer than 50 observations are excluded. Industries with fewer than 20 commuting zones with fewer than 50 observations are excluded. Fifty-three of 80 manufacturing industries meet this requirement.

Figure 10. Distribution of the 100-mile threshold ratio version of the Duranton and Overman agglomeration indexes across industries, by occupation type



Note: There are 80 manufacturing industries. The ratio version of the index is the share of pairwise distances under a certain mileage threshold for a given group divided by the share of pairwise distance under the threshold for all manufacturing workers.

Figure 11. Distribution across industries of the ratio of the R&D Duranton and Overman index to the productio or administrative index



Note: There are 80 manufacturing industries. All indexes are ratio versions with a 100-mile threshold. The ratio version of the index is the share of pairwise distances under a certain mileage threshold for a given group divided by the share of pairwise distance under the threshold for all manufacturing workers.

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9 Appendix

Table A1. Occupational Classifications

Code	Title	Category
MANAGERIAL AND PROFESSIONAL SPECIALTY OCCUPATIONS		
Executive, Administrative, and Managerial Occupations:		
3	Legislators	Administrative
4	Chief executives and public administrators	Administrative
7	Financial managers	Administrative
8	Human resources and labor relations managers	Administrative
13	Managers and specialists in marketing, advertising, and public relations	Administrative
14	Managers in Education and related fields	Educational
15	Managers of medicine and health occupations	Health
16	Postmasters and mail superintendents	Governmental
17	Managers of food-serving and lodging establishments	Administrative
18	Managers of properties and real estate	Administrative
19	Funeral directors	Administrative
21	Managers of service organizations, n.e.c.	Governmental
22	Managers and administrators, n.e.c.	Administrative
Management Related Occupations:		
23	Accountants and auditors	Administrative
24	Insurance underwriters	Administrative
25	Other financial specialists	Administrative
26	Management analysts	Administrative
27	Personnel, HR, training, and labor relations specialists	Administrative
28	Purchasing agents and buyers, of farm products	Administrative
29	Buyers, wholesale and retail trade	Administrative
33	Purchasing managers, agents and buyers, n.e.c.	Administrative
34	Business and promotion agents	Administrative
35	Construction inspectors	Governmental
36	Inspectors and compliance Administrators, outside construction	Governmental
37	Management support occupations	Administrative
Professional Specialty Occupations		
Engineers, Architects, and Surveyors:		
43	Architects	R&D
Engineers:		
44	Aerospace engineer	R&D
45	Metallurgical and materials engineers, variously phrased	R&D
47	Petroleum, mining, and geological engineers	R&D
48	Chemical engineers	R&D
53	Civil engineers	R&D
55	Electrical engineer	R&D
56	Industrial engineers	R&D
57	Mechanical engineers	R&D
59	Not-elsewhere-classified engineers	R&D
Mathematical and Computer Scientists:		
64	Computer systems analysts and computer scientists	R&D
65	Operations and systems researchers and analysts	R&D
66	Actuaries	R&D
67	Statisticians	R&D
68	Mathematicians and mathematical scientists	R&D
Natural Scientists:		
69	Physicists and astronomers	R&D
73	Chemists	R&D
74	Atmospheric and space scientists	R&D
75	Geologists	R&D
76	Physical scientists, n.e.c.	R&D
77	Agricultural and food scientists	R&D
78	Biological scientists	R&D

Table A1. Occupational Classifications

Code	Title	Category
79	Foresters and conservation scientists	R&D
83	Medical scientists	R&D
Health Diagnosing Occupations:		
84	Physicians	Health
85	Dentists	Health
86	Veterinarians	Health
87	Optometrists	Health
88	Podiatrists	Health
89	Other health and therapy	Health
Health Assessment and Treating Occupations:		
95	Registered nurses	Health
96	Pharmacists	Health
97	Dietitians and nutritionists	Health
Therapists:		
98	Respiratory therapists	Health
99	Occupational therapists	Health
103	Physical therapists	Health
104	Speech therapists	Health
105	Therapists, n.e.c.	Health
106	Physicians' assistants	Health
Teachers, Postsecondary:		
113	Earth, environmental, and marine science instructors	Educational
114	Biological science instructors	Educational
115	Chemistry instructors	Educational
116	Physics instructors	Educational
118	Psychology instructors	Educational
119	Economics instructors	Educational
123	History instructors	Educational
125	Sociology instructors	Educational
127	Engineering instructors	Educational
128	Math instructors	Educational
139	Educational instructors	Educational
145	Law instructors	Educational
147	Theology instructors	Educational
149	Home economics instructors	Educational
150	Humanities profs/instructors, college, n.e.c.	Educational
154	Subject instructors (HS/college)	Educational
Teachers, Except Postsecondary:		
155	Kindergarten and earlier school teachers	Educational
156	Primary school teachers	Educational
157	Secondary school teachers	Educational
158	Special Educational teachers	Educational
159	Teachers , n.e.c.	Educational
163	Vocational and Educational counselors	Educational
Librarians, Archivists, and Curators:		
164	Librarians	R&D
165	Archivists and curators	R&D
Social Scientists and Urban Planners:		
166	Economists, market researchers, and survey researchers	R&D
167	Psychologists	R&D
168	Sociologists	R&D
169	Social scientists, n.e.c.	R&D
173	Urban and regional planners	R&D
Social, Recreation, and Religious Workers:		
174	Social workers	Governmental
175	Recreation workers	Governmental
176	Clergy and religious workers	Governmental

Table A1. Occupational Classifications

Code	Title	Category
Lawyers and Judges:		
178	Lawyers	Administrative
179	Judges	Governmental
Writers, Artists, Entertainers, and Athletes:		
183	Writers and authors	Entertainment
184	Technical writers	R&D
185	Designers	R&D
186	Musician or composer	Entertainment
187	Actors, directors, Producers	Entertainment
188	Art makers: painters, sculptors, craft-artists, and print-makers	Entertainment
189	Photographers	Entertainment
193	Dancers	Entertainment
194	Art/entertainment performers and related	Entertainment
195	Editors and reporters	Entertainment
198	Announcers	Entertainment
199	Athletes, sports instructors, and officials	Entertainment
200	Professionals, n.e.c.	Administrative
TECHNICAL, SALES, AND ADMINISTRATIVE SUPPORT OCCUPATIONS		
Technicians and Related Support Occupations		
Health Technologists and Technicians:		
203	Clinical laboratory technologies and technicians	Health
204	Dental hygienists	Health
205	Health record tech specialists	Health
206	Radiologic tech specialists	Health
207	Licensed practical nurses	Health
208	Health technologists and technicians, n.e.c.	Health
Technologists and Technicians, Except Health		
Engineering and Related Technologists and Technicians:		
213	Electrical and electronic (engineering) technicians	R&D
214	Engineering technicians, n.e.c.	R&D
215	Mechanical engineering technicians	R&D
217	Drafters	R&D
218	Surveyors, cartographers, mapping scientists and technicians	R&D
223	Biological technicians	R&D
Science Technicians:		
224	Chemical technicians	R&D
225	Other science technicians	R&D
Technicians, Except Health, Engineering, and Science:		
226	Airplane pilots and navigators	Transportation
227	Air traffic controllers	Transportation
228	Broadcast equipment operators	Entertainment
229	Computer software developers	R&D
233	Programmers of numerically controlled machine tools	Production
234	Legal assistants, paralegals, legal support, etc.	Administrative
235	Technicians, n.e.c.	Administrative
Sales Occupations:		
243	Supervisors and proprietors of sales jobs	Sales
Sales Representatives, Finance and Business Services:		
253	Insurance sales occupations	Sales
254	Real estate sales occupations	Sales
255	Financial services sales occupations	Sales
256	Advertising and related sales jobs	Sales
Sales Representatives, Commodities:		
258	Sales engineers	Sales
274	Salespersons, n.e.c.	Sales
275	Retail sales clerks	Sales
276	Cashiers	Sales

Table A1. Occupational Classifications

Code	Title	Category
277	Door-to-door sales, street sales, and news vendors	Sales
Sales Related Occupations:		
283	Sales demonstrators / promoters / models	Sales
290	Sales workers--allocated (1990 internal census)	Sales
Administrative Support Occupations, Including Clerical		
Supervisors, Administrative Support Occupations:		
303	Administrative supervisors	Administrative
Computer Equipment Operators:		
308	Computer and peripheral equipment operators	Administrative
Secretaries, Stenographers, and Typists:		
313	Secretaries	Administrative
314	Stenographers	Administrative
315	Typists	Administrative
Information Clerks:		
316	Interviewers, enumerators, and surveyors	Administrative
317	Hotel clerks	Administrative
318	Transportation ticket and reservation agents	Administrative
319	Receptionists	Administrative
323	Information clerks, n.e.c.	Administrative
Records Processing Occupations, Except Financial:		
326	Correspondence and order clerks	Administrative
328	Human resources clerks, except payroll and timekeeping	Administrative
329	Library assistants	R&D
335	File clerks	Administrative
336	Records clerks	Administrative
Financial Records Processing Occupations:		
337	Bookkeepers and accounting and auditing clerks	Administrative
338	Payroll and timekeeping clerks	Administrative
343	Cost and rate clerks (financial records processing)	Administrative
344	Billing clerks and related financial records processing	Administrative
Duplicating, Mail, and Other Administrative Machine Operators:		
345	Duplication machine operators / Administrative machine operators	Administrative
346	Mail and paper handlers	Administrative
347	Administrative machine operators, n.e.c.	Administrative
Communications Equipment Operators:		
348	Telephone operators	Administrative
349	Other telecom operators	Administrative
Mail and Message Distributing Occupations:		
354	Postal clerks, excluding mail carriers	Administrative
355	Mail carriers for postal service	Governmental
356	Mail clerks, outside of post Administrative	Administrative
357	Messengers	Administrative
Material Recording, Scheduling, and Distributing Clerks:		
359	Dispatchers	Administrative
361	Inspectors, n.e.c.	Administrative
364	Shipping and receiving clerks	Transportation
365	Stock and inventory clerks	Administrative
366	Meter readers	Administrative
368	Weighers, measurers, and checkers	Administrative
373	Material recording, scheduling, Production, planning, and expediting clerks	Production
Adjusters and Investigators:		
375	Insurance adjusters, examiners, and investigators	Administrative
376	Customer service reps, investigators and adjusters, except insurance	Administrative
377	Eligibility clerks for government programs; social welfare	Governmental
378	Bill and account collectors	Administrative
Miscellaneous Administrative Support Occupations:		
379	General Administrative clerks	Administrative

Table A1. Occupational Classifications

Code	Title	Category
383	Bank tellers	Administrative
384	Proofreaders	Administrative
385	Data entry keyers	Administrative
386	Statistical clerks	Administrative
387	Teacher's aides	Educational
389	Administrative support jobs, n.e.c.	Administrative
390	Professional, technical, and kindred workers--allocated (1990 internal census)	Administrative
391	Clerical and kindred workers--allocated (1990 internal census)	Administrative
SERVICE OCCUPATIONS		
Private Household Occupations:		
405	Housekeepers, maids, butlers, stewards, and lodging quarters cleaners	Business Services
407	Private household cleaners and servants	Professional Services
408	Private household workers--allocated (1990 internal census)	Professional Services
Protective Service Occupations		
Supervisors, Protective Service Occupations:		
415	Supervisors of guards	Governmental
Firefighting and Fire Prevention Occupations:		
417	Firefighting, prevention, and inspection	Governmental
Police and Detectives:		
418	Police, detectives, and private investigators	Governmental
423	Other law enforcement: sheriffs, bailiffs, correctional institution Administrators	Governmental
Guards:		
425	Crossing guards and bridge tenders	Business Services
426	Guards, watchmen, doorkeepers	Business Services
427	Protective services, n.e.c.	Business Services
Service Occupations, Except Protective and Household		
Food Preparation and Service Occupations:		
434	Bartenders	Professional Services
435	Waiter/waitress	Professional Services
436	Cooks, variously defined	Professional Services
438	Food counter and fountain workers	Professional Services
439	Kitchen workers	Professional Services
443	Waiter's assistant	Professional Services
444	Misc food prep workers	Professional Services
Health Service Occupations:		
445	Dental assistants	Health
446	Health aides, except nursing	Health
447	Nursing aides, orderlies, and attendants	Health
Cleaning and Building Service Occupations, Except Households:		
448	Supervisors of cleaning and building service	Business Services
453	Janitors	Business Services
454	Elevator operators	Business Services
455	Pest control occupations	Business Services
Personal Service Occupations:		
456	Supervisors of personal service jobs, n.e.c.	Professional Services
457	Barbers	Professional Services
458	Hairdressers and cosmetologists	Professional Services
459	Recreation facility attendants	Professional Services
461	Guides	Professional Services
462	Ushers	Professional Services
463	Public transportation attendants and inspectors	Governmental
464	Baggage porters	Professional Services
465	Welfare service aides	Governmental
468	Child care workers	Professional Services
469	Personal service occupations, n.e.c.	Professional Services

Table A1. Occupational Classifications

Code	Title	Category
FARMING, FORESTRY, AND FISHING OCCUPATIONS		
Farm Operators and Managers:		
473	Farmers (owners and tenants)	Farm
474	Horticultural specialty farmers	Farm
475	Farm managers, except for horticultural farms	Farm
476	Managers of horticultural specialty farms	Farm
Other Agricultural and Related Occupations:		
Farm Occupations, Except Managerial:		
479	Farm workers	Farm
480	Farm laborers and farm foreman--allocated (1990 internal census)	Farm
483	Marine life cultivation workers	Farm
484	Nursery farming workers	Farm
Related Agricultural Occupations:		
485	Supervisors of agricultural occupations	Farm
486	Gardeners and groundskeepers	Professional Services
487	Animal caretakers except on farms	Farm
488	Graders and sorters of agricultural products	Farm
489	Inspectors of agricultural products	Farm
Forestry and Logging Occupations:		
496	Timber, logging, and forestry workers	Farm
Fishers, Hunters, and Trappers:		
498	Fishers, hunters, and kindred	Farm
PRECISION Production, CRAFT, AND REPAIR OCCUPATIONS		
Mechanics and Repairers:		
503	Supervisors of mechanics and repairers	Business Services
Mechanics and Repairers, Except Supervisors		
Vehicle and Mobile Equipment Mechanics and Repairers:		
505	Automobile mechanics	Professional Services
507	Bus, truck, and stationary engine mechanics	Business Services
508	Aircraft mechanics	Business Services
509	Small engine repairers	Business Services
514	Auto body repairers	Professional Services
516	Heavy equipment and farm equipment mechanics	Business Services
518	Industrial machinery repairers	Business Services
519	Machinery maintenance occupations	Business Services
Electrical and Electronic Equipment Repairers:		
523	Repairers of industrial electrical equipment	Business Services
525	Repairers of data processing equipment	Business Services
526	Repairers of household appliances and power tools	Professional Services
527	Telecom and line installers and repairers	Business Services
533	Repairers of electrical equipment, n.e.c.	Business Services
534	Heating, air conditioning, and refrigeration mechanics	Professional Services
Miscellaneous Mechanics and Repairers:		
535	Precision makers, repairers, and smiths	Business Services
536	Locksmiths and safe repairers	Business Services
538	Administrative machine repairers and mechanics	Business Services
539	Repairers of mechanical controls and valves	Business Services
543	Elevator installers and repairers	Business Services
544	Millwrights	Business Services
549	Mechanics and repairers, n.e.c.	Business Services
Construction Trades		
Supervisors, Construction Occupations:		
558	Supervisors of construction work	Production
Construction Trades, Except Supervisors:		
563	Masons, tilers, and carpet installers	Production
567	Carpenters	Production
573	Drywall installers	Production

Table A1. Occupational Classifications

Code	Title	Category
575	Electricians	Production
577	Electric power installers and repairers	Production
579	Painters, construction and maintenance	Production
583	Paperhangers	Production
584	Plasterers	Production
585	Plumbers, pipe fitters, and steamfitters	Production
588	Concrete and cement workers	Production
589	Glaziers	Production
593	Insulation workers	Production
594	Paving, surfacing, and tamping equipment operators	Production
595	Roofers and slaters	Production
596	Sheet metal duct installers	Production
597	Structural metal workers	Production
598	Drillers of earth	Production
599	Construction trades, n.e.c.	Production
Extractive Occupations:		
614	Drillers of oil wells	Production
615	Explosives workers	Production
616	Miners	Production
617	Other mining occupations	Production
Precision Production Occupations:		
628	Production supervisors or foremen	Production
Precision Metal Working Occupations:		
634	Tool and die makers and die setters	Production
637	Machinists	Production
643	Boilermakers	Production
644	Precision grinders and filers	Production
645	Patternmakers and model makers	Production
646	Lay-out workers	Production
649	Engravers	Production
653	Tinsmiths, coppersmiths, and sheet metal workers	Production
Precision Woodworking Occupations:		
657	Cabinetmakers and bench carpenters	Production
658	Furniture and wood finishers	Production
659	Other precision woodworkers	Production
Precision Textile, Apparel, and Furnishings Machine Workers:		
666	Dressmakers and seamstresses	Production
667	Tailors	Production
668	Upholsterers	Production
669	Shoe repairers	Professional Services
674	Other precision apparel and fabric workers	Production
Precision Workers, Assorted Materials:		
675	Hand molders and shapers, except jewelers	Production
677	Optical goods workers	Production
678	Dental laboratory and medical appliance technicians	Health
679	Bookbinders	Production
684	Other precision and craft workers	Production
Precision Food Production Occupations:		
686	Butchers and meat cutters	Professional Services
687	Bakers	Professional Services
688	Batch food makers	Professional Services
Precision Inspectors, Testers, and Related Workers:		
693	Adjusters and calibrators	Production
Plant and System Operators:		
694	Water and sewage treatment plant operators	Governmental
695	Power plant operators	Production
696	Plant and system operators, stationary engineers	Production

Table A1. Occupational Classifications

Code	Title	Category
699	Other plant and system operators	Production
OPERATORS, FABRICATORS, AND LABORERS		
Machine Operators, Assemblers, and Inspectors		
Machine Operators and Tenders, Except Precision		
Metal Working and Plastic Working Machine Operators:		
703	Lathe, milling, and turning machine operatives	Production
706	Punching and stamping press operatives	Production
707	Rollers, roll hands, and finishers of metal	Production
708	Drilling and boring machine operators	Production
709	Grinding, abrading, buffing, and polishing workers	Production
713	Forge and hammer operators	Production
717	Fabricating machine operators, n.e.c.	Production
Metal and Plastic Processing Machine Operators:		
719	Molders, and casting machine operators	Production
723	Metal platers	Production
724	Heat treating equipment operators	Production
Woodworking Machine Operators:		
726	Wood lathe, routing, and planing machine operators	Production
727	Sawing machine operators and sawyers	Production
728	Shaping and joining machine operator (woodworking)	Production
729	Nail and tacking machine operators (woodworking)	Production
733	Other woodworking machine operators	Production
Printing Machine Operators:		
734	Printing machine operators, n.e.c.	Production
735	Photoengravers and lithographers	Production
736	Typesetters and compositors	Production
Textile, Apparel, and Furnishings Machine Operators:		
738	Winding and twisting textile/apparel operatives	Production
739	Knitters, loopers, and toppers textile operatives	Production
743	Textile cutting machine operators	Production
744	Textile sewing machine operators	Production
745	Shoemaking machine operators	Production
747	Pressing machine operators (clothing)	Production
748	Laundry workers	Professional Services
749	Misc. textile machine operators	Production
Machine Operators, Assorted Materials:		
753	Cementing and gluing machine operators	Production
754	Packers, fillers, and wrappers	Production
755	Extruding and forming machine operators	Production
756	Mixing and blending machine operatives	Production
757	Separating, filtering, and clarifying machine operators	Production
759	Painting machine operators	Production
763	Roasting and baking machine operators (food)	Professional Services
764	Washing, cleaning, and pickling machine operators	Production
765	Paper folding machine operators	Production
766	Furnace, kiln, and oven operators, apart from food	Production
768	Crushing and grinding machine operators	Production
769	Slicing and cutting machine operators	Production
773	Motion picture projectionists	Production
774	Photographic process workers	Production
779	Machine operators, n.e.c.	Production
Fabricators, Assemblers, and Hand Working Occupations:		
783	Welders and metal cutters	Production
784	Solderers	Production
785	Assemblers of electrical equipment	Production
789	Hand painting, coating, and decorating occupations	Production
Production Inspectors, Testers, Samplers, and Weighers:		

Table A1. Occupational Classifications

Code	Title	Category
796	Production checkers and inspectors	Production
799	Graders and sorters in manufacturing	Production
Transportation and Material Moving Occupations		
Motor Vehicle Operators:		
803	Supervisors of motor vehicle transportation	Transportation
804	Truck, delivery, and tractor drivers	Transportation
808	Bus drivers	Transportation
809	Taxi cab drivers and chauffeurs	Transportation
813	Parking lot attendants	Transportation
815	Transport equipment operatives--allocated (1990 internal census)	Transportation
Transportation Occupations, Except Motor Vehicles		
Rail Transportation Occupations:		
823	Railroad conductors and yardmasters	Transportation
824	Locomotive operators (engineers and firemen)	Transportation
825	Railroad brake, coupler, and switch operators	Transportation
Water Transportation Occupations:		
829	Ship crews and marine engineers	Transportation
834	Water transport infrastructure tenders and crossing guards	Transportation
Material Moving Equipment Operators:		
844	Operating engineers of construction equipment	Production
848	Crane, derrick, winch, and hoist operators	Production
853	Excavating and loading machine operators	Production
859	Misc. material moving occupations	Production
Helpers, Construction and Extractive Occupations:		
865	Helpers, constructions	Production
866	Helpers, surveyors	Production
869	Construction laborers	Production
874	Production helpers	Production
Freight, Stock, and Material Handlers:		
875	Garbage and recyclable material collectors	Governmental
876	Materials movers: stevedores and longshore workers	Transportation
877	Stock handlers	Transportation
878	Machine feeders and offbearers	Production
883	Freight, stock, and materials handlers	Transportation
885	Garage and service station related occupations	Professional Services
887	Vehicle washers and equipment cleaners	Business Services
888	Packers and packagers by hand	Production
889	Laborers outside construction	Production
890	Laborers, except farm--allocated (1990 internal census)	Production
MILITARY OCCUPATIONS		
905	Military	Governmental

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