AN EXAMINATION OF THE TREND IN INDUSTRIAL DISPERSION IN OKLAHOMA FROM 1963 THROUGH 1974*

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Descriptive data have been used to show how industrial job creation is growing faster in nonmetro areas than in metro areas. For example, Haren [5] and Till [11] describe industrial decentralization in the 60s. Janssen and Tweeten [7] illustrate how the trend has continued into the 70s. In Oklahoma, Childs and Doeksen [1] report on how industry has decentralized from 1963 through 1971.

The objective of this paper is to examine and statistically test the dispersion of new manufacturing jobs with respect to size of community in Oklahoma from 1963 through 1974. Previous studies have either been descriptive or have used some measure of dispersion, such as entropy, without statistically testing the results. Garrison, for example, uses entropy to describe distribution of manufacturing employment among types of counties within the Tennessee Valley. These are classified by the largest city in each county [3]. His study indicates a slight increase in the equality of manufacturing employment among his designated county types, which range from entirely rural to metropolitan. Till examines the manufacturing employment growth rates of three types of counties, those containing a Standard Metropolitan Statistical Area (SMSA), those within fifty miles of an SMSA, and those in excess of fifty miles from an SMSA, where the counties within each distance zone are subclassified "by size of main city" [11]. He concludes that in no case were growth rates in manufacturing employment of the distant nonmetropolitan counties dwarfed by employment growth rates of either less distant non-SMSA counties or growth rates of the SMSAs themselves.

In addition to not statistically testing job creation from industrial dispersion, previous studies have relied upon those employment data reported at the county level from secondary sources. In using the county as the unit of measurement, two problems arise. First, some data go unnoticed. For example, if a community of 2,500 received a new plant but was not the "main city" in the county, this information was not separately considered. A second problem arises because secondary sources do not distinguish between increases in manufacturing employment coming from new plants and those which come from expanded plants. Increases in employment from new plants show current locational patterns, while those from plant expansions tend to reflect past locational patterns.

In summary, this study differs from previous ones in that dispersion of job creation from new manufacturing plants is statistically tested and the community is used as the unit of measurement. Regression is combined with entropy to statistically test dispersion. Before presenting and discussing data and empirical results, entropy as a measure of dispersion is discussed.

THE USE OF ENTROPY AS AN ANALYTICAL TOOL

The entropy concept had its beginning in thermodynamics where it was and is used to describe the disorder or randomness of a system. Theil [10] appears to have been the first economist to apply entropy to quantitative economics. He used entropy and related measures to examine income inequality, industrial concentration and geographic dispersion of

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demand. Horowitz [6] suggested that entropy can measure the degree of competition in an industry by quantifying the degree of uncertainty as to the firm that might be frequented by a customer chosen at random. Garrison [3] extended the use of this concept to measure the degree of randomness in a regional system. He suggested that the greater the entropy of industrial employment within a regional system, the greater the equality among counties in that system in attracting industry.

The task is to examine the entropy of new jobs created by new manufacturing plants with respect to community size intervals. The entropy measure is comprehensive in that the new employment share of each town is considered in its computation rather than the share of a major group such as an entire population interval. The entropy of job creation by new plants within this distribution of cities in year t can be written as

$$H(y)_t = \sum_{i=1}^{n} y_{it} \log \frac{1}{y_{it}}$$

$$y_i \geq 0,\ i = 1,\ 2, \ldots n;\ \sum_{i=1}^{n} y_i = 1$$

$$t = 1963, \ldots 1974 \qquad (1)$$

where

y_{it} = i^{th} community's share of the jobs created by new plants in the state in year t and
log = common logarithm [10, p. 290].

This index will take on its minimum value of zero when all jobs are created in one city. Entropy will take on its maximum value of log n when each city receives an equal share of the jobs.[1]

Because entropy considers the number of jobs received by each community, the measure has some very useful disaggregational properties. Once a number of sets, such as population intervals, are delineated, the total amount of dispersion in the system can be classified as dispersion among sets and dispersion within each set as shown in equation (2).

$$H(y)_t = \sum_{g=1}^{g} Yg_t \log \frac{1}{Y_{gt}} + \sum_{g=1}^{g} Yg_t\, Hg(y)_t \qquad (2)$$

where

$$Yg_t = \sum_{i \epsilon Sg} y_{it} \qquad g = 1, \ldots, G$$

and

$$Hg(y)_t = \sum_{i \epsilon Sg} \frac{y_{it}}{Yg_t} \log \frac{Yg_t}{y_{it}} \qquad g = 1, \ldots, G$$

The first term on the right in equation (2) is the between set entropy, which measures degree of equality among sets in year t where Yg_t is the share of new jobs received by set Sg in year t. The second term on the right is the weighted sum of within set entropies. The within set entropies, $(Hg(y)_t)$, measure equality of new job shares of the cities within each set in year t. These within set entropies are weighted by respective sets' share of jobs created by new plants in year t in the computation of total entropy.

DATA AND EMPIRICAL RESULTS

The major data source of this study is the *Listing of New and Expanded Manufacturers and Processors* published by the Oklahoma Department of Industrial Development [8]. This publication presents verified observations of jobs created by new manufacturing plants from 1963 through 1974. Sets used are constructed by combining Oklahoma's 560 communities into seven population groups based on 1970 Census of Population data. These population intervals are: 460 communities with less than 2,500 population; 43 with population from 2,500 to 4,999; 27 with population from 5,000 to 9,999; 18 with population from 10,000 to 24,999; eight with population from 25,000 to 49,999; two with population from 50,000 to 99,999; and two with 100,000 and over.

From 1963 through 1974, 655 new plants opened in Oklahoma to create 45,610 new manufacturing jobs. From examination of Table 1, it is

[1] Consider a system composed of three cities each receiving one-third of the jobs in year t. Entropy is then

$$H(y)_t = \sum_{i=1}^{n} y_i \log \frac{1}{y}$$

$$= \frac{1}{3} \log 1/\frac{1}{3} + \frac{1}{3} \log 1/\frac{1}{3} + \frac{1}{3} \log 1/\frac{1}{3}$$

$$= 1 \log 1/\frac{1}{3}$$

$$= \log 3$$

TABLE 1. JOBS CREATED IN OKLAHOMA BY NEW MANUFACTURING PLANTS CLASSIFIED BY CITY SIZE

City Size	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	Total	% Total
0 - 2,499	282	288	11	307	613	682	1,007	791	437	1,142	624	162	6,346	13.9
2,500 - 4,999	80	16	109	86	362	498	620	537	105	322	1,230	391	4,356	9.6
5,000 - 9,999	248	29	343	1,286	998	687	1,219	826	1,336	1,072	1,238	1,452	10,734	23.5
10,000 - 24,999	176	59	318	530	557	682	1,960	160	695	550	326	555	6,568	14.4
25,000 - 49,999	26	164	98	134	0	417	478	140	32	631	1,440	1,001	4,561	10.0
50,000 - 99,999	0	0	60	47	8	35	65	500	26	0	305	57	1,103	2.4
100,000+	2,809	386	372	410	773	250	1,337	432	1,005	350	2,934	822	11,942	26.2
Total	3,621	942	1,311	2,800	3,311	3,251	6,686	3,386	3,696	4,067	8,099	4,440	45,610	100.0
% of Total	7.9	2.1	2.9	6.1	7.3	7.1	14.7	7.4	8.1	8.9	17.8	9.7	1,000	100.0

apparent that there has been more activity recently than in the early years of the study's twelve-year time period. The first three year quarter provided 12.9 percent of the state's total jobs from these new plants, the second quarter accounted for 20.5 percent, the third quarter for 30.2 percent and the last for 36.4 percent.

Precise distribution of these jobs among the seven population intervals is given in the last two columns of Table 1. A more general and more easily understandable idea of the distribution can be obtained by examining the job shares of three broader population intervals which roughly divide the state's non-farm population into thirds. Communities of less than 10,000 population had 31.2 percent of the state's non-farm population and received 47.0 percent of new manufacturing jobs. The mid-sized communities from 10,000 to 99,999 and the metropolitan areas of 100,000 and over each had 34.4 percent of the non-farm population. Mid-sized communities though, received 26.8 percent of the new jobs while metropolitan areas received 26.2 percent. This illustrates the viability of the small community in attracting manufacturing plants. An index is needed which will examine dispersion of new manufacturing employment.

Results of the entropy computation from equation (2) are presented in Table 2. Total entropy for a given year measures the equality of job shares of all communities in general and is given in column two. Between set entropy, which measures dispersion of jobs among the seven population intervals, is given in column three. Columns four through ten contain within set entropies for each of the individual population intervals. It is interesting to note that in all twelve years, between set entropy has accounted for over half of total entropy. That is, job creation by new plants is more dispersed among the seven population intervals than within them. This is pointed out more strongly in Table 3.

Table 3 presents the relative entropies for each of the 108 entries in Table 2. Relative entropy measures the extent to which observed level of dispersion equals the maximum level. This index is calculated by dividing the observed entropy index by its upper bound, log n. For instance, total entropy in 1974 was 1.258213. If each of the 560 communities in Oklahoma had received an equal share of the jobs created by new plants, then total entropy would have taken on its maximum value of $H(y)_{1974} = \log 560 = 2.748188$. Relative total entropy for 1974 is then $1.258213 \div 2.748188$ or 45.8 percent. Relative between set entropy, given in column three of Table 3, measures the extent to which the seven population intervals shared equally in receipt of jobs created by new manufacturing plants. This index is calculated by dividing the observed between set entropy for any year by its maximum log 7. For example, in 1974 between set entropy was 0.722769. If each of the seven sets had received an equal share that year, between set entropy would have taken on its maximum value of $\log 7 = 0.845098$. Relative between set entropy for 1974 is then $0.722769 \div 0.845098 = 85.5$ percent. That is, dispersion of jobs among the seven population intervals was 85.5 percent of its maximum in 1974.

Relative within set entropy is computed by dividing the unweighted within set entropy for a given year, $Hg(y)_t$, by its maximum value, log ng, where ng is the number of communities within population interval g. For example, in 1974 the observed within set entropy for the 10,000 to 24,999 population interval was 0.862175. Had the eighteen cities in this class each received an equal share of jobs created by new plants therein, within set entropy would have taken on its maximum of log 18 =

TABLE 2. TOTAL, BETWEEN SET, AND WITHIN SET ENTROPY OF JOBS CREATED BY NEW PLANTS IN OKLAHOMA, 1963-1974

Year	Total Entropy	Between Set Entropy	Within Set Entropy*						
			Less than 2,500	2,500-4,999	5,000-9,999	10,000-24,999	25,000-49,999	50,000-99,999	100,000 and over
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10
1963	0.687669	0.367438	0.254096	0.701855	0.369636	0.643320	0.000000	0.000000	0.294361
1964	0.844783	0.598211	0.358340	0.427383	0.617871	0.598663	0.159750	0.000000	0.113954
1965	1.074550	0.709529	0.463431	0.302471	0.447580	0.529690	0.208367	0.000000	0.263693
1966	1.051358	0.661631	0.532248	0.588707	0.367384	0.574026	0.125507	0.224790	0.198419
1967	1.157557	0.681875	0.515354	0.072978	0.742040	0.467771	0.000000	0.000000	0.299090
1968	1.334325	0.773285	0.610187	0.611596	0.678275	0.690140	0.224227	0.000000	0.292285
1969	1.288488	0.751843	0.904449	0.884401	0.763044	0.355998	0.456221	0.000000	0.211620
1970	1.266039	0.780422	0.669301	0.826885	0.614762	0.101534	0.259825	0.000000	0.255633
1971	0.995612	0.638496	0.574931	0.315732	0.535651	0.420314	0.228144	0.000000	0.019207
1972	1.372284	0.729462	0.920701	0.589115	0.668357	0.652029	0.419728	0.000000	0.095124
1973	1.246855	0.733934	0.938737	0.777611	0.795084	0.788205	0.521932	0.036328	0.214010
1974	1.258213	0.722769	0.746505	0.588009	0.747306	0.862175	0.322110	0.000000	0.170931

*Unweighted within set entropies are reported here.

TABLE 3. RELATIVE ENTROPY: OBSERVED ENTROPY AS A PERCENTAGE OF ITS MAXIMUM

Year	Relative Total Entropy	Relative Between Set Entropy	Relative Within Set Entropy						
			Less than 2,500	2,500 4,999	5,000 9,999	10,000 24,999	25,000 49,999	50,000 99,999	100,000 and over
Col. 1	Col. 2	Col. 3	Col. 4	Col. 5	Col. 6	Col. 7	Col. 8	Col. 9	Col. 10
1963	25.0	43.5	9.5	43.3	25.8	51.2	0.0	0.0	97.8
1964	30.7	70.8	13.5	26.2	43.2	47.7	17.7	0.0	37.9
1965	39.1	84.0	17.4	18.5	31.3	42.2	23.1	0.0	87.6
1966	36.4	78.3	20.0	36.0	25.7	45.7	13.9	74.7	65.9
1967	42.1	80.7	19.4	4.5	51.8	37.3	0.0	0.0	99.4
1968	48.6	91.5	22.9	37.4	47.4	55.0	24.8	0.0	97.0
1969	46.9	89.0	34.0	54.1	53.3	28.4	50.5	0.0	70.3
1970	46.0	92.3	25.1	50.6	42.9	8.1	28.8	0.0	84.9
1971	36.4	75.6	21.6	19.3	37.4	33.7	25.3	0.0	6.4
1972	49.9	86.3	34.6	36.1	46.7	51.9	46.5	0.0	31.6
1973	45.4	86.8	35.3	47.6	55.5	62.8	57.8	12.1	71.1
1974	45.8	85.5	28.0	36.0	52.2	68.7	35.7	0.0	56.8
Mean	41.0	80.4	23.4	34.1	42.8	44.4	27.0	7.2	67.2

1.255272. The relative entropy index is then 68.7 percent for this population interval for 1974.

The last row of Table 3 contains means of the relative entropy series. While total entropy averaged 41.0 percent of its maximum over the twelve years examined, between set entropy averaged 30.4 percent. Average relative between set entropy also exceeded average relative within set entropy for each population interval. That is, while the degree of equality in receipt of jobs among the seven population intervals was quite high, 80.4 percent of its maximum, degree of equality among all communities was rather low, 41.0 percent of its maximum. This may imply that there are a few communities in each population interval which are experiencing a more rapid growth in manufacturing employment than the rest, and that these growing communities are sharing, more or less equally, increases in the state's employment created by new plants. Some support for this hypothesis is given by rather low levels of observed relative within set entropy in some intervals.

Information presented in Tables 2 and 3 does not readily convey whether dispersion as measured by entropy has increased, remained constant, or decreased over the twelve years covered by this study. To test for the existence of statistically significant changes in dispersion of jobs created by new plants, each of the nine entropy series presented in Table 2 was regressed on time.

General dispersion of jobs created by new plants among all Oklahoma communities as measured by total entropy exhibited a significant trend to increase over time. This is shown by the positive time coefficient estimated for total entropy in Table 4. Between set entropy has exhibited a positive trend with respect to time which is significant at the .05 level.

Three of the seven population intervals experienced significant increases in dispersion of jobs among their cities with respect to time. Those experienceing increasing interval dispersion were the less than 2,500 interval, the 5,000 through 9,999 and the 25,000 through 49,999 interval. In each of these cases, the coefficient of dispersion with respect to time exceeded that relating between set entropy to time. That is, equality within each of these sets has been increasing more rapidly than equality among sets.

Dispersion of these jobs created by new plants within the other four intervals did not exhibit trends which were statistically significant at the .05 level. Coefficients of dispersion over time within the 2,500 to 4,999 interval and the 10,000 to 24,999 interval were positive but were not significant. The dispersion of jobs created by new plants within the 50,000 to 99,999 population interval and the over 100,000 population interval has exhibited a small negative but insignificant trend.

TABLE 4. REGRESSION RESULTS

Entropy	Intercept	Time Coefficient [t-statistic, 11 d.f.]
Total	0.8744564 [9.59]***	0.0400839 [3.24]**
Between Set	0.5557879 [9.68]***	0.0189301 [2.43]*
Within Set		
0-2,499	0.2861667 [3.77]***	0.0511539 [4.96]***
2,500-4,999	0.441727 [2.97]*	0.1777273 [0.88]
5,000-9,999	0.3064546 [3.70]***	0.0413147 [3.67]***
10,000-24,999	0.4942273 [3.81]**	0.0096573 [0.55]
25,000-49,999	0.0209697 [0.29]	0.0342867 [3.55]**
50,000-99,999	0.0399545 [0-97]	-0.0028007 [-0.50]
100,000+	0.2681363 [5.12]***	-0.0099056 [-1.39]

*Significant at .05.
**Significant at .01.
***Significant at .005.

SUMMARY AND CONCLUSIONS

The objective of the paper was to examine dispersion of jobs created by new manufacturing plants in Oklahoma in seven community size groups from 1963 through 1974. Entropy and regression were used. The results were:

(1) On the average, equality of new manufacturing job shares as measured by between set entropy for the seven population intervals has been 80.4 percent of its maximum for the years covered.

(2) Dispersion of jobs created by new manufacturing plants among all communities, as measured by total entropy, has increased over time. This positive trend is significant at the .01 level.

(3) The equality of job shares of the seven broad population intervals, as measured by between set entropy, has also exhibited a trend to increase over the years 1963 through 1974. This trend is significant at the .05 level.

(4) Increases of within set entropy were found in the less than 2,500 population interval, the 5,000 to 9,999 interval, and the 25,000 to 49,999 interval which were significant at better than the .05 level.

In general, industry has shown a marked preference for the community of less than 10,000 in its locational decision. Industry has become more dispersed across population intervals as well as within three of these intervals. In no case has there been a significant negative trend in dispersion over the twelve years of this study.

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