RSP 14(2): 46-59.

CLIMATE AND MANUFACTURING LOCATION

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"The human consequence of climate [are] slight, perhaps negligible and certainly difficult to detect."
*Emmanuel Le Roy Ladurie***

Climate is an important economic resource. But, in many ways, climate is unlike most economic resources. First, it can have both a positive and negative influence on economic conditions. Its positive influence has been evident, for example, in the population growth rates for Fort Meyers, Florida, and similarly situated towns and cities in southern Florida. Its adverse effects are also notable. The well-known dustbowl period in the High Plains is a classic illustration. Thus, climate, as a resource, has a dual influence and this dual influence exists concurrently across regions and recurrently within regions.

Second, climate is unique in the sense it is, given our current state of knowledge and with an exception noted below, an immobile resource. Thus it is impossible for Nebraska to enjoy a southern Texas winter or South Carolina a New England autumn. As other economic resources, such as capital and labor, become interregionally more mobile the economic role of climate as a determining factor in decisions on where to locate economic activity has and will continue to increase.[1]

Climate, like other economic resources, can be adapted or changed by mankind. While climate modification on a wide scale is still in the esoteric/experimental stage the widespread adoption of central heating and air conditioning has certainly enabled our society to manipulate the human environment to better suit the specie. This ability has had important implications for the economy; much as the Industrial Revolution in the developed world focused attention on the ability to substitute capital for labor our increasing

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The research presented in this manuscript was funded by a grant from Environmental Data and Information Service Center (EDIS) of the National Oceanic and Atmospheric Administration (NOAA) of the U.S. Department of Commerce.

** *Times of Feast, Times of Famine: A History of Climate Since The Year 1000,* translated by Barbara Bray, Doubleday, Garden City, N.Y., 1971, pp. 119-20.

[1] Although the present paper focuses on the climate/manufacturing relationship it should be noted that the increasing importance of the tertiary sector and the amenity orientation of many of these activites further underscores the growing importance of climate considerations in the locational calculus.

ability to control our local environment (and the advent of OPEC) have brought to the fore the energy/climate tradeoff.

Climate influences the location of economic activity in three different, but interrelated ways. First, there is the role of climate implicit in the term amenity orientation.[2] Here households, especially the retired, are attracted to areas of high climatic amenities and people-serving tertiary industry follows. Second, emphasizing the fact that amenity location is a subclassification of labor orientation, industrial activity, especially firms employing skilled technical workers and professionals, are attracted to high amenity areas to take advantage of the agglomeration economies inherent in such location. "Silicone Valley" in the southern San Francisco Bay area would be the classic example of such development. As in the first case people, or more specifically skilled labor, may be viewed as an intervening variable between climate and industrial growth in the second instance.

Climate, however, can influence industrial location in a third way. Here the climate/energy relationship alluded to above becomes dominant. Firms may be becoming increasingly energy and hence climate-oriented as the real cost and use of energy has increased. Unlike the first two cases where climate works through the "people variable," here climate works (more directly) through energy costs to effect location and jobs and hence people "follow."

The purpose of this paper is, in a preliminary way, to assess the relative importance of the second versus third avenue of climatic effect on industrial location. By concentrating on the secondary or manufacturing sector of the economy the "household serving" effect of industrial migration should be minimized (but not eliminated).

Scope of the Study

Much has been written about the exodus of industry from the "Frost Belt" towards the "Sun Belt." Despite the popularity of these, or similar, climatic terms in the popular and professional literature, analysts have realized that such broad-brush treatment of climatic zones is "sloppy regionalizing" and thus fails to capture the variety and nuances of climatic variation.[3] Such a dichotomy, while on the surface emphasizing the role of climate, may actually confound the influence of climate with other variables when, for instance, the Frost Belt is coterminous with cities in the old industrial belt while the Sun Belt is congruent with cities such as Houston and Dallas/Fort Worth. This study, while clearly concentrating on the Frost Belt/Sun Belt phenomena uses entire states (including urban and rural areas) as the focus of analysis. Specifically three states in what is generally accepted as the Frost Belt (New York, Pennsylvania and Illinois) were chosen along with a like number from the Sun Belt (Georgia, Arkansas and Texas).

[2] This is the effect emphasized in the work of Irving Hoch.

[3] Browning, C. E. and Gesler, W. "The Sun Belt-Snow Belt: A Case of Sloppy Regionalizing," *Professional Geographer,* 31(1979), pp. 66-74.

The initial step in our analysis was to perform a shift/share analysis for the 707 counties in the six states utilizing employment data contained in the 1974 and 1979 editions of *County Business Patterns* tapes.[4] Our choice of 1974, of course, should emphasize the effect of the OPEC-induced oil embargo and subsequent escalation in the real price of energy. Our terminal data should minimize the impact of the recent recession and better capture long term (future?) growth trends in manufacturing employment. The actual form of the model used was:

(1) $WE_i^* = E_i^* - E_i = E_i(us^*/us) + E_i(us_i^*/us_i - us^*/us) + E_i(E_i^*/E_i - us_i^*/us_i)$

Change in Employment$_i$ = Net Shift$_i$ + Industry Effect$_i$ + Regional Effect$_i$

where:

E	=	regional employment in industry i in 1974
E_i^*	=	regional employment in industry i in 1979
us_i and us_i^*	=	analogous measures of U.S. employment in industry i in 1974 and 1979 respectively and,
us and us^*	=	total U.S. manufacturing employment in both periods.

Note that the comparison "base" was national growth in manufacturing. Given the confusion in terminology that exists in the shift/share literature it seems imperative that we specify ours. The sum of first terms on the right hand side of equation (S_iNS_i), which is the growth that may be attributed to overall national growth, is called the *net shift* (NS). Similarly defined (e.g. S_iIE_i) the second term, which measures the effect of industrial mix on regional development, is termed the *industry effect* (IE). The final term, which best captures the competitiveness or locational attraction of the individual county for manufacturing, is denoted as the *regional effect* (RE = S_iRE_i).

The net shift and regional effects will be used to investigate the basic premise underlying the Sun Belt/Frost Belt controversy. First, using the NS, is it true that the growth of manufacturing employment in southern counties exceeds that of the nation as a whole? Do northern counties lag? Second, addressing the RE, to what extent is growth performance due to *current* locational advantages of a county for manufacturing? The industry effect will be used as a preliminary test of the relative importance of the amenity induced location versus energy usage effect of climate on manufacturing growth. While such utilization of the NS and RE is consistent with the current literature on shift/share as a descriptive tool our use of the IE deserves further comment.

A favorable IE indicates that a specific county was relatively concentrated in 1974 in industries that grew rapidly over the 1974-79 period. If we assume that growth industries in the United States are (at least relatively) concentrated in the "high technology" end of the industrial spectrum and thus most likely to employ skilled and professional workers, these industries should be most influenced by the amenity qua labor-climatic orientation outlined above.

[4] Bureau of the Census, *County Business Patterns,* 1974 and 1979.

Conversely if we hypothesize that slow growth industries employ labor of an (average) lower skill level and if this type labor is more spatially ubiquitous, counties with a negative industrial effect, but in which total manufacturing employment growth exceeds the U.S. average, are more likely reflecting the energy-climate locational orientation. If southern counties are more likely to exhibit a negative industrial effect it, therefore, seems reasonable to emphasize the climate/energy relationship in recent Sun Belt developments.

The second part of our study attempts, through the use of meteorological data published by the National Oceanic and Atmospheric Agency (NOAA), to refine our definition of climate and avoid, to an extent, the gross oversimplification inherent in the terms Sun Belt and Frost Belt. Using Local Climatological and "No. 20" Stations (NOAA climate reporting stations) average annual mean temperatures (MEANS) and average number of days with maximum temperatures over 90° and minimum below 32° (EXTREMES) were computed for weather reporting districts and specific counties. These two measures of climatic variation were then compared with manufacturing employment growth as captured by the NS and RE calculated by district or county. Given the extreme *ceteris paribus* assumption inherent in these calculations at this point in our research agenda, nonparametric statistical tests were utilized to test for the expected relationship. Consistent with the literature we hypothesize a positive relationship between MEANS and both NS and (especially) RE. For EXTREMES a negative correlation was hypothesized.[5]

The third and final empirical part of our paper returns to the climate/amenity-versus climate/energy/location comparison by utilizing industry specific RE's defined as:

(2) $RE_i = E_i({}^{E}{}^{*}_{i}/E_i - {}^{us}{}^{*}_{i}/us_i)$

Our purpose in this part of the paper is to identify for those counties exhibiting a rapid manufacturing employment growth (e.g. positive NS), a favorable industrial effect (positive IE), and a competitive advantage (positive RE) from the "propulsive industries." The energy usage and occupational mix of these

[5] If climate is influencing location patterns through its effects on energy costs one must of course, exercise caution. For any firm energy costs are equal to $P_e \times Q_e$ where these terms represent the price and quantity of energy respectively. While climatic variables such as MEANS and EXTREMES may influence Q_e and energy costs and therefore equipment growth, a finding of no statistically significant correlation between climatic variables and employment growth does not refute the overall hypothesis of an energy cost/growth relationship. It does refute a *climate*/energy/growth hypothesis. At the interregional (or possibly interstate) level it might be anticipated that variations in Q_e are larger and more systematic than variations in P_e; such is not the case within states. While our climatic measures influence Q_e they are not likely to influence P_e; unfortunately variations in P_e, like variations in homogenous labor costs, market and material access etc. are beyond the scope of the present paper.

industries will then be determined to investigate the competing hypotheses concerning the channels of climatic impact on the locational calculus. A similar analysis for those counties exhibiting positive NS and RE, but negative IE will also be presented.

Shift/Share Results

The six states, that were analyzed using the shift/share model detailed in equation (1), include a total of 707 counties: New York (62), Pennsylvania (67), Illinois (102), Georgia (159), Arkansas (75) and Texas (242).[6] Of these counties Table 1 indicates, by state, the percent of counties in which manufacturing employment grew faster than that in the U.S. between 1974 and 1979. In general these results confirm the Frost Belt/Sun Belt dichotomy; note

Table 1: Percent of Counties Exhibiting Positive Net Shift

State	Percent
New York	31%
Pennsylvania	28
Illinois	40
Georgia	56
Arkansas	44
Texas	59

Source: Computed from 1974 and 1979 *County Business Patterns.*

however, the similarity between Illinois and Arkansas. A Chi-Square contingency test of no relationship between the region of the country in which a county was located (North vs. South) and the sign of the net shift was rejected at the 99% confidence interval ($x^2 = 26.359$).

For the regional effect (RE) similar results were obtained. (See Table 2.) Again a Chi-Square test rejected the null hypothesis of no relation between

Table 2: Percent of Counties Exhibiting Positive Regional Effects

State	Percent
New York	27%
Pennsylvania	36
Illinois	42
Georgia	67
Arkansas	49
Texas	62

Source: See Table 1.

region and sign for the regional effect $x^2 = 39.70$). Note that five of the six states, New York being the exception, show a higher percent of counties reporting a favorable RE than positive NS. Particularly striking is the im-

[6] Twelve Texas counties reported no manufacturing employment in either 1974-1979 and were therefore deleted from the study.

provement in Pennsylvania's position comparing Tables 1 and 2; the locational advantages of this state are most severely underestimated if one focuses solely on the net shift. In the southern states only one county exhibited employment growth faster than that of the U.S. manufacturing base as a whole (positive NS) yet exhibited a competitive locational disadvantage for manufacturing growth (negative RE); thirty one counties exhibited the opposite pattern (negative NS, positive RE). For the northern states sixteen counties showed sign reversals when comparing NS and RE: six from positive NS to negative RE, ten from negative to positive.[7]

Turning to the industrial (mix) effect (IE) in Table 3, quite different results were obtained. The demarkation between Frost Belt and Sun Belt does not emerge. In fact, of the six states, two northern states had the most favorable industrial mix, from a 1974-1979 growth perspective at the beginning of the period. At the other extreme Georgia and Pennsylvania entered the period

Table 3: Percent of Counties Exhibiting Positive Industrial Effects

State	Percent
New York	52%
Pennsylvania	18
Illinois	55
Georgia	11
Arkansas	27
Texas	43

Source: See Table 1

with unfavorable industrial mixes. A more definitive regional pattern emerges, however, if we combine the IE with the NS and RE effects of the previous two tables. If we combine a negative IE (unfavorable industrial mix), positive RE (favorable competitive effect) and positive NS (manufacturing growth exceeding U.S. average employment growth) the resulting pattern is illustrated by Table 4. What emerges we will call the "Southern Pattern" of growth.

Table 4: Percent of Counties Exhibiting "Southern Pattern"

State	Percent
New York	16%
Pennsylvania	27
Illinois	15
Georgia	51
Arkansas	36
Texas	31

Source: See text.

[7] To the extent the regional effect measures the future competitiveness of these states and the net shift reflects 1974-79 performance, one might hypothesize that future prospects for five of the six states (exception New York) appears more favorable than their own recent past.

Counties exhibiting positive NS combined with positive RE and IE's ("Most Favored" County Status) are geographically more ubiquitous as shown in Table 5. Recalling our hypothesis that growth industries are likely to be high

Table 5: Percent of Counties Exhibiting "Most Favored" County Status

State	Percent
New York	11%
Pennsylvania	1
Illinois	23
Georgia	4
Arkansas	8
Texas	27

technology, high labor skilled industries amenity-oriented industries while slowly growing (or declining) industries are more likely to employ a more uniquitous semi- or unskilled labor force and be energy-oriented, the results of Tables 4 and 5 strongly suggest that much of the Frost Belt vs. Sun Belt differential expansion manufacturing is energy related rather than amenity-oriented.

Climatology Results

The objective of this part of our study is to combine the shift/share results reported above with climatology statistics reported by the National Oceanic and Atmospheric Administration.[8] NOAA publishes detailed statistics for two types of reporting stations: Local Climatological Data Stations, which are usually located in SMSA's (frequently at major airports) and U.S. No. 20 Stations which are geographically more dispersed. In New York state, for instance, there are eight of the former reporting stations (three in New York City) and thirty three of the latter. To maximize geographical coverage it was decided to use statistics from both types of stations. While this presented no problem with annual mean temperature (MEANS) it posed a problem for our desired measure of variability of temperature, namely degree days. These measures are available only for the larger stations. As a result we substituted the sum of the days for which the maximum temperature was 90°F or above and the number of days the minimum temperature was 32°F or below. These data, available for all reporting stations, became our EXTREMES. Table 6 shows, for each state, the number of climatological stations by type and the reported range of state MEANS and EXTREMES. While MEANS conform to the expected North-South division of the six states, high and low EXTREMES show an almost alternating ordering skipping across the Mason-Dixon line.

[8] The primary sources of climate data were the appropriate state issues of *Climatogography of the United States No. 60* published by the Environmental Data and Information Service, Nashville Climatic Center, NOAA, Asheville, N.C., 1978. Data reported were annual averages taken, typically, over a twenty (plus) year interval.

Table 6: Number of Climatological Stations and Range of State MEANS and EXTREMES

State	LCDS*	No. 20**	Temperature Mean*** High	Temperature Mean*** Low	Temperature Extremes*** High	Temperature Extremes*** Low
New York	8	33	54.5	40.2	194	88
Pennsylvania	8	22	55.6	44.5	173	100
Illinois	7	23	59.6	47.9	168	113
Georgia	7	25	67.1	54.7	147	80
Arkansas	2	20	63.5	58.2	175	123
Texas	18	49	73.8	55.4	207	92

* Local Climatological Data Stations

** U.S. No. 20 Stations

*** Measured in degrees Fahrenheit

Our investigation of the relationship between climate and manufacturing activity will proceed at three levels. First, using the entire six states we will look at the interregional effect of climate. Second, partitioning the states into Frost Belt and Sun Belt categories, intraregional/interstate climate effects were sought. Finally we investigated intrastate comparisons of climate and manufacturing employment growth. Our basic *modus operandi* was to compare MEANS and EXTREMES with both NS and RE. Given the extreme *ceteris paribus* assumptions of such comparisons our basic approach was to construct Chi-Square contingency tables where NS (RE) were categorized as positive or negative and MEANS (EXTREMES) above or below average for the appropriate reference group.

Before proceeding to our results one additional problem with the climatology data must be addressed. Observations are reported for specific locations, but over what area can these observations be taken as indicative? Two choices were available: we could utilize the multi-county climatological districts defined by NOAA or we could use observations as reflecting climate in the county containing the reporting station. Climatological districts cover quite a range of counties. In Texas, for instance, the smallest district contains three counties with four reporting stations while the largest contains forty three counties with fourteen stations.[9] Although we pursued both approaches only the results emanating from the more conservative avenue of utilizing station reports for individual counties will be reported in the text.[10] Where significant results were found at the district level they will be reported in footnotes.

Interregional Results

Pooling all counties in the six states having both manufacturing employment and weather data available yields 206 counties for MEANS compari-

[9] The mean temperature range for the three county area was 73.2°F to 73.8°F; for the forty-three county area the range was 63.4° to 68.3°F.

[10] Where we had the luxury of more than one reporting district in a county observations on MEAN and EXTREMES were averaged.

sons and 205 for EXTREMES. Overall mean temperature was 58° for this sample of counties. Total number of days with either daily maximum over 90°F or minimum under 32°F averaged 146.4 days a year. Comparing counties with above and below average MEAN with those experiencing positive and negative NS in a 2 × 2 contingency table resulted in a Chi-Square value of 12.69. At the 99% confidence interval, therefore, we can reject the hypothesis of no relation between annual mean temperature and faster manufacturing employment growth, 1974-1979. Specifically, and as expected, those counties with above average MEANS tended to be those experiencing growth rates faster than the overall U.S. average. A similar test was performed using RE in place of NS. The results were even stronger: $x^2 = 19.92$. Those counties which exhibited a strong locational attraction for manufacturing employment growth had above average MEANS.

If we replace MEAN with EXTREMES in the above two tests and results are quite different. At the 90% confidence interval it is not possible to reject the null hypothesis of no relationship EXTREMES and NS. Looking at the contingency table comparing EXTREMES with the RE the x^2 value equals 3.00 which is significant at the 90% interval. As expected those counties with an above average number of days either over 90°F and/or below 32°F were likely to be at a competitive disadvantage as a location for manufacturing expansion (having a negative RE).

Intraregional Results

For the three northern states climatological data were available for a total of 89 counties: New York (34), Pennsylvania (26) and Illinois (29). The overall mean annual average temperature was slightly under 50°F (49.9°F) and number of days with extreme heat or cold weather averaged 149.9. In comparing MEANS with both NS and RE we could not reject the null hypothesis of no relationship. Similar results were obtained if the EXTREMES variable was substituted for MEANS.[11] While such a test can hardly be called conclusive it seems that if a relationship between climate and manufacturing location exists in these northern states it will require a more sophisticated model to identify it.

Climatological data were available for 22 counties in Arkansas, 31 in Georgia and 63 in Texas; this totals 116 counties. The average of three state MEANS was 64.1 and the overall average of EXTREMES was 143.6. A comparison of county MEANS (versus the overall region MEANS) and both NS and RE sign was inconclusive; we could not reject null hypothesis. Turning to the results when EXTREMES are substituted for MEANS a different result emerges. The Chi-Square statistic is significant at the 90% confidence interval when above and below average EXTREMES are compared to the sign of RE (but not NS). As expected those counties having above average EXTREMES are less likely to report a positive competitive advantage (RE) for manufacturing expansion 1974-1979.

[11] While the x^2 statistic was never significant it is heartening to note that in both MEAN and EXTREMES tests RE performed better than NS.

Intrastate Results

For the northern states of Illinois, Pennsylvania and New York too few counties were available to meet the common criteria for expected cell observation numbers ($n \geq 5$) so Chi-Square methods could not be applied. Visual inspection of the contingency tables for these states, however, suggests a random table and, therefore, an inability to reject the null hypothesis of no relation between climate and manufacturing employment growth.[12]

Similar statistical problems hinder our utilization of Chi-Square tests for Arkansas and Georgia but, not surprisingly, Texas with its large geographic size provides enough country observations for a meaningful test of the climate/growth relationship. For that state we were unable to reject the hypothesis of no causation running from MEANS to either NS or RE although as usual RE performed better than NS. For Texas, however, we could reject, at the 90% confidence interval, the null hypothesis of no relationship between EXTREMES and RE (but not NS).[13] Again, as found at the intraregional level for the South as a whole, above average temperature extremes were less likely to be associated with a positive competitive or regional effect.

Summary of the Climatology Results

Clearly at this point in our research agenda caution is called for in interpreting the results presented above. Two, somewhat contradictory, considerations dictate such caution. First, in testing the climate/employment growth relationship using a simple correlation coefficient (or what is conceptually similar — a Chi-Square contingency table) one must be aware of the possibility of multicollinearity between climate and the "true" locational determinant(s). Second, in those cases where no significant relationship was found, or where sample size precluded analysis, consideration must be given to the severe *ceretis paribus* assumptions being used; a multiple variable technique might better delineate the impact of climate on location.

Recognizing these limitations of our results to date it seems appropriate to summarize our results in the form of three tentative hypotheses: (1) The favorable performance of the south with respect to growth in manufacturing employment, 1974-1979 (the Sun Belt phenomena) is climate related. Specifically the interregional shift of activity seems to be primarily in response to higher annual average temperature MEAN with variations around the MEAN, as measured by our EXTREMES, being a secondary factor. (2) Within southern, but not northern, states expansion in manufacturing activity appears to be negatively related to high temperature extremes, but not related to average temperature levels. (3) Within states, both northern and southern,

[12] This conclusion was further bolstered by utilization of climatological district averages and percent of counties exhibiting positive NS or RE. For all three states, utilizing Spearman Rank Correlation tests, no relation was found between climate variables and NS/RE.

[13] Using climate district data for Georgia a statistical significant, at the 95% interval, a negative relationship was found between MEAN and RE. The Spearman Rank Correlation coefficient was −0.817.

the pattern of manufacturing employment growth does not appear to be (primarily) climate related.

Industrial Composition Results

During the 1974-1979 period five two digit SIC industries experienced employment growth exceeding 10% nationally: SIC's 38 (Professional, Scientific Instruments), 37 (Transportation Equipment), 30 (Rubber and Misc. Plastics), 27 (Printing and Publishing) and 35 (Machinery, except electrical). As hypothesized above four of the five had an above average representation of skilled workers in 1978.[14] The exception was Rubber and Misc. Plastics. All five of these industries used lower than average (for manufacturing) energy per dollar of shipments.[15] Overall, as expected, there was a positive, significant (99%) correlation between two digit SIC growth rates and percent of the industrial labor skilled (Spearman Rank Correlation Coefficient = 0.644). A similar correlation between energy usage and growth was negative, but not significant at the 90% confidence interval (SRCC = −0.258).

We suggested above two channels by which climate might influence industrial location. The first was through energy usage; the second through the amenity/labor-orientation. It was hypothesized that the former linkage was especially crucial in the case of recent Sun Belt gains. Further, it was expected that industries most likely to reflect this orientation would exhibit not only relatively high energy usage coefficients, but also would employ rather ubiquitious semi- and unskilled labor. At the two digit SIC level the industries that most closely matched this pattern were: 22 (Textiles), 32 (Stone, Clay, Glass), 24 (Lumber), 26 (Paper), 30 (Rubber) and 20 (Food Processing).[16] At the opposite end of the spectrum those industries exhibiting the highest percent of their labor force in skilled occupation *and* lowest energy usage coefficients (and therefore most likely to be, *ceteris paribus,* amenity-oriented) were: SIC 27 (Printing and Publishing), 38 (Professional and Scientific Instruments), 37 (Transportation Equipment) and 35 (Machinery, except electric).

The next step in our analysis utilized those counties exhibiting a "Most Favored" county status (see Table 5) or the "Southern Pattern" (see Table 4). For these counties equation (2) was applied to identify those industries (at the

[14] Skilled labor is measured by the percent of an industry's work force in professional, technical, managerial/administrative, and craftsman occupational classifications in 1978. See Bureau of Labor Statistics, *The National Industry — Occupation Matrix, 1970, 1978 and Projected 1990,* U.S. Dept. of Labor Bulletin 2086, April 1981, volume 1.

[15] Energy use was measure by dividing btu's consumed by value of shipments. Both data sets were for 1976. See Bureau of the Census, *Fuels and Electric Energy Consumed, Industry Group* and *Industries and General Statistics for Industry Groups and Industries* (Annual Survey of Manufactures, 1976, M76(AS) 41 and 1), U.S. Dept. of Commerce, GPO, Washington.

[16] These industries were identified by comparing the difference in their ranks with regard to percent skilled and btu energy use per dollar of shipments.

three digit SIC level where possible) whose regional effect (RE_i) accounted for at least 20% of the county total regional effect (RE).[17]

"Most Favored" Counties

Since these counties, due to their favorable IE as well as RE, were good locations for growth industries it was anticipated that many of the industries observed would be from the rapid growth group (see above). Further it was anticipated that the northern counties would be more heavily weighted towards the amenity-oriented industries identified above while the southern counties would exhibit more specialization in the energy-oriented group of industries.

A Chi-Square test, conducted at the two digit SIC level, rejected the null hypothesis of no difference in the distribution between northern and southern counties at the 99% confidence interval (x^2 = 36.77). The largest differences between theoretically expected frequencies and the observed distribution are for those industries listed in Table 7. A Chi-Square test focusing on energy intensive versus skilled labor intensive industrial classifications, however, was unable to reject the null hypothesis. Focusing on the six two digit

Table 7: Industrial Pattern: "Most Favored" Counties

SIC	Industry	Region Favored
27	Printing and Publishing	North
30	Rubber & Misc. Plastics	North
36	Electrical Machinery	North
20	Food Processing	South
24	Lumber	South
32	Stone, Clay and Glass	South

manufacturing industries listed in Table 7 those industries favoring the south reported an average 29.7% of their labor force in skilled classifications in comparison to 40.3% for those favoring the north and 36.5% for overall manufacturing in the U.S. In contrast to an overall energy use in U.S. manufacturing of 12,000 btu's per dollar of shipments the three SIC's favoring the south reported an average coefficient of 18,000 while those favoring the north registered an energy use coefficient of 4,000 btu's per dollar of shipments. Hence, as expected, southern industry was more energy intensive than its northern counterparts and employed a more ubiquitous labor force.

"Southern Pattern" Counties

The overall unfavorable industry mix of these counties, indicated by the negative IE, led us to expect a paucity of observations in this group of counties for SIC's 27, 30, 35 and 37-38. On the other hand, if our hypothesis concern-

[17] For the "Most Favored" pattern all counties were used; for the "Southern Pattern" all counties in Pennsylvania, New York and Illinois were used. For the three southern states, due to the large numbers involved, every other county, in an alphabetical list of those exhibiting this pattern, was utilized (N = 93). The average number of industries identified per county using the criteria outlined in the text ranged from 2.6 per county to 3.9 per county.

ing amenity/labor versus energy orientation is valid we expect northern counties to report more observations than their southern counterparts for SIC's 27, 35 and 37-38 while the opposite pattern should occur for SIC's 20, 22, 24, 26, 30 and 32.

A Chi-Square test did reject the hypothesis of no significant difference (95% confidence interval) in the two digit SIC distribution of northern versus southern counties exhibiting this pattern. Table 8 identifies those SIC's which departed the most from the expected frequency. A further Chi-Square test utilizing the amenity/labor oriented industries versus energy intensive industries rejected the null hypothesis at the 95% confidence interval. As expected southern counties "specialized" in those two digit SIC's which were energy intensive while northern counties relied more heavily on relatively high-skilled labor/amenity oriented industries.

Table 8: Industrial Pattern: "Southern Pattern" Counties

SIC	Industry	Region Favored
26	Paper & Allied Products	North
27	Printing and Publishing	North
20	Food Processing	South
22	Textiles	South
23	Apparel	South
24	Lumber	South

Those industries listed in Table 8 as favoring the south had an average of 23.2% of their labor force in professional, technical, administrative and craftsman categories; for those industries favoring the northern counties the ratio was 43.8% (compared to a 1978 U.S. manufacturing average of 36.5%). While this suggests, as expected, that amenity-oriented industries are more likely to favor northern locations the energy coefficients for southern industries (6,000 btu's per dollar of shipments) versus that for northern industries (14,000) argue against the climate/energy southern nexus. However, if the energy coefficient for SIC 265 is substituted for that of SIC 26 the northern coefficient is reduced to 3,000 precisely half that of the southern counties.[18]

Overall our investigation of the industrial composition of growth in "Most Favored" and "Southern Pattern" counties, both categories of counties expanding at rates exceeding overall U.S. manufacturing growth, has produced results consistent with our hypothesis of the primacy of the climate/energy versus climate/amenity orientation as the major explanation of the effect of climate on manufacturing location.

[18] Although SIC 26 was the second most intensive energy-user (27,000 btu's per dollar of shipments), SIC 265, which accounted for 66% of northern observations, reported a coefficient of 4,000 btu's (versus a U.S. manufacturing average of 12,000).

Conclusions

The lead quotation introducing this article is intriguing to say the least. Certainly the interest of the popular press as well as the professional literature in the Sun Belt/Frost Belt phenomena belies Señor Le Roy Ladurie's evaluation of the human consequences of climate. Our research to date, as summarized above, also casts doubt in this assertion. At this point in our agenda, however, we must agree that "[t]he human consequences of climate [are] . . . certainly difficult to detect."

This manuscript has advanced two major hypotheses. The first: the post-OPEC oil embargo expansion of manufacturing employment (1974-1979) has been influenced by climate conditions. Although our results to date concerning this hypothesis are indicative at best we cannot reject the hypothesis. Further, as might be expected, at the interregional level it is average annual mean temperature which is positively associated with growth; extreme variations in temperature play a secondary role. At the intraregional level temperature extremes play a larger (negative) role in manufacturing growth. Site specific or, more correctly, county specific location does not appear to be climate related. Throughout the analysis of this hypothesis the fact that climatic variables correlated more highly with the regional (competitive) effect than with the total net shift lends further credence to climatic variables directly or indirectly entering the locational calculus of manufacturing firms.

Accepting for the moment the first hypothesis that climate matters, our second hypothesis dwelt on the channel by which climate has influenced southern growth in manufacturing. Two alternative channels were suggested: a climate/amenity/labor-orientation and a climate/energy-orientation. It is our hypothesis that the latter channel is largely responsible for growth in southern manufacturing employment. Preliminary tests of this hypothesis, based on the industrial (mix) effect in a shift/share analysis, supported, in a tentative fashion, this hypothesis. Such support, however, rested on the assumption that industries most responsible for southern manufacturing growth (e.g. more typically industries that were expanding slowly at the national level) employed a spatially more ubiquitous labor force and were relatively energy intensive. Subsequent research on the occupational characteristics and energy utilization of two digit manufacturing SIC's favoring the south tended to substantiate this assumption.