# COMMUNICATIONS

## INCOME AND MIGRATION REVISITED*

### *I. INTRODUCTION*

The observed migration to areas of pleasant climate has been essentially ignored by economists in formal model-building efforts, although some recent articles have noted the empirical importance of temperature (see Cebula and Vedder [1]; Graves [2]). One important theoretical implication arising from this movement is that existing tests of the effect of income differentials on migration in the literature are subject to serious bias. By way of illustration, consider a city—Chicago or Detroit, for example—which is sufficiently cold, damp, and windy that the labor force must be compensated by, say, $1000 per year in higher incomes to remain there rather than move. Clearly, only if income is higher than the income-compensating $1000 in the inclement city will any net income benefit be obtainable from migration to that area. Thus, as will be seen in the empirical section, the income coefficient in existing net migration regressions has a strong downward bias due to the omitted climate variables' correlation with the income variable.

Another implication of the model presented here is that much of the observed interregional difference in net migration rates may be due to climate. In recent years, the West has experienced more net in-migration than have the other regions. The region-dummy variables, important in explanations of past migration, are of less value for the prediction of future migration since no theoretical model predicts the continuing importance of the dummy variables. The present model indicates that the regional net migration differentials may be expected to continue because in large part they reflect the interaction of weather differences across regions with rising national incomes.

The model is briefly described in Section II, with empirical results supporting the model and its implications presented in Section III.

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## II. THE MODEL

The goods that enter the individual's preference function may usefully be categorized as those (ordinary) goods whose quantity may be varied in any location and those whose nature is location-specific. Each location supplies a fixed vector of goods in the second category; hence, demand revisions due to changed tastes, relative prices, or incomes can only be exercised by relocating. Formally,

$$U = U(X, C) \tag{1}$$

where $X$ and $C$ are, respectively, the tradable and location-fixed goods.

The utility function will be maximized subject to the usual budget constraint, except that the price of the location-fixed good is revealed in implicit markets, principally in nominal wage rate differentials for labor of equivalent skill. Without restrictions on mobility and with reasonably efficient information transfer, these wage differentials will, at least approximately, compensate those living in undesirable locations. Were this not the case, the undesirable cities would disappear over time.

An immediate implication of this price-theoretic approach for observed migration is that the estimated effect of real income differentials must be biased downward in usual regression analyses. Even a carefully constructed traditional cost-of-living index used to deflate median income differentials across locations will fail to correct for the fact that undesirable locations will have higher, and desirable locations lower, nominal incomes than will locations having average location-specific characteristics. Hence a portion—perhaps a large portion—of remaining income differentials over space will not represent real utility differences. As a consequence, the estimated effect on migration of a one-dollar difference in *real* income will be biased downward unless the location-fixed characteristics are controlled for in the regression.

In the empirical section to follow, the climate variables are taken to be the primary location-fixed goods. Clearly, the point is more general with other variables, such as crime or pollution, entering, but most of these are felt to be of less importance for inter-SMSA migration than they would be in an investigation of intra-SMSA movements.[1]

## III. EMPIRICAL RESULTS

A regression analysis was undertaken using net in-migration (number of in-migrants divided by the number in the receiving population) between 1960

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[1] Earlier work (see Graves [2]) has shown pollution and crime to have little impact on inter-SMSA migration.

and 1970 for the 138 Standard Metropolitan Statistical Areas (SMSAs) for which all climatic data were available.[2] The results of the analysis are shown in Table 1, while variable definitions with summary statistics are listed in the Appendix.

For the empirical analysis, the primary climatic variables used are annual heating degree days and cooling degree days, separately or in combination.[3] Heating (cooling) degree days are the number of degrees the daily average temperature is below (above) 65 degrees Fahrenheit. Heating degree days are determined by max(65 − Average Daily Temperature, 0). A day with an average temperature of 50 degrees, for example, has 15 heating degree days. All days having an average temperature of above 65 degrees have zero heating degree days, but some positive number of cooling degree days (for example, a day of 80 degrees average temperature has 15 cooling degree days). The annual figures used are the sum of the heating degree days (cooling degree days) over the entire year. The mean values and standard deviations for these and other variables employed in this study are in the Appendix.

In equations (1) through (4) of Table 1, the relationship between net migration and temperature is displayed under linear and quadratic specification. The results show the importance of temperature, especially very warm temperatures, on migration. Very warm temperatures are likely to be particularly important for migration decisions after retirement.

In equation (5), net migration is regressed on the traditional economic variables, income and unemployment, which the literature has shown to influence migration to provide a reference equation with which to compare the properly specified equations that follow. The results are quite typical of the economics literature on migration with both variables being marginally significant and of the expected sign.

That there are biases, as anticipated at the theoretical level, in equations (1) through (5) may be seen in equation (6). In comparing equations (3), (5), and (6), not only are the income and unemployment effects observed to be larger and much more significant, but the equation with the warmth variable as well as the economic variables explains a larger

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[2] The economic variables (from [4]) are all with respect to the 1960-defined SMSAs, while the climate variables are normals for the 1931–60 period, except for cooling degree days which are only available for more recent periods. The dependent variable, net migration, is defined as (number of 1960–70 in-migrants)/(1960 receiving SMSA population) times 100. Hence, the mean value of this variable was 2.29, with individual city values ranging from about +50 to −30.

[3] Other proxies examined in this and in earlier work include: number of freezing days, days temperature was greater than 90° F., January and July average maximum and minimum temperatures, etc.

percent of the variance of net migration than the sum of either the warmth or economic variable equations separately.

It is, of course, possible that other weather variables may influence whether of not an area has a nice climate. Holding temperature constant, one might expect that lower humidity and lower wind speed would make an area more attractive. Humidity (*ANNHUM* in Table 1) is particularly relevant for summer comfort, as reflected by inclusion of the "THI" (temperature and humidity index) in weather forecasts. The case for wind speed (*ANNWND*) is less clear, but the suggestion is that a lower wind speed would reduce the chill of any given winter temperature (the "wind chill index" of weather reports) and reduce blowing dust during the summer.[4] Equations (8) through (14) test these hypotheses and in all cases show very significant negative effects of humidity and wind speed on net migration.

The importance of the various weather controls in equations (8) and (9) suggests the possibility that much of the importance of the regional dummy variables often employed in migration analyses may be due to climatic differences. In particular, the West and South have been cited as having larger net migration than the other regions. Equation (10) reports on a regression of net migration against income, unemployment, and the various regional dummies (omitting the Northeast as the bench mark).

The West appears to have a large and significant effect on net migration. The difficulty with this finding is that one gets no indication of why the West is so attractive; hence, it is not possible to say whether the high net in-migration will continue. Adding regional dummies to specifications given by equations (8) and (9) in arriving at equations (11) and (12) suggests that a great deal of the effect of the West is due to weather (particularly low humidity as suggested by the loss of significance of this variable upon inclusion of the West dummy). The correlation between humidity (ANNHUM) and West is −.51. Since, with the weather variables included, there is little a priori reasoning suggesting a one-tailed test of significance for the West dummy, it appears to be insignificantly different from zero. This finding suggests that some explanations of the West regional effect based on, for example, military expenditures, should be reexamined. This is not to imply that there are no additional reasons for any remaining influence of the West variable, but rather that climatic differences can account for most of the regional effect.

Throughout equations (1) through (12), cooling degree days and heating degree days have not appeared together in the same equation. This is done

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[4] It should perhaps be noted that all of the presumed signs on the weather variables are with respect to the spectrum of cities existing in the U.S. Clearly, the relationships must be nonlinear over sufficiently large ranges—a city having 150 degree temperatures, zero humidity, and zero wind speed would never become optimal regardless of income.

## TABLE 1

NET MIGRATION *(NETMIG)* BETWEEN 1960 AND 1970 FOR 138 SMSAs

(*t*-values in parentheses)

| Eqn # | C | *MEDINC* | *UMEMP* | *WARMTH* | *(WARMTH)*$^2$ | *ANNWND* | *ANNHUM* | *W* | *S* | *NC* | *DEGDAY* | *(DEGDAY)*$^2$ | $R^2$ | F-stat. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) | −.8653 | | | .00214 | | | | | | | | | .021 | 2.90 |
| | (.392) | | | (1.70) | | | | | | | | | | |
| (2) | 5.990 | | | | | | | | | | −.00084 | | .016 | 2.25 |
| | (2.19) | | | | | | | | | | (1.50) | | | |
| (3) | 7.910 | | | −.01077 | $+.33\text{X}10^{-5}$ | | | | | | | | .083 | 6.12 |
| | (2.19) | | | (2.43) | (3.03) | | | | | | | | | |
| (4) | 7.105 | | | | | | | | | | −.00148 | $+.72\text{X}10^{-7}$ | .017 | 1.16 |
| | (1.50) | | | | | | | | | | (.65) | (.29) | | |
| (5) | −7.069 | .00291 | −1.4804 | | | | | | | | | | .053 | 3.78 |
| | (.696) | (1.92) | (1.77) | | | | | | | | | | | |
| (6) | −14.72 | .00519 | −2.059 | −.00915 | $+.35\text{X}10^{-5}$ | | | | | | | | .195 | 8.05 |
| | (1.08) | (3.01) | (2.55) | (1.99) | (3.22) | | | | | | | | | |
| (7) | −.1156 | .00645 | −1.688 | | | | | | | | −.00527 | $+.35\text{X}10^{-6}$ | .136 | 5.23 |
| | (1.08) | (3.65) | (2.04) | | | | | | | | (2.25) | (1.42) | | |
| (8) | 46.32 | .00483 | −1.596 | −.01724 | $+.39\text{X}10^{-6}$ | −2.914 | −.3819 | | | | | | .338 | 11.12 |
| | (2.62) | (2.98) | (3.48) | (3.83) | (3.27) | (4.46) | (3.21) | | | | | | | |
| (9) | 31.91 | .00619 | −2.013 | | | −2.275 | −.396 | | | | −.00650 | $+.58\text{X}10^{-6}$ | .224 | 6.31 |
| | (2.06) | (3.63) | (2.54) | | | (3.07) | (2.61) | | | | (2.87) | (2.39) | | |
| (10) | −3.96 | .00275 | +2.4112 | | | | | 13.971 | +2.6567 | −2.9791 | | | .191 | 6.23 |
| | (.28) | (1.39) | (2.88) | | | | | (3.38) | (.67) | (.81) | | | | |

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|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (11) | 32.82 | .00461 | −2.934 | +.01476 | $+.46X10^{-5}$ | −2.352 | −.2206 | 5.207 | −.4485 | −2.7540 | | | .354 | 7.79 |
| | (1.64) | (2.50) | (3.76) | (2.82) | (3.94) | (3.19) | (1.42) | (1.11) | (.11) | (.82) | | | | |
| (12) | 33.67 | .00429 | −2.894 | | | −1.735 | −.1340 | 6.476 | −4.438 | −4.297 | −.00680 | $+.60X10^{-6}$ | .266 | 5.16 |
| | (1.74) | (2.18) | (3.41) | | | (2.23) | (.89) | (1.28) | (.94) | (1.18) | (2.93) | (2.48) | | |
| (13) | 46.04 | .00479 | −2.557 | −.02124 | $+.60X10^{-5}$ | −2.649 | −.3715 | | | | +.00151 | $-.25X10^{-6}$ | .346 | 8.54 |
| | (2.12) | (2.93) | (3.31) | (3.71) | (4.84) | (3.76) | (3.04) | | | | (.41) | (.76) | | |
| (14) | 87.45 | .00415 | −2.628 | +.01025 | | −3.180 | −.8177 | −1.078 (ANTMVR) | | | +.00737 | | .332 | 9.22 |
| | (3.58) | (2.47) | (3.47) | (4.02) | | (4.37) | (4.89) | (4.74) | | | (4.16) | | | |

*Key: MEDINC* = 1960 SMSA median family income; *UNEMP* = 1960 SMSA unemployment rate; *WARMTH* = number of cooling degree days; *ANNWND* = average wind speed; *ANNHUM* = average humidity; *W* = West dummy; *S* = South dummy; *NC* = North Central dummy; *DEGDAY* = number of heating degree days. More precise definitions are in the Appendix.

in equation (13), although with four terms representing temperature, multicollinearity was a problem. In an effort to circumvent this difficulty, equation (14) was estimated. The variable *ANTMVR* (annual temperature variance) was created by subtracting, for each SMSA, the monthly average minimum January temperature from the monthly average maximum July temperature. The temperature variance term has an obvious cost interpretation—both winter-related expenses (heating, warm clothing, cold weather recreation equipment) and summer-related expenses (air conditioning, cool clothing, warm weather recreation equipment) would be incurred for indoor and outdoor comfort and recreation in a high annual temperature variance SMSA. The interpretation of the overall impact of temperature on net migration suggested by equation (14) is that, holding temperature variance constant, both warm and cold SMSAs are desirable, though possibly not to the same people.

The relative importance of the variables in equation (14), Table 1, in explaining net migration is shown below. In this equation

$$\begin{aligned} \mathrm{dln}NETMIG = {} & \underset{.250}{10.45(\mathrm{dln}MEDINC)} - \underset{.265}{5.76(\mathrm{dln}UNEMP)} + \underset{.692}{6.60(\mathrm{dln}WARMTH)} \\ & - \underset{.367}{12.73(\mathrm{dln}ANNWND)} - \underset{.515}{21.23(\mathrm{dln}ANNHUM)} \\ & + \underset{1.123}{14.19(\mathrm{dln}DEGAY)} - \underset{.800}{28.65(\mathrm{dln}ANTMVR)} \end{aligned}$$

the elasticities at the means precede the respective variables, while the Beta coefficients[5] are below the elasticities. This equation indicates that differences in the climate variables across SMSAs are much more important determinants of net migration than are median income and unemployment rate differentials. This is an important finding since weather differences across SMSAs will presumably continue over time, while income and unemployment levels may vary among cities over time. Illustrating differences in the two measures of relative importance, humidity, even though it has a larger elasticity than warmth or cold, is relatively less important in determining net migration since it exhibits less variation across SMSAs than the temperature variables.[6]

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[5] Beta coefficients (defined as $\mathrm{Beta}_X = (s_{XX}/s_{YY})(b_X)$, where $s_{XX}$ = the standard deviation of the independent variable under consideration, $s_{YY}$ = the standard deviation of the dependent variable, and $b_x$ = the ordinary least squares regression coefficient for the same independent variable) tell one which of the variables are "most likely" to move any given percentage in the data.

[6] The regressions of Table 1, as well as other not reported on, were also run in semi-log and double-log form (with one added to the dependent variable in the latter case) with no apparent improvement in the description of the migration phenomenon.

## *IV. SUMMARY AND CONCLUSIONS*

The analysis presented here shows that due to the presence of income-compensating differentials for bad weather in an area, all previous studies of inter-SMSA migration will have bias in the income coefficients (presumed to capture the benefits of migration). That is, the income effect on migration tends to include things migrants do not want along with the higher incomes that they do want. As a result, it was hypothesized that the income coefficient is downward biased when the bads are omitted from the regression. This hypothesis was supported for weather by the empirical results.

Similar biases are present in the coefficient on unemployment rate in the SMSA. Comparing equation (5) with equation (14) reveals that the true effect of unemployment is almost twice as large and significant as one would be led to believe if weather differences are uncontrolled for. Compare this finding with the literature on migration: "One of the most perplexing problems confronting migration scholars is the lack of significance of local unemployment rates in explaining migration" [3, p. 411].

It has been suggested that the migration mechanism is inefficient in reallocating labor supplies, in light of the persistent interregional wage and unemployment rate differentials. From the conceptual experiment outlined here, it seems clear that there is no reason to expect the movement of migrants to occur in such numbers as to equalize wage and unemployment rates. Indeed, should such movement occur, it is quite clear that the utility obtainable by identical individuals would not be the same.

Finally, the paper suggests a reason for the pervasive findings of differential regional migration rates. To a policy-maker trying to determine future demands for public services, such an explanation is vitally important in that it gives a reason for expecting continued high migration into western cities.

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## *APPENDIX*

Variables examined during the course of this research, with their means and standard deviations, are listed below. Additional variables were examined in earlier work (number of days below 32° F. or above 90° F., etc.), but were found to be less adequate proxies for the desired climatic variables than those used here. The correlation matrix for the variables below is available upon request.

| *Variables* | | *Mean* | *S.D.* |
|---|---|---|---|
| *WMXTEM* | = average January maximum daily temperature | 45.63 | 12.85 |
| *WMNTEM* | = average January minimum daily temperature | 27.33 | 11.71 |
| *SMXTEM* | = average July maximum daily temperature | 88.29 | 5.55 |
| *SMNTEM* | = average July minimum daily temperature | 66.08 | 6.05 |
| *JANDAY* | = normal heating degree days (January) | 892.70 | 361.82 |
| *DEGDAY* | = normal heating degree days (annual) | 4414.86 | 2147.87 |
| *WETMON* | = normal inches of rainfall in the wettest month | 4.53 | 1.60 |
| *DRYMON* | = normal inches of rainfall in the driest month | 1.75 | .93 |
| *WETANN* | = normal inches of rainfall (annual) | 35.27 | 13.20 |
| *JANSNO* | = Mean total inches January snowfall | 5.76 | 6.01 |
| *ANNSNO* | = mean total inches annual snowfall | 23.17 | 24.59 |
| *W1HUM* | = 1 p.m. EST January relative humidity, percent | 62.69 | 9.37 |
| *W7HUM* | = 7 p.m. EST January relative humidity, percent | 65.09 | 10.32 |
| *S1HUM* | = 1 p.m. EST July relative humidity, percent | 54.04 | 9.12 |
| *S7HUM* | = 7 p.m. EST July relative humidity, percent | 56.36 | 14.90 |
| *JANWND* | = mean wind speed in January (m.p.h.) | 10.16 | 2.02 |
| *JULWND* | = mean wind speed in July (m.p.h.) | 8.20 | 1.58 |
| *STORMS* | = annual mean number of days having thunderstorms | 40.89 | 16.95 |
| *FOG* | = annual mean number of days having heavy fog | 24.64 | 15.38 |
| *WARMTH* | = cooling degree days (as defined in text) | 1475.93 | 952.27 |
| *ANNHUM* | = (*W1HUM* + *W7HUM* + *S1HUM* + *S7HUM*)/4 | 59.54 | 8.89 |
| *ANNWND* | = (*JANWND* + *JULWND*)/2 | 9.18 | 1.63 |
| *ANTMVR* | = (*SMXTEM* − *WMNTEM*) | 60.96 | 10.47 |
| *MEDINC* | = SMSA median income in 1960 | 5777.90 | 781.55 |
| *UNEMP* | = SMSA unemployment rate in 1960 | 5.03 | 1.42 |
| *W* | = West dummy | .15 | .36 |
| *S* | = South dummy | .44 | .50 |
| *NE* | = Northeast dummy | .14 | .36 |
| *NC* | = North Central dummy | .27 | .44 |
| *NETMIG* | = Net SMSA in-migration between 1960 and 1970 | 2.29 | 14.10 |
| $(WARMTH)^2$ | | 904917. | $.14 \times 10^7$ |
| $(DEGDAY)^2$ | | $.46 \times 10^7$ | $.49 \times 10^7$ |

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