CENTRAL PLACE DEVELOPMENT IN A TIME-SPACE FRAMEWORK*

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MOST scholars in geography and related social sciences have recognized that the locational structure of man's economic, political and cultural activities is not in a static state. Yet very little attempt has been made to conceptualize the manner by which the spatial arrangement of man's establishments change over time. This study seeks to provide at least a partial solution for meeting this need. *(1)*

AN EVOLVING SETTLEMENT STRUCTURE. The geometric patterns of human settlement are linked by a framework of transport lines which, through time, have varied greatly in their capacities for volume and speed of traffic. If the speed of man's transport carriers were uniform throughout the world, if he could travel in any direction and over any type of terrain at a given speed—neither faster nor slower—then it is possible that settlement patterns would exhibit some of the geometric regularity of the Christaller-Lösch models. *(2)*

In reality, however, the adoptions of transport innovations which alter the time and cost distances separating man's functional establishments have occurred neither simultaneously nor uniformly in all directions from all points on the earth. While such considerations shed doubt upon suggestions for static and formal patterns of spatial organization, it is not the intent of this effort to discredit the central place networks of Christaller and Lösch; rather, the descriptive model proposed in this study seeks to characterize the dynamics of the settlement-transport complex. Thus spatial patterns will be viewed as phenomena evolving in a realm of time-space.

RELATIONSHIPS OF POINTS IN TIME-SPACE. In outlining a model for characterizing the dynamic state of settlements in time-space, an approach traditional to the physicist but in many respects new to the geographer will be utilized. In modern physics and philosophy, distance is no longer considered a a universally valid parameter for describing the relationships between points, events or particles in space. For the physicist to describe such relationships, it is necessary that he view them in time-space and that he know their positions, their velocities and the directions in which they are moving. By velocity, he means the time-rate at which the distance between points, events or particles changes. *(3)*

Geographers, as physicists, have traditionally been concerned with the positions of points (places) in space and with the directions of movements between them. However, geographers have not employed the concept of "velocity" in studying spatial relationships. Yet it might be of value and not too far-fetched for the geographer to ask "at what 'velocities' are settlements approaching one another in time-space?"

A DYNAMIC MODEL OF THE SETTLEMENT STRUCTURE. The manner in which "velocity" through time-space is to be considered in a study of evolving settlement patterns demands clarification. Acknowledging the word of the physicist, that time-space is the most valid parameter for measuring the relationships between two points, the changes in travel-times required between Edinburgh and London will be considered. These changes and the corresponding transportation innovations and improvements are illustrated in Figure 1. *(4)*

The trip from Edinburgh to London that took approximately four days or 5,760 minutes by stagecoach in 1776 can, assuming "normal" conditions, be made by a turboprop airplane in 180 minutes today (including land-travel from airport to center of town). This can be expressed in a form analogous to velocity by subtracting the re-

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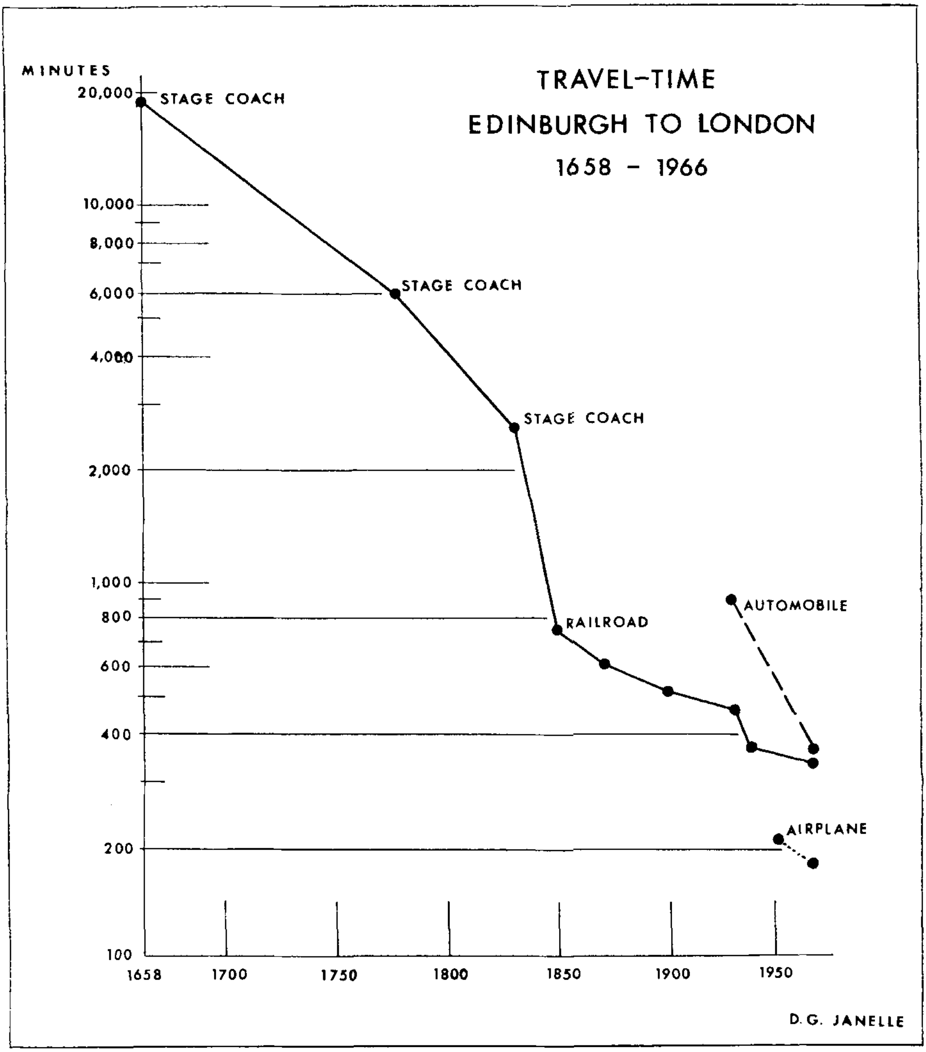

Figure 1.

quired travel-time today from that of 1776 and dividing by the time-travel interval in years. By this procedure it is found that Edinburgh and London have been approaching each other in time-space at the average rate of 29.3 minutes per year for the past 190 years. Thus:

$$\frac{\text{TRAVEL-TIME (1776)} \text{ minus } \text{TRAVEL-TIME (1966)}}{\text{INTERVAL IN YEARS}} = \text{Average Rate of Time-space Convergence}$$

$$\frac{5{,}760 \text{ min.} - 180 \text{ min.}}{190 \text{ Years}} = 29.3 \text{ minutes per year}$$

If only railroad travel from about 1850 to the present is considered, then Edinburgh and London have been approaching each other at the average rate of 3.4 minutes per year for the past 116 years.

$$\frac{750 \text{ min.} - 360 \text{ min.}}{116 \text{ Years}} = 3.4 \text{ minutes per year}$$

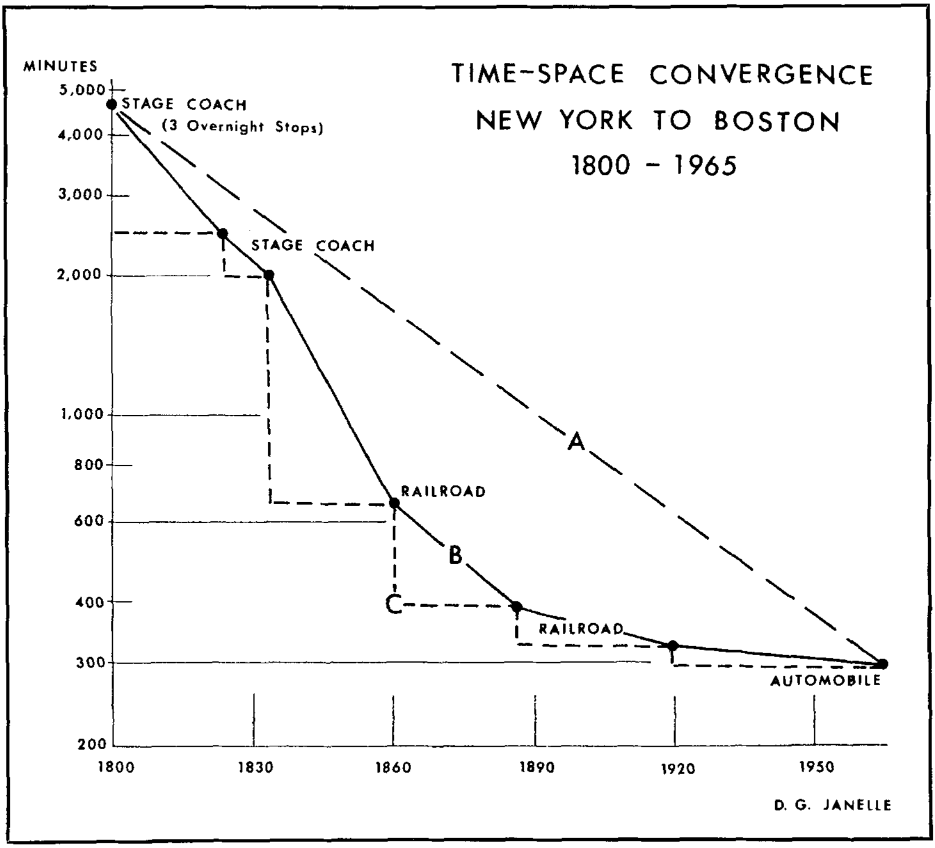

Figure 2.

A comparison of this 1850–1966 *convergence rate* (as "velocity" will be defined) with the one for the 1776–1966 period reveals the responsiveness of this measure to the introduction of transport innovations. Furthermore, this measure reduces distance to a concept that is relative to man's means of traversing space. Reference to this measure as a "time-space convergence rate" rather than as a "velocity" is preferred. Conceptually, the convergence rate is not a velocity—it is a time-rate change of time. It is, however, mathematically analogous to velocity as defined by the physicist, and it provides a tool for describing the changes in time-space relationships between settlements.

SOCIAL PHYSICS. Models in social science which bear close resemblance to models and laws in physical science (*i.e.*, Zipf's gravity model *(5)* or the "velocity" model developed in this study) are frequently referred to as products of social physics. It is generally conceded, however, that congruence of social science models with those of physical science should not be a goal of objective research. Both Lukermann and Berry *(6)* have acknowledged the pitfalls of such undertakings. Nonetheless, as Berry observes, the mere congruence of a social science model with one in the physical sciences should not discredit its value. Fortunately, the time-space convergence model proposed here is easily verifiable without reference to physics. This model provides a means of measuring a purely cultural conception—man's frequently-referred-to "shrinking world."

CHARACTERISTICS OF SETTLEMENT CONVERGENCE. The geographical implications of a "shrinking world" are many and varied, and the time-space convergence model greatly facilitates the understanding of this change. But before one attempts to prognosticate the future time-spatial relationships of places, an understanding of the model's characteristics is essential.

As proposed, the convergence measure is a linear function of time. In reality, however, cities cannot continue to approach each other at a constant rate. Investigations have revealed that an asymptotic relationship exists in the convergence of places. *(7)* Thus, although settlements should continue to approach each other with the introduction of new transport innovations, they will most likely do so at an ever decreasing rate. (Note line B on the semilogarithmic graph of Figure 2). This notion has at least intuitive appeal because any change in transport-speed between two points lessens the maximum possible time-space gain that can be attributed to any future increase in travel-speed. There is also a practical limit to the reduction of the time-space separation between places—it seems safe to assume that there will always remain some friction in the forms of traffic congestion and transfer-time along with technical limitations that will prevent the instantaneous transfer of goods and passengers.

Whereas the convergence model portrays time-space relationships as continuous functions of time (line A in Figure 2), it is more realistic to view settlement convergence as a non-continuous and step-like function of time (line C in Figure 2). For example, the opening of a new limited-access highway between two points is likely to result in a very abrupt change in their time-space relationships. Thus, the convergence rate is constantly changing and is marked by a series of recurrent accelerations and decelerations which correspond to improvements and deteriorations in transport-accessibility. Although, for purposes of this paper, the author has not attempted to characterize convergence by means of differential or difference equations, it is realized that such procedures would give a more general validity to many of the views presented herein.

THE LATENT SIGNIFICANCE OF DISTANCE. Aside from the asymptotic and step-like nature of settlement convergence, another peculiarity is the manner in which convergence is related to distance. Because this property is less apparent than those already indicated, it will be considered in detail.

Given a homogeneous transport line (one on which it is possible to travel at a given speed over its entire length), the convergence rates between a settlement and each successive settlement along this line will change with distance. For example, in 1840 Flint and Saginaw, Michigan were both connected with Detroit by a stage coach line capable of traveling an estimated 4.5 miles per hour. *(8)* Today these same cities are joined by a limited-access highway over which automobiles can legally travel up to 70 miles per hour. Yet because this improvement is stretched over a greater distance between Saginaw and Detroit (93 miles) than between Flint and Detroit (59 miles), Saginaw and Detroit have been approaching one another in time-space at the average rate of 9.9 minutes per year for the past 125 years as compared with only 6.4 minutes per year for Detroit and Flint. Since this property of convergence is not intuitively obvious, the hypothetical example in Figure 3 is intended to clarify it.

For the example in Figure 3, it is assumed that a homogeneous transport system existed between settlements A through F in the year 1950 and that transport innovations by 1970 will also result in a homogeneous transport connection. The average speed between these settlements was 25 miles per hour in 1950 and will be 50 miles per hour in 1970. Thus, the absolute times for travel between any two of these places have in all cases been cut in half. Yet in spite of this, and in spite of the homogeneity of the transport routes, the convergence rate for place A with each successively more distant place is not the same—it increases with distance. Thus in this example settlements 50 miles apart are approaching each other five times as fast as those 10 miles apart. If the data in Figure 3 were plotted on a scatter diagram, it would be noted that the convergence rates are a linear function directly related to distance.

Although transport innovations seldom lead to homogeneous route changes, it has been determined that an increase in transport-speed on a route connecting successive places will generally result in greater con-

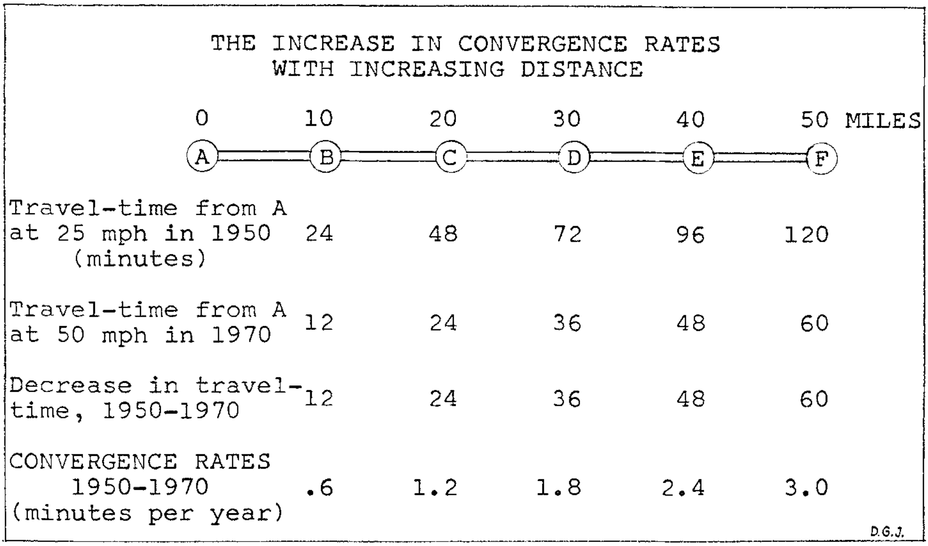

Figure 3.

vergence rates for the more distant places than for the closer or intervening ones. Thus with every increase in the speed of travel, the significance of distance decreases more rapidly for the more distant points. On the whole it is expected that this declining significance of intervening space benefits the more distantly-spaced larger cities more than it benefits the smaller ones. For instance, with continued reductions in travel-time, people living relatively near Flint may find that with an additional small increment of time-expenditure they can continue on to Detroit, where the choice of commodities and the range of services are more varied than those in Flint. It is even possible that for certain functions Flint will no longer represent an intervening opportunity for some residents and commercial firms situated between Saginaw and Detroit.

In general it can be stated that any transport improvement will tend to be of greatest advantage to the highest-ordered center that it connects. And the greater the difference in the hierarchical or functional order of centers joined by the transport improvement, the greater the likelihood that the highest-ordered center will continue its growth in dominance over an expanding tributary area. Thus it appears that the relationship of time-space convergence with distance for any given transport improvement is a factor which helps to augment the dominance of the higher-ordered centers in the central place structure. This conclusion, based on the study of the covariation of distance and the convergence rates, may have important implications for private and governmental planning agencies, for businessmen and for academicians interested in understanding the development and competitive status of central places.

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(1) For a more complete discussion of this problem see Janelle, Donald G., *Spatial Reorganization and Time-space Convergence,* Unpublished Ph.D. thesis, Dept. of Geography, Michigan State Univ., 1966.

(2) Christaller, Walter, *Central Places in Southern Germany,* Baskin, Carlisle W. (trans.) Prentice-Hall, Inc., Englewood Cliffs, N. J., 1966; Lösch, August, *The Economics of Location,* Woglom, William H. and Stolper, Wolfgang F. (trans.), Yale University Press, New Haven, 1954.

(3) Bridgman, P. W., *A Sophisticate's Primer of Relativity,* Routledge and Kegan Paul, London, 1963, pp. 28, 70.

(4) Based on O'Dell, A. C., *Railways and*

Geography, Hutchinson's Univ. Library, London, 1956, pp. 179–183.
(5) Zipf, George Kingsley, *Human Behavior and the Principle of Least Effort*, Addison-Wesley Press, Inc., Cambridge, Mass., 1949.
(6) Lukermann, Fred E., "The Role of Theory in Geographical Inquiry," *The Professional Geographer*, Vol. 13, pp. 1–6, March, 1961; Berry, Brian J. L., "Further Comments Concerning 'Geographic' and 'Economic' Economic Geography," *The Professional Geographer*, Vol. 11, pp. 11–12, January, 1959.
(7) Janelle, *op. cit.*, pp. 106–110.
(8) Estimated on basis of information in Bigham, Truman C. and Merrill, Robert J., *Transportation Principles and Problems*, McGraw-Hill Book Co., Inc., New York, 1952, p. 53.

NEW MAPS

Maps 18, 19, 20, and 21 of the GE-50 series published by the Bureau of the Census, are titled "Retail Trade in the United States, 1963"; "Sales of Retail Shopping Goods Stores for Selected Standard Metropolitan Statistical Areas in the United States, 1963"; "Wholesale Trade in the United States, 1963"; and "Hotel-Motel Receipts in the United States, 1963." They are similar in base and style to earlier maps of the series, with each main map on a 1 : 5,000,000 scale. Price is 50 cents each at the Superintendent of Documents, Washington, D.C. 20402.

The Denoyer-Geppert Company has issued several new wall maps, among others a map of Israel, 35 × 87 inches, using a scale of 3 miles to the inch, and showing relief and elevation by the Wenschow shaded technique. The map editor, David H. K. Amiran, of the Hebrew University of Jerusalem, has included an inset map of modern Jerusalem. The political boundaries, of course, are those of the pre-1967 war. The map shows up well in large classrooms, and should have a good sale for church use as well as in classrooms.

Folios 13 and 14 of the *Serial Atlas of Marine Environment* have been issued by the American Geographical Society. The former, "Distribution of the Euphausiid Crustacean Meganyctiphanes norvegica," is by John Mauchline and Leonard R. Fisher; the latter report is entitled "Distribution of North Atlantic Pelagic Birds" by Robert Cushman Murphy.

Four multicolored maps of the 48 conterminous states have been received from Brian J. L. Berry, University of Chicago. They were prepared April 1967 for the Social Science Research Council Committee on Areas for Social and Economic Statistics in cooperation with the Bureau of Census, U. S. Department of Commerce. These maps are titled: Commuting Fields of Central Counties, Commuting Fields of Central Cities, Functional Economic Areas of the United States, and Consolidated Urban Regions of the United States. The scale is approximately 1 : 5,000,000, the same as the GE-50 series, which makes possible interesting comparisons.

The Department of State, Office of the Geographer, has issued Geographic Report No. 13, "North America: Civil Divisions." It consists of an up-to-date statement, with maps, of the political divisions of the continent. For each division, a brief descriptive outline contains the name of the capital, the area of the unit, a list of minor civil divisions, and a few pertinent comments. Pamphlets of this type provide a very handy reference source for the geographer.

Increased interest in the Middle East nations has led Denoyer-Geppert to bring out a new political map of that area, 44 × 64 inches, at a scale of 65 miles to the inch. Boundaries have been corrected to March, 1967. The emphasis is so strongly political that the map will find favor among political scientists; the relatively small number of natural features of land relief shown here will make it less useful in most geography classrooms.