

UC Irvine

UC Irvine Previously Published Works

Title

STRUCTURING A TRANSPORTATION NETWORK - GERMAN - LEUSMAN,C

Permalink

<https://escholarship.org/uc/item/9bm6f00w>

Journal

ANNALS OF THE ASSOCIATION OF AMERICAN GEOGRAPHERS, 71(3)

ISSN

0004-5608

Author

WERNER, C

Publication Date

1981

Copyright Information

This work is made available under the terms of a Creative Commons Attribution License, available at <https://creativecommons.org/licenses/by/4.0/>

Peer reviewed



Strukturierung eines Verkehrsnetzes.

Christoph Leusmann.

Geographische Institute der Universität, Bonn, 1979. xii 157 pp., bibliog., figs. Bonner Geographische Abhandlungen, 61. DM 32,-.

Reviewed by Christian Werner

LEUSMANN, in *Strukturierung eines Verkehrsnetzes*—"Structuring a Transportation Network"—develops operational definitions of transportation network structure and applies them to an actual network, the railroad system of Southern Germany. More specifically, the author proposes a number of accessibility indices which he then aggregates into three "structural components" by means of factor analysis. With their help he establishes an ac-

cessibility classification for the nodes of the network. The components are then linked to the network's socioeconomic environment through regression and correlation analysis. The concluding section reflects on possible extensions of this research in the direction of a comprehensive accessibility index.

The approach is based on graph theory and multivariate analysis and is fairly straightforward. But since the book is written in a language with which the American reader is usually not familiar, and in an academic jargon that makes the text almost incomprehensible, a relatively detailed summary of its content may be in order.

The author starts by considering a network serving a particular transportation mode—in this case rail transportation. It is assumed that the network has several properties convenient for analytical purposes, namely that, as a graph, it is linear, planar, and connected. He introduces three different weights for the links of the network. First, any pair of network nodes x , y is assigned the weight 1 or 0 depending on whether x and y are connected by a network link or not. The second weight of each link is defined as its length in kilometers, and the third is defined as the number of daily trains between the two nodes connected by the link. The values of the three weights of the network links can conveniently be organized in the form of three matrices, the first one of which is the well-known adjacency matrix. Even if two nodes are not connected by a link they are connected by one or more paths each of which has two or more links. The author now proceeds to define weights for each network path using the weights of its individual links. Depending on the particular type of link weight and the particular way in which the weights of the links in a path are aggregated, different path weights can be defined (e.g., summing the metric lengths of the path links). Since nodes may be connected by several paths, the author stipulates that for each pair of nodes only one path will be considered; it is chosen by some preestablished criterion (for example, the path with the smallest weight). The three steps of 1) defining a particular link weight and, based on it, 2) a particular path weight, and 3) selecting one path for each pair of nodes, lead to a matrix each cell of which shows the weight of the selected path connecting the cell's entry nodes. For each type of link weight and each particular operation of aggregating the weights of links in a path to a path weight we will get a

particular matrix which the author calls a "network functional." Each row lists the weights of the selected paths by which the row entry node is connected to all other network nodes, and these weights can be aggregated in a variety of ways—summation, averaging, choosing the minimum or maximum—so as to produce a single index. This index describes some property of the row entry node with regard to all others and constitutes, by definition, a measure of its accessibility.

The process of specifying weights for the links, then for the paths, then selecting one path for each pair of nodes and defining, on the basis of their weights, an accessibility measure for each node is called, in the terminology of the author, "structuring" of the network. Each structuring produces a particular accessibility index, and by pursuing numerous avenues of defining and aggregating link weights, the author generates a total of twenty-one accessibility indices, including all the familiar ones like the Associated Number, the Shimmel index (both for topological and metric distances), the degree and the potential of a network node, the nodal entropy, the skewness of the frequency distribution of number of network nodes versus distance from the node under consideration, and combinations integrating two or more of these indices.

Recognizing that these indices often measure similar properties of a node's position within a network, the author now applies factor analysis to find the main "structural components" which together account for the diversity of the index values of the network nodes. The data employed in the analysis are various index values of the nodes of the railway network in Southern Germany. Not surprisingly, the components reflect and spell out the input on which they are based: They consist of 1) a "local" component (called "significance") representing indices like nodal degree (i.e., number of links incident at a node); 2) a "global" component (called "primary location") characterizing a node's position with regard to all other nodes (e.g., the Shimmel index); and 3) a "regional" component (called "secondary location") on which those accessibility indices load rather heavily which are based on the network in the larger vicinity of each node. Examples for the latter would be the skewness measure mentioned above, or the indices counting the number of nodes within three links or within 50 kilometers of a particular

node. With the help of these three structural components, the author proceeds to group the network nodes into six types. Discrimination between the nodes is based, in part, on their relative network position—from central to intermediate to peripheral to remote—and, in part, on their nodal degree. The result of the classification is presented as a map which gives rise to some reflections on possible interdependencies between the accessibility and the relative location of nodes.

Finally, since any transportation network evolves as a result of the demand for spatial interaction and, in turn, influences the evolution of such a demand, the author studies the relationship between the three structural network components and several parameters measuring socioeconomic properties of the network nodes (population density and growth, percentages of agricultural and industrial employment, proportion of commuters).

To summarize the main research results: 1) The twenty-one accessibility indices as applied to the railroad network of southern Germany can be interpreted as the combined effect of three structural components. They represent, respectively, the local, regional and global elements of the accessibility measures.

2) The structural components permit the classification of the network nodes into six groups, each of which consists of nodes which share particular qualities of access. Their spatial arrangement might be governed by some ordering principle.

3) Statistically significant regression equations relate the structural components to selected socioeconomic characteristics of the network nodes.

To evaluate the work, we can consider first the nature of the indices. Although the number of accessibility indices of which one can conceive has no upper limit, and although it is doubtful whether it is even possible to define a set representative for all possible indices, it would at least be desirable to reduce the largely accidental character of the index set to be investigated. The most obvious shortcoming of the indices is that they are all one-dimensional, in as much as relative location is expressed by distance measures only (e.g., number of links or kilometers) without any recognition of the direction of paths or links, or the sequential order in which they join a node. Both intervening opportunity models and common sense make it

clear that geographic network and flow phenomena in two dimensions can usually not be collapsed into one dimension without loss of crucial information—unless we study, like Thünen, an idealized world. By necessity, the three structural components show the same limitation: they summarize the information content of the author's 21 indices in the form of local, regional and global access, i.e., spatial concepts which are functions of distance but otherwise uniform in all directions.

Second, the classification of network nodes is subjective in as much as: 1) the structural components from which the classes have been derived are based on subjective input and; 2) the grouping process does not lead to any "natural" breakdown of the nodes into classes. Rather, the author arrived at the six classes of network nodes through subjective choice.

Whereas these are largely unavoidable limitations, it is unfortunate that the investigation of nodal types and their spatial distribution ends with the classification and its graphic display. There are neither empirical findings nor a hypothesis nor is there any deductive scheme that would link the differing accessibilities of nodes to their relative location (as, for example, Christaller has done by deriving the spatial arrangement of nodes from their centrality). There is, however, what the author calls "a model sketch of the spatial organization of constitutive node-types." It is a sketch of an idealized map which shows the spatial distribution of the network nodes as a function of their class membership. As such, it is the illustration of a hypothesis about a possible accessibility/location relationship. What is still missing is the quantitative formulation of the principles establishing spatial order among the nodes on the basis of their accessibility—let alone a theory from which these principles could be derived. Nevertheless, the author's suggestion of a systematic accessibility pattern in space seems promising; its exploration might eventually contribute some significant theoretical insights to the still minute body of location theory in transportation geography.

Third, the regression with the highest multiple correlation coefficient relates the structural component called "significance" to five socio-economic variables, with $r^2 = 0.27$. Since both the accessibility indices incorporated in the "significance" component and the socio-economic variables are all of the familiar type, it is not surprising that the multivariate analysis pro-

duces results which apparently do not improve on those already reported in the literature. Although the relationship is statistically significant, it once again demonstrates the relatively loose dependence between the variables which are commonly used to describe "important" parameters of society and the transportation network. Certainly, there are numerous obvious omissions, the competing and cooperating function of other transport networks being just one example. Perhaps we fail to measure the "right" societal characteristics because they are forces of tradition, of politics and economic power which often elude recognition, let alone a means of measuring them.

Another source of possible shortcomings is, of course, the methodology. Networks and their flows constitute the implementation of many individual decisions. Multivariate analysis as applied here does not deal with any of them but only with some of the parameters which, it is hoped, might somehow work as surrogates. Moreover, the dynamic quality of the network/flow/society interplay is altogether missing. Many of these difficulties are recognized and discussed by the author; however, their magnitude and complexity go, for the most part, well beyond the scope of this book.

The seemingly intractable and elusive nature of the book's topic is also reflected in its language. Sentences are frequently too contrived and too long (up to, say, half a page, which is a record even by German standards). At times they create vague impressions through subtle implication and shades of possibility, more familiar from exercises in literary criticism than science (which, after all, is supposed to tell us simply and clearly what is and what is not). Often, instead of evidence and arguments, there is an extensive use of words like "meaningful" ("sinnvoll") and "reasonable" ("vernünftig") when the statements in question are neither one nor the other, unless one makes rather specific assumptions. Even the mathematical language is unwieldy and reaches, on occasion, artistic levels of surreal design (and quite unnecessarily so), culminating at one point in a symbol having no less than thirteen subsymbols in the form of numerous left and right super- and subscripts. Footnotes account for up to half of the text over large segments of the book, containing primarily elaborations and examples which fit perfectly well into the main text.

Aside from its form, the book raises some

substantive questions of scientific thought and method. A large part of it deals with the formulation and combination of new accessibility indices; their application to a real world network is shown on maps (and there are more than thirty of those in the book). But formulating, applying, and displaying definitions do not, by themselves, produce any new knowledge about the world. Where well-defined properties of empirical phenomena are related to each other, i.e., accessibility of nodes to their relative location in the network or to their socioeconomic make-up, the conclusions are either vague or weak. On the other hand, a major objective of the book is the formal conceptualization of network structure. Here, the author is clearly successful in sharpening and integrating various efforts in the literature with his own, which deal with the definition of accessibility and its relation to the notion of the structure of a network. Thus, one is tempted to say that the author has produced a superior apparatus of scientific inquiry which, however, has not produced equally superior results when applied to the concrete case of analyzing a real world network. On some occasions the author seems to rely on information which is not presented, and which one would expect as part of the output rather than the input of the study. For example, he apparently judges the adequacy of indices on the basis of the values they assign to the nodes of his sample network. But what yardstick, what outside knowledge, what expectation, guides him in these judgments? It almost seems as if he has a preconceived notion as to how the nodes should be ranked by an accessibility index (e.g., high for Munich or Stuttgart, of course). This would indicate that he seeks an objective measure which fits his subjective and a priori judgment. But such an index would give us knowledge not about the world, but only about the author, as he sees it.

Despite its appearance, the book is not so much an orthodox research exercise with well defined purpose, methods and findings, but much more a painful struggle to come to grips with and strengthen the shaky scientific basis of transportation network analysis in geography. As such it is primarily a contribution to the improvement of our scientific language: rather than learning new discoveries about networks, we are being confronted with the inadequacy of questions, definitions, tools and findings in transportation geography, i.e., with its embryonic state

as a science. By the standards of our profession, the book is definitely courageous and ambitious, and it succeeds in constructing a methodological framework for the ongoing exploration of that elusive feature called accessibility. This makes it a commendable effort despite the shortcomings which, almost invariably, accompany such an unorthodox research venture in geography.

Dr. Werner is Professor of Geography at the University of California at Irvine, CA 92717.

