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A Model of Hierarchical Internal Migration

Most nations of the world are subdivided into smaller political units-counties, departments, states, provinces, etc. Often, these geographic units are aggregated to form regions. No explicit rules, in general, are employed to devise these groups. The author, however, has developed a systematic procedure for regionalization which utilizes internal migration data. Regions found by this method have relatively large internal and relatively small external population movements. They form functional groups of counties, departments, etc.

The procedure has been previously used to analyze migration patterns in many countries, among which are France, Italy, Spain, Turkey, the United States, the U.S.S.R., and Japan (Slater, 1975: 1976 a, b, c; in press, a). Some traditional regions such as New England (the United States), Shikoku, Chugoku, Kyushu, and Tohoku (Japan), Galicia, Extremadura and Aragon (Spain) and Patagonia, Mesopotamia and Cuyo (Argentina) have been identified as migration regions, while others have not.

Migration data for three Eastern European nations have been studied with 40 $\times$ 40 interdistrict Romanian table for 1972, a 28 $\times$ 28 interprovincial Bulgarian table for 1971, and a 25 $\times$ 25 inter-subdivision Hungarian matrix for 1973 are analyzed. The ij-entry of each table is the number of people who moved from unit i to unit j. Since diagonal entries of the table are not taken into account here-though they can be-the ii-entries are recorded as zero.

The regionalization algorithm utilized has two parts. In the first, each square internal migration table is adjusted through an iterative scaling process to have uniform row and column sums. (All row and column sums equal an arbitrary constant, here chosen to be 100.) Sheer size effects associated with differences in total in-and out-migration between geographic units are removed. Entries of the adjusted table are measures of interaction, or functional linkages, between the units. The interaction structure of the original flow table (M), as measured by the cross-product ratios--(M_{ij}/M_{ik}) (M_{hk}/M_{hi}) $(i \neq h,\ j \neq k)$--

are unchanged by the adjustment. The adjustment is accomplished by alternately scaling all rows so that they sum to 100 and then all columns so that they, too, sum to 100. This scaling procedure is iterated until adequate convergence to a final table in which all row and column sums are simultaneously equal to 100 is obtained. This procedure will, in fact, converge if the positive entries of the internal migration table form a connected structure, i.e. cannot be decomposed. In practice, the procedure has converged for all tables so far studied. The entries of the adjusted (doubly-standardized) table are estimates of the flows that would occur between the areas if each one had 100 people leaving, as well as entering.

Regions are composed of geographic areas with strong mutual interconnections. To identify such regions, a hierarchical clustering procedure--part 2 of the regionalization algorithm--is applied to the adjusted table. It is based on graph-theoretic concepts. A graph is constructed with one vertex for each area. Initially, there are no links between these vertices. The largest entry of each adjusted table is found. If it is located in the *ij*-cell, a link is constructed emanating from vertex *i* and terminating at vertex *j*. The link associated with the second largest entry is then inserted, etc. As links are so added, in order of decreasing magnitude, changes in the *strong components* of the graph are noted. A strong component is a collection of vertices, in which a path of directed links exists from any vertex to any other one. Strong components are thus composed of mutually reachable vertices. Initially, the strong components consist of the areas themselves. As links are inserted, strong components join together until eventually all areas lie in one strong component. This process is hierarchical in nature and can be represented by a tree diagram (dendrogram). Dendrogram analyzed here is presented in Figure 1. If area *i* and area *j* were first joined together in a strong component when a link corresponding to a value of *t* in the adjusted table was inserted, then *i* and *j* are shown uniting in the dendrogram at a *threshold* equal to *t*. Greater detail concering the analytical methods employed here are given in Slater (1976 a).

Well-defined regions are those which are stable--i.e., do not subdivide or agglomerate--over a wide range of thresholds. Examples of such regions in Romania are the north Moldavian districts of Botoşani and Suceava; a northeastern region composed of Bacău and Neamţ; a sub-Carpathian-Danube Plain region containing Dîmboviţa, Prahova, Brăila, Buzău, Argeş, Galaţi, and Vrancea; the northeastern districts of Iaşi and Vaslui; a southwestern region formed by Gorj, Mehedinţi, Caraş-Severin, Dolj and Olt; the northwestern Carpathian districts of Cluj, Sălaj and Bistriţa-Năsăud; two western districts that border Hungary--Arad and Bihor; the northwestern border districts of Maramureş and Satu Mare (the more strongly bound pair of districts); a central Carpathian cluster of Alba and Sibiu; an eastern Carpathian group composed of Braşov, Covasna, Harghita and Mureş; the southern districts of Ilfov and Teleorman; and the Blak Sea districts of Constanţa and Tulcea. No formal tests of significance are available for evaluating these groupings.

Bucharest, as well as Constanţa and Tulcea, together exhibit a behavior similar to that shown by London, Paris, Istanbul, Moscow, Barcelona, and Milan in parallel regionalization studies (Figure 1). They are isolated from

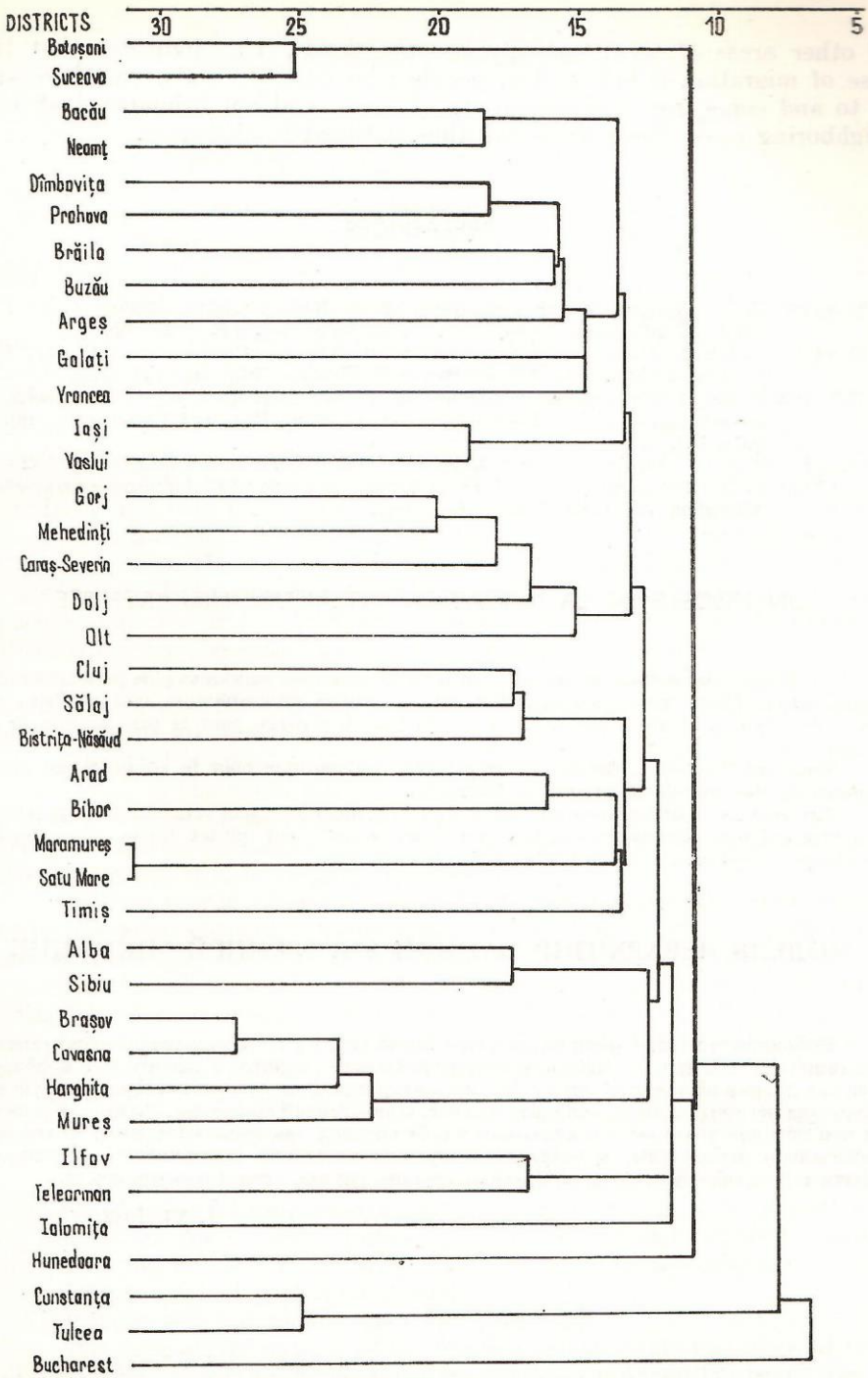


Fig. 1: Hierarchical clustering of Romanian districts.

all other areas at comparatively low thresholds. This indicates that their base of migration is broad; i.e., people who move to and from these areas go to and come from a wide variety of areas, and not primarily just a few neighboring ones. These areas are thus national in character.

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UN MODELE DE LA MIGRATION INTERIEURE HIERARCHISEE

La plupart des nations du monde sont divisées en unités politiques plus petites: districts, départements., Etats, provinces, etc. Souvent, ces unités géographiques sont agrégées pour former des régions. Il n'y a pas de règles explicites, en général, pour la planification de ces groupes.

Pourtant, l'auteur a développé un procédé systématique pour le groupage par régions utilisant les données de la migration intérieure.

Les régions trouvées par cette méthode comprennent les mouvements de la population extérieure qui sont relativement faibles et intérieures qui sont plutôt fortes. Elles forment des groupes fonctionnels de districts, départements, etc.

МОДЕЛЬ ИЕРАРХИЗИРОВАННОЙ ВНУТРЕННЕЙ МИГРАЦИИ

Большинство стран мира разделено в более мелкие единицы: уезда, департаменты, провинции, штаты и т. д. Часто, эти географические единицы агрегируются в области. Пока нет планирования этих групп. Всё же, автор назвил некотрую систематическую процедуру для регионализации, использу данные. о внутренней миграции. Регионы нахождённые при помощи этого метода включают в себя внешнее движение населения, являющееся относительно небольшим, и внутренее движение населения, язляющееся относительно большим. Они образуют функциональные группы уездов, департаментов и т. д.

1. VI. 1978.