C. Spatial Concentration and Dispersion Trends in Population Distribution in the Federal Republic of Germany

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1. INTRODUCTION: DECENTRALISATION VS. DISPERSION

The term "decentralisation" will be used here to denote those activities which are aimed at achieving a more even spatial distribution of population, employment and resources; for instance by delegating public tasks and decisions to local and regional authorities. The term "dispersion" or "dispersive" will be used here to characterise actual spatial distributions of population, employment, etc. The terms "decentralisation/ centralisation" are not congruent with those of "dispersion/ concentration" for it is certainly possible that all decisions having an effect on the spatial distribution of population and economic activity are taken at a fully decentralised level (e.g. are individualised) and lead - for this very reason - to spatially concentrated structures.

A discussion of the conditions under which spatial concentration and dispersion trends occur has to be preceded by answers to the following important questions:

1) How can the degree of spatial concentration (or dispersion) of population, employment and other economic factors, which are variable with time (i.e. which are time-point specific), be measured?

2) Which factors effect changes in these spatial distributions?

3) Does (economic) activity at higher spatial levels (macro-economic or other activities) have an influence on the spatial distribution of population and employment at lower

levels?

In the following three sections these questions will be analysed on the basis of data for the Federal Republic of Germany. The results are presumably relevant not only for the Federal Republic.

2. RELATIVE ENTROPY AS A MEASURE OF POPULATION CONCENTRATION/DISPERSION

Many indicators and indices have been developed to measure levels of concentration for spatial distributions. They can be categorised as follows (see Hart 1954, Duncan 1957, and Warntz and Neft 1960):

1) Measures of concentration derived from Lorenz curves (e.g. the GINI-Index or the "Index of Disimilarity").

2) Nearest neighbourhood measures indicating average distances between objects in space.

3) Centrographic measures which are defined by means of distribution parameters such as the mean, median and variance for two-dimensional distributions.

4) Measures of potential by which spatial distributions are characterised not only by one or a few members but by a value of the potential for every object distributed in the space (i.e. for every region, town, etc.).

Here a relatively little seen measure of concentration will be used which, in contrast to the more usual measures, has the advantage that it can also be used to compare population concentration in countries of different sizes (Paschen and Buyse 1971, Geisenberger and Malich 1971, and Wilson 1970). Only relative quantities are used in the definition, namely those which relate the proportion of parts of a region or country to those of the whole.

If P_1, ... P_n are the numbers of inhabitants of areas 1, ..., n then only the quantities $p_i = P_i/\Sigma P_i$ enter into the calculations for the measure.

To characterise the degree of irregularity (concentration) of the distributions P_1, ..., P_n the following parameters are used:

$$H = -\Sigma P_i \log P_i \qquad 0 \leq H \leq \log n \qquad (1)$$

H is based on the concept of entropy as used in physics and information theory. If the distribution is absolutely uniform (all areas have the same population) then H is maximum, H = log n. If the total population occurs in only one area H is minimum, H = 0. The parameter H thus measures concentration or dispersion but has the property that its values are dependent on the number of spatial units being considered. For example, if the population of both the United States and the Federal Republic were to be equally distributed among their states then the H value for the US (with 50 states) would be much higher than that for the FRG which has only 11 states.

The parameter, however, can easily be normalised so that the number of spatial units being considered has no influence, thus:

$$H^* = \frac{\log n - H}{\log n} \qquad 0 \leq H^* \leq 1 \qquad (2)$$

H* is called "relative entropy" in order to express the fact that the entropy of the distribution has been normalised so that the maximum value of log n.H lies in the interval [0, log n] where 0 indicates absolute concentration and H* lies in the interval [0,1] where 0 indicates a uniform distribution and 1 the condition of absolute concentration whereby the number of spatial units under consideration does not affect the value of H*. Examples are given in Figure 1.

The measure H* will first be used to characterise the inter-regional distribution of population and afterwards for the intra-regional distribution at the community level within a region.

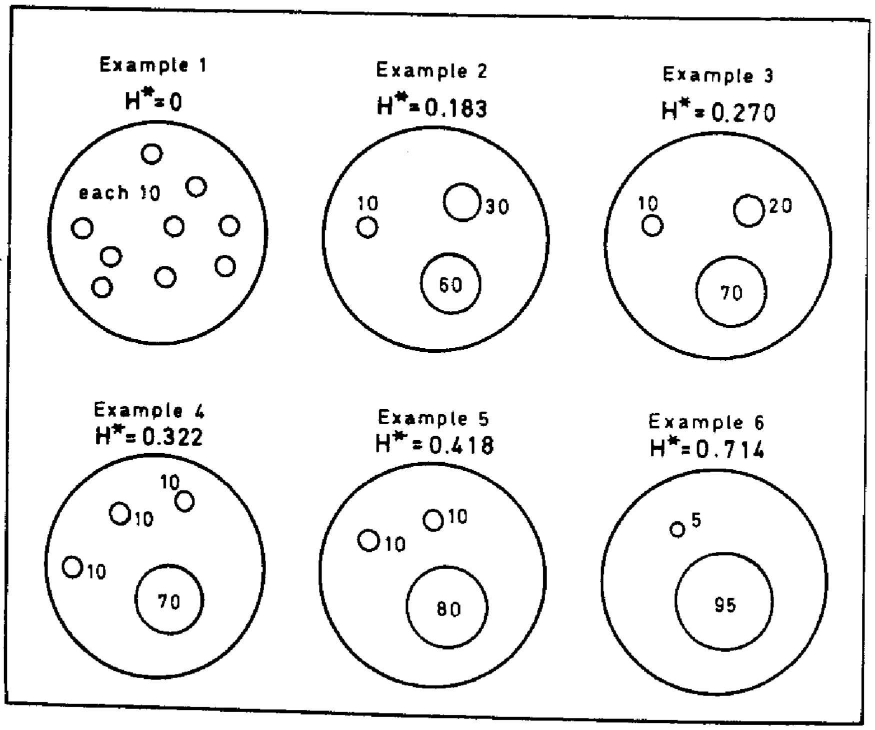


Figure 1

EXAMPLES OF THE APPLICATION OF THE CONCEPT OF ENTROPY AS A MEASURE OF CONCENTRATION FOR THE INTRA-REGIONAL DISTRIBUTION OF POPULATION

3. CONCENTRATION AND DISPERSION OF INTER- AND INTRA-REGIONAL POPULATION DISTRIBUTIONS

a) Inter-Regional Population Distribution and its Change at Differing Spatial Levels

Between the full census years of 1961 and 1970 in the Federal Republic of Germany both concentration and dispersion processes were observed as occurring together at different spatial levels. The question therefore arises as to whether the concentration observed at the state level and the dispersion process observed at the regional planning level (79 regions) are dependent one from the other or are mutually interdependent. The following was observed:

year	1961		1970		1980
H* (State level)	0.139	concentration →	0.143	concentration →	0.148
	1961		1970		
H* (regional planning level)	0.059	dispersion →	0.052		

If the 11 states are divided into two groups, the northern and the southern states, and H* is calculated on the basis of these two large regions so formed then with $H^*_{61} = 0.110$, $H^*_{70} = 0.097$ and $H^*_{80} = 0.089$ dispersion is observed. If the Federal Republic is divided into three spatial categories (the cores of metropolitan regions, the outer areas of these regions, and the rest of the country), and H* is calculated on the basis of the first two categories only, then neither concentration or dispersion can be observed in that $H^*_{75}=H^*_{80}$. Putting the third category into the calculation results in a slight dispersion process being observed with $H^*_{75} = 0.010$ and $H^*_{80} = 0.009$. An even more differentiated picture is obtained if the 79 planning regions are aggregated to three categories (the main metropolitan regions, mixed urbanised/rural regions and rural regions); in the period 1961-80 H* demonstrates a concentration process but with dispersion between 1961 and 1970 and concentration in 1970-80 ($H^*_{61} = 0.073$, $H^*_{70} = 0.071$ and $H^*_{80} = 0.078$).

It can well be that there have been times in which, as opposed to other times, it can be said that there existed a trend towards decentralisation. On the other hand it is clear that periods of general dispersion cannot be easily identified, because at every spatial level the population distribution in the Federal Republic dispersed or concentrated differently.

b) Analysis of the Intra-Regional Population Distribution and its Change

The following analysis is based on population statistics for the 24,000 communities existing in the Federal Republic in 1961. Between 1950 and 1961 the boundaries of the communities were subject to considerable change as a result of successive communal reorganisations and they were again particularly affected for the same reason after 1968. This would have made an inter temporal comparison of population distribution at this level extremely difficult if the National Statistical Office had not calculated population figures on the 1961 basis for both 1950 and 1961. Regions are formed in the analysis by aggregating the communities to 38 administrative units whereby the state Schleswig-Holstein and the "city" states of Hamburg, Bremen and Berlin each appear as a single administrative region.

In contrast to the last section the investigations were not made on the inter-regional distribution of population and its change but on the distribution of population at the spatial level of the communities within each region both in 1950 and 1961. Possible relationships between the population density of the regions and the intra-regional distribution of population as well as between density and distribution change were examined in order to obtain further insights into concentration/dispersion processes.

The following results were obtained:

1) The lower the population density of a region in 1950 the higher was its growth (in terms of yearly average rate) in relative entropy in the period 1950-61 (correlation coefficient = -0.58).

2) The higher the rate of change of population density 1950-61 the lower was the growth in relative entropy of the population distribution in the region (correlation coefficient = -0.49).

These relationships between the population density at the beginning of the decade 1950-60 and the rates of change in

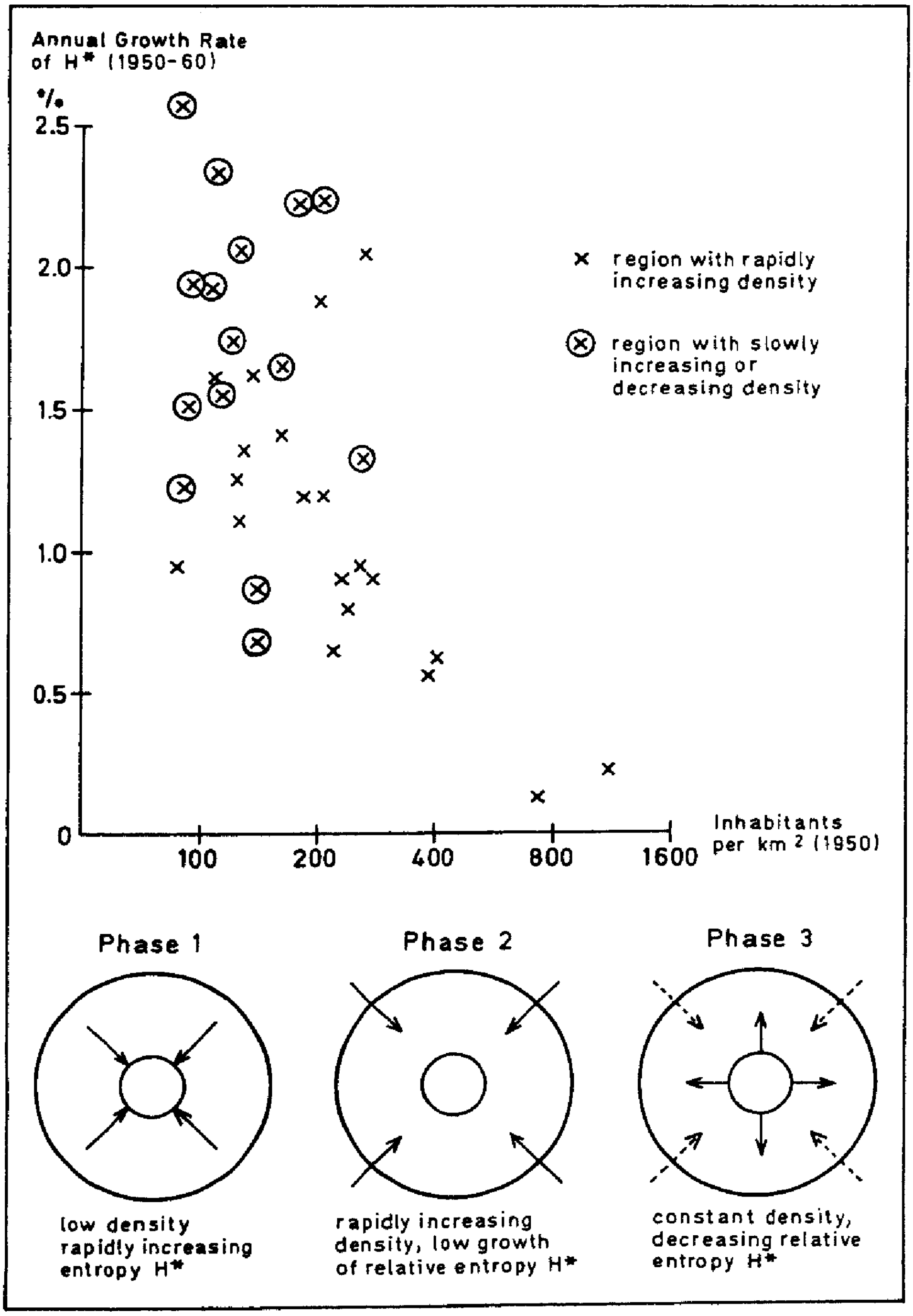


Figure 2

RELATIONSHIP BETWEEN POPULATION DENSITY AND RELATIVE ENTROPY

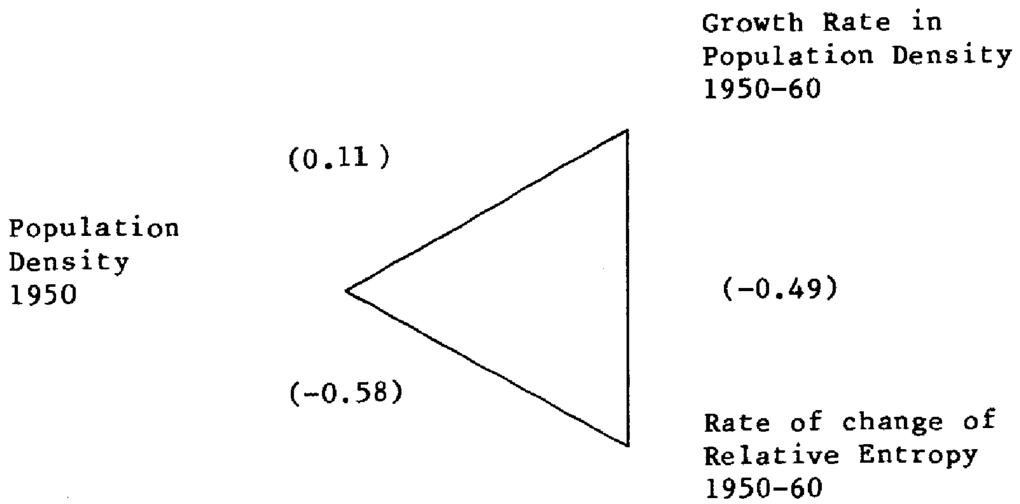
TABLE 1

Density and relative entropy of the intraregional population distribution[1)]

region (Regierungs-bezirke)	density pop. per km^2		relative entropy H^*		annual rate of change 1950-61	
	1950[1)]	1961	1950	1961	density	entropy
Schleswig-Holstein	165,7	148,0	0,223	0,267	− 1,02	1,63
Hamburg	2 148,8	2 452,2	1,000	1,000	1,21	0,00
Niedersachsen						
Hannover	211,0	221,3	0,291	0,370	0,44	2,23
Hildesheim	195,0	180,9	0,152	0,194	− 0,68	2,23
Lüneburg	90,3	86,8	0,148	0,196	− 0,37	2,59
Stade	97,4	86,5	0,126	0,149	− 1,07	1,50
Osnabrück	109,7	114,5	0,178	0,220	0,39	1,92
Aurich	122,8	117,7	0,134	0,158	− 0,38	1,54
Braunschweig ..	279,3	274,2	0,307	0,354	− 0,17	1,31
Oldenburg	149,0	142,3	0,160	0,175	− 0,42	0,84
Bremen	1 383,5	1 749,4	0,270	0,276	2,16	0,22
Nordrhein-Westfalen						
Düsseldorf	785,8	982,0	0,339	0,344	2,05	0,13
Köln	419,3	534,3	0,350	0,375	2,23	0,62
Aachen	251,7	303,9	0,216	0,235	1,73	0,78
Münster	261,8	309,7	0,226	0,249	1,54	0,89
Detmold	231,5	247,9	0,156	0,177	0,63	1,18
Arnsberg	396,7	469,2	0,318	0,339	1,54	0,58
Hessen						
Darmstadt	212,8	246,0	0,164	0,207	1,33	1,89
Kassel	137,1	136,6	0,167	0,209	− 0,03	2,06
Wiesbaden	306,9	357,9	0,347	0,383	1,41	0,90
Rheinland-Pfalz						
Koblenz	141,1	158,7	0,149	0,173	1,08	1,34
Trier	87,8	94,0	0,174	0,192	0,63	0,92
Montabaur	134,5	143,2	0,100	0,113	0,57	1,09
Rheinhessen	288,5	336,2	0,251	0,314	1,41	2,06
Pfalz	192,9	227,8	0,189	0,215	1,52	1,19
Baden-Württemberg						
Nordwürttemberg	230,5	287,1	0,239	0,257	2,01	0,64
Nordbaden	286,6	331,3	0,273	0,302	1,33	0,93
Südbaden	134,4	163,3	0,138	0,158	1,78	1,23
Südwürttemberg/ Hohenzollern ..	117,3	138,5	0,124	0,145	1,53	1,59
Bayern						
Oberbayern	150,4	168,6	0,308	0,367	1,05	1,61
Niederbayern ..	100,5	89,4	0,083	0,103	− 1,06	1,94
Oberpfalz	93,0	92,3	0,174	0,198	− 0,07	1,20
Oberfranken	148,7	144,9	0,176	0,189	− 0,24	0,66
Mittelfranken ..	168,5	180,4	0,326	0,378	0,62	1,37
Unterfranken ..	122,4	128,4	0,132	0,169	0,44	2,31
Schwaben	128,6	133,1	0,172	0,209	0,31	1,73
Saarland	372,3	417,8	0,187	0,188	1,06	− 0,05
Berlin (West)	4 463,5	4 568,6	1,000	1,000	0,21	0,00

1) Distribution of the population on communities within each region. Computed for constant borders of communities.
Source: H. Birg, "Zur Messung der regionalen Bevölkerungskonzentration in der Bundesrepublik Deutschland mit Hilfe des Entropie-Mapes", In: Viertel-jahrshefte zur Wirtschaftsforschung", Ed.: Deutsches Institut für Wirt-schaftsforschung, Heft 3, 1971.

density and relative entropy of the population distribution are global relationships obtained by regression analysis over all the 38 regions considered and can be summarised as follows (correlation coefficients in brackets):



The following statistically significant relationship was also obtained: the level of concentration of the population (H*) in a region at the end of the period 1950-61 was higher the higher the concentration at the beginning of the period and the lower the population density was at the beginning, thus (t test values in brackets):

$$H^*_{61,i} = 0.014 - 0.000097\, D_{50,i} + 1.179\, H^*_{50,i} + U_i \qquad (3)$$

$$(2.14) \quad (-3.46) \qquad\qquad (29.42)$$

$$r^2 = 0.98; \qquad i = 1, \ldots, 38 \text{ regions}$$

These results indicate that regional population changes in distribution can be represented by a phase model (see Birg 1971 for a fuller treatment). The model is illustrated symbolically in figure 2, the dates are given in table 1 and graphed in figure 2. The data, of course, do not validate the model, but they are good enough to allow the supposition that the model is correct.

In the phase model intra-regional concentration and dispersion processes are connected with inter-regional population movement.

Regions in Phase 1 have a low population density (150 inhabitants/km^2 or less - see figure 2). The intra-regional concentration of population starts to increase without an important influence of in-migration (for the regions in Phase 1 H* has the highest growth rate - see table 1, 6th column) and so the overall density changes only insignificantly. The process occurring is one of primary urbanisation taking place without the pressure of in-migration.

In Phase 2 the overall population density increases through in-migration and natural growth. The lower the density is at the beginning of the period, the higher is its rate of change (density has a negative coefficient in equation (3)). The process occurring is one of secondary urbanisation based on in-migration. The rate of increase in the concentration of the regional population distribution is less and can reach zero. At the same time the inter-regional population distribution tends towards more concentration because of inter-regional migration.

In Phase 3 the regional population density ceases to grow and a process of intra-regional dispersion - sub-urbanisation (van der Berg et al 1982) - occurs due to movements out of the city cores into the fringes of the cores. In the Federal Republic of Germany 300,000 people moved from the centres to the outer areas of the metropolitan regions and approximately the same number from thinly populated rural areas to these outer areas (Birg, 1980, p. 204). The relative entropy decreases. In the data considered for 1950-60 none of the 38 regions reached Phase 3 (the relative entropy decreased slightly only in Saarland). At the present time many regions have already passed through Phase 3 and are entering a new phase which, in the future, might prove to be a phase of re-urbanisation.

In the Federal Republic the primary urbanisation of Phase 1 through local migration and the secondary urbanisation of Phase 2 caused by inter-regional migration overlap with a still continuing process of international in-migration which is directed principally towards the cores of the metropolitan areas. Intra-regional, inter-regional and international migration are therefore closely connected. But core-fringe migration and the migration from abroad into the cores are only different aspects of the same general process.

4. DEMOGRAPHIC ASPECTS OF SPATIAL CONCENTRATION AND DISPERSION

The number of inhabitants of a region changes according to five basic demographic processes which, in general, have different effects on the distribution of population. On the basis of the 79 planning regions in the Federal Republic these processes had the following effects between the census years 1961 and 1970:

Births	⟶	Dispersion
Deaths	⟶	not yet investigated
Domestic Migration	⟶	Dispersion
International Migration	⟶	Concentration

The strongest influence on population distribution is that of inter-regional migration, the weakest that of deaths, for which no conclusive research results exist at the moment (see Gatzweiler and Stiens 1982, Birg 1982b, and Heinz and Stiens 1984).

If the effect of the population age structure of the regions on the number of births is eliminated by normalisation, the index of the frequency of births for the 79 regions (with average value 100) shows variations from 71 (Munich, Berlin regions) to 161 for the rural region Lingen (Birg 1975, p.24ff) The ratio of the minimum:maximum value is 71:161 i.e. 1:2.27. No trend can be observed that such disparities are decreasing although this is often anticipated in the literature. Because the less densely populated rural areas generally have a high birth rate and the densely populated regions low birth rates the effect of births on the distribution of population is one of dispersion. This trend to dispersion occurs simultaneously with the two effects of migration, inter-regional domestic migration also effecting a trend to dispersion and international migration effecting concentration.

The effect of the inter-regional migration will be demonstrated using two different migration models, one based on gravitation principles (with directed migration flows) and the other a population/employment model with in- and out-migration obtained by summing directed flows.

a) Dispersion and Concentration using Migration Flows Derived from Gravitation Models

Let the following simple gravitation model be assumed:

$$M_{ij} = a_o \frac{P_j^{a_1} P_i^{a_2}}{d_{ij}^{a_2}} \qquad a_o, \ldots, a_3 > 0, \; i \neq j \qquad (4)$$

Here M_{ij} is the migration flow from region i to region j and M_{ji} the flow in the opposite direction. From the structure of the model the following general conclusion can be drawn: migration flows influence the direction of dispersion for the interregional distribution of population if the parameter a_i (for the source region) is bigger than the parameter a_j (for the sink region). This arises because the magnitudes of the two migration flows are related according to:

$$\frac{M_{ij}}{M_{ji}} = \frac{P_j^{a_1} P_i^{a_2}}{P_i^{a_1} P_j^{a_2}} = \left(\frac{P_j}{P_i}\right)^{a_1 - a_2} \qquad (5)$$

Let $a_2 > a_1 > 0$ and $P_j > P_i$. Then $M_{ij} < M_{ji}$ from equation 5. Thus the smaller region has a positive net migration ($M_{ji} - M_{ij} > 0$) and the larger region a negative net migration ($M_{ij} - M_{ji} < 0$). If $a_2 > a_1 > 0$ and $P_i > P_j$ then $M_{ij} > M_{ji}$ and again the net migration for the smaller region is positive and for the larger negative. It can therefore be concluded that if the parameter a for the source region is larger than that for the sink region then a change in the population distribution in the direction

TABLE 2

Parameters of the Gravity Model on the State Level

Parameter[1)]	1964	1969	1971	1975
a_0	0.198	0.522	0.583	0.822
a_1	0.967	0.945	0.920	0.905
a_2	0.950	0.855	0.861	0.857
a_3	-0.949	-0.952	-0.942	-1.036
interval for all t-values	$9.98 \leq t \leq 18.9$			

1) See equation (4)

of dispersion occurs regardless of the relative population sizes of the two regions.

The question as to whether the parameter a for the source region is bigger than that for the destination region can be answered both "yes" and "no" for the Federal Republic - the result depends upon the regionalisation adopted as well as on the other parameters used in the model. On the basis of the 11 states the parameter a for the origin of migration (source) was smaller than that for the destination region (sink) in all the years investigated, i.e. the population distribution changed in the direction of an increased concentration (Table 2). This result is the same as that obtained by using entropy, as related above.

If the Federal Republic is delineated into the 79 planning regions results can be obtained in a much more differentiated manner. Since each state is composed of a subset of the 79 planning regions the gravitation model can be tested separately for individual states. The units being observed are migration flows so that the number of observations for an application of the model for the regions within a state is still satisfactorily large enough.

This number of observations varied between 156 for Nordrhein-Westfalen and 110 for Niedersachsen. Further, it was

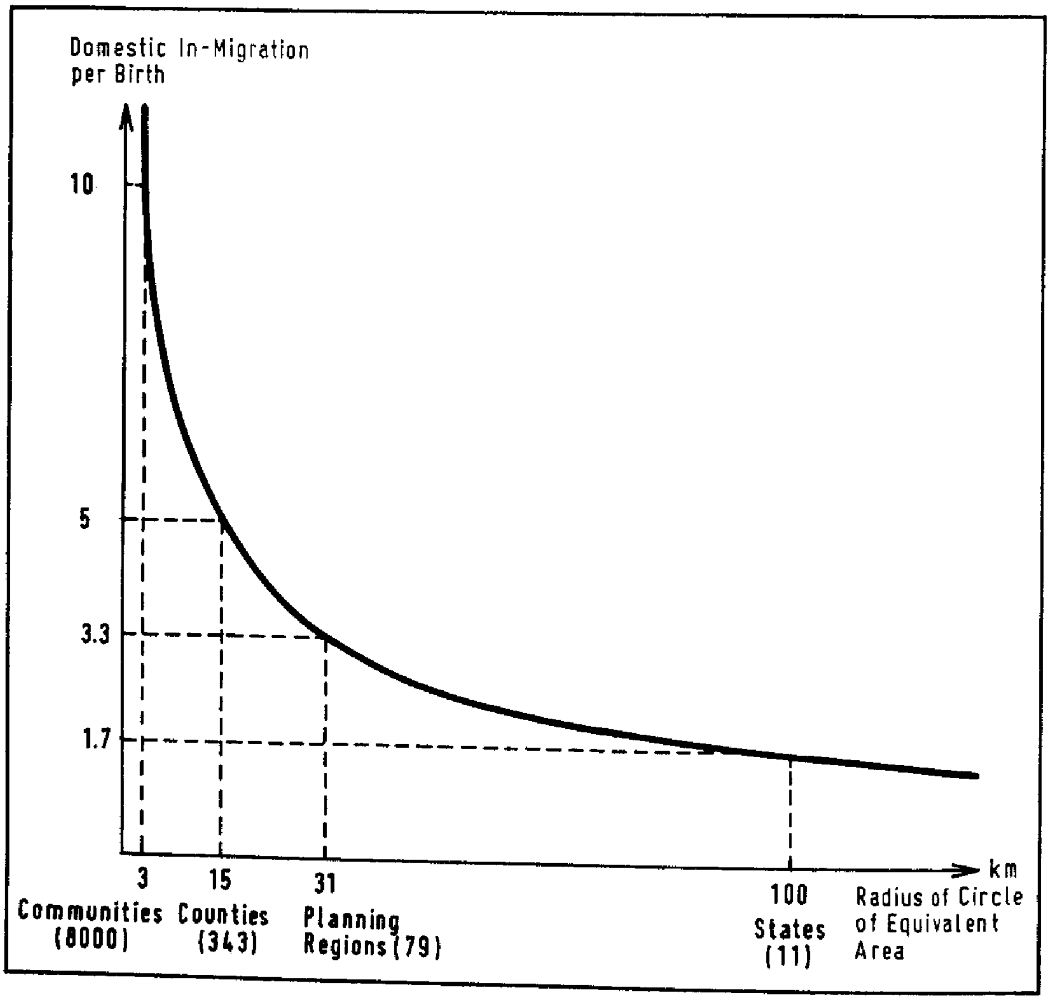


Figure 3

REGIONAL SIZE AND MIGRATION
(Administrative Units in the Federal Republic of Germany)

possible to perform another, more detailed, investigation in which only the flows between urbanised and rural regions were considered, those between urbanised and between rural regions being neglected.

As a result of the various calculations it was discovered that the migration flows in 1966 between the planning regions in Niedersachsen and in Baden-Württemberg led to increased concentration but in the state of Bavaria to increasing dispersion - the results for the other states were not statistically significant. A change in the direction of dispersion is the result of investigating the migration flows between the two subsets of urbanised and rural regions. The same result is obtained if the simple gravitation model is extended to include further variables such as those that describe the labour market, living conditions and income level differences (Birg 1975, p.24ff.)

By means of the analysis of the population statistics described above it can be concluded that concentration and dispersion processes occur simultaneously according to the spatial level of observation. Analysis of data on the components of population change (migration, births, deaths) leads to the result that causally specific concentration and dispersion effects can occur simultaneously. Here the trend is such that births contribute to a more even population (dispersion) and that the differing forms of migration have differing effects on the level of concentration and/or dispersion. Migration flows contribute far more to population change at the regional level than births and deaths (for every birth at the regional planning level in the Federal Republic three - on average - people migrate into the region and for every death three people move out of the region as shown in figure 3).

b) Dispersion and Concentration Using Migration Flows Derived from Population/Employment Models

Another model can be used to analyse concentration/dispersion processes arising from migration between the 79 planning regions which differs from the gravitation models in three respects:

1) The model is simpler because it uses cumulative in-migration and cumulative out-migration into and out of a region as dependent variables:

In-migration: $I_i = \Sigma M_{ji}$

$i,j, = 1, \ldots, 79$

Out-migration: $O_i = \Sigma M_{ij}$

2) The model is more realistic because it uses the change in the number of jobs available (ΔE_i) as an explanatory variable.

3) Finally the model has a more satisfactory theoretical structure because two equations are used and in-migration (I_i) and out-migration (O_i) are estimated separately. The regional population total (P_i) at the beginning of the considered period of time and change in regional employment in the period are the independent variables in the model. The model was applied for the period between the census years 1961 and 1970 and so the inter-regional migration observations used are those officially registered at the communal level in the period [1]. Aggregation of the number of movements over the period helps to smooth out the effects of the business cycle (see for example Feithen 1984). The following system (with standard deviations in parentheses) results from application of the two-stage least squares (TSLS) estimation method:

$$\underset{}{I_i} = \underset{(8272)}{15878} + \underset{(0.144)}{1.589}\,\Delta E_i + \underset{(0.027)}{0.955}\,O_i; \qquad r^2 = 0.95 \qquad (6)$$

$$\underset{}{O_i} = \underset{(7695)}{23628} + \underset{(0.019)}{0.216}\,P_i + \underset{(0.061)}{0.309}\,I_i; \qquad r^2 = 0.95 \qquad (7)$$

The cross-region estimations are statistically significant and the results can therefore be used for an analysis of concentration processes. Manipulating (6) and (7)

$$I_i = 54609 + 2.254\,\Delta E_i + 0.293\,P_i \qquad (8)$$

and

$$O_i = 40556 + 0.697\,\Delta E_i + 0.306\,P_i \qquad (9)$$

are obtained. The regional net migration is then obtained as:

$$N_i = I_i - O_i = 14053 + 1.558\,\Delta E_i = 0.014\,P_i \qquad (10)$$

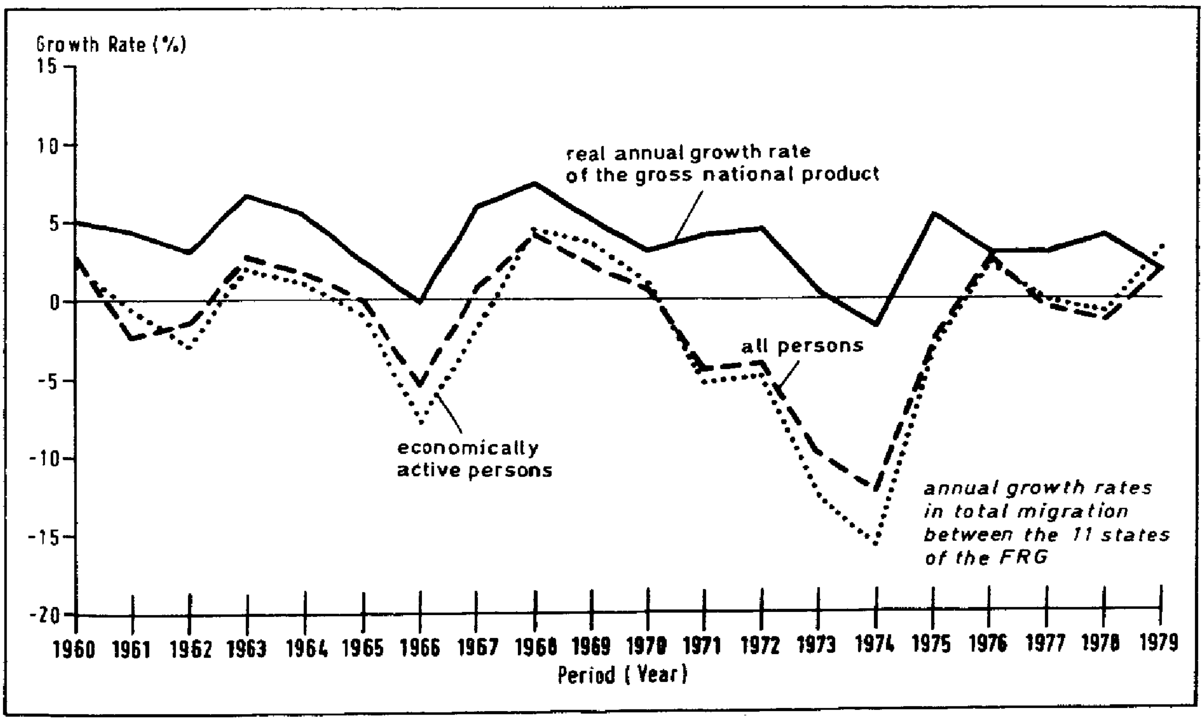


Figure 4

RELATIONSHIP BETWEEN MIGRATION AND PRODUCTION GROWTH RATES

The results imply that - ceteris paribus - net migration increases with an increase in the number of jobs available in a region but decreases with an increase in regional population at the beginning of the period. Thus this model, which on the basis of the estimations can be regarded as well founded, delivers results from which it can be concluded that inter-regional migration between 1961 and 1970 contributed to a dispersion of population. International migration effected a concentration because the in-migration from abroad was principally directed into the agglomeration areas (Birg, 1981).

5. THEORETICAL CONCLUSIONS

A theoretical explanation for the descriptive results presented above would be too much to ask for in a short paper. This concluding section can therefore only briefly review a few of the implications of the findings, which could be relevant for theories of settlement systems or for regional economics. Implications for theory and model building arise principally from the relationship discovered between the business cycle and the yearly migration incidence, a relationship obtained by considering a much neglected variable, namely the yearly number of personnel changes in existing employment (Fig. 4). Such changes arise not only from the personnel renewal process in which old employees retire and young people are engaged but also for other reasons connected with the process of capital renewal, in which - analogous to the factor labour - old production investments are replaced by new. If the rate of renewal on the personnel side is slower or faster than that of capital, friction can arise causing fluctuations on the labour market. But even when these rates of renewal are synchronised a large number of personnel changes take place because of the pursuance of careers - in the Federal Republic every fourth job is affected each year (Birg, 1984). Personnel changes and changes of job frequency imply changes of residence and it is for this reason that personnel changes are of theoretical importance in the consideration of concentration or dispersion processes.

A theoretically more satisfactory justification for the gravitation model can be developed by considering the relationship between the business cycle, the number of personnel changes and the number of migrations. By these means the consequences of concentration/dispersion arising from an improved migration model will be made clear.

It is assumed that the number of migrants from region i to region j is dependent on the number of comparisons of conditions in i and j made by potential movers before they actually decide to move. The number of comparisons made between alternatives in i and j is a function of two parameters, the number of inhabitants in i who make comparisons and the number of alternatives in j that can be compared.

It is assumed that the number of people who make comparisons is a simple monotonically increasing function of the number of inhabitants in i (P_i^{β}) and that the number of alternatives that can be compared in j is a monotonically increasing function of the number of unoccupied jobs there which in turn is assumed to be proportional to the total number of jobs both occupied and unoccupied. If this total number of jobs is assumed to be proportional to the number of inhabitants then the number of available jobs can be directly derived from the population size. Using exponential functions for the sake of simplicity then.

$$M_{ij}(t) \simeq (\gamma_j P_j(t))^{\alpha} \cdot P_i^{\beta}(t) \quad \text{where } \alpha, \beta > 0 \tag{11}$$

In this relationship $\gamma_j P_j(t)$ is the number of available jobs in region j and period t expressed directly in terms of the population size in j. The parameter γ will be called the fluctuation parameter. It expresses the relative frequency of personnel change in the region.

If, in addition, it is assumed that M_{ij} is also dependent on the distance between i and j then equation 11 can be expressed in such a way that the similarity with the gravitation model is evident:

$$M_{ij}(t) = \frac{(\gamma_j P_j(t))^{\alpha} P_i(t)^{\beta}}{d_{ij}^{\delta}}; \quad \alpha,\ \beta,\ \gamma,\ \delta > 0 \tag{12}$$

The question of how the population distribution is influenced by migration can be reformulated into the question of the essential parameter dependency of the ratio $M_{ij}:M_{ji}$. From equation 12

$$\frac{M_{ij}(t)}{M_{ji}(t)} = \left(\frac{\gamma_j}{\gamma_i}\right)^{\alpha} \left(\frac{P_j(t)}{P_i(t)}\right)^{\alpha-\beta} \tag{13}$$

can be obtained, which shows that two mutually independent effects influence the relative size of M_{ij} and M_{ji}. The first effect is based on the difference between the two "mass" parameters α and β. This effect was also derived earlier from the the simple gravitation model. The second effect concerns the difference between the fluctuation parameters γ_i and γ_j. In equation 13 the following can be observed:

1) The mass effect and the fluctuation effect act independently of each other. They can either complement or neutralise each other.

2) Even when the mass effect is zero the fluctuation effect can change the regional population distribution in the direction of a) concentration if the ranking $\gamma_i > \gamma_j > \gamma_r$ coincides with the population size ranking $P_i > P_j > P_r$ or b) dispersion for instance when the two rankings run in opposite directions.

How do these rankings actually compare? It is perfectly clear that the maximum number of personnel changes derived from a theoretical procedure combining a given number of persons with a given number of jobs increases strongly non-linearly with the increase in the number of jobs. If the actual number of changes correlates positively with the theoretical number then it can be concluded that the empirical rank order of the regional fluctuation parameters more or less coincides with that for the absolute size of the respective regional labour markets and that therefore the fluctuation effect causes a trend in the direction of concentration of the inter-regional population distribution. This occurs as long as the regional fluctuation parameters are different. This is some empirical evidence - as figure 5 shows - that this is so; the fluctuation parameters for the labour office areas in the state of Nordrhein-Westfalen correlate positively with the employment figures in these areas.

This result can be derived analytically for a two region case. Assuming that the natural population growth rates in the two regions are the same, the time dependent populations can be described by two interdependent differential equations:

$$P_1(t) = P_1(0) + \int_0^t rP_1(\tau)d\tau + \int_0^t (\gamma_1 P_1(\tau))^{\alpha} P_2(\tau)^{\beta} d - \int_0^t (\gamma_2 P_2(\tau))^{\alpha} P_1(\tau)^{\beta} d\tau \quad (14)$$

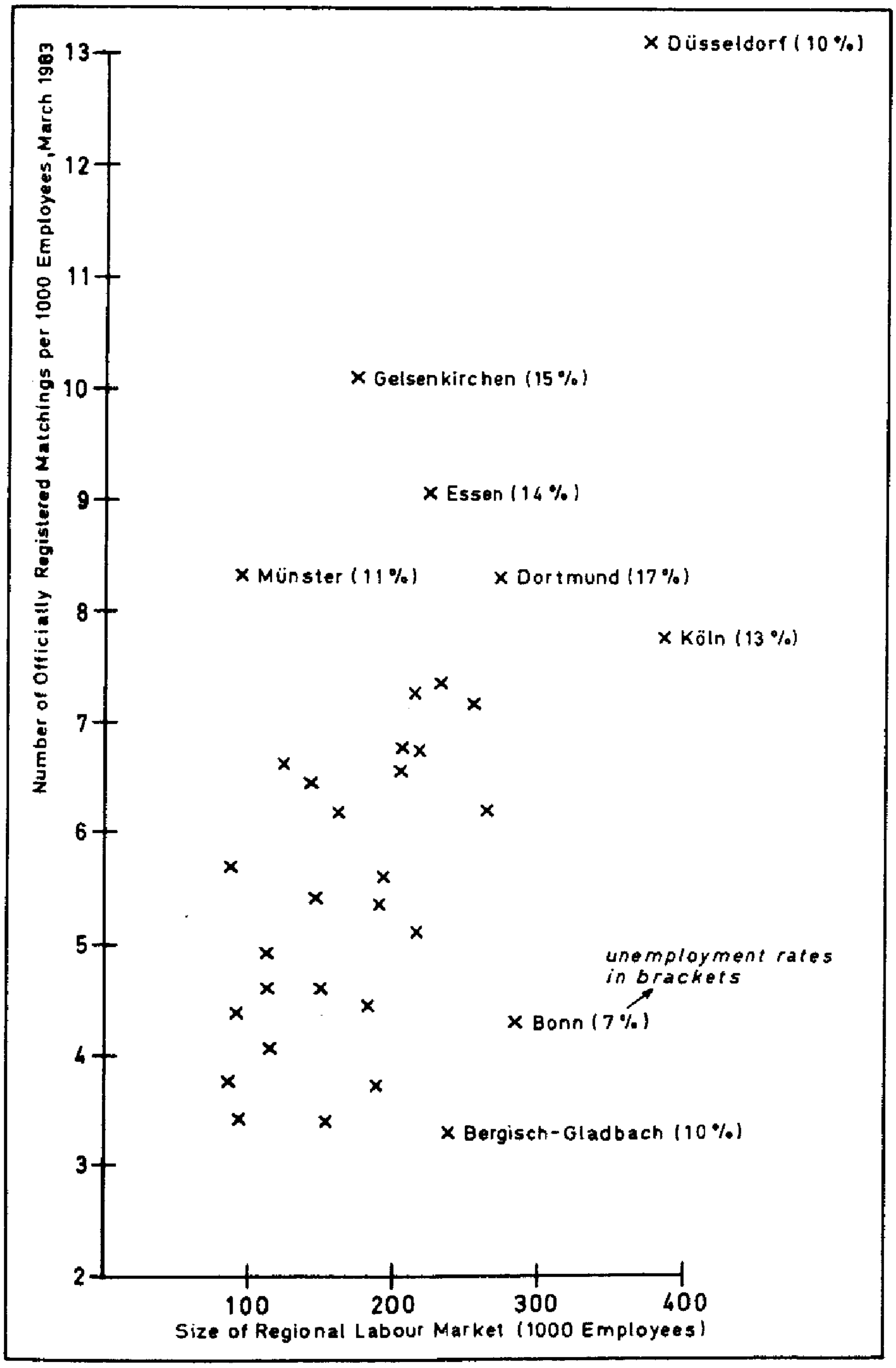


Figure 5

SIZE OF LABOUR MARKET AND PROPORTION OF SUCCESSFULL MATCHINGS

$$P_2(t) = P_2(0) + \int_0^t rP_2(\tau)d\tau + \int_0^t (\gamma_2 P_2(\tau))^{\alpha} P_1(\tau)^{\beta} d - \int_0^t (\gamma_1 P_1(\tau))^{\alpha} P_2(\tau)^{\beta} d\tau \quad (15)$$

In the equations r is the natural growth rate and the $P_i(0)$ are the populations at t=0. The populations change with time until an equilibrium situation is achieved at t=t* (see Birg 1982a) for which

$$\frac{P_1(t^*)}{P_2(t^*)} = \left(\frac{\gamma_1}{\gamma_2}\right)^{\alpha/(\beta-\alpha)} \quad (16)$$

Equation 16 shows that the higher the fluctuation parameter in region 1 with respect to region 2, the larger the population of region 1 relative to that of region 2 is in the equilibrium situation. As long as the population distribution is more dispersed than that of the equilibrium situation, which is determined by the two fluctuation parameters, then migration occurs in the direction of greater concentration. If, on the other hand, the population distribution is more concentrated than that of the equilibrium situation dispersive migrations take place.

These results are based on the assumption that the natural rate of growth in the two regions is the same. It would be more realistic to assume that the natural growth rate is dependent on the regional fluctuation parameter. By this means the relationships between fertility, personnel changes and migration could be investigated as well as their effects on concentration/dispersion processes - the differential equations arising would then have to be solved by a different method. That there is a connection between personnel changes in the life cycle and fertility can be empirically demonstrated and this fact opens new perspectives for the theory of generative behaviour (Birg et al 1984).

6. SUMMARY

The concept of relative entropy has been used in this paper to investigate regional concentration/dispersion trends in general as well as the concentration/dispersion effects of the various components of population change. Using a model the general effects of employment orientated migration have been derived. Differences in regional labour markets, particularly the relative frequency of personnel change as an indicator of the economic vitality of a region, are of the utmost importance in analysing inter-regional migration. The rate of personnel change correlates closely with the course of the business cycles and at the same reflects the levels of mobility present in the region for the pursuance of careers. It has been shown that this indicator is an important link for a syntheses of micro- and macro-analysis and opens new perspectives for such analysis as well as for the theory of the life cycle and of human fertility.

7. NOTE

In the Federal Republic change of abode has to be officially registered and registration and de-registration is only possible if both addresses, new and old, are know.

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