ASSESSING THE SPATIO-TEMPORAL INTEGRATION OF PERIODIC MARKET SYSTEMS BY A NEW MEASURE

A quantitative analysis of 52 cases

With 2 figures and 6 tables

REINHARD HENKEL

Zusammenfassung: Ein neues Maß zur Einschätzung der raumzeitlichen Integration von Systemen periodischer Märkte

Die raumzeitliche Integration von Systemen periodischer Märkte wurde bisher meist mit der von SMITH (1971) vorgeschlagenen Methode gestestet. Dieser Test ist jedoch nicht sehr befriedigend, da er es nicht ermöglicht, das Ausmaß der Integration in zwei Systemen miteinander zu vergleichen. Es wird daher ein neues Vergleichsmaß vorgeschlagen, das Marktsysteme verschiedener Marktwochenlängen und verschiedener Regionen vergleichbar macht und mit dem sich auch die zeitliche Entwicklung der Integration von Marktsystemen analysieren läßt. Die Zusammenhänge zwischen dem Ausmaß der Integration einerseits und der Länge der Marktwoche, der Größe des Marktsystems, dem städtischen oder ländlichen Charakter, der Entfernung zwischen den Märkten, der Zugehörigkeit zu verschiedenen Kulturregionen und der hierarchischen Anordnung der Märkte innerhalb eines Systems auf der anderen Seite werden untersucht. Dazu werden Daten von 52 Marktsystemen aus aller Welt herangezogen. Im Unterschied zur bisherigen Auffassung wird nur in einigen wenigen Fällen eine ungünstige räumliche Verteilung der Märkte durch eine effiziente zeitliche Anordnung ausgeglichen. Abschließend wird eine Klassifikation von Systemen periodischer Märkte bezüglich ihrer raumzeitlichen Integration vorgeschlagen.

The spatio-temporal synchronization of periodic market systems has been an intensively studied field especially in Anglo-Saxon geography (see the two bibliographies by BROMLEY 1974a, 1979). R. H. T. SMITH (1971, 1972) in particular has made comparative studies of a number of periodic market systems throughout the world (cf. also HAY a. SMITH 1980). He developed a method of testing the spatio-temporal synchronization, or as it was called later, integration (see R. H. T. SMITH 1979, 474–475), of a market system. This method examines if spatial and temporal distances of markets are inversely related. This inverse relationship corresponds to the so-called consumer hypothesis which was set against the trader hypothesis by HILL a. SMITH (1972). According to SMITH's test, only few of the market systems investigated proved to be well-integrated, and these were mainly three-day market week systems. The test was criticized and improved by introducing different distance measures by BROMLEY (1976) but it is still regarded the only means of assessing the spatio-temporal integration of periodic market systems. A major shortcoming of this method is that it only compares the mean spatial distances of markets of different temporal separation *within* one market system with each other. It does not allow comparison of different market systems. Hence the method is not comparative in a quantitative sense. Many publications on periodic markets are only case studies and draw far ranging conclusions from unsatisfactorily narrow studies.

Measuring spatio-temporal integration of market systems

Starting from a remark by A. L. MABOGUNJE (according to R.H.T. SMITH 1971, 335) that "if the appropriate metric for temporal spacings could be identified, we could hypothesize that the product of temporal and locational spacing will be constant", a different *comparative* measure of the degree of spatio-temporal integration within a market system has been introduced by the author (HENKEL 1982). As a measurement of the spatial component, it employs the nearest neighbour coefficient R which has been used for the analysis of two-dimensional point patterns. This indicates whether market places are more clustered or more uniform than a pattern resulting from a random process. The nearest neighbour coefficient R can be represented by

$$R = \frac{d_o}{d_e} = \frac{2 \cdot \sum_{i=1}^{N} d_{si}}{\sqrt{N \cdot A}}$$

N = number of market places,
d_o = observed mean nearest neighbour distance,
d_e = expected mean nearest neighbour distance if points are placed randomly,
d_{si} = spatial distance of a market place i to its nearest neighbour,
A = area of the study region.

The temporal component is represented by the measure T. This measure employs d_t, the mean temporal distance (in days) of the markets to the temporally next market held at their spatially nearest neighbour. This value is then calibrated by division by L, the mean time (in days) after which a market is held at a market place within a given system. This calibration allows market systems with different market week lengths to be compared to each other with respect to their temporal arrangements. Thus

$$d_t = \frac{\sum_{i=1}^{n} d_{ti}}{n}$$

d_{ti} = temporal distance (in days) of a market i to the temporally next market held at its spatially nearest neighbour,

n = number of markets held in one market week in the whole system,

$$L=\frac{l \cdot N}{n}$$

l = length of the market week underlying the system.

Therefore,

$$T=\frac{d_t}{L}=\frac{\sum_{i=1}^{n} d_{ti}}{l \cdot N}$$

Thus, the market integration coefficient M is

$$M=T \cdot R=\frac{2 \cdot \sum_{i=1}^{n} d_{ti} \cdot \sum_{i=1}^{N} d_{si}}{N \cdot l \cdot \sqrt{N \cdot A}}$$

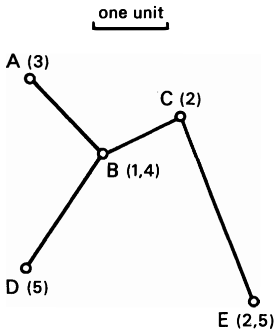

Fig. 1: Theoretical example for a system of periodic markets with five market places (N=5) and seven markets (n=7) held per 5-day market week (l=5), distributed over an area of A = 25 units

In the theoretical example with five market places (N=5) and seven markets (n=7) held per 5-day market week (l=5) (see fig. 1), the procedure is as follows: The nearest neighbour of market A is B. The spatial distance is $d_{sA}=1.414$ units, the nearest temporal distance $d_{tA}=1$ day (On market place B, two markets are held on day 1 and on day 4. As day 4 is closer to day 3 than day 1, day 4 is chosen; it has a 1 day temporal distance from day 3). The nearest neighbour of market B is C. The spatial distance between these is $d_{sB}=1.118$. The temporal distance of the market held at B on day 1 to market C is $d_{tB1}=1$, the one of the market held at B on day 4 to market C is $d_{tB2}=2$. The nearest neighbour to market C again is B. Their spatial distance is $d_{sC}=1.118$, their temporal distance $d_{tC}=1$. D's nearest neighbour is B. $d_{sD}=1.903$ and $d_{tD}=1$. E's nearest neighbour is C. $d_{sE}=2.693$, $d_{tE1}=0$ and $d_{tE2}=2$. Hence, with l = 5,

$$T=\frac{1+1+2+1+1+0+2}{5 \cdot 5}=0.320$$

and A = 25,

$$R=\frac{2\,(1414+1.118+1.803+2.693)}{\sqrt{5} \cdot 25}=1.457.$$

Hence, M = R · T = 0.466.

T varies between 0 and 0.5. The lower value is obtained if all spatially nearest neighbour markets take place on the same day. The highest value applies only to systems with a week length of an even number of days. In the cases of the market week length l being an uneven number, a maximum value of $T=\frac{l-1}{2l}$ can be obtained. This is due to the fact that the maximum temporal separation between two markets is $\frac{l}{2}$ if the market week length l is even but it is only $\frac{l-1}{2}$ if it is uneven. A random distribution of the market days on the different market places would result in values of

$$T=0.25 \quad \text{if } L=\frac{N \cdot l}{n} \text{ is even,}$$

$$T=\frac{L^2-1}{4L^2} \quad \text{if L is uneven or non-integer.}$$

The reason for this is that the expected value of the random variable "temporal separation between two markets" is $\frac{L}{4}$ if L is even and $\frac{L^2-1}{4L}$ if L is uneven or non-integer.

Market systems with T values below this random point are "temporally clustered" whereas systems with a T value above are "temporally regular".

The range of the nearest neighbour coefficient R is between 0 and 2.149 with a value of 1.0 indicating a random spatial distribution.

The minimum value of the integration coefficient M is also 0. This value is arrived at either if the nearest neighbour coefficient is 0 or if all spatially nearest neighbour markets take place on the same day.

The highest M value possible depends on the length (l) of the week. For regular lattices and for the special case with an equal number of markets for each day of the week, Hay a. Smith (1980, 152–157) have presented optimal configurations for market systems of different week lengths. For these cases, the following M values are obtained[1)]:

Market week length	M (Triangular lattice case)	M (Square lattice case)
2	0.000	1.000
3	0.716	0.667
4	0.537	0.500
5	0.430	0.400
6	0.358	0.667
7	0.307	0.571
8	0.269	0.500

M = 1 seems to be the upper limit for regular lattices. Thus, the integration coefficient can vary between 0 and a value near to 1. Provided that the markets are equally distributed throughout the market week, the M value for a pattern which is independently random in both spatial and temporal aspects therefore is

[1)] In three cases regarding the square lattices, (for l = 6,7 and 8) the configuration given by Hay a. Smith are not optimal in the sense of the integration coefficient developed here.

$$M = 0.25 \quad \text{if } L = \frac{N \cdot 1}{n} \text{ is even,}$$

$$M = \frac{L^2-1}{4L^2} \quad \text{if L is uneven or non-integer.}$$

Systems with M values below this are less integrated than random, those with values above are more integrated.

As with the nearest neighbour coefficient, two problems arise in this method. Firstly, the so-called boundary problem if the sample studied is too small (cf. KING 1969, 89), and secondly, the definition of the area A of the market system in order to establish the R value. Other problems encountered with the above developed method are that very often the data is not satisfactory with mapping inprecise and incomplete recording of the markets. Also, as with the nearest neighbour coefficient, the direct-line distance sometimes is too crude a measure. However, in very few cases only are maps available to give an accurate description of the communication system.

The 52 cases studied

Under investigation here is a body of 52 periodic market systems from all over the world (tables 1 a. 2). The data were collected from several publications[2]. Most of the systems have a 7-day market week. Two have a market week of three days, three a 4-day week, two a 6-day week, and one an 8-day week; these eight cases are all located in West Africa. There are three systems each with a 5-day and a 10-day market week. With one exception (Tivland in Nigeria), these are found in the Far East (China and Korea). The Buganda case (No. 16) has a 28-day week which is derived from a 7-day week.

The systems include between 11 and 432 market places, and thus are of very different size. Some market systems include other market systems within them. For instance, case 40, the biggest set of markets in the sample, includes cases 1 and 13. There are 13 systems with more than 75 market places and market days and they are of major interest since with them the boundary effects do not influence the nearest neighbour measure. The areas covered by the systems vary between 50 km² (urban markets within Quito) and 143,000 km² (the whole area of Tunisia). Included are four periodic market systems within cities (Quito, Singapore, Dortmund and Mexico City). In only 16 of the 52 cases (31%), does the number of market places equal the number of markets taking place during one market week, i.e. in these cases only one periodic market is held per market centre per market week. In the most extreme case (No. 41), on the average more than three markets are held at each market place in one 10-day market week.

The integration coefficients M for the 52 market systems, which were calculated with the help of a FORTRAN programme written by the author, vary between 0.0420 and 0.5635. Only four of them are below the random threshold of $M = 0.25 \left(\text{or } M = \frac{L^2-1}{4L^2}\right)$, three others being just above it. Five of these seven cases are located in Latin America. This is mainly due to the fact that in Latin America by far the largest number of periodic markets are held on Sundays. However, the R values here are also comparatively low: in 5 of the 8 Latin American cases, the spatial distribution of the market centres is not significantly different from a random one (at 1% significance level), whereas for the whole body, only 18 of the 52 cases have an approximately random pattern, the others (with the exception of the West Nigerian case which is clustered) being more regular than random.

Some specific questions may now be asked about the characteristics of the market systems studied:

- Does the size of a periodic market system influence its degree of integration?
- Are there differences in the degree of integration between systems of different week lengths and those of different cultural regions?
- Do the urban cases differ significantly from the rural ones?
- Does the degree of integration of different market systems depend on the spatial distance between the markets?
- Does the degree of integration change in time?
- Are there differences in the degree of integration if we take into account the hierarchy or size of markets?
- Does an advantageous temporal spacing of the markets substitute an unfavourable spatial arrangement (e.g. due to constraints like relief or varying population density)?

These questions are answered by means of analysis of the frequency distributions of the different means, by some significance tests as well as by some multivariate methods. With the range of case studies considered it is difficult to proceed to explanation of the causes of the different patterns, however this is attempted in some instances.

The size of a market system and its degree of integration

It is clear that the degree of integration of a market system is not dependent on its size: the Spearman rank correlation coefficients (which are thought to be an appropriate measure of dependence since particularly the N and n values are not normally distributed) between M on the one hand and the number (N) of the market places and the number (n) of the market days respectively on the other hand are not significantly different from 0 on 5% level. Likewise, the area (A) covered by the systems does not have a significant correlation with the degree of integration. Taking the 13 larger cases, no significant difference in the degree of integration can be observed in comparison with all cases studied. This also applies if the R and T values of the 13 larger cases are compared with those of the complete set. Looking at the 13 smallest cases (those with less than 24 market places) however, a significant difference at 5%

[2] In all cases, daily markets (if they occur) were excluded from the calculations because they are not periodic in a strict sense but rather almost permanent.

Table 1: Sources of the cases included in the study

Case Number	Authors	Year	Area	Source
1	Adalemo, I. A.	1974	Abeokuta, Western Nigeria	Fig. 8, Table 1
2	Beals,R. L.	1975	Oaxaca, Mexico	Maps 4, 6
3	Bohannan, L. a. P.	1957	Tivland, Nigeria	Fig. 2
4	Bohle, H.-G.	1981	NW-Salem, South India	Abb. 2
5	Bromley, R. J.	1974b	Quito, Ecuador	Fig. 3
6	Bromley, R. J.	1976	Central Highland Ecuador	Map 1, Fig. 3
7	Bromley, R. J. and Bromley, R. J.	1976 1980	Northern Highland Ecuador	Map 1 Fig. 4.1
8	Brown, J. R., Harvey, M. E.	1977	Southern Morocco	Fig. 2
9	Danks, P.	1977	East Anglia, England	Fig. 1
10	Deshpande, C. D.	1941	Bombay Karnatak, India	Map II
11	Dibes, M. Ch.	1978	Northern Syria	Karte 5
12	Edyau, J. P.	1971	Kaberamaido County, Uganda	Map IV
13	Filani, M. O., Richards, P.	1976	Ibarapa, Nigeria	Fig. 2
14	Frischen, A.	1972	Anloland, Southeastern Ghana	Abb. 1
15	Gezann, G. A.	1978	Lushoto District, Tanzania	Fig. 12.3
16	Good, C. M.	1975	Buganda Region, Uganda	Fig. 4
17	Gormsen, E.	1971	Pueblo-Tlaxcala, Mexico	Karte 2
18	Harriss, B.	1976	Eastern North Arcot, India	Fig. 2
19	Heermann, I.	1979	Bulsa, Northern Ghana	Fig. 1
20	Henkel, R.	1979	Bungoma District, Kenya	Fig. 4
21	Henkel, R.	1979	Trans Nzoia District, Kenya	Fig. 5 and field
22	Henkel, R.	1979	West Pokot District, Kenya	Fig. 5 work data
23	Hill, P., Smith, R. H. T.	1972	Katsina Emirate, Nigeria	Fig. 2
24	Ibrahim, F.	1979	Tunisia	Fig. 1a, b, c
25	Jackson, D. W.	1977	Central Sri Lanka	Map 6.VIII
26	Jackson, R. T.	1971	Gamu Highlands, Ethiopia	Fig. 1
27	Jackson, R. T.	1972	West Nile District, Uganda	Fig. 3
28	Jackson, R. T.	1978	Imerina, Madagascar	Fig. 4.3
29	Lindskog, P. A.	1979	Shire Highlands, Malawi	Fig. 3
30	Mahn, Chr.	1980	Walewale District, Ghana	Karte 4 and pers. comm.
31	Mahn, Chr. and McKim, W.	1980 1972	Tamale-Yendi Area, Ghana	Karte 4 and pers. comm. Fig. 2, 3
32	McBryde, F. W.	1947	Southwest Guatemala	Map 19
33	Oettinger, B.	1976	Western Anatolia, Turkey	Abb. 2
34	Oswald, K.	1980	Baringo District, Kenya	Karte 10
35	Park, S.	1981	Western South Korea	Fig. 2
36	Pyle, J.	1978	Mexico City	Fig. 8.1, 8.5
37	Schwimmer, B.	1976	Suhum, Southern Ghana	Map 5
38	Skinner, G. W.	1964	Szechwan A, China	Fig. 2.2
39	Skinner, G. W.	1964	Szechwan B, China	Fig. 3.2
40	Smith, R. H. T.	1971	Western Nigeria	Fig. 5
41	Spencer, J. E.	1940	Szechwan C, China	Fig. 1
42	Stine, J. H.	1962	Central South Korea	Fig. 1
43	Symanski, R., Webber, M. J.	1974	Highland Colombia	Fig. 3
44	Tamaskar, B. G.	1966	Sagar-Damoh, Central India	Fig. 1
45	Thorpe, J. K.	1978	Caspian Lowlands, Iran	Fig. 5.4
46	Tinkler, K. J.	1973	Nyambeni Hills, Kenya	Fig. 1c
47	Troin, J.-F.	1975	Northern Morocco	Planche 5
48	Unwin, P. T. H.	1981	Nottinghamshire, England	Fig. 1
49	Western, J.	1974	Central Southern Burundi	Fig. 2
50	Wiertz, H.	1982	Dortmund, West Germany	Fig. 5
51	Yeung, Y.-M.	1973	Singapore	Fig. 17, Table 18
52	Zahan, D.	1954	Mossi Yatenga, Upper Volta	Fig. p. 370

level between their mean R value and the global mean R value is observed. This shows that smaller cases exhibit a more regular spatial arrangement of the market places than all systems taken together, as measured by R. This may, however, be due to the above mentioned boundary effect. But this effect obviously does not disturb the measure of

Table 2: Data of the different measures used in the analysis (Explanation of the variables see text)

Case	N	n	A (km²)	l (days)	L (days)	d_o (km)	R	Significance of R	d_t (days)	T	M
1	34	56	2 280	8	4.86	5.010	1.2235	+	1.4821	0.3051	0.3733
2	39	39	15 791	7	7.00	10.134	1.0088	○	1.7692	0.2527	0.2550
3	12	12	818	5	5.00	6.937	1.6805	⋇	1.1667	0.2333	0.3921
4	60	60	4 975	7	7.00	5.007	1.0997	○	2.1833	0.3119	0.3430
5	16	21	50	7	5.33	1.189	1.3396	⋇	1.1905	0.2232	0.2990
6	66	82	16 056	7	5.63	8.432	1.0812	○	0.8293	0.1472	0.1591
7	33	35	12 733	7	6.60	8.664	0.8820	○	0.3143	0.0476	0.0420
8	24	35	58 056	7	4.80	32.488	1.3212	⋇	1.1429	0.2381	0.3146
9	42	48	10 497	7	6.13	10.768	1.3623	⋇	1.8750	0.3061	0.4170
10	90	90	48 863	7	7.00	17.050	1.4639	⋇	1.7777	0.2540	0.3718
11	37	44	20 351	7	5.89	15.859	1.2986	⋇	1.5682	0.2664	0.3460
12	23	23	1 300	7	7.00	5.472	1.4556	⋇	2.3478	0.3354	0.4882
13	34	36	3 356	4	3.78	5.553	1.1781	○	0.8889	0.2353	0.2772
14	20	20	2 287	4	4.00	7.650	1.4306	⋇	1.1000	0.2750	0.3934
15	50	53	2 368	7	6.60	3.422	0.9944	○	2.2075	0.3343	0.3324
16	137	318	19 843	28	12.06	12.302	2.0449	⋇	3.3284	0.2759	0.5635
17	81	81	37 833	7	7.00	13.611	1.2596	⋇	1.4198	0.2028	0.2555
18	40	40	6 348	7	7.00	8.908	1.4142	⋇	1.5750	0.2250	0.3182
19	39	69	5 060	6	3.39	7.066	1.2407	⋇	0.7536	0.2222	0.2757
20	40	49	2 330	7	5.71	5.775	1.5134	⋇	1.7551	0.3071	0.4648
21	13	14	2 128	7	6.50	8.966	1.4015	⋇	0.5000	0.0769	0.1078
22	11	12	6 285	7	6.42	15.631	1.3078	○	1.6667	0.2597	0.3397
23	161	235	24 517	7	4.80	6.919	1.1213	⋇	1.4766	0.3079	0.3453
24	124	124	143 122	7	7.00	19.237	1.1322	⋇	1.8065	0.2581	0.2922
25	111	119	9 380	7	6.53	5.581	1.2146	⋇	1.6639	0.2548	0.3095
26	16	25	670	7	4.48	5.159	1.5944	⋇	1.3200	0.2946	0.4698
27	99	146	9 907	7	4.75	4.835	1.0195	○	1.4863	0.3131	0.3192
28	59	59	7 804	7	7.00	7.355	1.2789	⋇	2.2542	0.3220	0.4119
29	37	71	1 669	7	3.65	4.438	1.3216	⋇	1.2958	0.3552	0.4694
30	16	16	4 595	3	3.00	10.102	1.1922	○	0.7500	0.2500	0.2981
31	35	35	38 160	6	6.00	17.730	1.0739	○	1.6000	0.2667	0.2864
32	49	50	9 900	7	6.86	8.282	1.1644	+	1.1000	0.1604	0.1867
33	92	97	74 100	7	6.64	19.784	1.4153	⋇	1.9278	0.2904	0.4110
34	51	57	5 700	7	6.26	6.648	1.2575	⋇	1.7193	0.2745	0.3452
35	110	114	10 125	5	4.82	6.574	1.3705	⋇	1.4123	0.2927	0.4012
36	36	41	693	7	6.15	2.533	1.1548	○	1.5366	0.2500	0.2887
37	23	45	425	7	3.58	3.256	1.5158	⋇	0.8222	0.2298	0.3484
38	13	39	894	10	3.33	6.480	1.5628	⋇	1.1026	0.3308	0.5169
39	12	36	362	10	3.33	4.708	1.7133	⋇	1.0556	0.3167	0.5426
40	432	432	75 369	4	4.00	6.252	0.9466	⊕	1.0949	0.2737	0.2591
41	76	244	3 391	10	3.11	4.600	1.3733	⋇	0.9549	0.3066	0.4223
42	25	25	1 684	5	5.00	6.687	1.6077	⋇	1.6400	0.3280	0.5273
43	38	47	.	7	5.66	.	1.5442	⋇	1.6383	0.2895	0.4470
44	140	144	17 900	7	6.81	7.002	1.2382	⋇	1.7083	0.2510	0.3108
45	36	43	4 470	7	5.86	6.657	1.1948	+	1.9767	0.3373	0.4030
46	13	39	1 319	7	2.33	5.491	1.0906	○	0.6923	0.2967	0.3236
47	380	401	120 360	7	6.63	10.878	1.2224	⋇	2.0773	0.3132	0.3828
48	28	28	2 228	7	7.00	5.064	1.1357	○	2.0357	0.2908	0.3303
49	31	41	2 162	7	5.29	5.297	1.2684	⋇	1.7317	0.3272	0.4150
50	16	29	271	7	3.86	2.324	1.1277	○	0.9310	0.2411	0.2719
51	48	51	129	7	6.59	0.796	0.9696	○	1.9608	0.2976	0.2886
52	60	60	17 780	3	3.00	12.389	1.4394	⋇	0.8000	0.2667	0.3838

Note: Significance of R:
⋇ = significantly deviating from random at 1% level (regular),
+ = significantly deviating from random at 5% level (regular),
○ = not significantly deviating from a random distribution,
⊕ = significantly deviating from random at 5% level (aggregated)

integration considerably, since the M values of the small cases do not significantly differ from the global M value. The same applies to the measure T of temporal spacing. T has a negative Spearman rank correlation with the mean nearest neighbour distance ($r_s = -0.3203$) significant at 5% level. This can be taken as a hint that if market centres are very widely spaced, an effective temporal arrangement ot the market meetings is not so necessary any more. This is to be expected due to the declining intensity of competition with increased spacing. There are of course exceptions (e.g. cases 9, 16, 32 and 47) which although widely spaced have a very favourable temporal arrangement or some urban cases (5, 36 and 50) which display a below average temporal spacing.

Market systems of different week lengths and of different cultural regions

As far as the market week lengths are concerned it can be stated that the 5- and 10-day market week systems seem to be by far the most integrated ones. This is mainly due to good spatial arrangement. As has already been mentioned, these cases most frequently occur in the Far East, the rather featureless surface of most areas studied (the three Chinese cases are all taken from the Red Basin) possibly favouring a regular spatial distribution of markets. The West African systems with 3-, 4-, 6- or 8-day market weeks, tend to have lower R, T and M values than the other systems but the differences are not significant.

If we divide the data into *cultural regions* (table 3), next to the Far East, the cases found in Eastern Africa are the most favourably arranged. In contrast to the Far East this is mainly due to an above average temporal spacing. Buganda (case 16) displays the highest M value overall, but here a very favourable spatial arrangement of the markets is decisive (R=2.04, a value which is very near the highest possible, i.e. R=2.149). This is an outcome of a well-organized political system in Buganda and the uniform, although not plain landscape in this region. If we omit the special case of Trans Nzoia in the former White Highlands of Kenya, (reasons for the unusual arrangement, see Henkel 1979, 172–174) the mean M and T values for the East Africa cases left differ significantly (on 5% level) from the overall means of these measures. The two cultural regions with above average integrated market systems have a different genetic background regarding marketing. Whereas periodic marketing is very old in the Far East (cf. e.g. Stine 1962, 70 and Ishihara 1976), it was introduced in Eastern Africa only in the colonial period, i.e. not earlier than the beginning of the 20th century (cf. Henkel 1979, 166–67).

In the first case, the very length of existence of market systems may have resulted in the well integrated pattern after a long trial-and-error process. In West Africa which also has a long tradition of periodic markets, high levels of integration have not resulted. In the East African cases, good colonial planning is possibly the reason for the high degree of integration.

As has already been mentioned above, the Latin American cases seem to be very poorly integrated. This is mainly attributable to the unfavourable temporal spacing: both mean M and T values for the 8 Latin American cases differ significantly (on 1% level) from the general M and T values. This is mainly the result of markets being held on Sundays in conjunction with attendance of mass (cf. Bromley 1976, 110). The values for both Ecuadorian cases would be still lower if the daily markets, which have been excluded from this study, were also included. An interesting exception, however, is Oaxaca (case 2). Although almost half of the markets (16 out of 39) are held on Sundays, a slightly more than random temporal spacing is attained (T=0.253).

Table 3: Spatio-temporal integration in the cultural regions

Cultural region	Number of cases	Mean values R	T	M
East Africa	13	1.350	0.290	0.389
West Africa	11	1.277	0.261	0.331
Latin America	8	1.179	0.197	0.242
Far East	5	1.526	0.315	0.482
Southern Asia	6	1.233	0.266	0.324
Middle East and North Africa	6	1.264	0.284	0.358
Europe	3	1.209	0.279	0.340

Urban and rural markets

In general, the spatio-temporal integration of periodic market systems within cities might be expected to be less pronounced because the distances to be covered by the consumer are not great and therefore the spatio-temporal competition of the markets for the consumers is not so strong (the mean nearest neighbour distances of the markets in the four urban cases range between 0.8 and 2.5 km). The data in this study confirm this supposition since all M values are less than 0.3 and therefore well below the overall mean (which is M=0.3488). Where there is a fairly good spatial arrangement (Quito with R=1.340), a bad temporal spacing is observed (T=0.223) producing a low M value. The reverse also occurs, e.g. Singapore with T=0.289, but R=0.970. This statement must be qualified since two of the urban cases are from Latin America (Mexico City and Quito), and within this cultural region, they display a high degree of integration. The reason is that in these cities the dominance

Table 4: Mean T and M values for groups used in analysis of variance

Spacing	Number of cases	Mean T value	Mean M value
$d_o < 4$ km	6	0.2627	0.3048
$4\text{ km} \leqq d_o \leqq 12.5$ km	33	0.2909	0.3828
$d_o > 12.5$ km	8	0.2545	0.3272

Table 5: Change of market systems in time

Area	Year	N	n	d_t (days)	d_o (km)	T	R	M	A (km²)	l
Caspian Lowlands,	1915	46	54	1.648	6.185	0.2764	1.255	0.3468	4470	7
Iran	1973	36	43	1.977	6.657	0.3373	1.195	0.4030		
Central	1940	43	47	1.532	7.878	0.2392	1.136	0.2718	9380	7
Sri Lanka	1974	111	119	1.664	5.581	0.2548	1.215	0.3095		
Western	1925	69	75	1.373	7.799	0.2986	1.288	0.3845	10125	5
South Korea	1970	110	114	1.412	6.574	0.2927	1.371	0.4012		
Northwest	1935	33	37	2.162	10.968	0.3463	1.529	0.5295	7340	7
Morocco	1972	34	38	2.105	9.524	0.3361	1.296	0.4358		

of the Sunday as the main market day is far less pronounced, a tendency which has also been observed in rural areas in Ecuador (Bromley 1976, 103, 119, 120).

The influence of the spatial distance between the markets on the degree of integration

We have seen that in general the urban periodic market systems display a below average degree of integration. This is because it is easy for the consumer to visit several markets and so the spatio-temporal competition of the markets is not very strong. Competition may shift to the kinds of goods offered. Hence, in many cities, a specialization of the markets is observed. On the other hand, we have noted (see Question 1) that very widely spaced market systems tend to have a rather low temporal integration since due to the great distances to be covered by the consumer it is not likely that he will be able or willing to visit more than one market at all. Both observations taken together lead to the assumption that in market systems where the mean spatial nearest neighbour distances are in an intermediate range the spatio-temporal competition is strongest. In order to test this assumption, the cases were divided into three sets: those with mean nearest neighbour distances (d_o) below 4 km, those between 4 and 12.5 km, and those above 12.5 km. These thresholds were chosen because they indicate gaps in the frequency distribution of the cases according to mean nearest neighbour distance. If the extreme cases 6, 7, 21 and 32 at the lower end and case 16 at the upper end are omitted, which seems reasonable since they somewhat distort the picture resulting from very low T values and very high R values respectively, an analysis of variance on the three sets of cases regarding the T and M values reveals F test values of 4.38 and 4.35, both of which are significant at 2.5% level. (The mean T and M values for the sets are found in table 4). The test on R for the same sets does not show a significant difference. It can therefore be concluded that those market systems which are spaced with an average nearest neighbour distance between 4 and 12.5 km have a better spatio-temporal integration than both those with low and those with high mean nearest neighbour distances.

Change in the degree of integration over time

Concerning the change of integration in time, four cases are available for study: north-western Iran 1915 and 1973 (Thorpe 1978), central Sri Lanka 1940 and 1974 (D.W. Jackson 1977), western South Korea 1925 and 1970 (Park 1981) and north-western Morocco around 1935 (Fogg 1938) and around 1972 (Troin 1975)[3]. In the Sri Lanka and South Korea cases, the market systems have grown considerably, the system in Morocco stagnated in terms of number of markets and market places, and in the Iranian case a decline of the system is observed (see table 5).

In all but the Moroccan case, the degree of integration grew in the time period under investigation. For Sri Lanka, this is due to a moderate growth of both spatial and temporal efficiency; for South Korea it is due to an improvement in the spatial arrangement pattern. The considerable increase in the spatio-temporal integration of the Caspian Littoral markets of Iran (from M = 0.3468 to M = 0.4030) is attributable only to a far better temporal arrangement of the system in 1973 compared with 1915. The nearest neighbour coefficient R of this system actually diminished during this period. By using the M measure, we can conclude that the Caspian Littoral periodic market system improved in terms of spatio-temporal integration although the size of the system decreased. R.H.T. Smith (1979, 474) assesses this case differently by saying that "no ... convergence towards spatio-temporal synchronization of market-places" can be observed. Here it can be seen that the M method may bring forth results different from those obtained by means of the SMITH method but it has to be stressed again that the latter is not really a comparative method for either different regions nor for different points of time.

The Morrocan case is difficult to assess. Its decline in integration is mainly attributable to a far less efficient spatial arrangement of market centres in 1972 compared with 1935 but the reasons are not clear. One observation that can be made in this connection is that a number of new markets have been started in the close neighbourhood of larger

[3] In the last case, only the area studied by Fogg was taken into consideration.

Table 6: Spatio-temporal integration of markets of different size or hierarchical level

Area	Size or level	A (km²)	l	N	n	d_t (days)	d_o (km)	T	R	M
Central Ecuador	all	16 056	7	66	82	0.824	8.43	0.1472	1.081	0.1591
	2nd to 4th order			27	41	1.073	13.50	0.2328	1.107	0.2577
Pueblo (Mexico)	all	37 833	7	81	81	1.420	13.61	0.2028	1.260	0.2555
	more than 400 stalls			19	19	2.000	22.31	0.2857	1.110	0.3172
West Nile (Uganda)	all	8 907	7	99	146	1.486	.84	0.3131	1.020	0.3192
	more than 500 attend.			41	70	1.229	.06	0.2997	1.093	0.3276
Western South Korea	all	10 125	5	110	114	1.412	6.57	0.2927	1.371	0.4012
	Regional			13	13	1.538	22.19	0.3077	1.590	0.4894
Northern Morocco	all	120 360	7	380	401	2.077	10.88	0.3132	1.222	0.3828
	gros + moyen			163	184	1.989	16.30	0.3209	1.200	0.3849
	gros			41	52	1.596	30.08	0.2892	1.110	0.3211

centres (Tangier, Tetouan, Ksar el Kebir) whereas some markets in the more remote rural areas have closed down. This may be due to a rural-urban shift in the population distribution. Variations in population density, which are considered in a model developed by GHOSH (1979), are not assessed in the model developed here[4].

The size or hierarchical component

One of the main criticisms of the R.H.T. SMITH method (see e.g. C.A. SMITH 1974, 185 and BROMLEY 1976, 112) is that it ignores hierarchical, functional and size stratifications of market places. This problem often arises because of lack of adequate data. In only 5 cases of the 52 studied was the number of markets great enough to justify a quantitative analysis of the integration of the markets of different sizes or hierarchical levels (table 6). In all but one case the high level or large markets display higher degrees of spatio-temporal integration than all markets taken together in the respective study areas. The only exception is Northern Morroco where the *gros souks* have a lower degree of integration than both all markets and the *gros souks* and *souks moyen* taken together. The reason for this exception may be that on the level of the *gros souks* which are on the average 30 km distant from each other, definite and stable market areas have developed. These areas which TROIN terms *réseaux de marches* do not overlap to a great extent (TROIN, Planche 5). In the West Nile and South Korean cases the higher integration index of the large markets is due to a more favourable spatial arrangement of these centres, and in both Latin American cases to a far higher temporal efficiency compared to all markets. In Central Ecuador, the higher temporal efficiency occurs despite the fact that Sunday is still the by far most important market day on this level (19 of the 41 markets are held on Sundays). The observation of a better spatio-temporal integration of the high level markets in Central Ecuador corresponds with BROMLEY'S (1976, 117–119) findings obtained by means of the improved SMITH method. In the Mexican case, a further step in the development can be noted. While in the whole market system Sunday is the dominant market day (46 of 81 markets), this dominance has disappeared with the 19 biggest markets: only one of these is a Sunday market.

Substitution of temporal for spatial competition

The last question is probably the most interesting one. According to UKWU (in HODDER a. UKWU 1969, 156), a consequence of market periodicity is "the partial substitution of temporal for spatial competition". But is this proposition in accordance with the findings of the cases studied here? If so, it would mean that there is a general tendency for those cases with weak spatial competition (low R values) to have high temporal competition (high T values) and vice versa. The 52 cases, however, display a positive, though not significant, correlation ($r_s = 0.209$) between R and T and not as would be expected, a negative one. There are, of course, some cases (e.g. 15, 27, 40 and 51) which compensate a rather low spatial efficiency by a good temporal arrangement, but this is not generally true, as can be seen in the scatter diagram (fig. 2). If we take the 16 cases with an R value that does not stand for a more regular than random pattern (not significant on 5% level), their mean T value is 0.2543 which is less than the overall mean T (0.2677). Although this difference is not significant either, we can definitely state that the hypothesis that a temporally efficient arrangement of market meetings compensates an unfavourable locational spacing is not true for the majority of cases investigated here.

[4] It has to be noted, however, that GHOSH'S study fails to include the temporal aspect in the arrangement of market systems. It only looks at the spatial distribution.

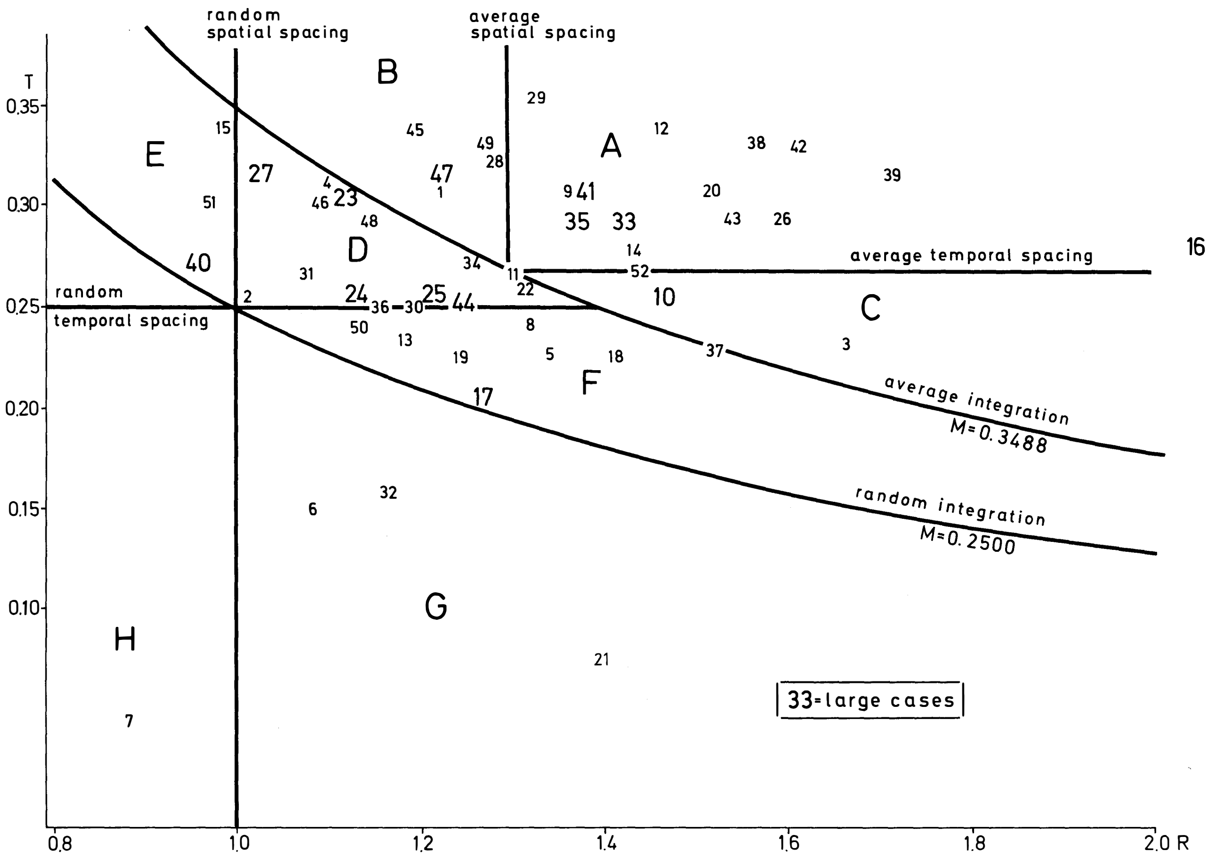

Fig. 2: Scatter diagram of the 52 market systems under study. The two axes are the measure R of the spatial pattern of the markets (nearest neighbour coefficient) and the measure T of their temporal arrangement. The 52 cases are classified into 8 groups (A to H)

Classification of market systems

With the help of the scatter diagram (fig. 2) it is now possible to group the cases:

A those with above average spatial and temporal spacing (14 cases),
B those with below average spatial spacing but an above average integration due to above average temporal spacing (5 cases),
C those with below average temporal spacing but an above average integration due to above average spatial (3 cases),
D those with above random but below average integration resulting from both above random spatial and temporal spacing (15 cases),
E those with below random spatial spacing but above random integration due to above random temporal spacing (3 cases),
F those with below random temporal spacing but above random integration due to above random spatial spacing (8 cases),
G those with below random integration in spite of above random spatial spacing (3 cases), and finally
H those with below random integration due to both below random spatial and temporal spacing (1 case).

The other theoretically possible cases (below random integration in spite of above random temporal spacing and above average integration in spite of below random spatial spacing) do not occur in this sample of market systems. The 13 larger cases (with more than 75 market places and market days), which as mentioned above are of major interest since boundary effects do not distort their values, are represented in groups A to F with the majority (9) being in groups A and D.

Conclusions

By applying to 52 cases from all over the world the measure developed here for assessing the degree of spatio-temporal integration, several patterns and attributes of periodic market systems become evident. There are certain cultural regions where integration is generally poor, e.g. Latin America. In others, e.g. the Far East and East Africa, it is high. Urban markets are less integrated than rural markets. Those market systems which have a mean nearest neighbour distance of between 4 and 12.5 km display a higher degree of integration than those with lower or higher mean distances. High-order markets are more integrated than low-order markets. In only very few cases is a substitution of temporal for spatial competition observed.

There are two major tasks which still have to be carried out to make the model developed here more realistic and verifiable: (a) the population distribution of the study area should be included in the assessment of the spatial component and (b) a test should be produced which proves if the degree of integration of a market system is significantly different from that of a system with randomly arranged market places and market meetings.

Acknowledgements

I want to acknowledge the help of Mr. Peter Grimmer Dept. of Geography, University of Heidelberg, West Germany, who carried out the tedious computer calculations, and of Dr. Adrian P. Wood, Dept. of Geography, University of Zambia, who gave me valuable hints on some topics and on the use of English in this article.

References

ADALEMO, I. A.: Spatial and temporal configurations of rural periodic markets in Western Nigeria. Unpublished Ph. D. dissertation, University of Michigan 1974.

BEALS, R. L.: The peasant marketing system of Oaxaca, Mexico. University of California Press, Berkeley 1975.

BOHANNAN, L. a. BOHANNAN, P.: Tiv markets. New York Academy of Sciences, Transactions, Ser. II, Vol. 19, 1957, 613–621.

BOHLE, H.-G.: Beobachtungen zum südindischen ländlichen Wochenmarkt. Erdkunde 35, 1981, 140–153.

BROMLEY, R. J.: Periodic markets, daily markets, and fairs: A bibliography. Monash Publications in Geography, No. 10, Melbourne 1974a.

– : The organization of Quito's urban markets: Towards a reinterpretation of periodic central places. Transactions of the Institute of British Geographers 62, 1974b, 45–70.

– : Contemporary market periodicity in Highland Ecuador. In: SMITH, C. A. (Ed.), 1976, 91–122.

– : Periodic markets, daily markets, and fairs: A bibliography supplement to 1979. University College of Swansea, Centre of Development Studies, Monograph No. 5, 1979.

– : Trader mobility in systems of periodic and daily markets. In: HERBERT, D. T. a. JOHNSTON, R. J. (Eds.): Geography and the urban environment, Progress in research and applications, Vol. III, Chichester 1980, 133–174.

BROWN, J. R. a. HARVEY, M. E.: The concept of market components and the spatial organization of periodic markets. Environment and Planning A 9, 1977, 1259–1280.

DANKS, P.: Some observations on medieval and postmedieval artefact distributions. In: CLARKE, D. L. (Ed.): Spatial Archaeology, London 1977, 353–381.

DESHPANDE, C. D.: Market villages and periodic fairs of Bombay Karnatak. Indian Geogr. Journal 16, 1941, 327–339.

DIBES, M. CH.: Die Wochenmärkte in Nordsyrien. Mainzer Gegr. Studien 13, 1978.

EDYAU, J. P.: Spatial relations of local markets in Kaberamaido County, Teso, Uganda. Kampala, Makerere University, Dept. of Geography, Occasional Paper 19, 1971.

FOGG, W.: A tribal market in the Spanish zone of Morocco. Africa 11, 1938, 428–458.

FILANI, M. O. a. RICHARDS, P.: Periodic market systems and rural development: The Ibarapa case study. Savanna 5, 1976, 149–162.

FRISCHEN, A.: Die periodischen Märkte des Anlolandes in Südost-Ghana. Erdkunde 26, 1972, 278–283.

GEZANN, G. A.: Itinerant salesmen and the periodic market system of Lushoto district, Tanzania. In: SMITH, R. H. T. (Ed.), 1978, 186–198.

GHOSH, A.: Changes in the spatial efficiency of periodic markets. Tijdschrift voor Economische en Sociale Geographie 70, 1979, 293–299.

GOOD, C. M.: Periodic markets and traveling traders in Uganda. Geographical Review 65, 1975, 49–72.

GORMSEN, E.: Wochenmärkte im Bereich von Pueblo. In: Jahrbuch für Geschichte von Staat, Wirtschaft und Gesellschaft Lateinamerikas 8, 1971, 366–402.

HARRISS, B.: Social specificity in rural weekly markets – the case of Northern Tamil Nadu, India. Mainzer Geographische Studien 10, 1976, 39–48.

HAY, A. M. a. SMITH, R. H. T.: The spatio-temporal synchronization of periodic market-places: A re-examination. Canadian Geographer 16, 1980, 149–164.

HEERMANN, I.: The development of markets among the Bulsa. Traditional values and new incentives. Mainzer Geographische Studien 17, 1979, 19–28.

HENKEL, R.: Periodic markets in Western Kenya. Erde 110, (1979), 165–180.

– : Analyse der raumzeitlichen Anordnung periodischer Märkte in West-Kenya mit Hilfe quantitativer Methoden. Mainzer Geographische Studien 21, 1982, 27–40.

HILL, P. a. SMITH, R. H. T.: The spatial and temporal synchronization of periodic markets: Evidence from four emirates in Northern Nigeria. Economic Geography 48, 1972, 345–355.

HODDER, B. W. a. UKWU, U. I.: Markets in West Africa. Ibadan 1969.

IBRAHIM, F.: Craftsmen in the periodic suqs of Tunisia. Mainzer Geographische Studien 17, 1979, 7–17.

ISHIHARA, H.: Periodic markets in Hopei Province, China during the Ming, Ch'ing and Min-Kuo periods. Mainzer Geographische Studien 10, 1976, 7–10.

JACKSON, D. W.: Polas in Central Sri Lanka: Some preliminary remarks on the development and functioning of periodic markets. In: SAMARASINGHE, S. W. R. DE A. (Ed.): Agriculture in the peasant sector of Sri Lanka. Peredeniya, Ceylon Studies Seminar, 1977, 56–84.

JACKSON, R. T.: Periodic markets in Southern Ethiopia. Transactions of the Institute of British Geographers 53, 1971, 31–42.

– : Essays on rural marketing in West Nile District. Kampala, Makerere University, Dept. of Geography, Occasional Paper 47, 1972.

– : Nineteenth century market systems in Ethiopia and Madagascar. In: SMITH, R. H. T. (Ed.), 1978, 664–80.

KING, L. J.: Statistical analysis in geography. Englewood Cliffs 1969.
LINDSKOG, P. A.: The periodic market-place exchange system in Malawi. Mainzer Geographische Studien 17, 1979, 53–63.
MAHN, CHR.: Periodische Märkte und zentrale Orte – Raumstrukturen und Verflechtungsbereiche in Nord-Ghana. Heidelberger Geographische Arbeiten 59, 1980.
MCBRYDE, F. W.: Cultural and historical geography of Southwest Guatemala. Washington D.C., Smithsonian Institution, Institute of Social Anthropology, Publication No. 4, 1947.
MCKIM, W.: The periodic market system in northeastern Ghana. Economic Geography 48, 1972, 333–344.
OETTINGER, B.: Die Wochenmärkte und ihre Rotationen im westlichen Mittelanatolien. Erdkunde 30, 1976, 19–24.
OSWALD, K. E.: Agrarwirtschaft und sozialer Wandel im Baringo-District/Kenya. Frankfurter Wirtschafts- und Sozialgeographische Schriften 35, 1980.
PARKS, S.: Rural development in Korea: The role of periodic markets. Economic Geography 57, 1981, 113–126.
PYLE, J.: Tianguis: Periodic markets of Mexico City. In: SMITH, R. H. T. (Ed.), 1978, 132–141.
SCHWIMMER, B.: Periodic markets and urban development in Southern Ghana. In: SMITH, C. A. (Ed.), 1976, 123–145.
SKINNER, G. W.: Marketing and social structure in rural China. Journal of Asian Studies 24, 1964, 3–43.
SMITH, C. A. (Ed.): Regional Analysis. Vol. I: Economic Systems. New York 1976.
– : Regional economic systems: Linking geographical models and socioeconomic problems. In: SMITH, C. A. (Ed.), 1976, 3–63.
SMITH, R. H. T.: West African market-places: Temporal periodicity and locational spacing. In: MEILLASSOUX, C. (Ed.): The development of indigenous trade and markets in West Africa. London 1971, 319–346.
– : The synchronization of periodic markets. In: ADAMS, W. P. a. HELLEINER, F. M. (Eds.): International Geography 1972, Vol. I Toronto 1972, 591–593.
– : (Ed.): Market-place trade – periodic markets, hawkers, and traders in Africa, Asia, and Latin America. Vancouver, University of British Columbia, Centre for Transportation Studies, 1978.
– : Periodic market-places and periodic marketing: Review and prospect, Part. I. Progress in Human Geography 3, 1979, 471–505.
SPENCER, J. E.: The Szechwan village fair. Economic Geography 16, 1940, 48–58.
STINE, J. H.: Temporal aspects of tertiary production elements in Korea. In: PITTS, F. R. (Ed.): Urban systems and economic development. Eugene, Oregon, University of Oregon, School of Business Administration, 1962, 68–88.
SYMANSKI, R. a. WEBBER, M. J.: Complex periodic market cycles. Annals of the Association of American Geographers 64, 1974, 203–213.
TAMASKAR, B. G.: The weekly market of the Sagar-Damoh plateau. National Geographical Journal of India 12, 1966, 38–50.
THORPE, J. K.: Periodic markets in the Caspian lowlands of Iran. In: SMITH, R. H. T. (Ed.), 1978, 81–98.
TINKLER, K. J.: The topology of rural periodic market systems. Geografiska Annaler B 55, 1973, 121–133.
TROIN, J.-F.: Les souks marocains: Marchés ruraux et organisation de l'espace dans la moitié du Maroc. Aix-en-Provence 1975.
UNWIN, P. T. H.: Rural marketing in medieval Nottinghamshire. Journal of Historical Geography 7, 1981, 231–251.
WESTERN, J.: Market development in Central Southern Burundi. East African Geographical Review 12, 1974, 34–45.
WIERTZ, H.: Wochenmärkte im Ruhrgebiet: Strukturen, Einzugsbereiche, Verflechtungen – Ein Vorbericht. Mainzer Geographische Studien 21, 1982, 74–82.
YEUNG, Y.-M.: National development policy and urban transformation in Singapore. The University of Chicago, Dept. of Geography, Research Paper No. 149, 1973.
ZAHAN, D.: Notes sur les marchés mossi du Yatenga. Africa 24, 1954, 370–377.

ZUR SOMMERWITTERUNG IN DER BUNDESREPUBLIK DEUTSCHLAND

Mit 9 Abbildungen

PETER FRANKENBERG

Summary: Summer-time weather in the Federal Republic of Germany

The analysis of the spatial and temporal patterns of the summer-time weather in the FRG presents a map of the mean annual numbers of days of summer-time weather. It is evident that the 50th parallel nearly separates a region with summer temperatures above average (Southern Germany) from a region with summer temperatures below average (Northern Germany). The analysis further identifies years of maximum similarity of summer-time weather by means of a PCA (principal component analysis) – followed by an analysis of spatial patterns of these similarities in time. Two main boundaries of summer-time weather appear according to the number of days with a maximum temperature ≥25°C and the number of days with precipitation ≥0,1 mm: the Main and Nahe valleys and the northern boundary of the "Rheinisches Schiefergebirge". Southwestern Germany mostly shows a marked affinity with Northern Germany.

In der Erinnerung an den Witterungsablauf einzelner Jahre spielt der „Sommer" stets eine bleibende Rolle, allein deswegen, weil seine Witterung die Ernteerträge und die Erntequalität (Wein!) ebenso entscheidend mitbestimmt wie das in unserer heutigen Zeit so wesentlich gewordene