THE URBAN GEOGRAPHY OF SOUTH AFRICA

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INSTITUTE FOR SOCIAL RESEARCH
UNIVERSITY OF NATAL
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INTRODUCTION

The broad goal set by this study is an analysis of the structure and form of the South African city system. Its immediate objectives are to identify the nature of a selected range of structural elements of the system per se. Valuable as this may be to a research worker concerned with purely academic considerations as an exercise in the application of theoretical and analytical frameworks in city system analysis, the study attains a wider perspective only when it is seen as a first step in an attempt to isolate the urban component in the greater system - the South African space economy, of which the cities of the country form a part. This is the end objective of the study which is being taken up in a wider work on the South African Space Economy.

While the analytical basis determining the study is framed within the growing body of contemporary urban theory, it is not proposed at this stage to attempt the development of an urban theory or model (either static or predictive) of the South African city system. Thus while frequent allusions are made to theory, this study is essentially an empirical work on a national city system. It is a starting point from which later research may develop towards the construction of a South African urban systems theory embodying the components of both structure and location contained in this report.

An attempt has been made to treat the city system comprehensively but a number of elements have remained uncovered. The most notable of these is a comparison of the system on an international basis. On the other hand severe data restraints have restricted the level of coverage to the elements treated in the report. It is indeed unfortunate that South African statistical data by city (for all sizes of urban places) is deplorably sparse despite the fact that more than half the population of the country is now urbanised. Urban data restraints at present impose an intolerable restriction upon both theoretical and applied research.

The set of structural elements of the city system considered in the study are presented systematically and then inter-related in a Principal Components Analysis (P.C.A.) later in the report. The P.C.A. has, however, been restricted to an analysis of 212 of the over 600 cities of South Africa, because of data restraints. In the conclusion also an attempt is made to indicate the significance of the findings for the broader study of the South African Space Economy.

Geographers, historians and economists have largely neglected the urban heritage of South Africa and the evolution of its city system - indeed it is today a most difficult task to reconstruct the past history of the system without recourse to very detailed examination of primary sources. Despite this difficulty, however, Chapter 1 of the study attempts to review the city system historically. An attempt is made to isolate the forces which have influenced the growth of the system in terms of the establishment of cities and of the process of urbanisation, from the time of the foundation of the system with the establishment of the refreshment station at the Cape of Good Hope in 1652 to the mid 1960's. The evolution of the system is treated largely within the framework of sequential growth suggested by the Friedmann (1966) model. In so far as it is possible, both economic and non-economic processes associated with the development of the system are stressed. Considerable scope exists, however, for a more fundamental treatment of the historical evolution of the system following the lines suggested by Pred (1966) in a penetrating study of the spatial dynamics of United States urban - industrial growth.

Recent work (Marshall 1969) has shown that an examination of structural elements of a set of cities has meaning only when the set of cities can be clearly identified as a system - i.e. a set of cities inter-connected and interacting within a defined network of lines of communication. It is the objective of Chapter 2, therefore, to identify the set of South African cities as a system and to isolate the level of connectivity which exists within it.

In Chapters 3, 4 and 5, size relationships, economic base analysis and urban service hierarchies are examined in some detail. These studies are in turn integrated in Chapter 6 in a Principal Components Analysis which, as noted earlier, is restricted to 212 cities in the system.

Chapter 7 is focussed upon the growth component of the city system and considers elements of the demographic potential of South Africa's urban population, a comparative analysis of city growth rates and relative 'shifts' in urban population in the period 1904 to 1960. Population statistics for earlier periods are regrettably not available for the entire country.

The summary and conclusions to the study attempt to draw together the findings from earlier systematic analyses of structural elements of the system and identify particular characteristics of the system which underpins the organisational structure of the South African Space Economy.

CHAPTER 1

HISTORICAL BACKGROUND TO THE DEVELOPMENT OF THE SOUTH AFRICAN CITY SYSTEM

C H A P T E R 1.

HISTORICAL BACKGROUND TO THE DEVELOPMENT OF THE SOUTH AFRICAN CITY SYSTEM

In analysing the history of a system of cities concern rests on the one hand with the nature and scope of processes associated with the establishment and spread of urban places, and on the other with processes associated with the growth of urban population and of urbanisation. Since a city system forms an integral part of the pattern of settlement and of economic, social and political development of a country, the processes which have been associated with its growth and structure must be sought in the broad tapestry of national development. Such an approach ensures that the analysis is not restricted to a narrow consideration of parochial factors related to the development of cities either individually or as a group, but that the inter-dependent roles of the city system and of other components of development in the evolution of the national space economy may be adequately displayed.

It is important furthermore that the study be set within a theoretical framework to permit its findings to be of value in comparative urban geography. It is appropriate in this introduction, therefore, to refer to elements of urbanisation theory, urban growth models, and a framework within which the history of an evolving system may be analysed.

It is generally agreed that the urbanisation process is a function of four factors. These are:

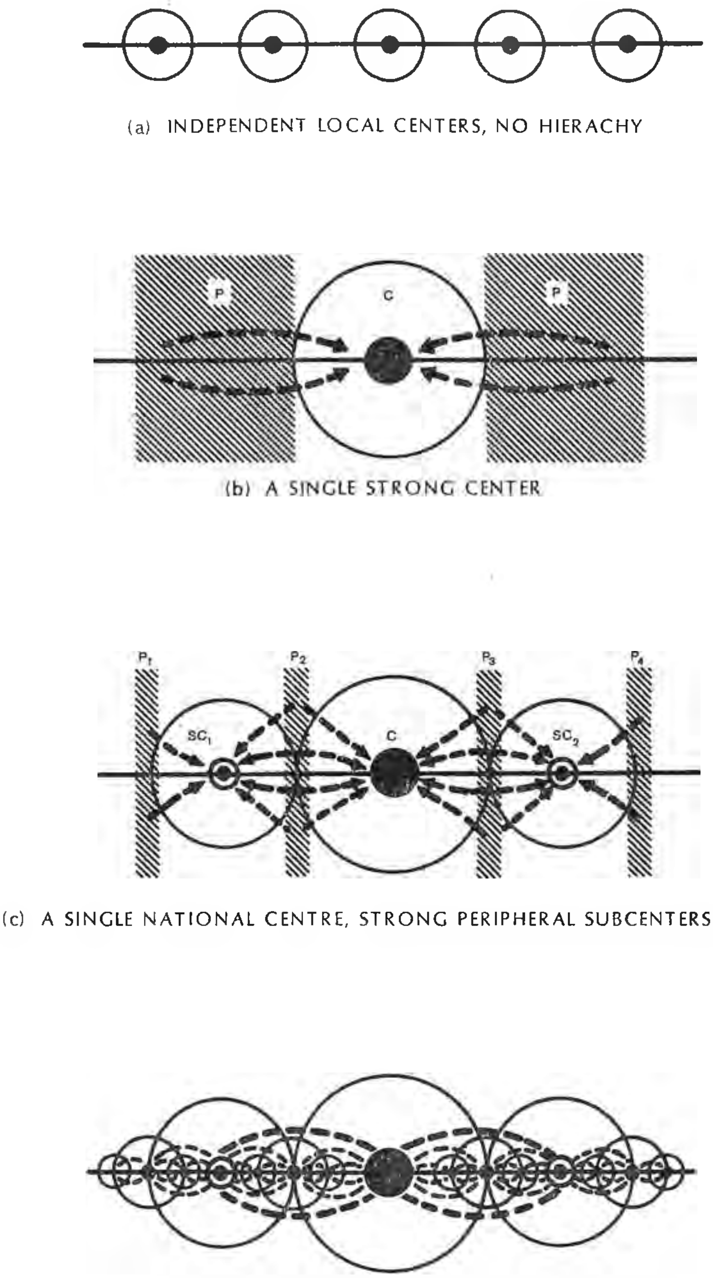
1. The size and growth of population.
2. The character of the natural environment and the controls available for the manipulation of the environment.
3. Levels of technological development.
4. Levels of social organisation.

The establishment of urban places and the maintenance and growth of urban agglomerations necessarily require a minimum total population. It follows also that the achievement of large urban agglomerations requires an increasingly large total population. The level of urbanisation, and the growth of urban population are, however, not necessarily directly correlated with the size of the total population, or of its growth. Thus, an increasing total population is in itself an insufficient force to promote urbanisation; it only permits urbanisation to take place. It is to the remaining three factors, therefore, that one must turn to identify the forces which enable a population to establish urban settlements and to achieve significant levels of urbanisation.

While environmental determinism is unsatisfactory as a solution to explain the pattern of city development in various parts of the world, evidence does exist to show that favourable natural environments are normally associated with more highly evolved city systems and relatively high levels of urbanisation. The greater significance of the environment, however, lies in the potential and stock of natural resources, their spatial disposition, and the ease with which they can be brought into production. But the presence of natural resources, however rich, is meaningless without the application of technology which enables the resources to be exploited and developed. Furthermore, the development of resources which promote the growth of urban occupations and of an urban economy can be effective only within a framework of social, economic and political organisation within which the motivation, direction and control of growth processes can take place.

Since the establishment of urban places and urbanisation are dynamic evolutionary processes, the levels and structures of the city system and of urbanisation at a particular stage depend on the levels of population growth, the stage of settlement, the pressures of external and internal economies of scale, the levels of technology, and the nature of social and political organisation at that time.

Friedmann (1966), in examining the problem of determining policies for regional planning has suggested a conceptual framework within which the pattern of development of a national economy may be viewed as a sequence of dynamic stages of growth, each identified by distinctive structures and levels of development. Friedmann, too, has been the first to show that 'for each major period of economic development through which a country passes there is a corresponding structure of the space economy'. [Figure 1]. The model integrates the three essential elements of a space economy, i.e. surfaces which describe variations in level of economic development, nodes which represent foci of organisation, and networks which describe the levels of integration and connectivity within the system. While the model has been designed as a framework within which the structural and spatial development of national and regional economies can be undertaken, it is of relevance to the present study for two reasons. On the one hand, the model provides an admirable structural and spatial framework within which



AFTER FRIEDMANN 1966

1. REGIONAL DEVELOPMENT POLICIES

the stages of economic, social, political, and technological development associated with the evolution of the city system may be analysed. On the other hand, it points to the significance of the city system in economic growth, and permits the analysis of the city system to be integrated with other components of development (surfaces of economic level and networks of integration) in the study of the national space economy.

The Friedmann model recognizes four fundamental phases of national development. These are the pre-industrial, transitional, industrial, and post-industrial stages of economic development. While not exactly comparable, Friedmann's stages of economic growth attempt to achieve the systematic sequential approach to national economic development originally suggested by Rostow's (1960) five stages of economic growth.

In the pre-industrial stage of development the economy is normally based upon self-suffient subsistence activity and principally agriculture. Production levels are low and limited by pre-modern technology in agriculture, transport and communications. In consequence there is a low level of integration within the system, and the existence of relatively isolated or poorly-linked enclaves of development are characteristic. Internal and external economies are small, and the demand for urban functions are correspondingly poorly-developed. A limited number of nodes may arise, each of which will tend to be the centre of a local community, but levels of inter-dependence of nodes and their surrounding regions are parochial. Hierarchical structures within the set of nodes will normally be weak or non-existent and interaction between nodes will normally be slow and severely restricted.

In the transitional stage which follows, pre-conditions, (which may permit sustained economic growth in the future) are created. The economy, however, normally remains based upon primary activity and is narrow based. The establishment of urban places may extend to new areas opened for settlement or occur at sites of resource development, and a higher level of inter-dependence between nodes may develop. Accessibility of new places to older centres of settlement at strategic points on lines of communication to those centres, will be decisive in determining their growth. A fully inter-dependent, hierarchical structure, within the set of urban places will, however, not yet have developed.

The nature of urban growth in the transitional stage normally encourages the development of primacy within the city system. The flow of investment and population is towards a single or a few centres which, because of their strategic location within the territory, are able to command the highest levels of development. These centres will become the foci of surrounding growth zones within which major elements of development will be concentrated. Concomitantly, a weakly-developed or economically stagnant periphery evolves at greater distances from the foci. Levels of integration of the periphery with the foci may be weak, and the principal centre will wield excessive influence in moulding basic political policy unless it is opposed by countervailing forces in the peripheral area.

The transitional stage of development is normally prolonged, and may last for more than 100 years. During the course of time significant differences in level of development in different parts of the evolving territory may occur. At the end of the period a set of relatively autonomous regional economies and socio-cultural systems each with its own administrative and commercial centres and traditional channels of movement may have evolved. In the later phases of the transitional stage, capital investment, resource development, and infrastructure may favour transition to an industrial stage of growth. Such development is normally associated also with a relatively high level of urbanisation as the process of rural·urban migration begins to accelerate.

In the industrial stage concentration of economic activity in the principal centre may continue, but a set of subsidiary centres which themselves may evolve to metropolitan status may develop, and encourage greater integration within the system. The subsidiary centres may evolve, in particular, at sites of developing resources, or may be economically strategically placed within the evolving space economy. Port cities are good examples. Higher levels of integration between nodes and between nodes and their surrounding regions now encourage the evolution of hierarchical structures within the city system.

The last stage of Friedmann's model, the post-industrial, in which the service sector of the economy becomes dominant, and the level of integration is complete, has probably not been reached in any country in the modern world today except perhaps in the United States. Friedmann notes, however, that whether further patterns of development lie beyond this stage must, in the absence of historical experience, remain an open question.

Hobart Houghton (1967) discussing the evolution of the South African economy has outlined five stages of economic growth using the five-stage model postulated by Rostow (1960). These stages, as previously noted, may be readily reduced to four, to conform to the Friedmann model of economic growth. They are:

1. *A PRE-INDUSTRIAL STAGE* which in South Africa extended from pre-European times, before 1652, to 1806.

2. *A TRANSITIONAL STAGE* from 1806 to 1933.

3. *AN INDUSTRIAL STAGE* which has extended from 1933 to the present day and if the projections of Hobart Houghton are accepted, is likely to continue to approximately 1993.

4. *A POST-INDUSTRIAL STAGE* which may develop after 1993.

Essential structural elements of the economy in the four stages are shown in Table 1.

The four sequential stages of growth are not necessarily mutually exclusive and the dateline divisions should be viewed as marking approximate periods of change in structure and levels of the economy. Each stage too, is characterised by sub-phases of progress towards the next stage of development. It should be remembered also that national levels of development may not necessarily be reflected in the same degree in all parts of the country at any particular time. In South Africa for example, very large discrepancies in level of development exist today between White occupied areas and those occupied by the Bantu Reserves. There are, furthermore wide absolute differences in economic level between the White and non-White groups in the country whether they be urban based or rural.

THE PRE-INDUSTRIAL STAGE

The pre-industrial stage in South Africa has two divisions. The first concerns the pre-literate and pre-modern economy and society of the Bushmen, Hottentot, and Bantu tribes who inhabited the territory of South Africa in pre-European time. Their herding and hunting economy, supported by a pre-modern technology which ranged from the Stone Age in the case of the Bushmen, to an iron-working culture amongst the Hottentots and Bantu, was controlled by a tribal and clan organisation which neither required nor produced forms of settlement which may in any way be related to permanent urban agglomerations.

TABLE 1.

STAGES OF ECONOMIC GROWTH : SOUTH AFRICA 1652 - 1960

Leading Economic Sectors	Stage	Dates	Total Population		Per cent Population				Percentage Contribution of Sectors to G.D.P.			Per cent of urban population in cities over 20,000
			White	Non-White	Rural		Urban					
					White	Non-White	White	Non-White	Primary	Secondary	Other	
1a. Hunting and herding.	Pre-White settlement	to 1652	-	?	-	100	-	-	100	-	-	-
1b. Mercantalist period under Dutch East India Company	Pre-industrial	1652-1806	27,000?	47,000? 1)	?	?	?	?	90?	?	?	-
2a. Agric-Pastoral	Transitional (early)	1806-1870	265,000?	?	75?	?	25?	?	75?	1-2?	24?	?
2b. Agric-Pastoral-Mining	Transitional (mid)	1870-1910	1,276,000	4,697,000	47	81	53	19	44	7	49	57
2c. Agric-Pastoral-Mining	Transitional (late)	1910-1933	2,003,000	7,585,000	32	76	68	24	35	15	50	69
3. Agric-Pastoral-Mining-Industrial	Industrial	1933-1960 → 1993?	3,088,000	12,915,000	17	62	83	38	25	23	52 2)	76

1) Within the limits of the Cape Colony only.
2) In 1965 the relevant values were 22%, 28% and 50%.

Note: While the monetary contribution of the sectors of the economy in 1965 indicate that secondary activity is now more significant than mining in terms of G.D.P., the distribution of 1. above by sector: Agric 49%, secondary, 20% and other 31% shows that primary activity remains the major source of work for the population. This is explained by the high proportion of Africans in agriculture & mining in particular.

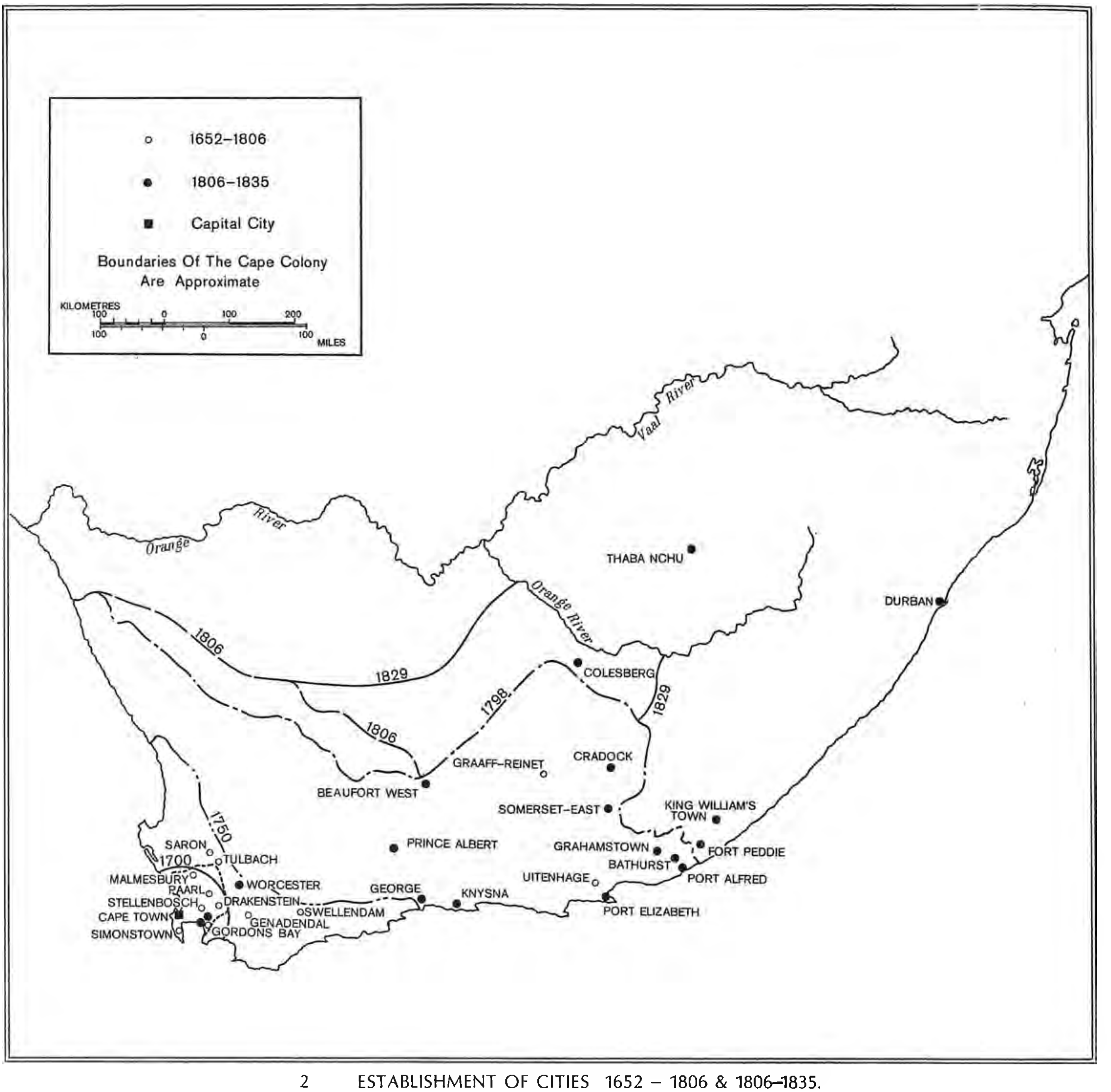
The second division concerns the establishment of the refreshment station at the Cape of Good Hope, 319 years ago, by the Dutch East India Company. With this event the modern history of South Africa may be said to have commenced.

The year 1652 in which the refreshment station was established, falls within the baroque phase of development in Europe. It was a period of extensive exploration, and of overseas settlement, colonisation and trade. The establishment of the refreshment station, therefore, must be seen in the perspective of the long distance sea trade-route from Europe to the East. The refreshment station was established to supply passing ships with fresh water, vegetables and meat, and was in itself not initially an urban place. In 1652 when Jan van Riebeeck, the first governor of the Cape, arrived, his duty was to establish a single comprehensive establishment under the direction of the Commander and a Council of Policy (de Kock 1924). The establishment was to contain a fortress, hospital, workshops, a mill and corn granary, and stables. The principal function of the station was to be agricultural for the cultivation of vegetables, and it was to barter livestock to supply fresh meat to passing ships. Its functional relationships were confined by its status as a supply station, and its orientation was towards the sea-route to the East, and towards Europe and Batavia, rather than to its hinterland on the sub-continent.

Although colonisation of the Cape was ruled out by the initial concept of the refreshment station it was inevitable that it should take place. Colonisation first commenced in 1659 with the settlement of 9 discharged soldiers and sailors on land on the banks of the Liesbeek River, not far from the station. Thus commenced the process of expansion of settlement and of a slowly-evolving agricultural economy which concerned relatively intensive cultivation within a short distance of Cape Town, and the growth of extensive and semi-subsistence pastoralism, practised by the trek boere, at greater distances from the focus. By the close of the pre-industrial phase in 1806 the official frontiers of the Cape Colony had advanced to the Fish River in the east and to beyond the edges of the Great Escarpment in the north. [Figure 2.]

A pre-industrial technology supported development in this phase and social and economic organisational frameworks restricted economic growth and social advance.

The tools and techniques of agriculture were simple, and levels and quality of agricultural production were low. The economy was characterised by a general lack of innovation. Apart from the technology of viticulture



2 ESTABLISHMENT OF CITIES 1652 – 1806 & 1806–1835.

introduced by the Huguenots from 1688, few major improvements were made in agriculture. In the animal livestock industry improvements were delayed until the end of the 18th century with the introduction of superior breeds of cattle and also merino-wooled sheep in 1789.

The restrictive mercantalist policies of the Dutch East India Company excluded the possibility of free trade and the growth of a market economy. Local manufacturing too, though in any event limited in potential by pre-industrial technology and small markets, was restricted by the Company to a few essentials. The settlement depended upon imports for manufactured articles of all kinds.

Although the Cape operated a money economy, paper money was only introduced in 1782, and the circulation of a wide variety of coinage gave rise to complicated problems of internal, as well as foreign, rates of exchange (de Kock 1924). Commercial transactions were conducted almost entirely by barter, and by means of metallic coins. There were virtually no facilities for the use of credit or bills of exchange. There were no commercial banks and no credit structure built upon a metallic reserve evolved. It was only at the beginning of the 19th century that the Cape began to pass through a transition from a money economy to a credit economy.

Apart from the restrictive influence of a pre-industrial technology, agricultural and pastoral activities were organised to take advantage of the abundance of land to counteract disadvantages of scarcity of labour and capital. Slave labour, a drain upon available capital, was used in agriculture as free labour was not readily available.

The abundance of land, lack of capital and inefficiency of slave labour encouraged the development of extensive rather than intensive farming and led to a widely dispersed settlement pattern. The level of integration of the population with the towns and other small nodes of urban settlement was in consequence limited to periodic visits to trade agricultural and pastoral products, purchase essentials, arrange marriages and to pay taxes.

Until the mid-19th century, in the earlier decades of the transition stage, effective communication by land and sea was severely restricted. Few bridges were constructed and transportation was undertaken by ox-wagon over unmade tracks. Horses provided for faster land travel.

The inefficiency of transport imposed severe restraints upon agricultural development. Thus relatively more intensive farming proved uneconomic at distances greater than three days journey from Cape Town (a radius of say 70 km.) Beyond that radius the loosely-knit system of semi-nomadic pastoralism of the trek boer evolved. Within the immediate vicinity of Cape Town and in the valleys bounded by the Hottentots Holland mountains therefore, an incipient growth zone developed about the focus. At greater distances lay a periphery characterised by a relatively stagnant economy.

The church was the principal institution of culture and education throughout the 18th century. Its influence as a nucleation force, in the establishment of small urban nodes, was significant but the restricted level of economic development and the dispersed pattern of settlement limited the number of churches established. Thus only five churches had been established by 1792 at Cape Town in 1666, Stellenbosch in 1685, Drakenstein in 1691, Tulbagh in 1743 and Malmesbury in 1745. A church was established at Graaff-Reinet in 1792.

The need for local administration and justice also led to the establishment of villages. Under the administration of the Company local government was established with a landdrost-and-heemraden system. The first landdrost was established at Stellenbosch in 1685, and thereafter at Swellendam in 1745 and at Graaff-Reinet in 1785. By 1785 therefore four judicial districts - Cape, Stellenbosch, Swellendam and Graaff-Reinet, had come into existence.

The system of local government established at the Cape subsequently spread also to the Orange Free State and Transvaal with the emigration of the Voortrekkers and became part of the Republican system of government. In the Cape it remained the only system until 1827.

Military organisation, based essentially upon the commando system, developed in the 17th century, played a relatively minor role as a process encouraging nucleation and urbanisation of the population.

After early attempts made to encourage immigration under the governorships of the van der Stels, father and son, it was discouraged because of the low level of economic development and poor prospects for economic expansion. Population growth depended, therefore, almost entirely upon natural increase.

In 1658, the Cape had approximately 57 colonists, by 1672, 168 and by 1700, 1,308. In 1701 the White population is recorded as totalling 1,265 persons - which by 1778 had increased to 9,721 persons. By 1795 the White population is estimated to have totalled approximately 15,000 persons. No information is available for the non-White population.

Thus while the rate of natural increase of the White population was high, absolute numbers remained small. With a small absolute population total, restricted immigration, low levels of economic growth, restricted political organisation, and a pre-industrial technological base, the rate at which new urban places were established and the level of urbanisation were low.

Between 1652 and 1806 only 13 urban places were established (Table 2.) Of these only Cape Town could be regarded as a truly urban place, and Katzen (in Wilson et al 1969) notes that its White inhabitants were almost all small retailers or boarding-house keepers who indulged in feverish petty smuggling and speculation when ships arrived. Otherwise the Cape White settlers were a rural community supported by a few hamlets.

The spatial distribution of urban places at the beginning of the 19th century reflects the spatial implications of the growth processes in the economy. (Figure 2, page 11). Thus, within a radius of some 70 km from Cape Town, in the incipient growth zone based upon arable farming, were located 10 of the 13 urban places. Only one place, Swellendam, served the southern Cape, and two frontier settlements, one at Graaff-Reinet and the other at Uitenhage, were established to control the eastward dispersal of trek boere towards the east, and to provide foci of organisation for the control of hostilities between the colonists and the southward-migrating Xhosa tribes. In the western Cape the mean distance to nearest neighbour of the urban settlements was approximately 26 kilometres. Swellendam, on the other hand, was 80 kilometres from the nearest urban node, and Graaff-Reinet and Uitenhage themselves separated by a distance of some 190 kilometres, were more than 400 kilometres from Swellendam and more than 600 kilometres from the focus in Cape Town.

Analysing the sets of cities in the regional city sub-system by nearest neighbour methods, furthermore, shows that in the Cape Town, Port Elizabeth, East London and Bloemfontein areas the distribution in each case may be classified as possessing a regular distribution component (Table 3). The finding suggests that despite very irregular relief, more particularly in the south-western

Cape, a tendency exists for cities to become distributed in a form which is most economic in the provision of services within an area. In the Johannesburg, Pretoria and Durban city sub-systems, on the other hand, the distribution of cities tends to be random. The combined influence of randomly distributed mining activity, areas of intensive agricultural development, and the pattern of transport routes, appear to underlie the finding. To explain the patterns, however, will require further intensive research.

It is interesting to note from Table 3 that in some cases formerly random distributions, such as occurred in the Cape Town, East London, Johannesburg, Bloemfontein and Kimberley sub-systems, have since changed in the direction of uniformity. The interstitial placement of new cities clearly explains the change in pattern with time.

In the last quarter of the 18th century the powers of the Dutch East India Company decayed. Thus between 1795 and 1803 the Cape was held temporarily by the British Government as a possession by conquest. From 1803 to 1806 Dutch rule under the Batavian Republic was re-established before the Cape was permanently annexed as a British Colony in 1806.

TABLE 2a.

ESTABLISHMENT OF CITIES 1652 - 1960 [1]

City Sub-System [2]	By 1806	1806-1835	Cumulated No.	1835-1870	Cumulated No.	1870-1933	Cumulated No.	1933-1960	Cumulated No.
Cape Town									
(a) Inner Zone	10	4	14	19	33	16	49	-	49
(b) Southern Cape	1	2	3	10	13	8	21	-	21
(c) Interior	-	3	3	7	10	18	28	-	28
Port Elizabeth	2	9	11	8	18	19	37	1	38
East London	-	-	-	14	14	30	44	-	44
Durban	-	1	1	18	19	56	75	2	77
Bloemfontein	-	-	-	13	13	20	33	-	33
Kimberley	-	-	-	9	9 3)	30	39	2	41
Johannesburg	-	-	-	18	18 43	93	111	13	124
Pretoria	-	-	-	3	3	14	17	2	19
Total	13	19	32	119	150	304	454	20	474

Notes:

1) The number of cities is smaller than the number recorded by the Department of Statistics in 1960. The discrepancy has come about by the exclusion of all places which may be regarded as sub-urban centres of metropolitan areas or functionally part of other centres. The universe considered includes all cities above 500 persons in 1960 which have been classified in the South African urban hierarchy - see Chapter 5.

2) The break-down into city sub-systems reflects the contemporary inter-relationships between cities in the national system of cities. It does not necessarily imply that the relationships between cities have remained static over time but it does provide a convenient spatial analysis framework which has been used consistently throughout this study. See Chapter 2 for the definition of the city sub-system.

3) Represents the cities established on the interior plateau after the Great Trek.

TABLE 2b.

ESTABLISHMENT OF CITIES BY PROVINCES

1652 - 1960

Province	By 1806	1806-1835	Cumulated No.	1835-1870	Cumulated No.	1870-1933	Cumulated No.	1933-1960	Cumulated No.
(a) Inner Zone	10	4	14	19	33	16	49	-	49
(b) Southern Cape	1	2	3	10	13	8	21	-	21
(c) Interior	-	3	3	7	10	18	28	-	28
(d) Port Elizabeth	2	9	11	8	18	19	37	1	38
(e) East London	-	-	-	17	17	36	53	-	53
(f) Kimberley	-	-	-	6	6	29	35	2	37
Cape Total	13	18	31	67	97	126	223	3	226
Natal	-	1	1	18	19	50	69	2	71
Orange Free State	-	-	-	17	17	52	69	6	75
Transvaal	-	-	-	17	17	76	93	9	102
Total	13	19	32	119	150	304	454	20	474

TABLE 3a.

MEAN DISTANCE IN KILOMETRES TO NEAREST NEIGHBOUR *(rA)*
1806 - 1960
(All places with more than 500 persons in 1960)

Region	By 1806	No.	By 1835	No.	By 1870	No.	By 1933	No.	By 1960	No.
Western Cape	25.6	10	21.8	14	16.2	33	15.0	49	15.0	49
Southern Cape	-	1	70.5	3	28.4	13	21.5	21	21.5	21
Western Cape Interior	-		111.5	3	101.6	10	51.1	28	51.1	28
Port Elizabeth	-	2	53.3	11	40.7	18	29.8	37	28.8	38
East London	-		-		31.4	14	26.7	44	26.7	44
Durban	-		-	1	27.8	19	19.9	75	19.3	77
Johannesburg	-		-				27.5	111	25.2	124
Pretoria	-		-		61.7	43	40.7	17	41.7 *	19
Bloemfontein	-		-				34.5	33	34.5	33
Kimberley	-		-				42.2	39	40.0	41
		13		32		150		454		474

* Increase is due to the establishment of Phalaborwa. Distances are the mean of straight line measurements between centres. City sub-systems are those of 1960 (see Chapter 2).

TABLE 3b.

DENSITY OF CITIES PER SQUARE KILOMETRE

Region	1806	1835	1870	1933	1960
Western Cape	.00035	.00049	.0012	.00173	.00173
Southern Cape	-		.00045	.000729	.000729
South-Western Cape Interior	-	.000027	.000051	.000142	.000142
Port Elizabeth	-	.00013	.00021	.000433	.000457
East London	-	-	.000199	.000594	.000594
Durban	-	-	.000184	.000728	.000747
Johannesburg	-	-		.000437	.000489
Pretoria	-	-	.000061	.000128	.000143
Bloemfontein	-	-		.000415	.000415
Kimberley	-	-		.000165	.000173

TABLE 3c.

EXPECTED MEAN DISTANCE TO NEAREST NEIGHBOUR *(r E)*
1806 - 1960

Region	1806	No.	1835	No.	1870	No.	1933	No.	1960	No.
Western Cape	26.73	10	22.59	14	14.43	33	12.02	49	12.02	49
Southern Cape			)	6	23.57	13	18.52	21	18.52	21
Western Cape Interior			)96.23		70.01	10	41.96	28	41.96	28
Port Elizabeth			43.58	11	34.42	18	24.03	37	23.39	38
East London					36.37	14	20.52	44	20.52	44
Durban					36.86	19	18.53	75	18.29	77
Johannesburg					)		23.92	111	22.61	124
Pretoria					(63.91	43	44.19	17	41.81	19
Bloemfontein					)		24.54	33	24.54	33
Kimberley					)		38.92	39	38.01	41

TABLE 3d.

NEAREST NEIGHBOUR STATISTICS *(R)* BY SUB-SYSTEM
1806 - 1960

Region	1806	1835	1870	1933	1960
Western Cape	.96	.97	1.12	1.25	1.25
Southern Cape		)	1.20	1.16	1.16
Western Cape Interior		) .88	1.45	1.22	1.22
Port Elizabeth		1.22	1.18	1.24	1.23
East London			.86	1.30	1.30
Durban			.75	1.07	1.06
Johannesburg			)	1.15	1.11
Pretoria			) .97	.92	1.00
Bloemfontein			)	1.41	1.41
Kimberley			)	1.08	1.05

TABLE 3e

DISTRIBUTION PATTERN BY NEAREST NEIGHBOUR STATISTICS

Sub-system	1806	1835	1870	1933	1960
South-Western Cape	*R*	*R*	*R*	*Au*	*Au*
Western Cape Interior		*R*	*Au*	*Au*	*Au*
Southern Cape			*Au*	*Au*	*Au*
Port Elizabeth		*Au*	*Au*	*Au*	*Au*
East London			*R*	*Au*	*Au*
Johannesburg				*Au*	*R*
Pretoria			*R*	*R*	*R*
Bloemfontein				*Au*	*Au*
Kimberley				*R*	*R*
Durban			*R-A*	*R*	*R*

R = near random, *A* = agglomerated, *Au* = approaching uniform

Notes:

1. The Nearest Neighbour Statistic $R = \frac{rA}{rE}$ where rA is the observed mean distance between nearest neighbours and rE is the expected mean distance to nearest neighbour. $rE = \frac{1}{2}\rho^{-\frac{1}{2}}$ where ρ is the density of cities per square kilometer.
The extreme values of R are:

0 - maximum aggregation

1 - random

2.15 - uniform

2. Areas examined are regional city sub-systems, where necessary broken down into sub-areas to take into account major discontinuities of environment and potential for urban settlement. This is particularly important in the Cape Town sub-system where differences between the South Western Cape, Southern Cape and Western Cape Interior have been separately treated in the analysis.

These events initiated a period of change which was to lead on to the transitional stage of development. The restrictions and limited levels of development which characterised the mercantalist period under the Dutch East India Company were little changed during the first British occupation. Under the Batavian Republic, however, significant reforms were planned under Governor Janssens and Commissioner de Mist. Their rule, however, was too short to have any impact on the life and attitudes of the colony; traditionalism was unshaken till after the second British occupation (Hobart Houghton 1967). The plans proposed under the Batavian Republic are important, however, as they indicate the directions in which change was to take place in the transitional stage. They included six heads:

1. Reorganisation of the structure of civil government.
2. Establishment of new systems of judicial administration.
3. Improvements in agriculture and livestock farming.
4. Removal of restrictions on trade.
5. Development of education.
6. Improvements in the relationships between the colonists and the African tribes on the unstable eastern frontier.

THE TRANSITION PHASE:

The first 25 years of British administration of the Cape Colony, from the second occupation in 1806 until 1831, are characterised by a phase of arbitrary administration. Many of the planned changes proposed under the Batavian Republic, however, were undertaken. The most important of these was the abandonment of mercantalist government, and the gradual introduction of representative institutions. Between 1806 and 1811 restrictions on trade were lifted; the first postal communications were introduced between Cape Town and inland districts; a state bank (The Government Discount Bank) was established, and improvements in social conditions of the non-White population were introduced.

Between 1811 and 1814 improvements in the land tenure system were introduced to ensure greater security for the farming population, and new tax systems were laid down. On the eastern frontier stricter controls were introduced, and Grahamstown was established as a military post in 1812.

The period 1814 to 1826, during which time Lord Charles Somerset was Governor of the Cape, is of particular significance in setting off the transitional stage from the pre-industrial stage of development. It was during this time that the 1820 Settlement on the eastern frontier took place.

The need to create a buffer of closely settled land between the tribal lands to the east and the White-occupied colony to the west under-lay the planning of the 1820 Settlement. In Britain, economic depression, following the Napoleonic Wars, facilitated the immigration of considerable numbers of people. Some 5,000 to 6,000 immigrants were encouraged to emigrate to the Cape. The settlement was established in the Zuurveld of the eastern Cape, south of the Fish River. Structurally the settlement was poorly planned, and, coupled with a succession of crop failures, its growth was slow and difficult. Many of the settlers failed as farmers, but after abandoning their land gradually developed a market economy in the eastern Cape. De Kock (1924) notes that by gradually extending their commercial operations not only among the natives but also among their Dutch fellow colonists, they ultimately laid the foundations of large and successful mercantile establishments. After four years of blights and floods, the conditions of the settlers started to improve in 1824 - 1825.

The establishment of agriculture and pastoral activities and the creation of urban foci of organisation at Grahamstown and Port Elizabeth supported by a number of smaller villages including Bathurst, and the possibility of establishing a small port at Port Alfred, led to the emergence of a second incipient growth zone in the Cape Colony. Seen in a wider context, the settlement was the first major event to introduce growth into the stagnant peripheral economy which had previously characterised the eastern frontier zone. Distance from the principal focus in Cape Town, while hindering communication and integration on the one hand, encouraged the growth and development of Grahamstown as a rival centre of trade and administration. It also gave rise to a growing desire for independence from Cape Town, and underlay the development of separatist movements which even today are not entirely without meaning in the eastern Cape Province. The overall effect of the establishment of the 1820 Settlement and of subsequent economic growth in neighbouring areas such as Cradock and Somerset East, was to create a relatively autonomous regional economy with its own administrative and commercial centres relatively weakly integrated with the principal focus and characteristic of criteria of transition in Friedmann's model. Until 1840 Grahamstown remained the principal focus of the eastern province, militarily, administratively, commercially and culturally. After 1840, however, its dominant role, more particularly as a commercial centre, was gradually taken over by Port Elizabeth as the principal centre of trade in the eastern Cape.

Between 1806 and 1832 the White population of the Cape Colony had more than doubled to 66,000 persons. The total population increased in the same period from 74,000 persons to 129,000 persons. Despite the introduction of new organisational frameworks and advances in agricultural and pastoral economies, however, the forces of urbanisation remained relatively weakly developed. In the period up to 1835 an additional 19 new urban places had come into being in South Africa. [Table 2, page 15] Four of these were located in the western Cape growth zone, two in the southern Cape, three in the western Cape periphery, and nine had come into being in the eastern frontier zone principally as a result of the 1820 Settlement and its subsequent expansion. [Figure 2, page 11]

Cape Town remained the only urban centre with a considerable population. The White population of the city had increased from approximately 5,000 persons in 1802 to nearly 9,000 in 1827. The total population in the same period increased from approximately 16,000 to approximately 20,000 persons. Grahamstown, the principal centre of the eastern frontier, on the other hand, had a total White population of approximately 3,000 persons in 1828 (including military personnel). The civilian population probably numbered some 1,500 persons (Watts 1957). The population of the remaining urban nodes was probably not more than a few hundred persons in each place.

The level of urbanisation is difficult to estimate in the absence of accurate data. It is probable, however, that approximately 16 per cent of the White population of the Cape Colony was resident in Cape Town, and a further approximately 5 per cent in Grahamstown. A rough guess would suggest that possibly a further 10 to 15 per cent of the population was urban and living in the remaining 29 small villages and hamlets of the Colony. Thus, by 1827 it is possible that approximately 30 to 35 per cent of the White population was urban. This value is relatively high and suggests that the urbanisation forces of the service, commercial and administrative functions of the towns had strongly influenced the pattern of the White population distribution. Levels of urbanisation of the total population, on the other hand were much lower.

From 1806 to 1827 rural local government remained under the old landdrost-and-heemraden system. Following the report of a commission of enquiry, however, a new system of local government was introduced in 1827. Green (1957) notes that judicially the colony was divided into local magisterial districts, each with a resident magistrate competent to deal with civil and criminal cases. For civil administration the colony was divided into 11 local civil divisions - Cape, Simonstown, Stellenbosch, Worcester, Swellendam, Goerge, Beaufort West, Graaff-Reinet, Uitenhage, Somerset East and Albany. Each division was in charge of a civil commissioner who undertook the non-judicial duties of the landdrost. Partly because of the development of a regional economy in the eastern Cape, based on wool and the existence of a number of thriving towns, and because of the difficulty of controlling the eastern frontier from Cape Town, the colony was for a period divided into two provinces - a western and eastern province. This process in part recognized the separatist characteristics which had evolved in the east.

Changes in forms of local government, in the financial structure of the colony, the activities of missionaries, the emancipation of the slaves in 1834, coupled with problems of increasing land scarcity and irritation over the imposition of controls over land, and insecurity along the eastern frontier, among other factors, now led to that remarkable phase of South African development which included the Great Trek and the permanent settlement of vast tracts of country in the interior and in Natal by the Voortrekkers. These developments were important, not only for the subsequent political growth of South Africa, but carried with them important implications for the economic, social and physical development of the country. It marks also an important phase in the development of the city system.

In pursuing the pattern of development, it is important to distinguish between the older settled areas of the Cape Colony, on the one hand, and the new territories into which the Trek penetrated, on the other. In the older Cape Colony, trends initiated in the first three decades of the 19th century did not cease. In 1847-48 the northern boundary of the colony was extended to the Orange River, and the eastern frontier to the Keiskama River. British sovereignity was proclaimed also over the territory between the Keiskama and the Great Kei Rivers in 1847, and the area became a separate Crown Colony. Between 1834 and 1856 the eastern frontier zone was subject to frequent disturbance and insecurity, and economic development was seriously retarded. In 1865 British Kaffraria was finally annexed to the Cape Colony. Despite unsettled conditions on the frontier, however, economic progress was made in agriculture, trade, banking and the construction of roads and bridges. In general, however, in comparison with subsequent development the rate of progress was slow. (de Kock 1924)

Improvements in agriculture and pastoralism are shown both in the quality and volume of production. Wool exports in particular rose for example, from 144,000 pounds in 1834 to 14,900,000 pounds in 1856. Enhanced volumes of trade, on the other hand, are shown by the rise in value of exports and imports. In 1834 the value of exports from the Cape Colony was £370,000. By 1856 the value had risen to £1,330,000. Imports on the other hand rose from £463,000 in 1834 to £1,588,000 in 1856. The improved financial organisation of the colony also is reflected in the growth of banking. Before 1831 only one bank, the State Discount Bank, had existed, but by 1856, 18 new banks had been established in the colony. From 1844 a vigorous programme of road-construction was undertaken to offset the disadvantages arising from the absence of navigable waterways and railways. Ocean transport also was improved, and a steamship service was established between Cape Town and England, and between Cape Town and Port Elizabeth. Ocean transportation however, was hampered by the lack of harbour and dock accommodation.

In the organised migration of the Voortrekkers to the interior some 5,000 people had crossed the Orange River by the middle of 1837 and by 1845 the number had swollen to perhaps 14,000 persons. (Wilson et al 1969)

In the period between 1835 and 1856 the groundwork of the new settlement was being laid. On the highveld political consolidation of the widely-scattered population took place from the middle 1850's. The Orange Free State Republic was founded in 1854, and in the Transvaal, the three main groups of Boer settlers focussed in the west on Potchefstroom and Pretoria, in the east at Lydenburg, and in the north in the Soutpansberg region, were amalgamated in 1860 into the South African Republic. While political unity was being forged unsettled conditions and an economy based on semi-subsistence pastoralism were not conducive to development.

In Natal the first settlement at Durban was established in 1824 by a small party of trader-adventurers seeking wealth from the ivory trade. After the arrival of the Voortrekkers, Pietermaritzburg was founded as the capital of the Natalia Republic in 1838 while Weenen was established as a settlement in central Natal.

During five years of rule under the republic few social or economic advances were achieved and hostilities between Boer and Zulu were frequent. Following the British annexation of Natal in 1843, elements of transition became evident. These were associated on the one hand with the immigration and permanent settlement of British and German settlers in the late 1840's and early 1850's, to replace the Boer population which had trekked to the highveld following the annexation. On the other hand administrative measures were introduced for the local government of the Colony and, as was the case also on the eastern frontier of the Cape, provision was made for the permanent demarcation of tribal reserves.

Wilson et al (1969) note that economic development remained slow. Durban was the only port and all but the smallest vessels had to use the ocean anchorage. Most roads were mere waggon-tracks; many rivers were unfordable in flood; and the road between Durban and Pietermaritzburg was not much better. Postal services were provided by African runners.

Farming enterprises in Natal were impeded not only by the lack of efficient communications, but also by the settlers' initial ignorance of the potential of the soil and climate, and by diseases of crops and stock. In the sub-tropical coastal region, settlers experimented hopefully with a number of sub-tropical crops, before identifying sugar cane as the most suitable commercial crop. In the interior field crops and animal livestock herding formed the basis of a subsistence economy but wool became a commercial product.

In this period also policies in relation to those parts of the country held by African tribal groups evolved. In the Cape a policy of political and economic integration was introduced under the Grey administration and the Ciskei patchwork of small reserves intermingled with White held lands was established. A similar pattern evolved in the Colony of Natal, while in the South African Republic it was government policy to establish "locations" in each ward of each district. Wilson et al (1969) however, note that, between the Orange and Limpopo rivers, Afrikaners and Africans jostled one another in innumerable sectors in the area. Thus 'before 1877 locations were neither surveyed nor clearly delimited and African land tenure was on sufferance' (Wilson et al 1969, 436). In the areas occupied by African tribes (both within and without the areas settled by Whites) traditional economies prevailed. Steadily, however, immigration of Black labour to the White areas took place.

In the period between 1856 and 1870 conditions in South Africa became more favourable for economic development and the foundation of national prosperity was laid. (de Kock 1924). Growth was favoured by relatively peaceful conditions, except for the hostilities which occurred in the Free State between the Free State Republic and the Basuto Nation and an economic depression in the middle 1860's hindered advance.

Political stability existed in all four of the territories which were later to become part of the Union of South Africa. In the Cape and Natal representative colonial governments had been established and the Transvaal and Orange Free State had evolved into independent republics.

Advances were made also in the field of transportation. In Natal the first railway in South Africa was opened between the Point and Durban in 1860, and in 1863 a line from Cape Town to Wellington was opened. A penny postal service was inaugurated in Cape Town in 1860 and extended to other centres in the following decade. Telegraphic communications were developed and by 1864 Grahamstown was linked to the capital city. In Natal a telegraph service was installed between Pietermaritzburg and Durban. Harbour works in Cape Town commenced in 1860 and early attempts at improving the harbour at Durban were made from the middle 1850's.

Banking facilities also were improved and by 1862 there were 29 local banks in operation in the Cape Colony. In Natal, the Natal Bank had been established, and in the Orange Free State, the Bloemfontein Bank.

The economy in the four territories, however, remained based essentially upon agriculture and pastoralism. The pastoral industry continued to provide the greatest volumes of products for export including particularly wool, hides and skins, ostrich feathers and mohair. The export of wool increased from 14,900,000 lbs. in 1856 to 41,000,000 in 1870; the number of hides and skins exported grew from 864,000 to nearly 3,000,000 and the value of ostrich feathers exported rose from £7,500 to £87,000.

Agricultural production on the other hand, was limited primarily by the capacity of the domestic market, as there were few demands by foreign markets for agricultural products produced in South Africa. Only small quantities of wine, maize and sugar were exported.

The Cape Colony was by far the furthest advanced in agriculture and stock farming. By 1870 progress had been made in the cultivation of field crops, viticulture, fruit-growing, wool-production, cattle farming, dairying and horse-breeding, and a commencement had been made with ostrich farming. In the Orange Free State, field crops and wool production had expanded on a smaller scale and in Natal early experiments with sub-tropical crops had led to the establishment of sugar as the primary commercial crop of the coastal margin. The growth of the sugar industry was assisted by the immigration of indentured Indian workers to the sugar cane estates from 1860 and the annual production of sugar rose to approximately 10,000 tons by 1870. In the interior of Natal field crops and livestock-herding expanded slowly and wool remained the chief product of trade. In the South African Republic the economy was almost entirely confined to pastoral activities, mainly in the rearing of cattle and to a lesser extent sheep.

Advances in agriculture and pastoral activities in the two colonies and interior republics gave rise to an expanding volume of trade between the Cape and Natal ports and inland districts. The value of exports from the ports grew from £1,300,000 in 1856 to nearly £3,000,000 in 1870, and imports from £1,600,000 to £2,800,000. Imports comprised principally manufactured articles and exports primarily pastoral produce.

By the close of the 1860's the White population of South Africa had increased to approximately 265,000 persons. Growth in population continued to be determined largely by high rates of natural increase supplemented by relatively small flows of immigrants from Europe. South Africa never attracted the volumes of immigrants which flowed to North America, Australia and other British territories in the 19th century.

By far the largest White population (180,000 persons) was resident in the Cape Colony. Natal, the Orange Free State and the Transvaal by comparison, were very lightly populated with 18,000, 35,000 and approximately 20,000 Whites each. Statistics of the non-White population of South Africa by 1870 are not available. In the Cape Colony, however, the 1865 Census suggests that the non-White population in that Colony was in excess of 1.3 million persons.

While the level of progress achieved economically, socially and technologically in the first 70 years of the transition stage was not inconsiderable, forces conducive to a high rate of urbanisation remained relatively weak. An agricultural economy in which intensive production of commodities for the internal market was small, and in which the principal trading component concerned primary pastoral products for export, tended to favour only the coastal port centres of Cape Town, Port Elizabeth, East London and Durban. Places located on the principal transport routes gained marginal benefits from the provision of services to transport riders. The small absolute size of population also led to a low level of demand for those services which are performed in urban places. Furthermore, the lack of diversification in urban occupations did not favour a high rate of urbanisation. In the trekker republics attitudes more strongly orientated to an independent rural way of life, discouraged the establishment of urban places and their growth.

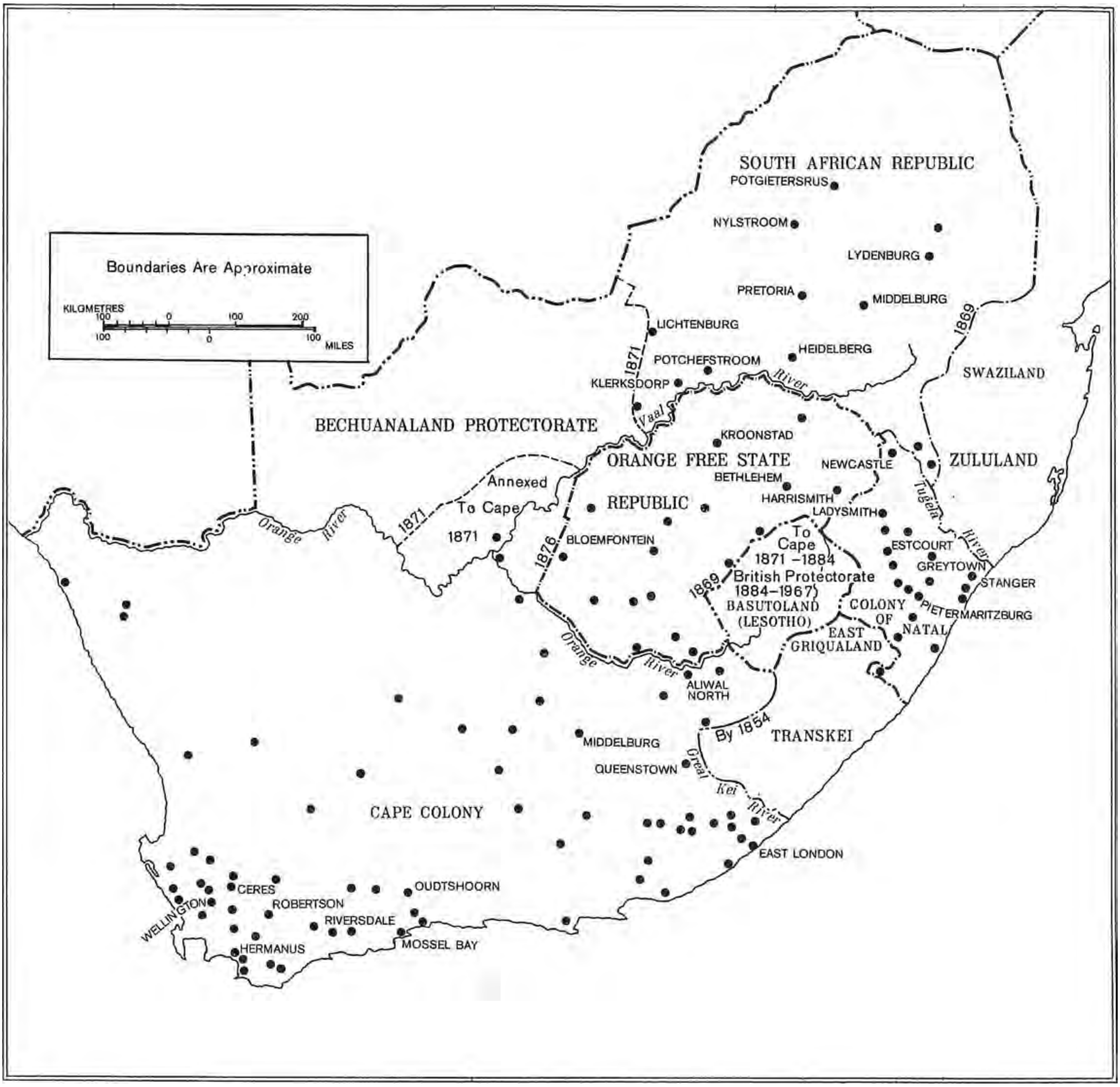
In the absence of accurate census data the level of urbanisation is impossible to determine. By extrapolation of the percentage of the population living in urban areas available from later census data, however it is possible to estimate the probable levels of urbanisation reached by 1870. By that year it is suggested that perhaps 30 per cent of the White population of South Africa was urbanised, and approximately 16 per cent of the total population. There are likely to have been strong regional differences in levels of urbanisation more particularly between the Cape and Natal on the one hand, and the Transvaal and Orange Free State on the other. In the republics, urbanisation forces were, for economic and social reasons, in general more weakly developed than in British colonies. Wilson et al (1969) note that on the other hand in the mid-19th century more than 50 per cent of the White population of Natal lived in Pietermaritzburg and Durban. In the Cape Colony, approximately 22 per cent of the total population lived in urban areas in 1875.

By 1870 higher levels of economic development, a larger absolute population, a lengthy period of settlement extending over 200 years, and a more advanced integration of the economy, as reflected in the greater availability of transportation and communication networks in the Cape, had resulted in a considerable expansion of the number of urban places established in the Colony. The number of urban places had trebled to 99 centres, while in the remaining three territories, only 51 urban places had been established since 1835. [Figure 3].

The growth in the number of urban places in the Cape Colony concerned the establishment of new pioneer service and administrative towns in new territories annexed to the Colony on the one hand, and the establishment of new service centres within the established mesh of urban places in the older settled parts of the Colony on the other. New pioneer towns were established in particular in the eastern frontier zone, in the area between the Keiskama and Kei Rivers in British Kaffraria, and along the northern frontiers of the colony as settlement spread after 1835.

In Natal only Durban had been established by 1835 and in that colony together with the Orange Free State and Transvaal the number of places in 1870 represents the absolute increment of centres established in the 35 years after the Great Trek.

Regional differences in levels of economic growth and potential for urban growth are shown by the number of places established by 1870. [Table 2, page 15]. In the south-west Cape a favourable environment, access to markets and transportation continued to foster the



3 ESTABLISHMENT OF CITIES 1835 – c.1870.

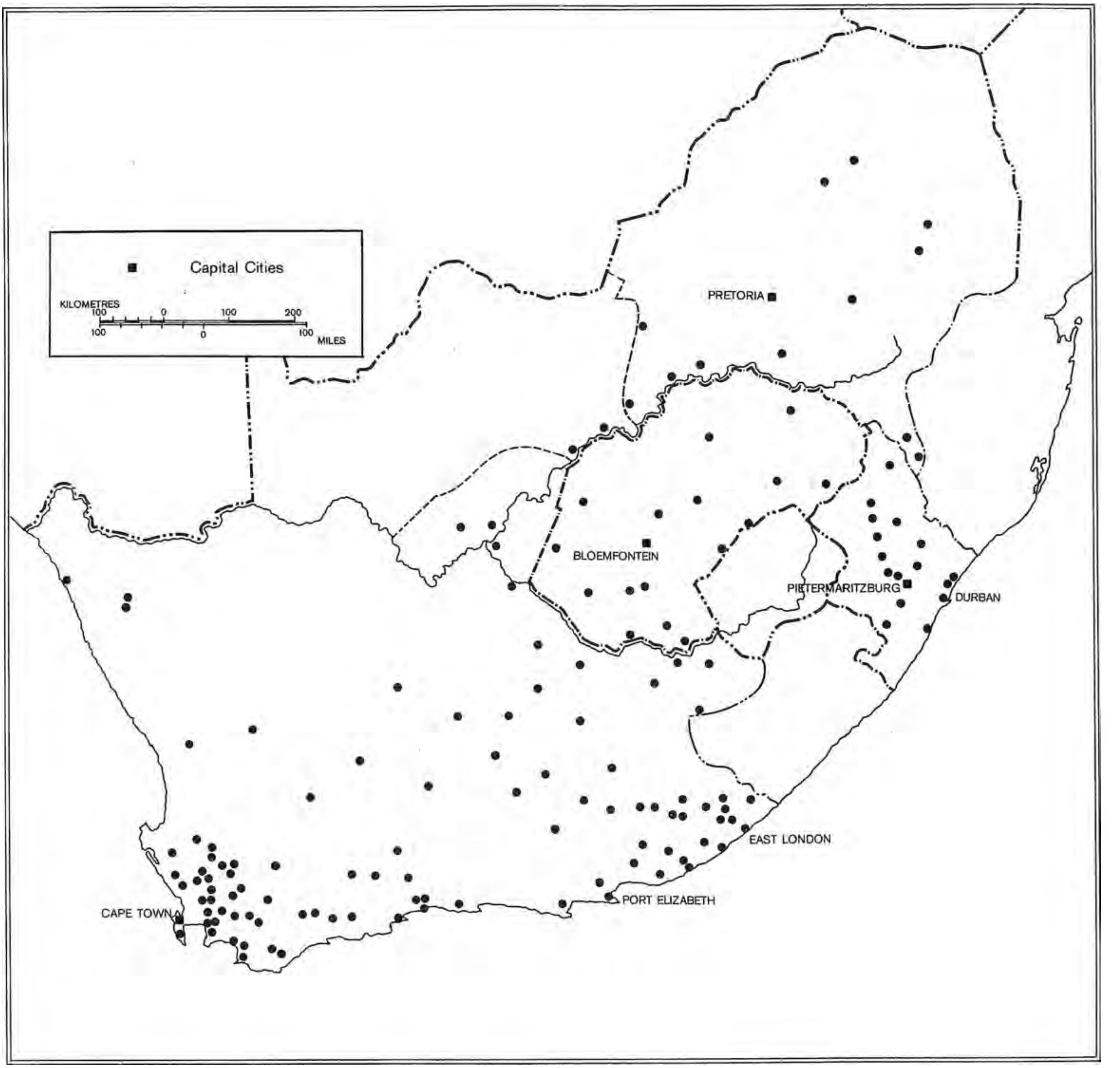
establishment of new towns, and by 1870 19 new urban places had been established. The urban mesh of 33 places in the south-west Cape, with a mean distance of 16 kilometres to nearest neighbour, represented the only closely-spaced and integrated regional set of cities in South Africa at the time. [Figure 4 and Table 3].

Closer settlement and the development of wheat farming and ostrich farming in the southern Cape had led to an increment of 10 new places in that region while the more arid interior periphery of the western Cape, dependent upon an extensive pastoral economy and a widely-dispersed population, only 7 additional places had been added by 1870. In the southern Cape the mean distance to nearest neighbour within the urban mesh was 28 kilometres while in the western Cape periphery it was over 100 kilometres.

In the eastern Cape frontier zone, in the hinterlands of Port Elizabeth and East London, more intensive settlement, advancement of the wool industry and expansion of settlement beyond the Keiskama River since 1848 had led to the growth of the number of urban places. In the Port Elizabeth hinterland 8 places were added, and in East London an absolute increment of 14 new urban places came into existence. The urban mesh in the hinterlands of these port cities, however, reflect a far more dispersed pattern of settlement and development than was the case in the western Cape region. Thus the distance to nearest neighbour within the Port Elizabeth hinterland mesh was 41 kilometres, and in the East London hinterland 31 kilometres.

In Natal only Pietermaritzburg and Weenen were established during the period of republican rule from 1838 to 1843 but 16 new urban places were established under British colonial rule as administrative and commercial centres in the colony. The urban mesh of Natal developed within a strongly linear framework, north and south from Durban and inland following the pattern of commercial sugar-growing on the coast, and the major trade route to the interior. The mesh was relatively-closely spaced and mean distance to nearest neighbour was 28 kilometres.

In the Orange Free State and the Transvaal only 33 urban places had come into existence since the Great Trek as service and administrative centres for a widely-dispersed population practising a pastoral economy. While there is little evidence to support the view, it is probable that the level of integration within the urban mesh was low, and that individual nodes depended for their support largely upon their surrounding region. No urban place had a significantly-large population and the mean distance to nearest neighbour within the mesh was



4 TOTAL CITIES IN c.1870.

approximately 62 kilometres. Earlier settlement and a somewhat more advanced economy in the Free State, however, is revealed in a closer mesh in comparison to the very widely-spaced set of urban places in the Transvaal Republic.

The distribution of the urban mesh in South Africa as a whole in 1870 reflected the potentialities of the environment to support an agricultural and pastoral economy and the restraints imposed by environmental hazards such as aridity and pest-infested areas on the one hand, and economic, social and technological forces which influenced the pattern of settlement on the other. Lands held by African tribes in an irregular horseshoe from the northern Cape to the Ciskei possessed few if any urban nodes. [Figure 4].

Much of the north-western and northern Cape Colony, the north-western, northern and eastern portions of the Transvaal (outside of African held land) were practically unsettled by Whites in 1870, due to aridity in the northern margins of the Cape and north-western Transvaal, and to malaria and sleeping sickness in the northern and eastern Transvaal lowveld areas. These areas remained a pioneer fringe of settlement in South Africa until very recent times. The concentration of White settlement in the south-western, southern and eastern Cape, the Orange Free State, southern and central Transvaal, and in Natal, on the other hand, reflected more favourable environmental conditions suitable for pastoral activities and rainland agriculture

In essence the pattern of settlement also reflected a typical colonial situation in which penetration of the interior proceeds from a number of coastal settlements. Initial movements were north-east and eastwards from Cape Town towards the Eastern Cape grassland areas. Following upon the establishment of the 1820 settlement in the Eastern Cape and the growth of Port Elizabeth and Grahamstown, the direction of settlement was essentially northwards following in the wake of the Great Trek and resulting in a swathe of urban nodes from the Eastern Cape to the central Transvaal. In Natal a similar pattern of inland penetration from a coastal settlement is apparent.

Great distances and low levels of integration between the principal nodes on the coast, Cape Town, Port Elizabeth, East London and Durban, favoured the evolution of regional economies each focussed on a port city. Integration of the hinterlands with the port cities, decreased progressively with distance over the slow and frequently ill-made waggon roads. Political differences between the British colonies and the Boer Republics of the interior also hindered economic and social integration. In outline therefore, the spatial structure of development is that of a number of focal coastal settlements surrounded by limited areas of more intensive development in their immediate hinterland, beyond which lay an outer periphery with a weakly-developed pastoral economy, more particularly in the Orange Free State and Transvaal, weakly integrated with the coastal cities. The major centres of urban growth, apart from the focal coastal cities, were in general located within the immediate hinterland of those cities while the outer peripheral areas were served by a set of small widely-spaced centres weakly integrated with one another. Thus, although evidence is scant, it is likely that a system of cities functioning within an hierarchical functional framework within the territory of South Africa did not exist at that stage.

Population data for urban areas in 1870 are not available. The 1875 Cape Colony census gives some indication of the rank-size relationship within the set of urban centres in the Colony. Taking the Cape Colony as a whole the level of primacy within the set of cities was 65 per cent, which is relatively high. Cape Town occupied the primate position. Assuming a structure of regional economies it is evident that within the western Cape regional economy, focussed upon Cape Town, the level of primacy was 78 per cent. In the Eastern Cape, the hinterland of Port Elizabeth had a primacy index of 44 per cent and in the border area, with King William's Town as the largest town, a low level of primacy existed (30 per cent). These values suggest that the urban economy in the western Cape had become highly concentrated in Cape Town, whereas in the Eastern Cape and Border areas, with less well-developed regional economies, lower levels of urbanisation and of integration, the urban economy remained more dispersed resulting in a lower level of primacy. This is particularly true of the border area which by 1870 remained largely dependent upon the Eastern Cape (Port Elizabeth and Grahamstown) for higher order services.

THE MID AND LATE TRANSITION PHASES: 1870 TO 1910 AND 1910 TO 1933.

The transition phase up to 1870 was characterised by slow growth of an agricultural-pastoral economy with low absolute levels of volume and output. Pockets of intensive or semi-intensive development had emerged on the coastal margin in the south-west Cape, Eastern Cape and Natal, but in general these areas were poorly integrated with the interior. Levels of transportation technology, using the ox-waggon in particular, were largely responsible for this situation. The pattern of the space economy was circumferential, focussed upon a number of coastal cities surrounded by recognisable growth zones weakly integrated with an interior periphery.

This pattern was typical also of the development of the space economies of Australia and Latin America.

The discovery of diamonds and the establishment of a diamond industry in 1870, and subsequently the discovery and development of the Witwatersrand goldfields in the Transvaal from 1885 brought about fundamental changes in the structure and spatial pattern of economic development in South Africa and of its city system. Within a short space of 20 to 30 years major primary industries had been established in the interior and the periphery became subject to dramatic change in the late transitional phase and in the subsequent industrial stage of growth.

The mid transitional phase was not a period of simple uninterrupted progress. The period from 1870 to 1910 was characterised not only by the dramatic stimulus induced by the mineral discoveries but was also a period in which development and integration were severely hampered by political divisions and hostilities. In this period the annexation of the Transvaal Republic as a British Colony took place following the decline of its economy and administration in 1877. This event was followed by the first war of independence in 1881. The disturbing influences of the Jamieson Raid and the subsequent Anglo-Boer War of 1899 - 1902 more severely disrupted growth. It was only after a period of reconstruction following the Anglo-Boer War and the ultimate political unification of the four territories in the Union of South Africa therefore, that consolidation and economic advance as a national unit could take place. Even then development was hampered, as it had been also in the period from 1870, by periodic economic depressions.

The Act of Union provided for the development of a uniform land policy in relation to tribal-held lands and in terms of the occupation and ownership of land by Africans. The Land Act of 1913 provided for scheduled areas within which African land rights were entrenched. Approximately 9.2 million hectares were scheduled. In 1936 the Native Trust and Land Act made provision for additional land to be purchased in released areas. The land provided for in African reserves under the Act increased the potential area to about 15 million hectares or 14 per cent of the area of South Africa.

While levels of development in African Reserves based upon subsistence production and income earned from migratory labour have remained low to the present time, the need for administrative and service centres led to the establishment of urban nodes in Reserve areas during the Transition stage.

In assessing the level of development to 1870 and requirements for the promotion of further development, de Kock (1924) listed five necessary factors:

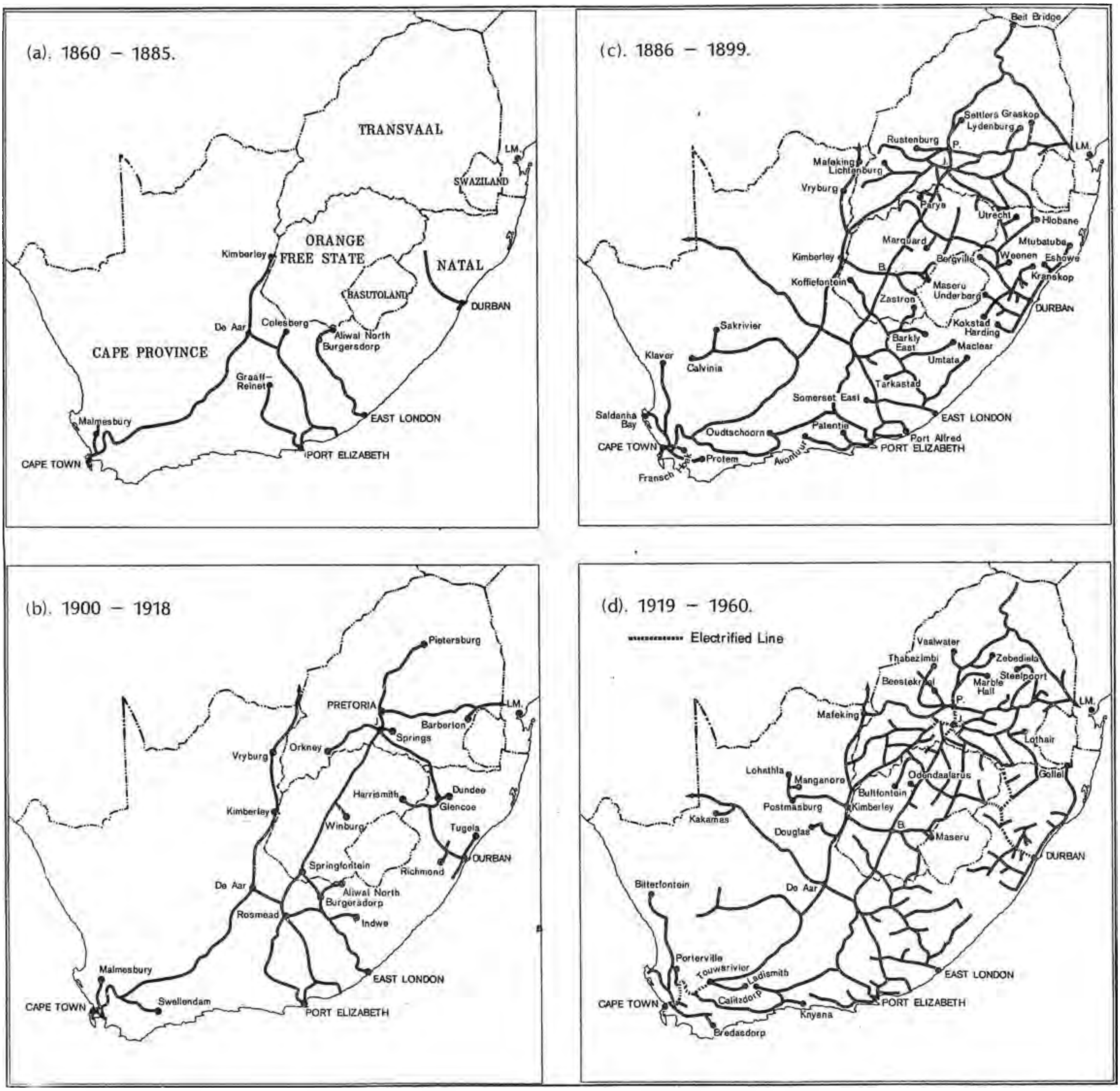
1. Cheaper and better methods of transportation from the interior to the coast;
2. Capital to undertake construction of railways, telegraphs and telephones, and the further extension of banking facilities;
3. Valuable commodities of small bulk for export, with a view to acquiring an increased purchasing power abroad, such being the easiest means of obtaining the manufactured articles required by the inhabitants of a new country;
4. A wider local market for agricultural produce; and
5. New sources of revenue to enable the state to undertake more functions and increase its activities in the public interests.

These needs were satisfied in considerable measure by the opening of the diamond fields at Kimberley in 1870. Foreign capital flowed to South Africa, and by 1880 the value of diamond production had reached £3 million per annum. Exports and imports through Cape and Natal ports rose to £9 million and £11.5 million respectively by 1882, and agricultural production was gradually commercialised.

Technological advances included, in particular, the building of main line railways from the coastal ports to the new focus in the interior, which favoured a higher level of economic integration. By 1885 the railways from Cape Town and Port Elizabeth had reached Kimberley; and the line from East London, Burghersdorp and Aliwal North. In Natal attempts to compete with the Cape ports had encouraged the construction of a line to the interior, which by 1885 reached Estcourt. Wagon traffic, greatly increased in volume, supplemented the tentacular lines from the coast. [Figure 5].

Telegraph communications were also extended, and by 1876 a line had been completed between Kimberley and Cape Town. In 1879 a Natal telegraph line was completed, and offices were established at Pretoria and Standerton by that year. The year 1882 marks the date of the introduction of the telephone to South Africa, and in 1880 cable communication between the Cape and Europe had been established.

Other advances in transport included harbour development at Cape Town after 1860 and in Durban after 1880, and improvements in road and bridge construction.



5. DEVELOPMENT OF RAILWAY NETWORK 1860 – 1960

An expanding local market created by a substantial rise in immigrant population, rising income levels and mining needs, stimulated commercial development. Manufacturing industry, however, apart from a growing mining engineering component, hardly developed beyond simple processing, repairs and manufacture of waggons, blacksmithing, candle making, furniture and other industries designed to meet local needs.

The ports and urban centres located upon principal transport routes to Kimberley, and, in particular, those located upon the railway routes, were most favoured for economic growth. The importance of a location upon a railway route is reflected for example in the conflict which developed between centres to attract the railway to themselves. The decision to route the Port Elizabeth-Kimberley railway through Cradock and not through Grahamstown, is a case in point and led to the serious decline of the latter as a major commercial centre in the eastern Cape. (Watts, 1957). The influence of construction of railway lines upon urban places is also reflected in the rapid expansion of the commercial function at railheads, where a transfer of goods took place to waggons. Commercial prosperity was frequently followed however, by an equally rapid period of decline as the railway was extended to the next most distant centre.

The effects of diamond-mining upon the South African economy were felt most strongly in the Cape Colony. The state revenue of the Colony rose from £600,000 in 1870 to £2.4 million in 1881. In the same period the revenue of Natal rose from £120,000 to approximately £500,000, in the Orange Free State from £60,000 to £200,000, and in the Transvaal from a few thousand pounds to approximately £200,000. Political rivalry and division, however, constituted a hindrance to the integration of the economy, and regional interests remained paramount.

The discovery and proclamation of the Witwatersrand Goldfields in 1885 was to have far-reaching effects upon the subsequent pattern of development in South Africa. Its immediate benefits led to an enhanced capital flow of far greater dimensions than had entered the country during the years in which diamond-mining dominated the economy, and led to a re-orientation of the interior focus.

Railway and communications lines were extended and re-orientated upon Johannesburg. [Figure 5]. By 1892 the line from the eastern Cape had been completed to Germiston, and the Cape line had reached Fourteen Streams, and was linked to Johannesburg in 1897. In 1891 the Natal line from Durban was completed to Volksrust, and to Johannesburg in 1895. During this time also the Transvaal Republic, attempting to establish a rail route independent of British colonies, had established the Johannesburg-Lourenco Marques line by 1894.

The inflow of capital, of population, and the establishment of a major primary industry in the Transvaal stimulated in particular the economy of the Transvaal and less directly, the Orange Free State, while trade through the ports expanded considerably, the Transvaal and Orange Free State had previously remained marginal to the major areas of economic advance.

Production, imports and exports and state revenue reflect the pattern of growth. By 1890 the value of gold production had reached £1.9 million, by 1894 £7.6 million, and by 1898 £16 million. Imports by the Cape and Natal ports rose to more than £12 million in the period between 1889 and 1891. State revenue, on the other hand, in the Transvaal, rose from £218,000 in 1885-86, to £1.5 million in 1889-90, in the Cape from £1.9 million to £2.4 million, in Natal from £500,000 to £800,000, and in the Orange Free State from £186,000 to £281,000.

The stimulus of primary industry led to an enhanced level of commercial activity and agricultural production. Advances in primary industry and in commerce, however, were hampered by restraints imposed upon them by political issues and economic depressions until the period of physical reconstruction, and the movement to political unity had been completed with the creation of the Union of South Africa in 1910.

The mineral discoveries of the late 19th century led to what Rostow (1960) has termed the period of the creation of pre-conditions for sustained economic growth. They did not in themselves constitute a phase of the industrial stage of development (Hobart Houghton, 1967). By 1912 the economy remained narrow based and manufacturing contributed only 7 per cent of national income [Table 10] while primary activity contributed 44 per cent of which 27 per cent came from mining. Gold, a wasting resource, was the principal basis of the economy and modern technology had not been extended over a wide range of other natural resources.

The Act of Union eliminated artificial political barriers to growth and brought about a "common market" of 6 million people (Hobart Houghton, 1967). Furthermore, branch line railway construction to serve agricultural communities, a uniform national policy and administration of railways and harbours, favoured economic integration and older patterns of regional economies began to break down. Nett domestic product rose from R266 million in 1912 to R602 million by 1935.

TABLE 4.

GROWTH OF THE TOTAL URBAN AND RURAL POPULATION OF SOUTH AFRICA 1904 - 1960

Area	1904	1936	1960
All Races			
Urban	1,210,487	3,155,896	7,463,005
Rural	3,964,340	6,431,967	8,539,792
Total	5,174,827	9,587,863	16,002,797
Whites			
Urban	588,397	1,346,193	2,571,883
Rural	528,837	657,141	516,609
Total	1,117,234	2,003,334	3,088,492
Coloureds			
Urban	224,731	436,107	1,028,022
Rural	220,260	333,134	481,236
Total	444,991	769,241	1,509,258
Asiatics			
Urban	44,733	153,704	396,517
Rural	77,578	65,987	80,608
Total	122,311	219,691	477,125
Africans			
Urban	352,626	5,373,705	3,466,583
Rural	3,137,665	1,219,892	7,461,339
Total	3,490,291	6,595,597	10,927,922

Source: Republic of South Africa Bureau of Statistics (1968). Report No. 02-02-01.

During the 1920's also the foundations of industrial expansion were created by the establishment of the Electricity Supply Commission in 1922, tariff protection in 1925 and particularly by the formation of the Iron and Steel Corporation in 1928. Thus, while agriculture and mining remained the principal contributors to the economy, industry's share of nett domestic product rose from 7 per cent in 1912 to 15 per cent by 1935, as the country moved towards the industrial stage of development.[Table 10.]

Stimulated by economic expansion in the late transition phase, the total population of South Africa rose from 5.2 million persons in 1904 to 9.6 million persons in 1936, while the urban population grew from 1.2 million to 3.2 million persons. [Table 4]. The percentage of the population living in urban places increased from 23 per cent to 33 per cent - a factor of 1.4. [Table 5].

TABLE 5.

PERCENTAGE OF THE POPULATION LIVING IN URBAN AREAS

Race	1904	1936	1960	1967
White	52.7	67.2	83.3	86.1
Coloured	50.5	56.7	68.1	70.2
Asiatic	36.6	70.0	83.1	85.8
African	10.1	18.5	31.7	34.8
Total	23.4	32.9	46.6	49.8

Source: Republic of South Africa (1968), Report No. 02-02-01.
The 1967 percentages were calculated from figures in Pienaar and Ass. (1967): Stats: 1967 Population Republic of South Africa.

The rate of urbanisation between 1870 and 1904 and between 1904 and 1936 was remarkably constant and was not greatly below that experienced in the industrial stage from 1936 to 1960. [Figure 6].

By 1904, 53 per cent of the White population was urban but by 1936 the proportion had grown to 67 per cent, illustrating the relatively early urbanisation of Whites as mining, commercial and other urban services expanded and encouraged international and local rural-urban migration. [Table 5].

Between 1904 and 1936 also the Asiatic urban population grew rapidly to 70 per cent of the total but the African population remained the least urbanised group (19 per cent in 1936). It is important to note, however, that the rate of increase of the African urban population was the greatest in the period. Thus, the percentage of the African population which was urban increased by a factor of 1.9 between 1904 and 1936.

The racial composition of the urban population of South Africa has always been heterogeneous and contained all elements of the population, but a concomitant of the growth of urban-based primary industries (mining) was a steady relative increase in the proportion of non-White population. While natural increase and relatively large-scale immigration of Whites to the urban areas took place, the proportion of the urban White population declined from 49 per cent in 1904 to 43 per cent in 1936. The Coloured population, on the other hand, declined from 19 per cent to 14 per cent, while the Indian population rose from 3.7 per cent to 4.9 per cent, and the African population from 29 per cent to 39 per cent. [Table 6].

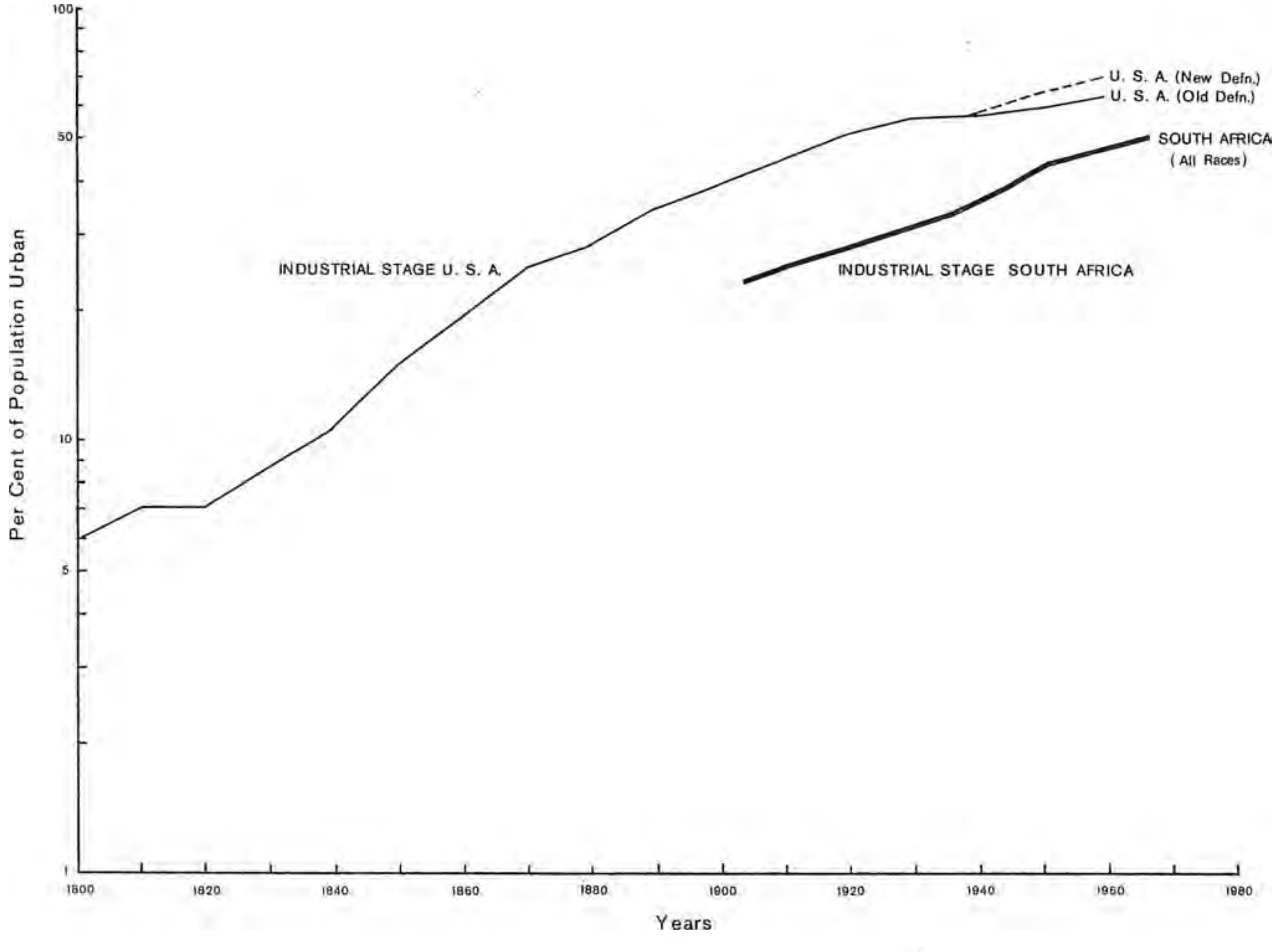
TABLE 6.

RACIAL COMPOSITION OF THE URBAN POPULATION 1904 - 1960

	Percentage Distribution of Races				
Year	White	Coloured	Asiatic	African	Total
1904	48.6	18.6	3.7	29.1	100.0
1936	42.7	13.8	4.9	38.7	100.0
1960	34.5	13.8	5.3	46.5	100.0

Growth of the urban population is associated with the expansion of cities established in earlier years but most particularly with the rapidly growing mining and commercial centres established in the transition phase. The phase between 1870 and 1933 constituted the largest absolute increment of new urban places in South African history. In the 63 year period 304[1] new urban places

1. It should be remembered that only places with more than 500 persons in 1960 have been considered in tracing the history of town establishment. Furthermore, sub-urban centres are not accounted for in the incremental periods. Thus the total number of places established in the period 1870 to 1937 is likely to be considerably higher than the 304 places considered here.



6 GROWTH OF THE PERCENTAGE OF THE TOTAL POPULATION 1904–1967

were created including Kimberley and the gold mining towns of the Witwatersrand. [Figure 7 and Table 2].

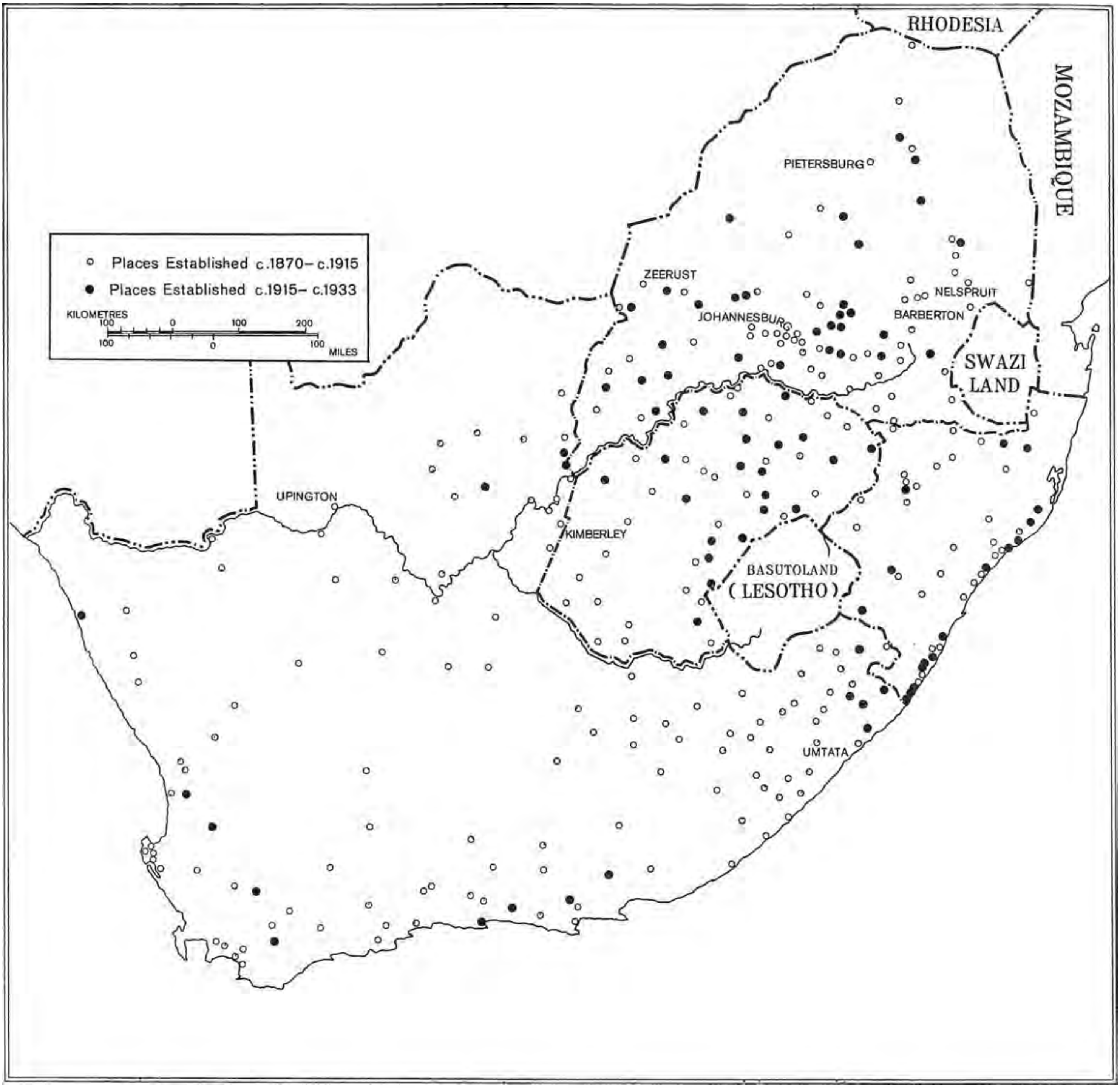
In 1904, 68 per cent of all urban places had populations smaller than 2,000 persons but 57 per cent of the urban population lived in 11 cities with more than 20,000 persons and 28 per cent in cities with more than 100,000 persons. [Figure 8 and Tables 7 and 8] Only two cities (Cape Town and Johannesburg), had populations in excess of 100,000 and three cities (Cape Town, Johannesburg and Durban) had more than 50,000 persons.

By 1936, 20 cities had populations in excess of 20,000 persons and they contained 69 per cent of the urban population. The number of cities with more than 100,000 persons had increased to 5 and 44 per cent of the urban population lived in these cities. The trend towards metropolitan concentration is not unexpected and is an essential characteristic of transition towards an industrial stage of development. It has continued through the industrial stage and is likely to break down only as the economy becomes more widely spread in the later stages of economic growth.

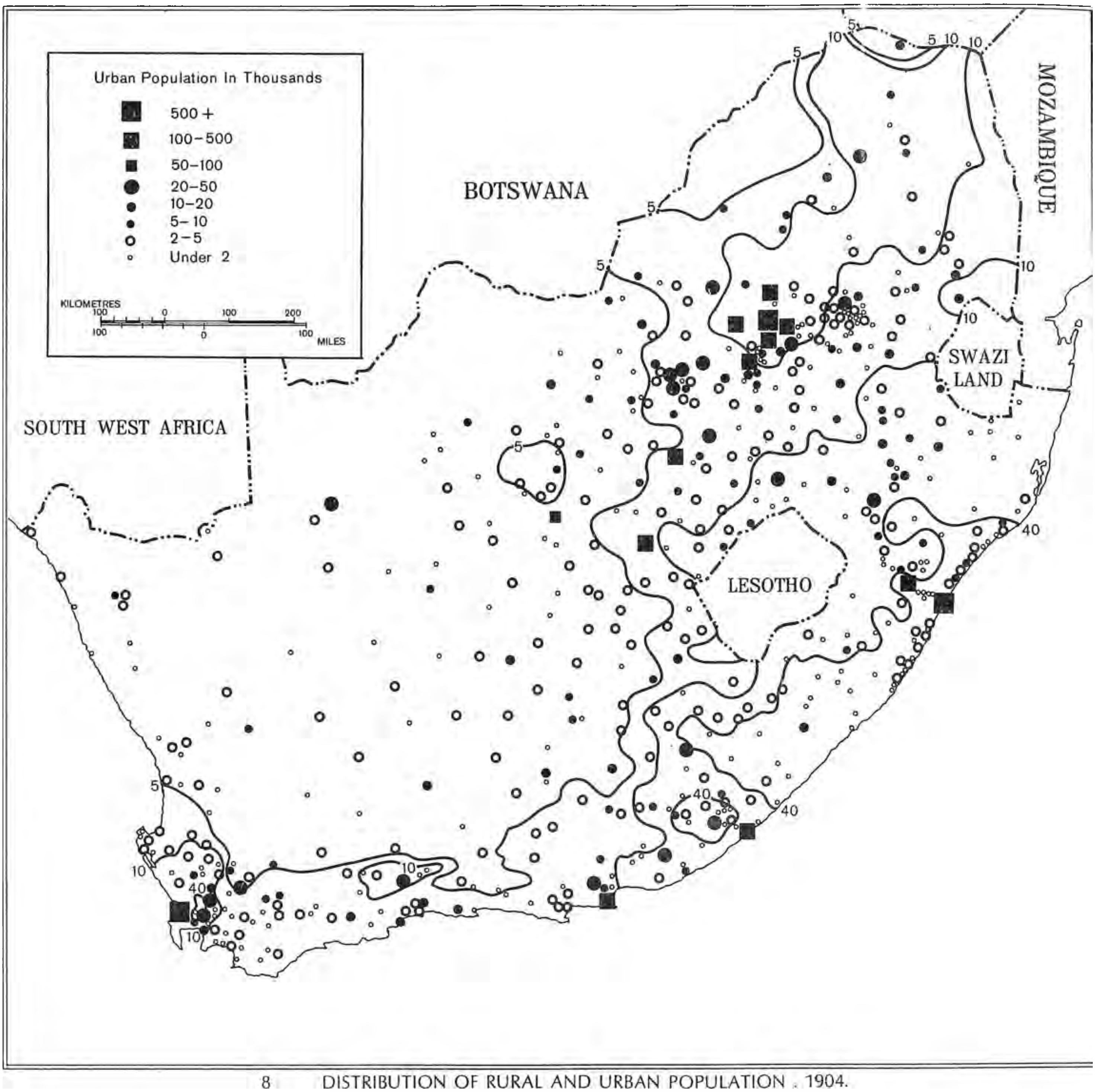
It should be noted, however, that the level of national primacy in the city system was moderate in both 1904 and 1936 and that it has remained moderate in the succeeding industrial stage of development. [Table 9] In 1904 the level of national primacy was 54 per cent (taking the Witwatersrand as the largest unit) or 41 per cent (taking Johannesburg as the largest city). By 1936 the corresponding levels were 58 per cent and 41 per cent. These values suggest that by the late transition phase the city system was reasonably balanced in terms of rank-size relationships.

The spread of the 304 new urban places established between 1870 and 1933 reflects the need for urban services arising from an increasing volume and intensity of agricultural and pastoral production, the exploitation of mineral resources, the expansion of the rail and road networks and the spread of settlement into formerly marginal areas. [Figures 9 and 11].

A very high proportion, 79 per cent, of the new urban places were established in the period 1870 to 1915 in response to the rapidly expanding economy based upon mining and agriculture. [Figure 7]. While new centres were established throughout the country the relative rate of increase in the number of places was highest in the Johannesburg, Pretoria, Kimberley and Durban city sub-systems. (i.e. in the area of the country most closely affected by the mineral discoveries). A high rate of increase occurred also in the East London sub-system where the establishment of administrative centres in the Transkein territories after 1870 accounted for a large proportion of new urban places.



7 ESTABLISHMENT OF CITIES c.1870 – c.1915, c.1915 – c.1933.



8 DISTRIBUTION OF RURAL AND URBAN POPULATION . 1904.

TABLE 7a.

NUMBER AND POPULATION OF CITIES
ACCORDING TO SIZE OF POPULATION
ALL RACES 1904 - 1960

Size Group	1904		1936		1960	
	No.	Population	No.	Population	No.	Population
- 500	41	14,186	77	25,913	-	-
500-999	61	44,698	131	97,124	122	89,270
1,000-1,999	75	107,539	114	161,664	135	192,065
2,000-4,999	52	150,720	110	326,355	204	615,784
5,000-9,999	15	106,337	31	222,720	65	464,229
10,000-19,999	7	94,509	11	158,042	32	440,902
20,000-49,999	8	278,172	7	231,102	27	871,848
50,000-99,999	1	69,903	8	531,178	8	649,539
100,000-499,999	2	344,423	4	874,291	8	1,530,621
500,000-999,999	-	-	1	527,507	2	1,471,041
+ 1,000,000	-	-	-	-	1	1,137,806
Total	262	1,210,487	494	3,155,896	604	7,463,005

Source: Republic of South Africa (1968)

TABLE 7b.

PERCENTAGE OF THE POPULATION RESIDENT IN CITIES
BY SIZE GROUP

Size Group	1904			1936			1960		
	%	Cumulated %		%	Cumulated %		%	Cumulated%	
		% Less Than	%More Than		% Less Than	% More Than		% Less Than	% More Than
- 500	1.17	1.17	100.00	.82	.82	100.00	0.00	0.00	100.00
500-999	3.69	4.86	98.81	3.08	3.90	99.17	1.20	1.20	100.00
1,000-1,999	8.88	13.74	95.12	5.12	9.02	96.09	2.57	3.77	98.80
2,000-4,999	12.45	26,19	86,24	10,34	19,36	90,97	8.25	12.02	96,23
5,000-9,999	8.78	34.97	73.79	7.06	26.42	80.63	6.22	18.24	87.98
10,000-19,999	7.81	42.78	65.01	5.01	31.43	73.57	5.91	24.15	81.76
20,000-49,999	22.98	65.76	57.20	7.32	38.75	68.56	11.68	35.83	75.85
50,000-99,999	5.77	71.53	34.22	16.83	55.58	61.24	8.70	44.53	64.17
100,000-199,999	28.45	100.00	28.45	7.90	63.48	44.41	10.87	55.40	55.47
200,000-499,999	-	-	-	19.30	83.28	36.51	9.64	65.04	44.60
500,000-999,999	-	-	-	16.71	100.00	16.71	19.71	84.75	34.96
+ 1M	-	-	-	-			15.25	100.00	15.25
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	

TABLE 8.

PERCENTAGE OF CITIES IN DIFFERENT SIZE GROUPS
1904 - 1960

Size Group	1904		1936		1960	
	%	Cumulated %	%	Cumulated %	%	Cumulated %
- 500	15.6	15.6	15.6	15.6	-	-
500-999	23.3	38.9	26.5	42.1	20.2	20.2
1,000-1,999	28.6	67.5	23.1	65.2	22.4	42.6
2,000-4,999	19.8	87.3	22.3	87.5	33.8	76.4
5,000-9,999	5.7	93.0	6.3	93.8	10.8	87.2
10,000-19,999	2.7	95.7	2.2	96.0	5.3	92.5
20,000-49,999	3.1	98.8	1.4	97.4	4.5	97.0
50,000-99,999	.4	99.2	1.6	99.0	1.3	98.3
100,000-499,999	.8	100.0	.8	99.8	1.3	99.6
500,000-999,999	-	-	.2	100.0	.3	99.9
+ 1,000,000	-	-			.1	100.0
	100.0	100.0	100.0	100.0	100.0	100.0

TABLE 9

LEVELS OF PRIMACY WITHIN THE NATIONAL AND REGIONAL CITY SYSTEM 1904 - 1960

City System	1875	1904	1936	1960
National	64.8 1)	54.3 2)	57.5 2)	53.1 2)
Regional				
Cape Town	77.7	87.1	89.5	89.4
Port Elizabeth	44.3	54.4	68.5	74.2
East London	29.5	57.8	62.3	65.9
Johannesburg	?	91.0 3)	95.0 3)	89.9 3)
Pretoria	?	89.9	86.6	89.4
Durban	?	61.6	78.1	80.6
Bloemfontein	?	69.2	78.5	84.8
Kimberley	?	83.7	76.7	65.6

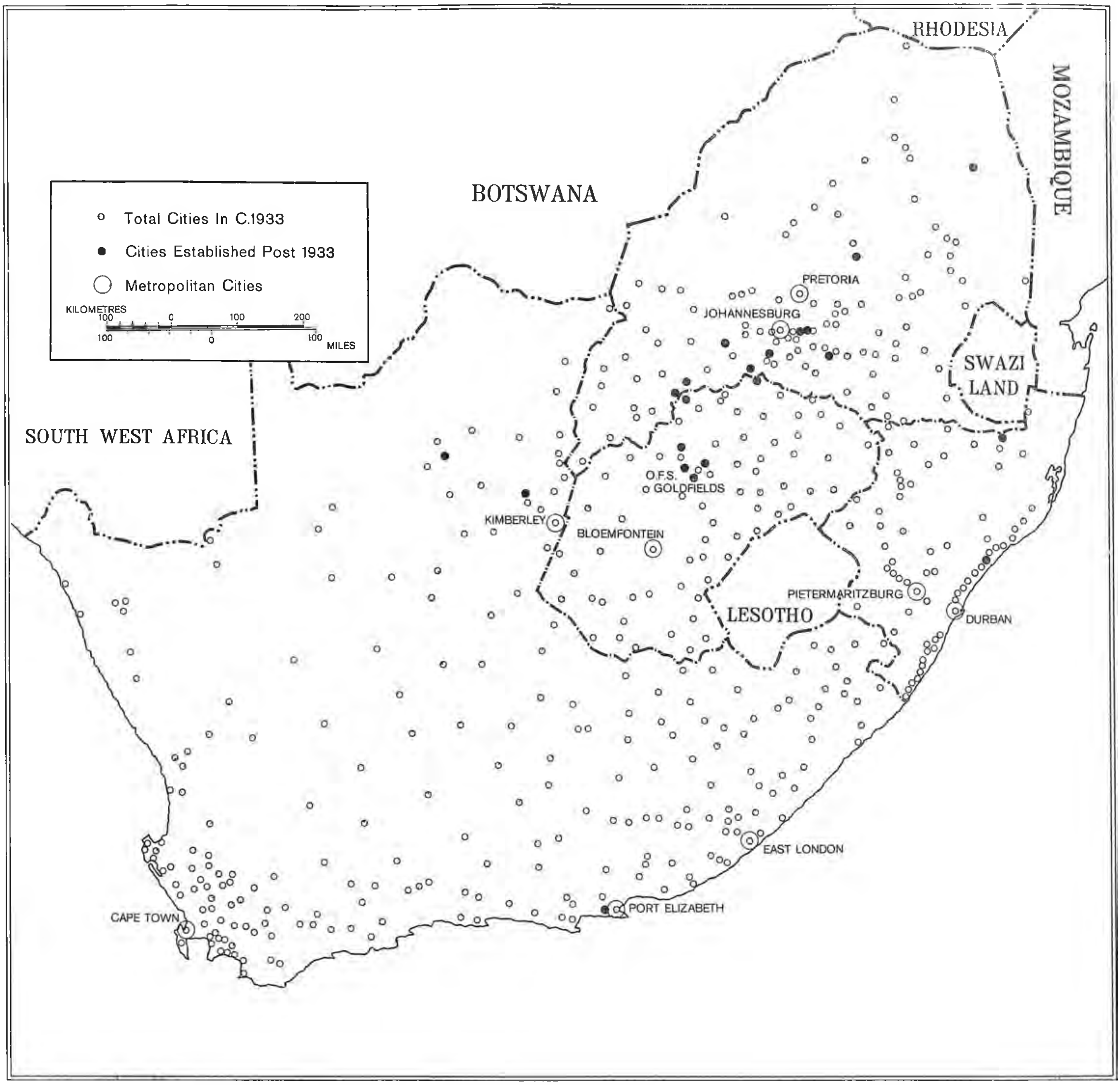
Notes:

1) Refers to the Cape Colony only. Source: Census of the Cape Colony, 1875.

2) If Johannesburg is taken as the largest city instead of the Witwatersrand, the level of National Primacy drops to 41.0 in 1904, 41.3 in 1936 and 37.1 in 1960.

3) Regional Primacy index based on Witwatersrand as the largest city in each year. The index drops to 69.1 in 1904, 68.0 in 1936 and 69.8 in 1960 if Johannesburg is taken as the largest city.

4) The Primacy Index = $\frac{\text{Population of largest city}}{\text{Population of four largest cities}} \times 100$



9 TOTAL CITIES

In the older city sub-systems of Cape Town, Port Elizabeth and Bloemfontein on the other hand, the rate of growth of new centres was lower.

Between 1915 and 1933 the rate of increase in the number of new urban places declined but the trend for the Johannesburg, Pretoria and Durban sub-systems to have higher rates of increase was maintained. [Figure 7] The Bloemfontein, Kimberley and Port Elizabeth sub-system enjoyed more moderate rates of increase in the number of new urban places.

As a result of the growth of the urban mesh by 1933, mean distance to nearest neighbour had substantially declined in all city sub-systems.[Table 3] The most closely spaced mesh remained in the South Western Cape where mean distance to nearest neighbour declined to 15 kilometres. In the southern Cape and the city sub-systems focussed upon Port Elizabeth, Durban and Johannesburg, mean distance ranged from 20 to 28 kilometres. In the western Cape interior and in the city sub-systems of Pretoria and Kimberley mean distances, while lower than in 1870, remained relatively high (51 kilometres, 41 kilometres and 42 kilometres respectively). The Bloemfontein sub-system was intermediate with a mean distance of 35 kilometres. [Table 3]

THE INDUSTRIAL STAGE OF DEVELOPMENT 1933 - 1993?

The year 1933 sets the industrial stage off from the transitional stage for a number of reasons (Hobart Houghton 1967). These are the devaluation of the South African pound with a consequent stimulus to gold mining, commencement of production of iron and steel from Iscor, and political conditions which favoured economic development and an increasing employment of non-White labour in all sectors of the economy. The movement of Africans from the low-productivity subsistence farming sector into the modern sector of the economy was particularly marked.

The most significant structural change in the economy was the increasing importance of manufacturing industry as a contributor to the net domestic product and national income of South Africa. [Table 10.] The contribution of three main sectors of the economy - agriculture, mining and manufacturing - have consequently changed markedly. In 1932-33 the contribution of manufacturing was approximately 14 per cent of net national income. By 1963-64 the proportion had increased to 28 per cent while the contribution of agriculture declined from 12 per cent to 9 per cent and of mining from 24 per cent to 13 per cent. The trend in the growth of manufacturing was one which had commenced during the late transitional phase when in 1912 the proportion contributed by manufacturing to net national income was 7 per cent, and by 1924-25 it had reached 12 per cent. The contribution of services to the gross national product, on the other hand, has remained relatively constant since 1936, and has changed periodically by only 1 or 2 per cent.

TABLE 10.

NATIONAL INCOME (IN MILLIONS OF RANDS)

Year	Total	%	Agriculture	%	Mining	%	Manufacturing	%	Other	%
1912	266	100	46	17	72	27	18	7	65	49
1933	474	100	61	13	113	24	64	14	118	50
1945	666	100	164	12	192	14	265	20	356	53
1960	4510	100	496	11	630	14	1051	23	2333	52
1964	6095	100	558	9	764	13	1698	28	3075	51

Source: Union of South Africa (1960) and Republic of South Africa (1967)

Using the Friedmann criteria for identifying the structure of an economy, the South African economy today is clearly at the industrial stage of development. [Table 1.] It is important to note however, that though the contribution of manufacturing to the gross domestic product is the largest component, a very considerable proportion of the population remains dependent upon agriculture for a living. This is accounted for primarily by the high proportion of African workers dependent upon agriculture. Thus agriculture provided employment for nearly 40 per cent of the total economically-active population of South Africa in 1960 (Hobart Houghton 1967). The same author notes (p.67) that:

> "the actual number of persons engaged in agriculture exceeds the combined totals of all workers in mining, manufacturing and construction industries in the country. In addition, there were some 600,000 African peasant families in the reserves dependent, at least partly, on agricultural activities. These findings illustrate the extent to which South Africans, in spite of great mining and manufacturing industries, are still largely dependent upon farming activities for a livelihood, and South Africa, in

the matter of employment of its people, is still basically an agricultural country."

The most prominent features associated with the development of the principal sectors of the economy in the industrial stage may be summarised as follows:

Agricultural output increased from R112,000,000 in 1936 to R1,009 million in 1965. The increase can be attributed partly to rises in prices but also to a marked growth in volume of output. Thus using the period 1936 to 1939 as a base equal to 100, the volume of production by 1959 had reached 181. (Hobart Houghton 1967, 47) Among the principal factors which have led to increased agricultural production have been improvements in marketing and the increasing application of technology and animal science.

Despite the application of planned development in the Bantu reserves since the publication of the Tomlinson Commission in 1956, the level of production in the reserves has remained low. The level of spending power including income earned from migratory labour is also low, and demand for services and other urban-based activities remains weak. Forces of urbanisation within the reserves consequently are weakly developed. Border industrial development in areas such as Hammarsdale (near Durban) and Rosslynn (near Pretoria) has induced urbanisation of the African population locally, but these areas are essentially parts of neighbouring metropolitan areas.

While gold and diamond-mining have remained vitally important sectors of the economy, and gold production has been enhanced by the opening of new gold fields in the Orange Free State, the most important structural change in the mining industry in the industrial stage has been the growing importance of base mineral mining. Thus in 1936 gold-mining contributed R159,000,000 while other mining produced only R18,000,000. By 1965, on the other hand, the value of gold output had risen to R767,000,000, but other mining to R386,000,000. The increasing importance of base minerals and coal-mining is associated with the development of manufacturing industry since 1936 and growth of the iron, steel and engineering industries is of particular importance.

The growth of manufacturing industry in the 20th century commenced in the last two decades of the transition phase. At that stage industries related to mining, such as the manufacture of explosives and mining engineering, were of particular significance. In that period too, industrial development was mildly stimulated by shortages of imported goods, during the First World War, and by the imposition of protective tariffs in 1925. Thus, between 1925 and 1929 the value of gross output from manufacturing rose by 39 per cent. Between 1929 and 1933, however, due to depressed economic conditions the value of net output from manufacturing industry declined by 10 per cent.

A period of rapid industrialisation took place following the devaluation of the South African pound in 1933. Thus, in the period 1933-1939 the value of industrial net output more than doubled to R128,000,000 - an increase of 110 per cent. In contrast to earlier periods also non-White employment increased more rapidly than White, from 76,000 to 143,000, or about 88 per cent compared with a 63 per cent increase in White labour (Hobart Houghton, 1967, 118). In the same period the number of industrial establishments rose from 6,543 to 8,614.

The stimulus to industrial development of war-time shortages between 1939 and 1945 is reflected in an increase in the net value of output of 116 per cent to R276,000,000. Since the war, industrialisation has progressed further, and the net output by 1962-63 had reached a level of R1,442,000,000 and the number of establishments had increased to nearly 12,000.

The growth of manufacturing industry in South Africa has been related to a circular and cumulative process in which the mining industry provided the initial multiplier effect. With growth of income and of population, together with other stimulants including protective tariffs, the circular sequence of industrial development has become cumulative. Cumulative growth of industry, furthermore, has resulted in expansion of tertiary activity, public investment, transport networks at local, regional and national levels, and has stimulated the development of other infrastructural elements of development. These in turn may be considered to have had a secondary multiplier effect which has further raised the threshold for development.

The basis of railway transport infra-structure was laid in South Africa in the late transition phase. [Figure 5] By 1911 7,548 miles of railways were open. By 1931 the mileage had risen to 13,098 miles but since that date the mileage of railway has increased slowly. The volume of rail traffic, however, increased by a factor of 5 between 1929 and 1965 to over 30 million ton/miles. Improvements in railway technology including rolling stock, locomotives, rail construction, and electrification also have considerably improved the level of integration provided by the rail network.

While new media of transport provided by the automobile and bus emerged during the late transition phase it is during the industrial stage that road transportation has assumed major proportions. Thus in 1930 the total number of motor vehicles in South Africa was approximately 186,000 but by 1964 the number had risen to 1,366,000. Growth in volume of road transport has been made possible also by considerable extension and improvement of the road network. In 1916 there were 47,000 miles of road in South Africa, but by 1959 the mileage had increased to 112,000 of which nearly 10,000 miles were tarred. The national road system, which is designed to link all major centres in the country, is now all but complete, and is being supplemented by improvements in provincial road networks. Thus the level of integration provided by fast motor traffic is now superior to that provided by the rail network.

Air services, which were fully developed only during the industrial stage, today link all major centres with an ever-increasing frequency of daily flights.

Other elements of infrastructure, associated with economic development during the industrial stage, have been in particular the growth of the Electricity Supply Commission grid which today supplies over 80 per cent of the total consumption of electricity in South Africa. The development of nationally-important water supply authorities and an integrative postal, telephone and telegraph service among other elements also provide evidence of a maturing industrial society.

Board, Davies and Fair (1970), in analysing the space economy, have demonstrated the pattern of "economic surfaces" which distinguish the levels of South Africa's economic landscape in the industrial stage. The pattern reveals the level of economic disparity between advanced and less advanced areas and between urban and rural areas and emphasises the importance of economic concentration in the metropolitan areas of the country.

The economic surfaces were mapped using criteria of "economic volume" (in terms of gross domestic product per square mile by magisterial districts) on the one hand, and criteria of "economic welfare" (obtained from a principal components analysis performed on 15 variables)[1] on the other. The results of analyses of the volume and welfare aspects of the economy are mapped in combination in Figure 10 and tabulated in Table 11. (Board, Davies and Fair, 1970, p.371)

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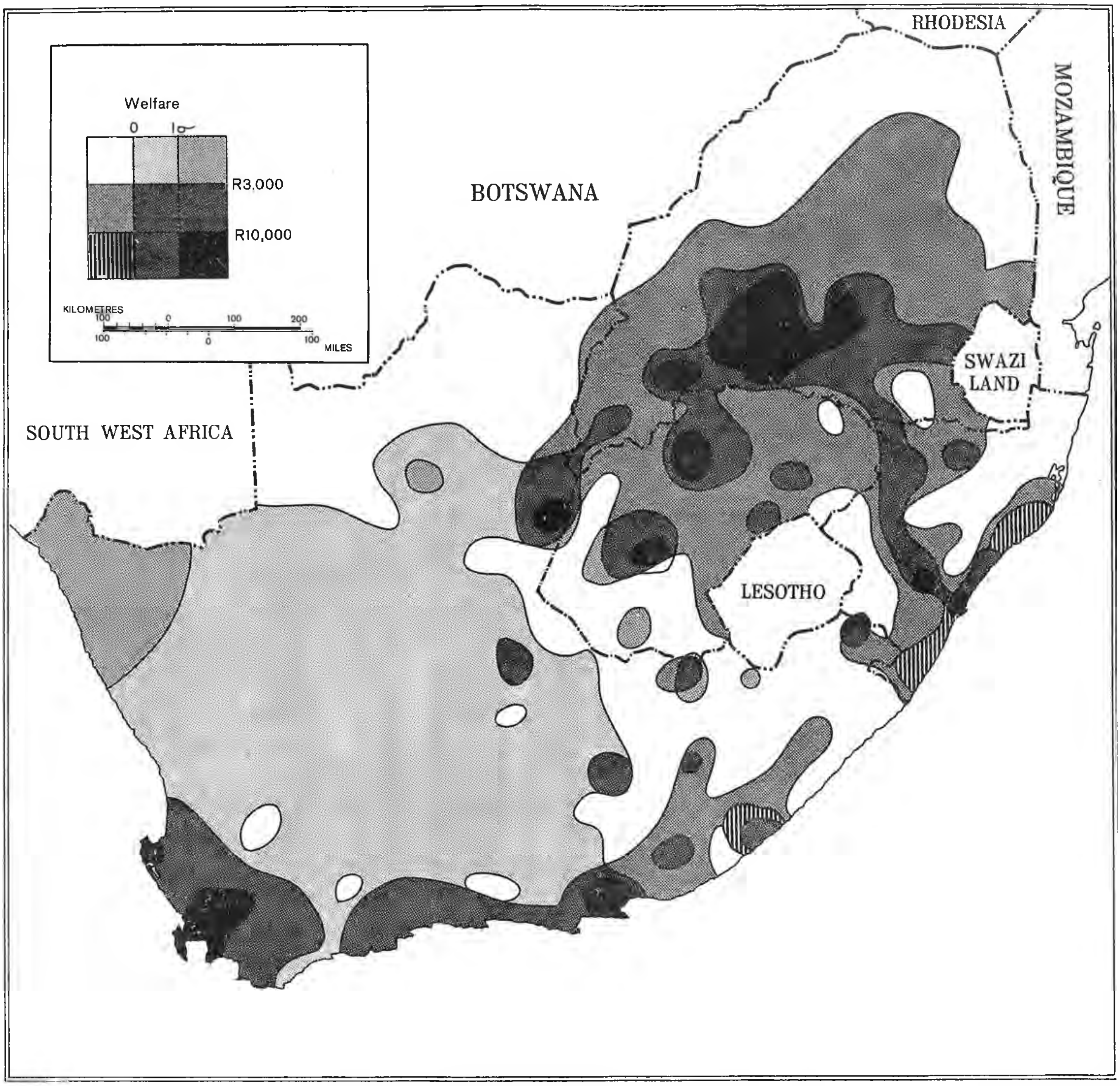
1. For details of the variables and of the analyses undertaken see the Appendix to the Space Economy article by Board, Davies and Fair (1970, 387)

TABLE 11

ECONOMIC SURFACES BY GROSS DOMESTIC PRODUCT AND AREA[1] 1960

	Contribution to G.D.P.			
Surface	R000	% for S.Africa	Square Miles	% for S.Africa
1. High				
Southern Transvaal	1,828,698	38.2	7,515	1.6
Western Transvaal	146,386	3.1		
Northern Orange Free State	180,060	3.8		
South-Western Cape	581,068	12.2		
Durban-Pietermaritzburg	392,577	8.2	8,339	1.8
Port Elizabeth-Uitenhage	184,566	3.9		
Bloemfontein	65,786	1.4		
Kimberley	57,724	1.2		
Total	3,436,865	71.9	15,858	3.4
2. Upper	504,704	10.6	53,858	11.4
3. Medium				
(a)	63,945	1.3		
(b)	418,294	8.8		
Total	482,239	10.1		
4. Medium				
(a)	31,199	0.7	401,733	85.2
(b)	115,063	2.4		
Total	146,262	3.1		
5. Low	211,713	4.4		
South Africa	4,781,783	100.0	471,445	100.0

1) Table taken from Board, Davies and Fair (1970)



10 SOCIO–ECONOMIC SURFACES OF SOUTH AFRICA, 1960.

Surface 1 combines high levels of volume and welfare and demonstrates the concentration of the economy upon the metropolitan, industrial and mining areas which constitute 72 per cent of the gross domestic product of South Africa. [Table 11] The heaviest concentration occurs in the north-east of the country where the Southern Transvaal and its environs account for 45 per cent of the total G.D.P. A further 24 per cent is contributed by the three coastal areas of Cape Town, Port Elizabeth-Uitenhage, Durban-Pietermaritzburg and their environs.

Surface 2 with moderately high levels is circumferential about surface 1 and occurs in belts between the summits of the space economy, notably between the Southern Transvaal and Durban, on the one hand and along the Cape south coast on the other. Surfaces 1 and 2 together account for over 82 per cent of the country's G.D.P. but occupy only 15 per cent of its area.

Surfaces 3 and 4 with moderate levels occupy most of the rural area occupied by Whites. In the pastoral west, dry and sparsely occupied, economic welfare per head is relatively high (in terms of total population) compared to the moister, more intensively worked but more densely settled east where high African population totals with a relatively high degree of under-employment account for moderate levels of productivity per head. The two surfaces account for 13 per cent of the total G.D.P.

Surface 5 represents the "valleys" of the economic landscape and generated only 4 per cent of the total G.D.P. in 1960. It is largely coincident with the horseshoe of under-developed African reserves extending from the Ciskei in the south-east, through the Transkei, Natal, northern and north-western Transvaal, to the northern Cape Province.

The surface also includes large tracts of the eastern Cape Province and southern Orange Free State in areas which experience problem orientated transitional environments.

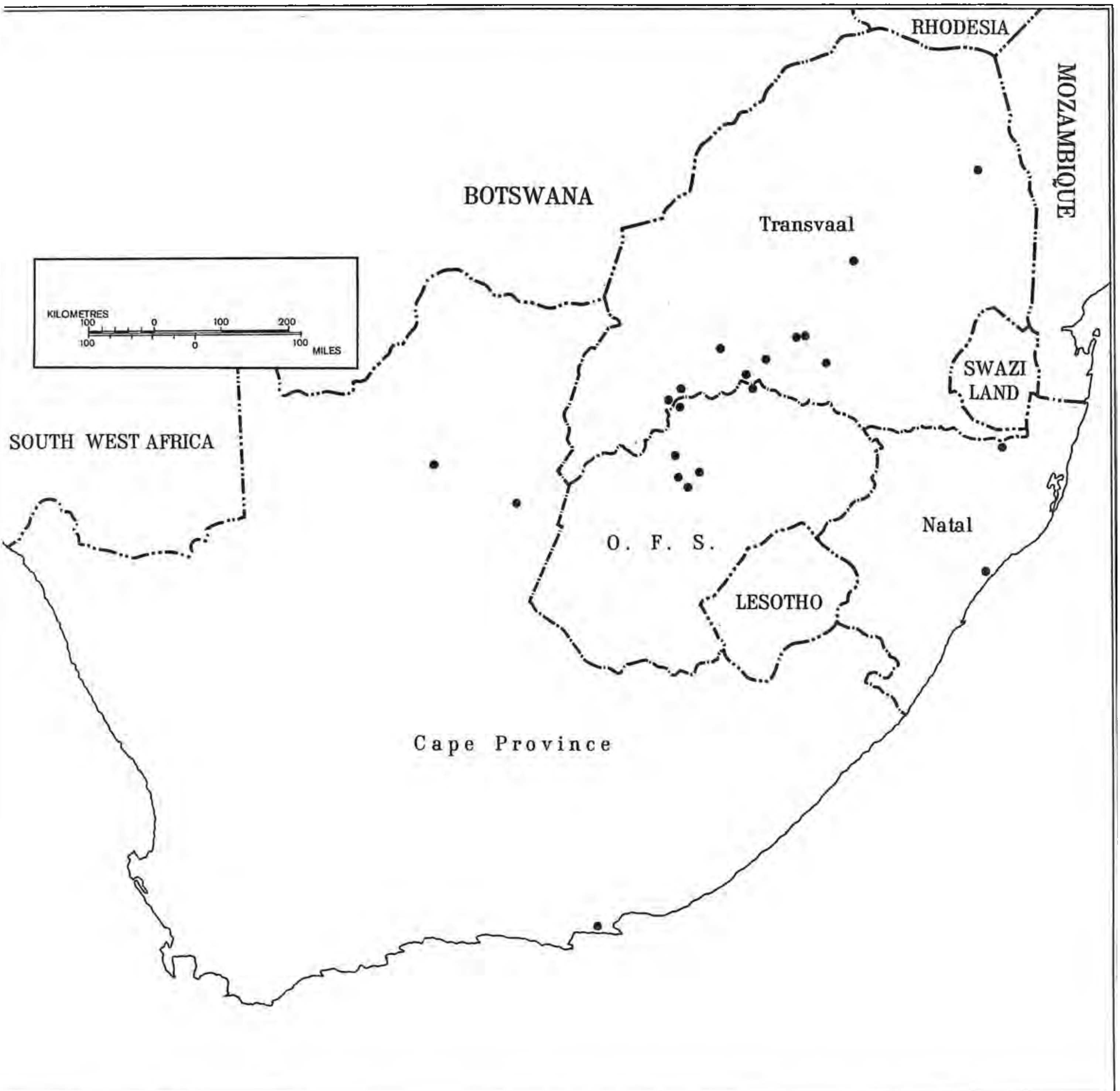
Between 1936 and 1960 the total population of South Africa increased from 9,588,000 persons to 16,000,000 in 1960.[Table 4] This increase represents a growth of approximately 67 per cent in the period compared to 60 per cent in the period 1911-1936. In the same period the White population increased from 1.3 million to 3 million, and the non-White population from 4.7 million to nearly 13 million of which Africans totalled 10.9 million.

In the industrial stage the proportion of the population which was urban rose from 33 per cent in 1936 to 47 per cent in 1960. [Table 5] It is estimated that the present level of urbanisation is probably 50 per cent. During this stage, the level of White urbanisation rose from 67 per cent to 83 per cent; Coloureds from 57 per cent to 68 per cent; Asiatics from 70 per cent to 83 per cent, and Africans from 19 per cent to 32 per cent. The growth pattern of the urban population in the industrial stage represents a continuation of the growth pattern initiated in the late transition phase. The rate of urbanisation remained remarkably constant in the two periods. [Figure 6] This is probably explained by the waning influence of mining as an urbanising force, and the development of industry as the principal urbanising force in the industrial stage. It is generally agreed by research workers that employment in mining has become stabilised and that growth of employment in non-agricultural activities will in future depend on the growth of manufacturing industry and tertiary activity.

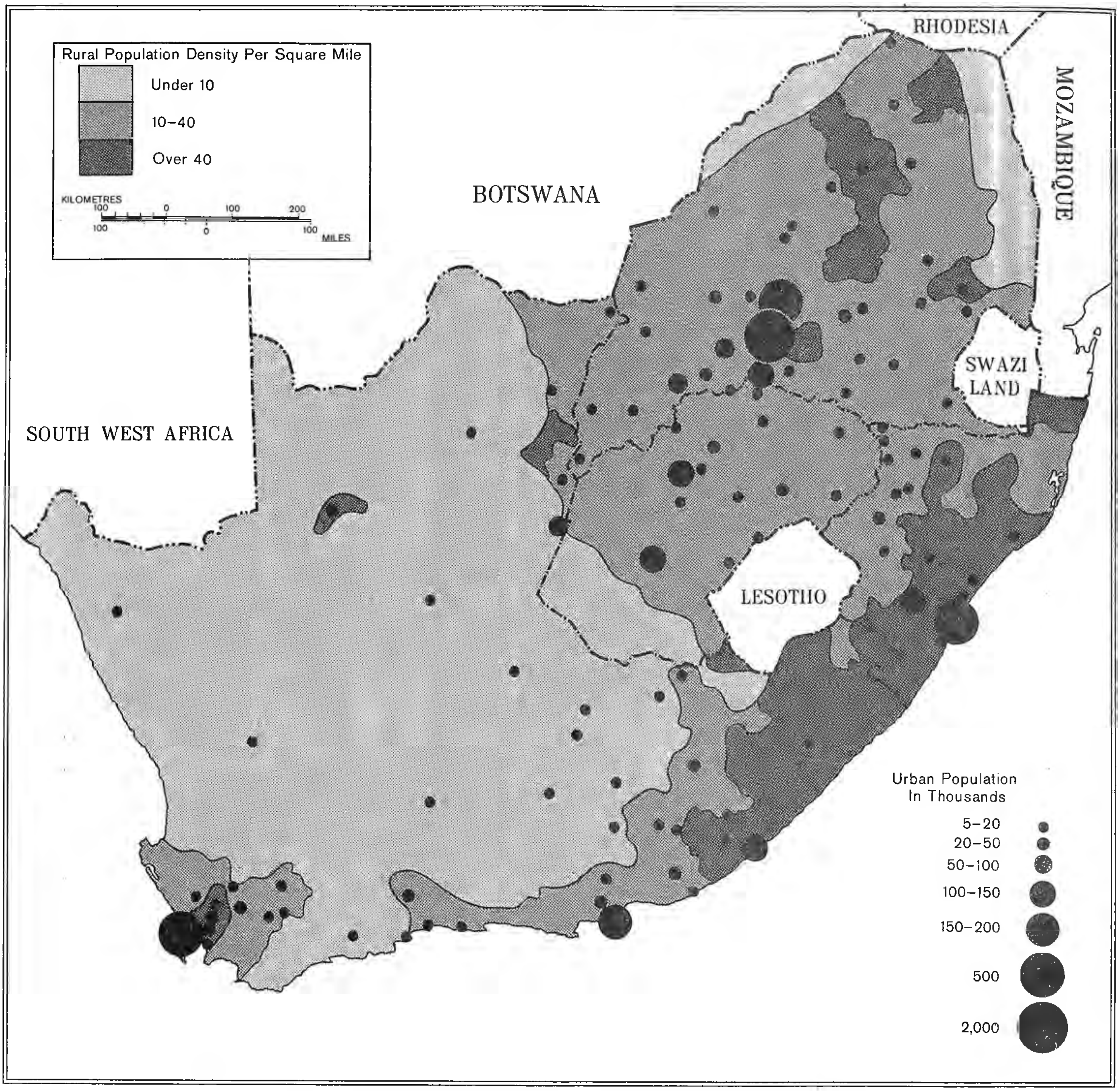
Throughout the late transition phase and the industrial stage the rate of urbanisation of the non-White population groups has been somewhat higher than that of the White population. Of all race groups, however, the rate of urbanisation of the Africans has been highest, and in the industrial stage since 1936, the African urban population has grown at an accelerated rate. African rural-urban migration has been subject to restrictive influences, more particularly since 1948 and it is probable that, under unrestricted forces, the rate of urbanisation of the African population would have been even higher than it has been.

The higher rates of urbanisation of the non-White population groups have resulted in a continuation of the trend established in the transition phase for the proportion of Whites in the urban population to drop as that of the non-White population increases [Table 6] Thus, between 1936 and 1960 the proportion of Whites in the urban population dropped from 43 per cent to 35 per cent, and that of non-Whites increased from 57 per cent to 66 per cent. The proportion of Coloureds and Indians in the urban population has remained relatively constant, but with an accelerated growth rate. The proportion of the Bantu population has increased from 39 per cent to 47 per cent.

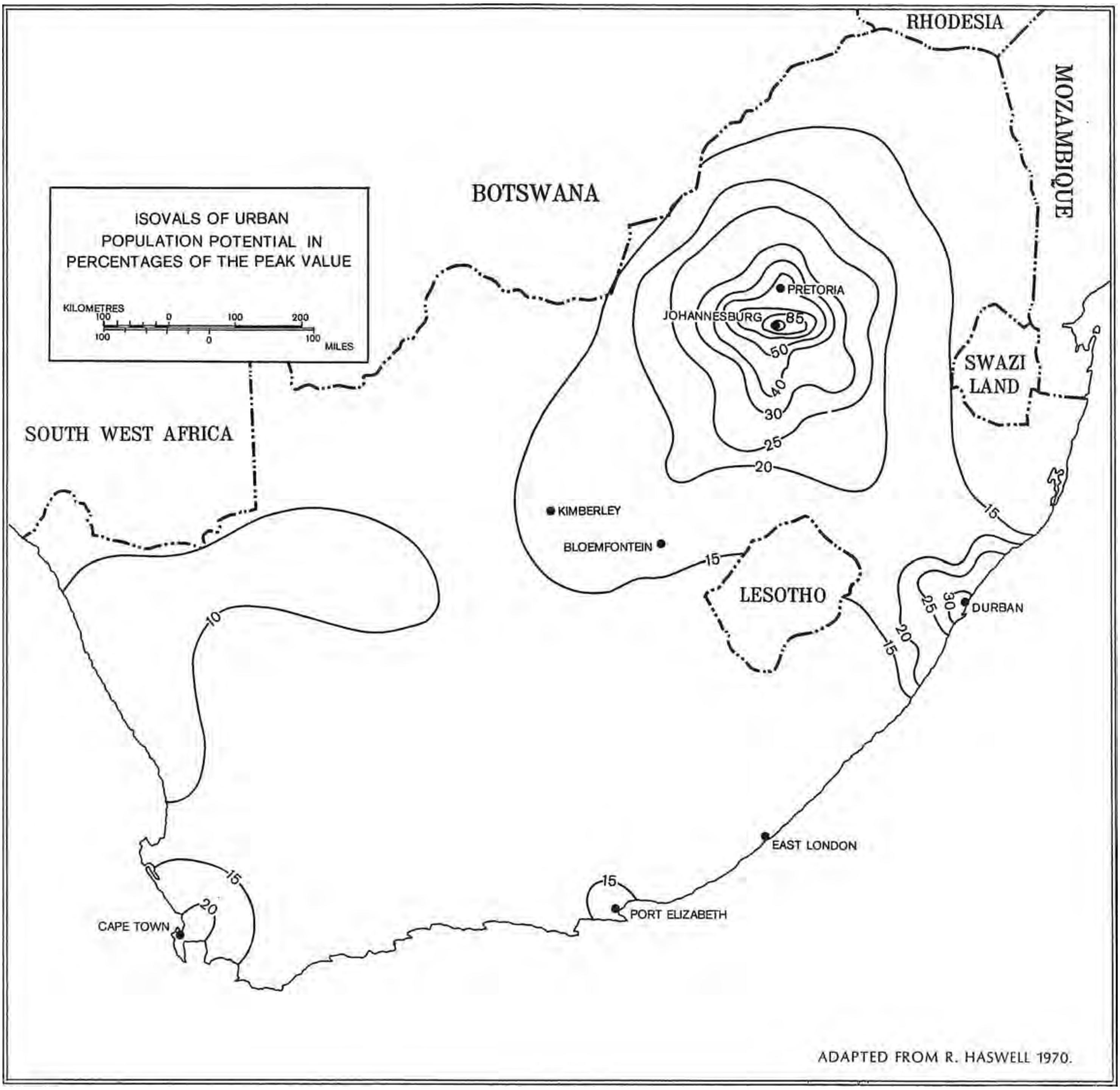
The number of new urban places established in the industrial phase was small. [Figures 9 and 11 and Table 2] Between 1933 and 1960 only 20 places were established mainly as new industrial centres, resource outposts, and resorts.



11 CITIES ESTABLISHED POST c 1933.



12a DISTRIBUTION OF RURAL AND URBAN POPULATION 1960.



12b URBAN POPULATION POTENTIAL 1960.

For the most part, therefore, the growth of urban population has been associated with growth of urban places in existence by 1936.[1] The majority of new places established since 1936 lie within the Johannesburg and Durban city sub-systems.

Whereas in 1904 no cities in South Africa had a population of more than 500,000 persons, 3 cities (Johannesburg, Cape Town and Durban) had populations of this size in 1960. [Figure 12 and Tables 8 and 9] The number of cities with more than 100,000 persons on the other hand, increased from 2 in 1904 to 6 in 1960, and those with more than 20,000 from 8 to 27.

While the increase in the number of cities with more than 20,000 persons gives an indication of the trend towards the growth of larger cities in South Africa, the percentage of the population resident in cities by size is more revealing. In 1904, 96 per cent of all urban places had populations of less than 20,000. In that year, however, 57 per cent of the total urban population was resident in cities with more than 20,000. By 1936 when the number of cities with less than 20,000 persons still remained at 96 per cent of the total, cities with more than 20,000 people contained 68 per cent of the total urban population. By 1960 the proportion of cities with populations of less than 20,000 persons had dropped slightly to 93 per cent, but cities with more than 20,000 contained 76 per cent of the total urban population.

In the case of cities with more than 100,000 persons, less than 1 per cent of the cities in 1904 were of that size but they contained 28 per cent of the urban population. The respective proportions increased to 1 per cent of the cities by 1960 containing 56 per cent of the total urban population. The trend towards large city development is perhaps most strongly revealed by the growth of very large cities with populations of more than 500,000 persons. No cities of this rank existed in 1904 but by 1936 17 per cent of the urban population lived in Johannesburg, the only city of its kind, and by 1960 three cities - Johannesburg, Cape Town and

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1) An alternate measure of the absolute growth in the number of urban places, as officially defined for statistical purposes, shows that the total number of cities grew from 262 places in 1904 to 494 places in 1936 and to 604 places in 1960. These values, however, include suburbs of metropolitan cities which have been excluded from the analysis discussed in this chapter.

Durban - together contained 35 per cent of the total urban population.

The most characteristic feature of urbanisation in the industrial stage, therefore, has been the growth of large metropolitan concentrations which are, as shown above, the poles about which the economy is distributed. The characteristics and structure of the contemporary city system will be discussed in chapters which follow.

CHAPTER 2

IDENTITY OF THE CITY SYSTEM

C H A P T E R 2.

IDENTITY OF THE CITY SYSTEM

In the previous chapter the forces which have underlain the process of urbanisation, and the evolution of the South African city system, were discussed within a broad socio-economic framework. It is now necessary to define more clearly the nature of the contemporary city system before undertaking detailed analyses of its structure.

A system is generally understood to be a complex whole or a set of connected things or parts, or a group of objects related or interacting so as to form a unity. Thus the first step in defining a system is to identify its parts on the one hand, and the connections between the parts on the other. Here we are concerned with a city system in which the parts are defined as the urban nodes or cities, while the connections consist of networks and flows of transportation, communications, capital , migration and so on, which link the nodes into a system.

The review of the historical background to urban development in South Africa has shown that in the pre-industrial and earlier phases of transition, city development was associated with the evolution of regional economies each with its own separate networks of transport and communication, orientated about the coastal ports which were the foci of the most intensive development. Political disunity, furthermore, hindered spatial economic integration.

The discovery of diamonds at Kimberley in the late 1860's and subsequently the gold discoveries of the Witwatersrand, led to a re-orientation of networks of transport and communication, with the development of new foci in the interior. The rapid expansion of the economy which affected most parts of the territories of South Africa, and the establishment of the Union of South Africa rapidly changed the organisational structure of the country, and permitted a steady increase in the level of national economic integration. While regional consciousness and organisational patterns of the past persist in varying degrees in the present-day patterns of development, the economy of South Africa may be considered to be an integrated whole - in other words, a national system for which the cities provide the organisational foci. Notwithstanding the difference in economic level between the White and Bantu held areas of South Africa, large scale flows of labour, money, goods and services have effectively integrated the Bantu reserves into the national economy.

Movement of non-Whites into the South African economy has been such that 80 per cent of the labour force is non-White, mainly in semi-skilled and unskilled work. An over-generalised dichotomy of a modern exchange economy on the one hand and a subsistence economy on the other is scientifically unacceptable. The urban nodes of the Bantu reserves are consequently included here as part of the national city system. Differences in level of development, it will be shown, have however, a marked influence on the structure and distribution of the city system.

Evidence of the existence of the city system, its attributes and characteristics, more particularly in terms of hierarchical structures normally associated with integrated systems, and the identity of its spatial orientation, will be sought in this and succeeding chapters. In this chapter attention will be drawn to the pattern of linkage which provides the identity of the system. The analysis, furthermore, will provide evidence for the recognition of different levels of linkage, and for the identification of nested sub-systems within the national city system. The hierarchical networks of linkage will in turn anticipate hierarchical structures within the set of nodes which form the parts of the system.

Evidence of multi-dimensional functional contacts between nodes in a system may be sought in a wide variety of network and flow patterns. Inter-city telephone flows, however, are accepted as one of the best single indices of connectivity. For this reason particular attention will be paid to the pattern of telephone traffic flow, but confirmatory evidence will be presented in an examination of other forms of network.

The pattern of linkage between nodes is most simply determined by the application of graph theory analysis to the concept of nodal flow developed by Nysteun and Dacey (1961). Graph theory relevant to the analysis of flow data has been fully discussed by Nysteun and Dacey in their study of Washington State, and only the major elements of the methodology need be outlined here.

The data used in the analysis of nodal flow in South Africa is a national sample of inter-city telephone traffic drawn for three days in 1963, and in its raw state constitutes a 270 x 270 adjacency matrix.

The original 270 x 270 adjacency matrix was broken down to a series of seven smaller matrices with a maximum 120 x 120 construct to conform to the capacity of available computer programmes. Interlocking of the matrices to obtain the national nodal structure was ensured by the inclusion of all major cities and all cities in overlap zones between the matrices in each computation. To incorporate direct and indirect associations between cities the power series of the adjacency matrices were computed by normal matrix manipulation in the form:

$$B = Y + Y^2 + Y^3 + \ldots\ldots\ldots\ Y^n.$$

where Y is the adjacency matrix, and B the matrix which evaluates both direct and indirect flows between cities. The nodal structure within the system may then be determined by:

1. Identifying the largest or nodal flow of inter-city telephone calls between city pairs;

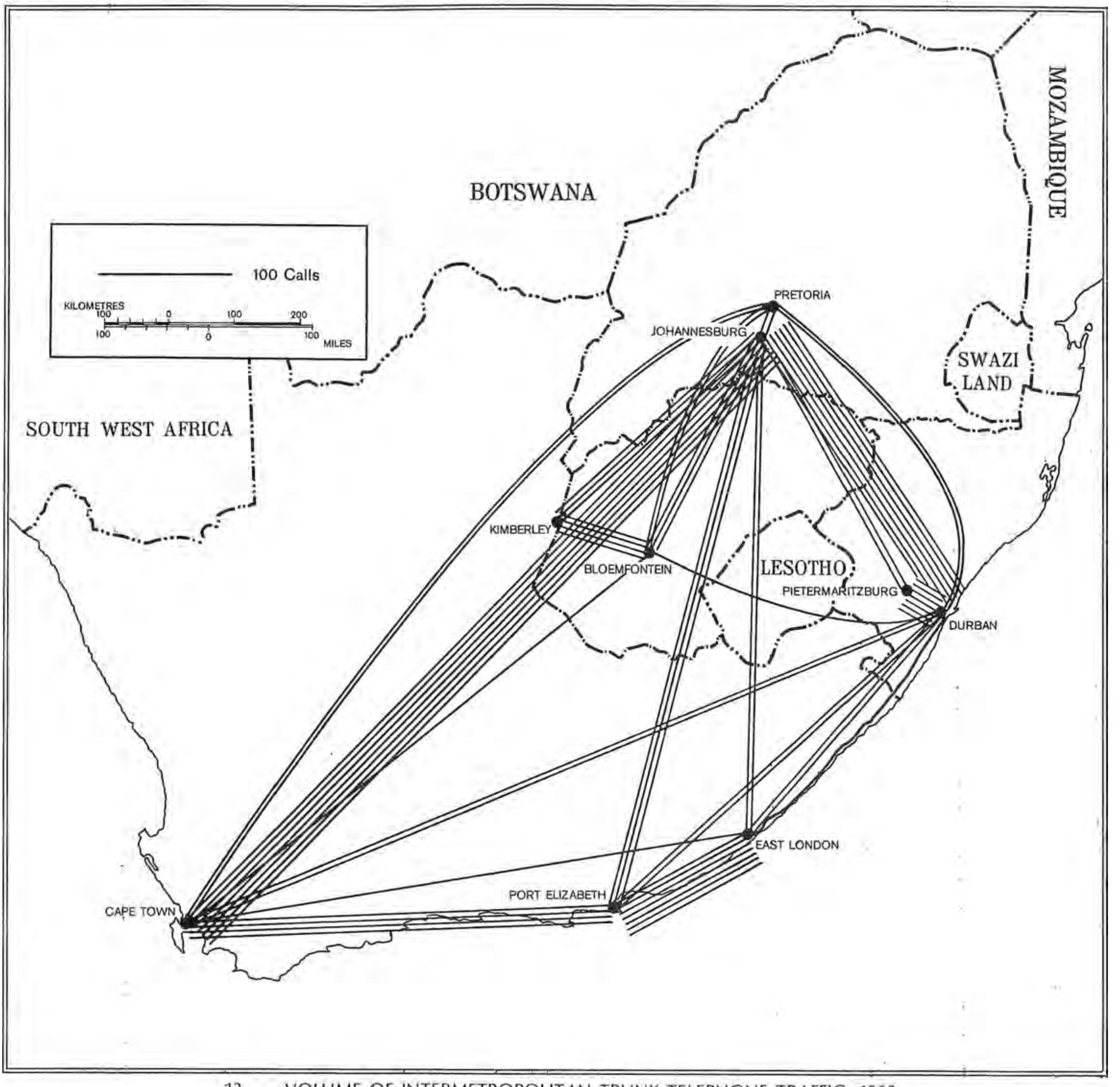
2. Ranking the cities by the total number of incoming calls;

3. Assigning an orientation from cities with smaller total associations to one with larger total associations;

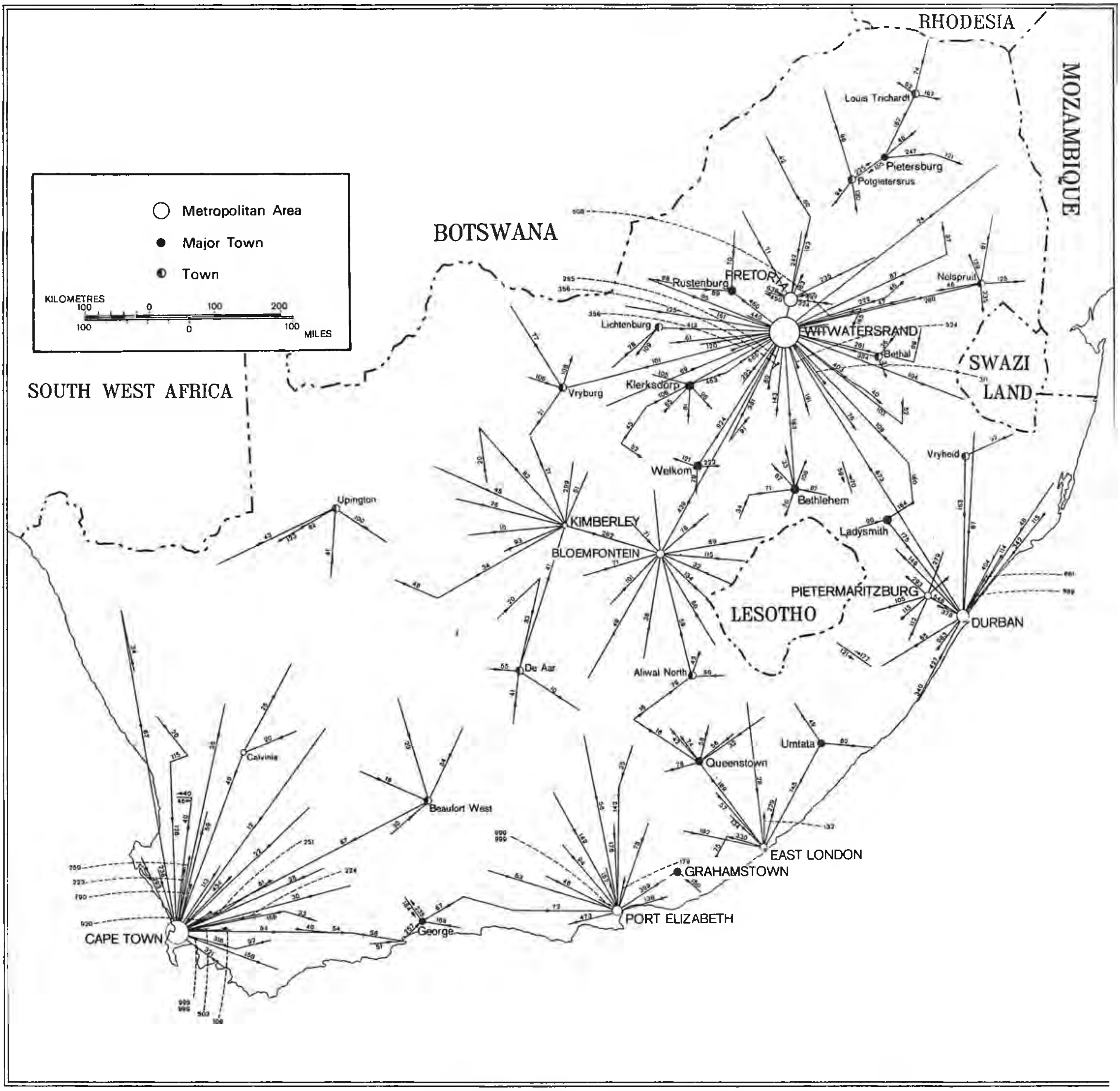
4. Identifying non-orientated cities as centres of isolated sub-systems.

The associations between nodes are derived from an analysis of matrix B and may be considered at two levels - nodal flows which identify a high level or national system of linkage on the one hand, and those which identify sub-systems on the other. The first level of measurement takes into account inter-metropolitan flows between the 9 largest metropolitan cities in the country (the Witwatersrand is regarded as a single functional unit in the analysis). The second level, or sub-national level of analysis takes into account all cities in the sample. [Figures 13 and 14].

The pattern of inter-metropolitan nodal flow identifies the Witwatersrand as the principal national terminal within the system, and the focus of centripetal nodal flows which integrate the cities of Durban, Pietermaritzburg, Pretoria, Bloemfontein and Kimberley with the national focus. Inter-metropolitan nodal flow also links Cape Town into the national system. The nodal flows between Durban and the Witwatersrand and Cape Town and the Witwatersrand show that interaction is greatest between the dominant national core and the two major coastal cities of Durban and Cape Town. Port Elizabeth and East London, on the other hand, are less well integrated at the national level, and are isolated in a secondary or peripheral nodal system in which Port Elizabeth is the terminal.



13 VOLUME OF INTERMETROPOLITAN TRUNK TELEPHONE TRAFFIC, 1963.



14 NODAL FLOW OF TELEPHONE TRAFFIC, 1963.

At the sub-national level of analysis in which all cities in the sample are included, metropolitan centres in the national system of linkages tend to become the foci of individual sub-systems. Cape Town, Port Elizabeth and East London are the terminals of a regional sub-system in the western Cape, eastern Cape and Border. In the north of the country, however, the Witwatersrand is the terminal for a complex system comprised of a composite and integrated set of sub-systems which individually focus upon Durban, Pretoria, Bloemfontein and Kimberley, with Klerksdorp emerging as an interesting independent 'inlier'. The evidence points to a high level of integration within the city system in the north of the country, focussed upon the Witwatersrand and transcending purely regional boundaries. In the Cape Province, on the other hand, the existence of independent sub-systems suggests the survival of regionally-orientated economies.

Marginal location on the peripheries of the city system give rise to independent sub-systems focussed upon George, Upington and Pietersburg as terminal centres. The frequency of telephone traffic next in importance to the nodal flows, however, shows that these sub-systems may be linked to neighbouring systems focussed upon metropolitan cities. Thus Upington may be linked to the Kimberley sub-system, George to the Cape Town sub-system, and Pietersburg to the Pretoria sub-system.

The integration of the city system is shown, furthermore, by the existence of lower order nested sub-systems focussed upon dependent places within metropolitan sub-systems or upon terminal places in isolated lower-order systems. The foci of dependent lower-order sub-systems are cities located mainly in peripheral localities where they enjoy competitive advantages with the metropolitan foci. Cities such as Nelspruit, Bethlehem, Welkom and Lichtenburg in the Johannesburg and Pretoria city sub-systems, Pietermaritzburg, Ladysmith and Vryheid in the Durban sub-system, Queenstown and Umtata in the East London sub-system, Aliwal North and De Aar in the Bloemfontein and Kimberley sub-system, and Beaufort West and Calvinia in the Cape Town sub-system are cases in point.

In all, 18 dependent nested lower-order sub-systems may be identified. Twelve of these are located within the Johannesburg, Pretoria and Durban sub-systems. More than 50 per cent of urban places sampled within these sub-systems form a part of one of the lower-order nested sub-systems. The finding suggests that within the three city sub-systems the level of integration is high and that it is more strongly hierarchically organised than in other city sub-systems. Thus the pattern of inter-city associations in the city sub-system of Cape Town, Port Elizabeth, East London, Kimberley and Bloemfontein tend to be more highly focussed upon the metropolitan cities, and hierarchically-organised associations are less well developed.

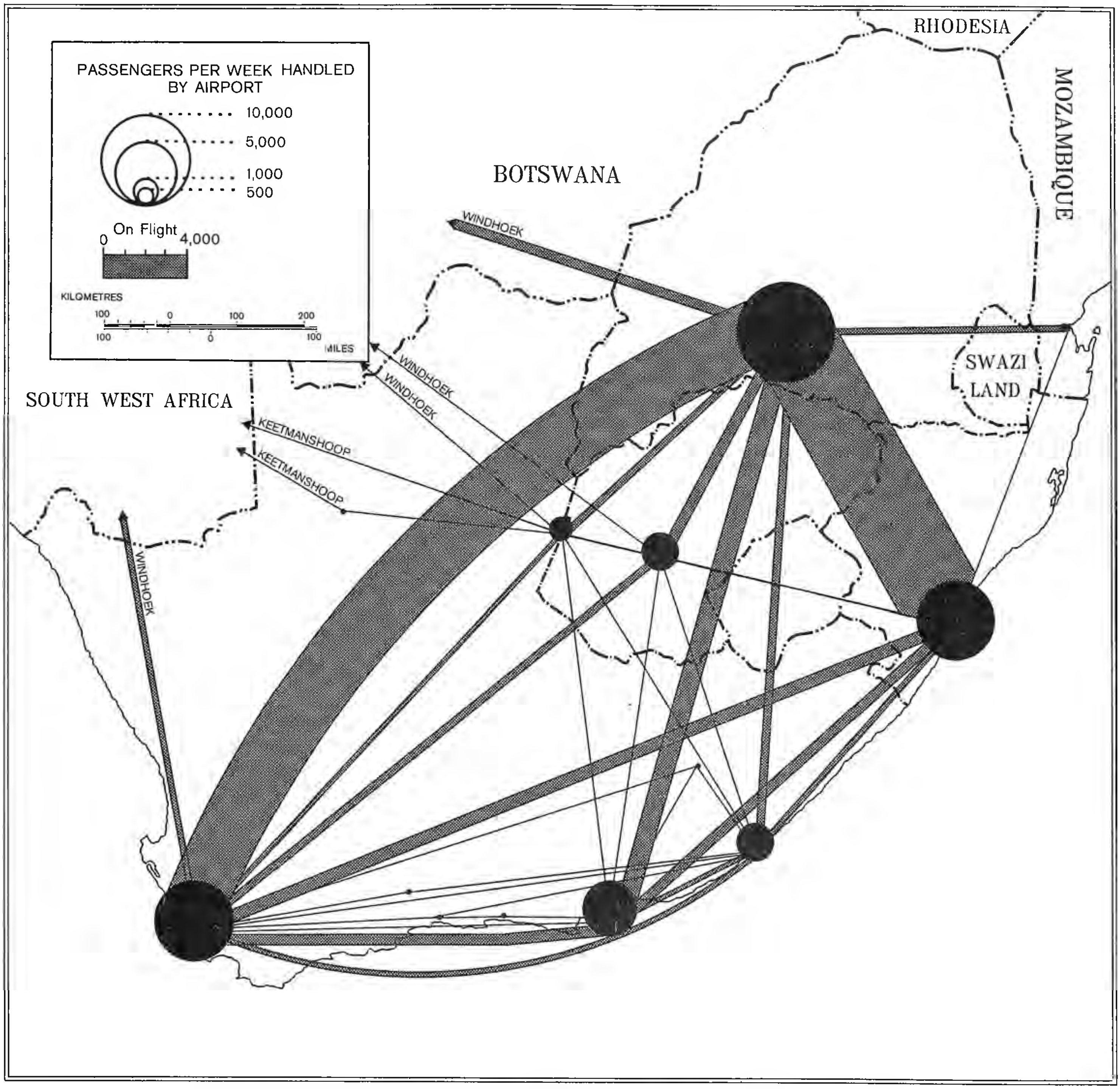
Evidence of a national system of linkages is given also by the movement of passengers on the domestic airline. [Figure 15]. Two routes stand out above all others: the Johannesburg to Durban, and the Johannesburg to Cape Town axes. The apices of this system, which repeat the pattern of inter-metropolitan nodal flow of telephone traffic, handled over three-quarters of the inland air passengers in 1965. Less important connections follow the coast from Durban to Cape Town, some including the intermediate centres of East London and Port Elizabeth.

Rail freight movements and the national road network confirm the importance of the radial flows between Johannesburg and the ports of Cape Town and Durban. [Figures 16 and 17]. In addition, they show that significant flows exist also to Lourenco Marques and Port Elizabeth, and to a somewhat lower degree to East London. The national road system, developed since 1936, today provides a relatively higher degree of connectivity at the national level than does the rail system, more particularly between centres located on the coastal margin.

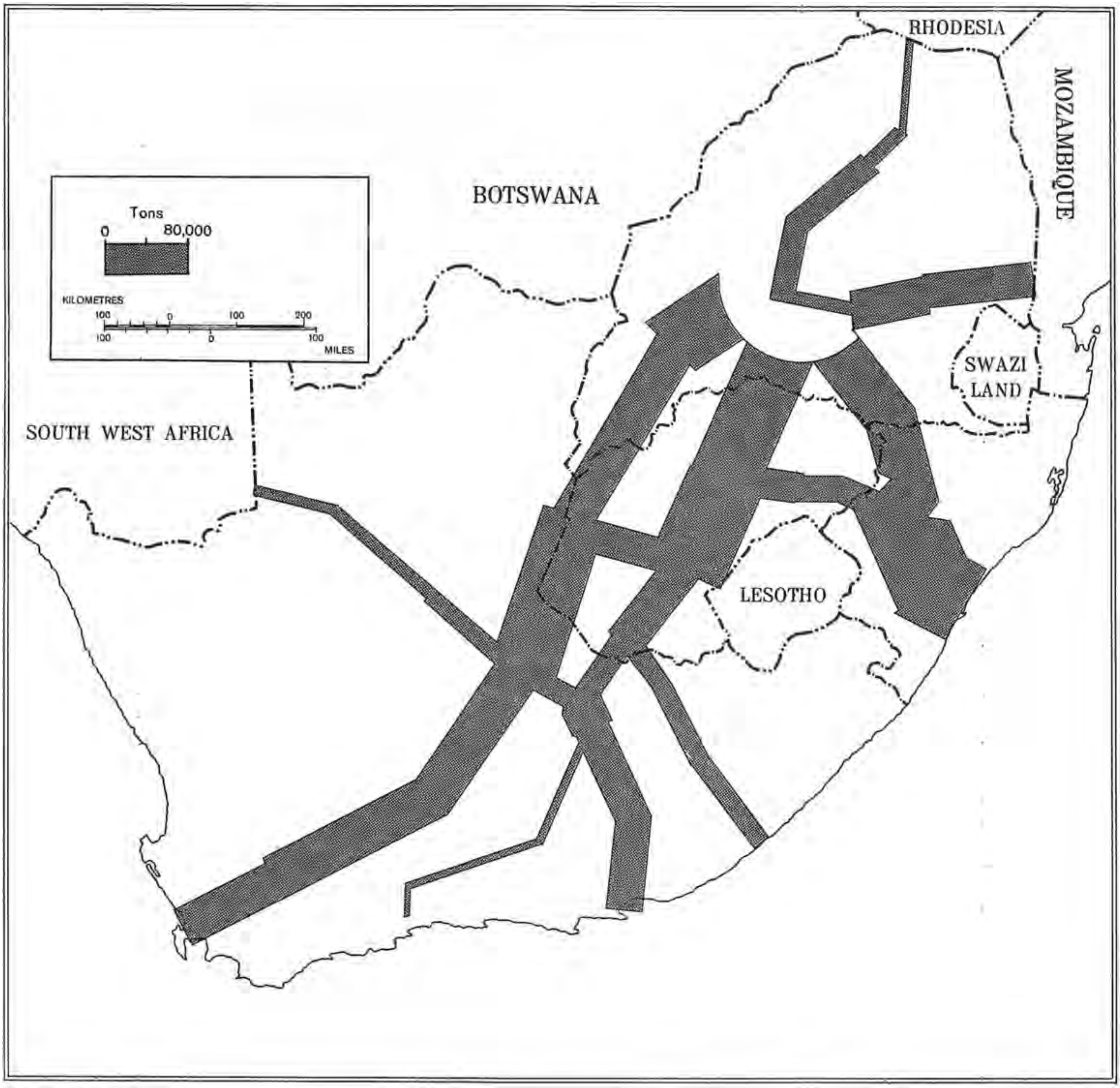
At the sub-national level patterns of road traffic volume and newspaper circulation confirm the structure of city sub-systems focussed upon metropolitan centres. [Figure 18]. In the north of the country road traffic flows, like the nodal flow of telephone traffic, reveal a high level of integration of the set of sub-systems which focus on Johannesburg, Durban, Pretoria, Bloemfontein and Kimberley. Johannesburg emerges as the organising focus of the integrated set of sub-systems.

To sum up, the evolution of networks of transportation and communication in South Africa, more particularly since the late transition stage of development has provided the basis for the development of an integrated national city system which has grown out of a set of semi-independent systems formerly weakly linked.

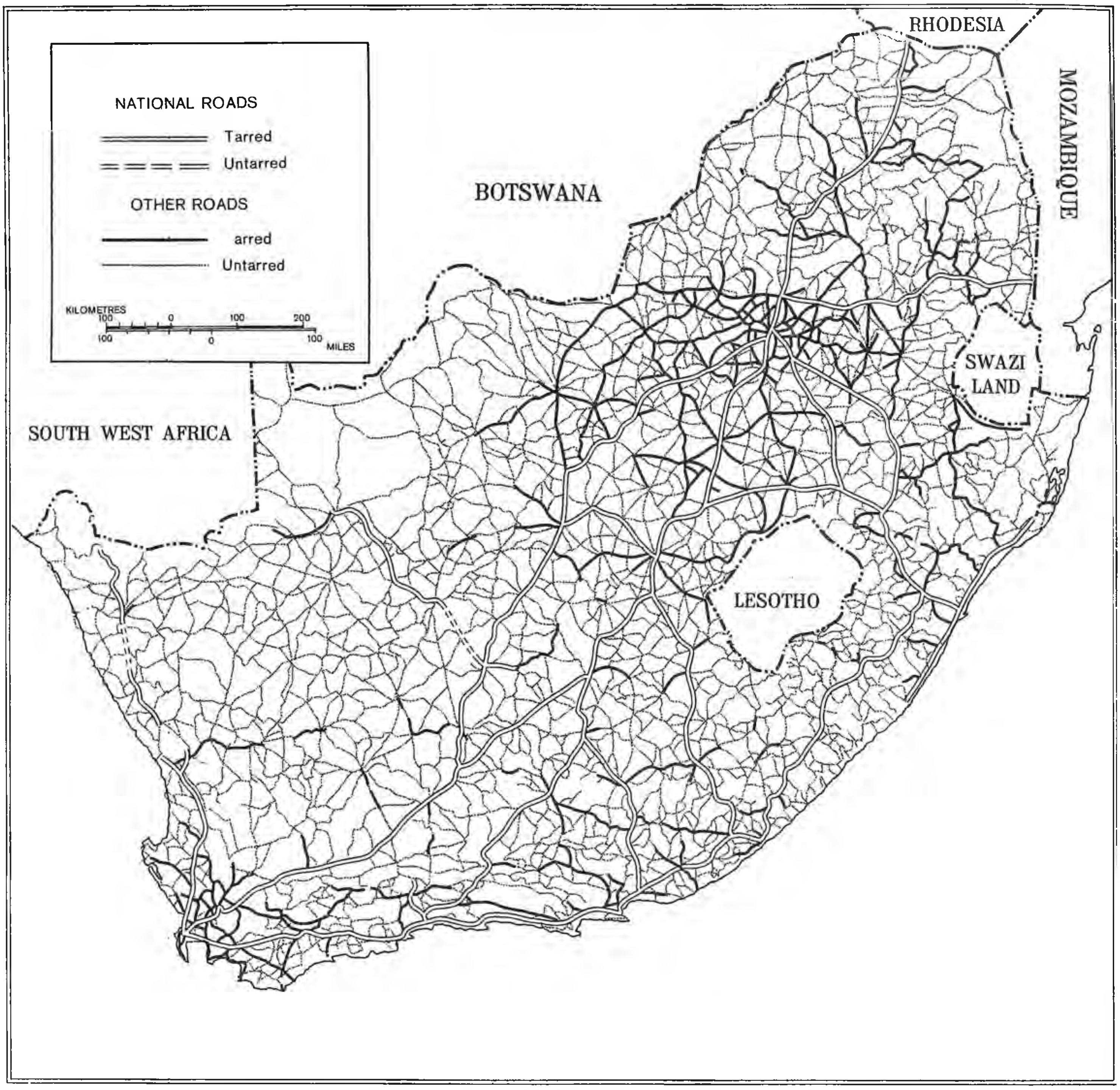
The city system is organised about its metropolitan nodes, one of which dominates the others. A composite picture of inter-metropolitan telephone nodal flow, air passenger traffic and rail freight flows, shows that interaction is greatest between the dominant national focus of the Witwatersrand and the major coastal nodes, Durban and Cape Town. Interaction between other metropolitan centres and the national focus is relatively less well developed.



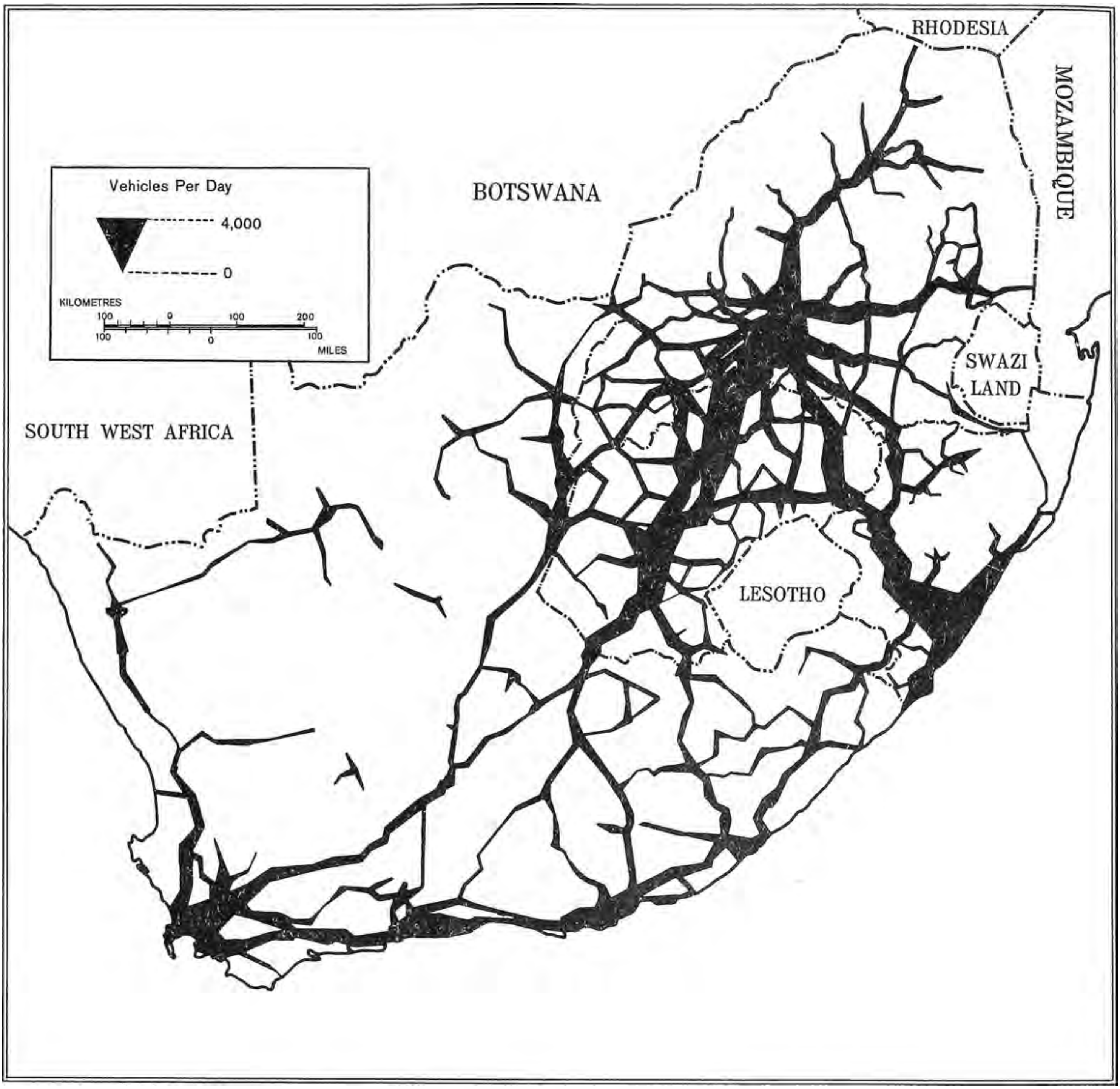
15 PASSENGER TRAFFIC ON SOUTH AFRICAN AIRWAYS DOMESTIC ROUTES, 1966.



16 VOLUME OF RAIL FREIGHT ON MAIN RAIL LINES, 1965.



17 ROAD PATTERN OF SOUTH AFRICA, 1963.



18 ROAD TRAFFIC VOLUME, 1965 – 1967.

In the light of telephone traffic nodal flow and newspaper circulation, each metropolitan focus plays a significant part in organising regional city sub-systems. Thus three distinct city sub-regions are organised about Cape Town, Port Elizabeth and East London. The dominance of the national focus on the Witwatersrand, however, is such that it draws into its sphere of organisation a system of sub-systems covering the northern two-thirds of the country and including the sub-systems focussed individually upon Durban, Pretoria, Bloemfontein and Kimberley. This group of inter-connected sub-systems may be defined as the Principal Sub-system.

The organisational structure of the city system provides a useful framework within which characteristics of the system and its sub-systems may be analysed in the chapters which follow. Furthermore, since a city system of inter-connected nodes displays major elements of the organisational framework of the total economic system of which it is a part, the analysis is useful as a basis for the logical expansion of the study into an analysis of the national space economy. Such a study has been taken up elsewhere by Board, Davies and Fair (1970)[1]

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1) See: Board, C., Davies, R.J., and Fair, T.J.D. The Structure of the South African Space Economy. Regional Studies, Vol. 4., p.367-392, 1970

CHAPTER 3

SIZE RELATIONSHIPS WITHIN THE CITY SYSTEM

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SIZE RELATIONSHIPS WITHIN THE CITY SYSTEM

At the world scale, in a single country or in an individual region, there will generally be relatively few large cities, a greater number of medium-sized places and many smaller cities. On the basis of empirical observation the statistical relationship between cities of different sizes in a city system is normally expressed in the rank size rule. The first researcher to observe this statistical regularity in the distribution of city sizes was Auerbach (1913). Zipf (1941) first enunciated the rank size rule which states that if the cities of a country are arrayed in order of size the second largest city will have about half the population of the largest city, the third city about a third of the population of the largest city, and so on.

The rule may be stated as: $P_i = P_1 \times r^{-q}$ where P_1 is the population of the largest city, P_i the population of the ith city in a series 1, 2, 3 - - - to i, r is the rank of the ith city and q is a constant. In the special case expressed by the rule the value of q is unity and represents the ideal slope of a line joining cities of various sizes arrayed in rank order on double logarithmic paper. Thus, according to the rank-size rule, the population of a city multiplied by its rank $(p_i.r)$ should approximate the population of the largest city.

As noted by Harris (1970), the rank size rule is not a law of necessary behaviour, but is a statistical regularity which appears when large numbers of cases are considered. Marshall (1969) has pointed out that Thorndike (1941) and later Berry and Garrison (1958), have suggested that the rank size rule is obscure and seemingly devoid of logical foundation. Stewart (1958) furthermore, has indicated that data on city sizes for certain countries are fitted more closely by an S-shaped curve on logarithmic paper than by a straight line. Berry (1964) in addition has shown that countries with a regular (or log-normal) rank-size distribution of cities do not necessarily have a high level of economic maturity, but Boal and Johnson (1965) have suggested that the rank size pattern might be used as a norm or optimum towards which planning programmes could be directed. Harris (1970) on the other hand, has pointed out that the analysis of rank-size distributions may be a device to suggest interesting intellectual problems in the analysis or urban systems. Irregular slopes, he points out, "either unusually steep ones

> or very gentle ones, pose questions. Answers to such questions may involve consideration of the historical evolution of the cities of an area, the geographical structure of settlement, transportation facilities, territorial division of labour, political and administrative factors in defining areas subordinate to cities, specialised industrial development, and commercial factors in the shaping of tributary areas" (p.132)

He emphasises that the method is suggestive and not definitive, since there are many factors other than mere size which enter into the relationships within city systems.

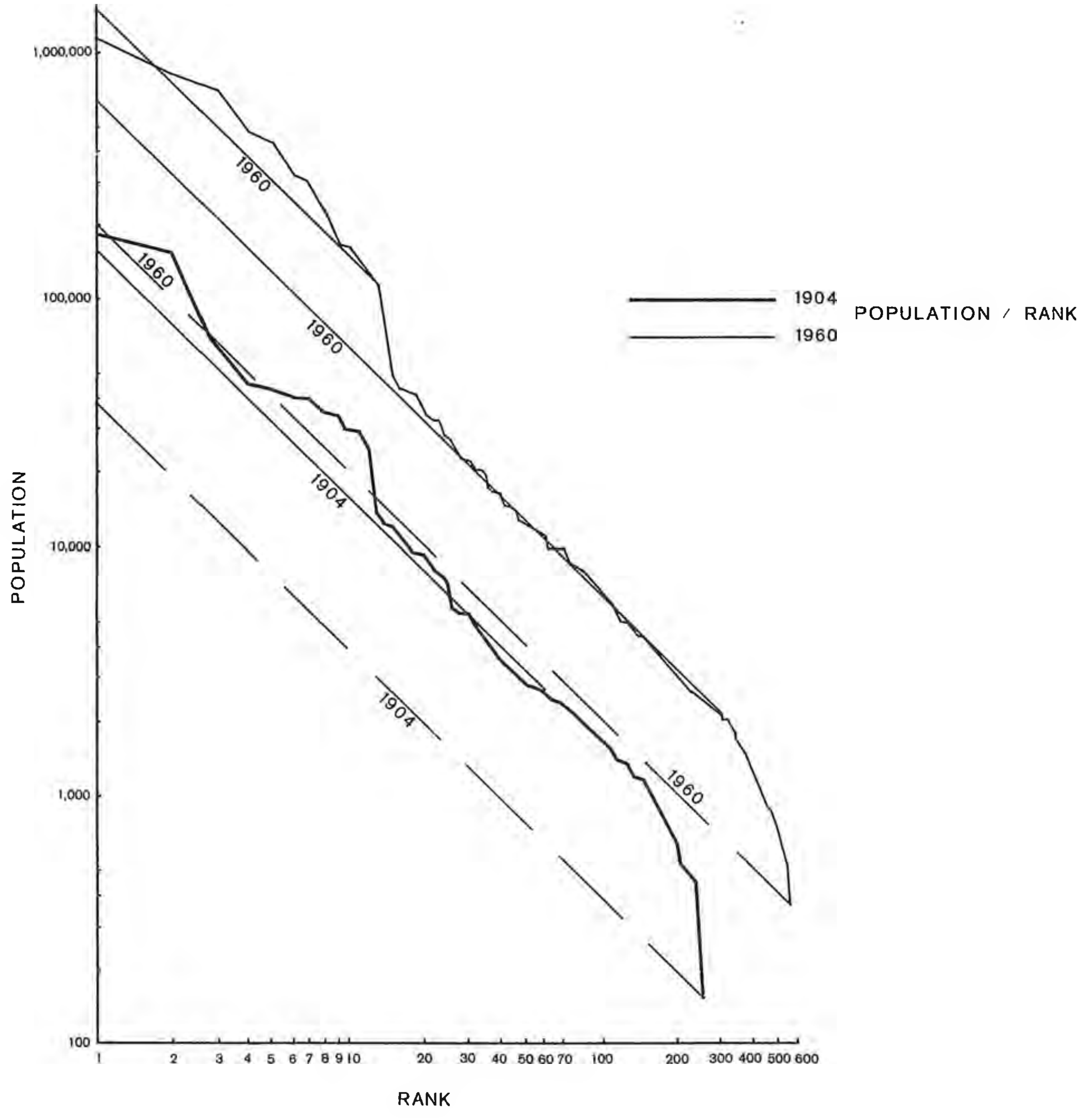
Studies of the rank-size relationship of cities in South Africa have been undertaken for two periods of time, first in 1904 in the late transitional phase of economic development, and secondly in 1960 midway in the industrial phase of growth. The analysis, furthermore, has been undertaken on a national level including all cities within the national system on the one hand, and at a regional level using the framework of city sub-systems identified in the previous chapter, on the other.

THE NATIONAL SYSTEM:

The rank-size curve for 1904 [Figure 19] assumes a form such that the distribution of cities of more than 14,000 persons is irregular and step-like, that the distribution of cities between 1,000 and 14,000 persons is relatively smooth and that the curve for cities below 1,000 is relatively smooth but population drops rapidly with decreasing rank.

The expected rank-size curve where $(q = -1)$, based upon the smallest city in the system, predicts that the population of the largest city should be approximately 38,000 persons. The actual size of Cape Town in 1904 was 188,000 persons. The curve therefore, has no apparent relationship to the actual distribution of cities. Bearing in mind, however, that the population of cities tails off steeply with declining rank after a population of approximately 1,000 a base at that level may result in a more meaningful application of the rule. Using a population of 1,140 for the city ranking 150th, the prediction of the population for the largest city is 171,000 persons. This is a value which approximates closely to the actual population.

Relating the actual distribution to the predicted rank size distribution, using 1,000 persons as a base, suggests that within the size range 1,000 to 14,000 the distribution of cities is approximately that predicted by the rank size rule. Cities larger than 14,000 persons, however, are larger than predicted by the rule, and are distributed in a step-like fashion.



19 RANK – SIZE DISTRIBUTION OF THE NATIONAL CITY SYSTEM, 1904 & 1960.

The pattern is suggestive, on the one hand, of concentration of population within the larger cities, and the existence of several relatively independent regions with limited functional integration on the other. The step below 1,000 persons, furthermore, may suggest that smaller places were incompletely integrated within the system, and were consequently far smaller than expected.

The curve of the distribution of cities in 1960 resembles the distribution in 1904 [Figure 19]. Its form is such that population size drops steeply below the level of 2,000 persons, is relatively smooth between a population of 2,000 and that of 48,000, and is then broken by a steep step between the middle-sized cities and metropolitan cities. Thus, a relatively large step of some 30,000 persons occurs between the largest middle-sized city (Klerksdorp) and the first metropolitan city (Kimberley) with a population of 78,000. Above a population of 78,000 the distribution of metropolitan cities is relatively smooth.

Using the population of the smallest city as a base, the rank size rule predicts the population of the largest city as approximately 200,000 persons. This level is less than one-quarter of the actual size of Johannesburg in 1960. Using a population of 2,000 as a base, however, the expected population of the largest city rises to 642,000. This level is still some 400,000 persons less than the actual population. The expected curve on a base of 2,000, however, conforms closely to the distribution of cities between 2,000 and 48,000 persons which is the level at which a step to the metropolitan cities occurs. A second expected curve based on a population of the smallest metropolitan city (78,000) however, predicts that the largest city will have a population of approximately 1,100,000. This population is only 37,000 persons short of the actual total.

In interpreting the form of the curve two suggestions appear possible:

1. The rank-size distribution of the South African national city system does not conform to the distribution predicted by the rank-size rule, but occupies an intermediate position described by Berry (1961) as nearest rank-size between the limiting cases of primacy and log normality.

2. The step-like formation of the curve between the middle range of cities and metropolitan cities may reflect what Harris (1970) has referred to as residual regionalism or a lack of full spatial integration within the city system. A structure of this type has previously been alluded to in examining connectivity within the national city system.

3. The steep decline of population with rank for cities below 2,000 persons, may suggest that small cities in the system have lost their potential for growth and are of decreasing significance in the urban system.

A primacy index[1)] calculated for the South African city system has a value of 38 per cent (where Johannesburg is taken as the largest city). If the Witwatersrand is defined as the largest unit, the index rises to 53 per cent [Table 9]. The first value is much below the world average of 55 per cent and the second roughly equivalent to the average. South Africa ranks with Italy (32 per cent), Poland (40 per cent), Canada (40 per cent), Spain (40 per cent), and Australia (42 per cent) in terms of its level of national urban primacy.

REGIONAL CITY SUB-SYSTEMS:

The principal city sub-system consisting of the integrated set of sub-systems focussed respectively upon Johannesburg, Pretoria, Durban, Bloemfontein and Kimberley, has a rank size distribution which conforms closely to the national pattern, [Figure 20a.] This is not unexpected since the sub-system contains a considerable proportion of the cities within the national system.

Within the sub-system, Johannesburg, the largest city, was two times its expected size in 1904, and 2.7 times its expected size in 1960. The sub-system has a relatively moderate primacy index of 42 per cent. Like the national system, however, the distribution is headed by the set of metropolitan cities within which

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1) Primacy Index = $\frac{P1}{P4} \times 100$ where $P1$ = population of the largest city and $P4$ is the total population of the four largest cities in the system. After Ginsburg, M. (1961)

economic activity is concentrated, and these are separated from the middle range of cities with populations of less than 43,000 by a step. A rank size distribution based upon a minimum population of 2,000 however, again conforms closely to the distribution of cities between 2,000 and 43,000. The population of cities below 2,000 declines steeply with decreasing rank.

The city sub-systems integrated with the metropolitan cities of Cape Town and Port Elizabeth by comparison are less balanced than the distribution of the principal sub-system. Both sub-systems have a high level of regional primacy (Cape Town 89 per cent and Port Elizabeth 73 per cent) and in both 1904 and 1960 the largest cities of the sub-systems were considerably larger than predicted by a rank size distribution. In the East London sub-system, on the other hand, the primacy index of 63 per cent is intermediate between that of the principal system and those of Port Elizabeth and Cape Town. East London, too, was only 1.3 times the size predicted for 1904 and 2.2 times the size predicted for 1960. [Figure 20 (b,c,d) and Table 9]

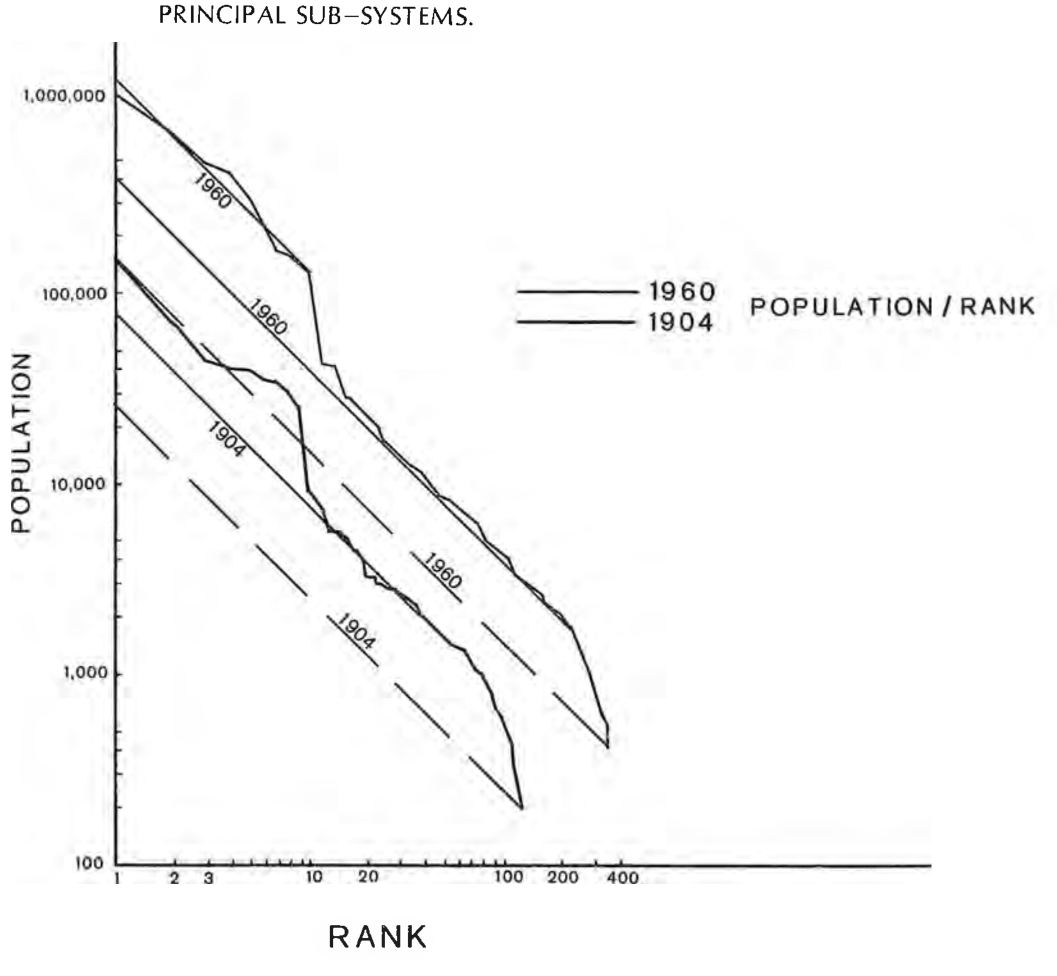
For both the national and regional sub-systems the concentration of population and of economic activity in the principal cities is demonstrated by the increase in the value of the ratio of actual to expected size of the largest city between 1904 and 1960 [Table 12].

TABLE 12

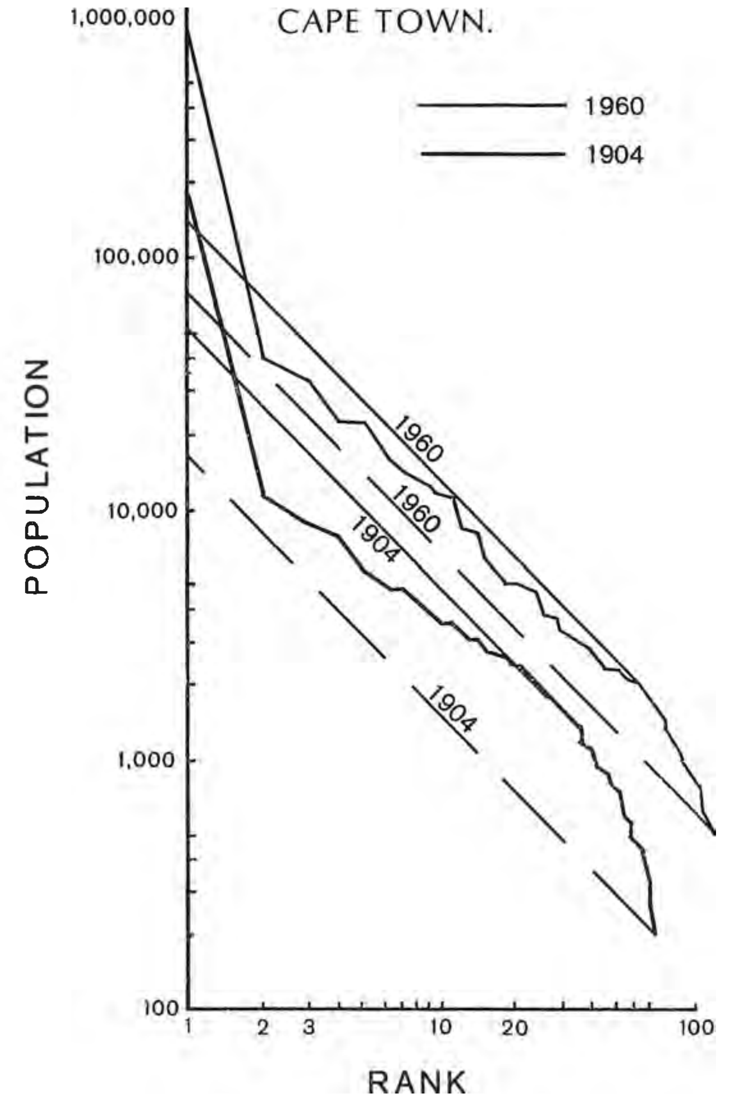
ACTUAL AND EXPECTED SIZE OF LARGEST CITY 1904 AND 1960 BY CITY SUB-SYSTEM

System	*a* Actual 1904	*b* Expected 1904	$\frac{a}{b}$	*c* Actual 1960	*d* Expected 1960	$\frac{c}{d}$
National	189,000	171,000	1.1	1,138,000	642,000	1.8
Cape Town	189,000	48,000	3.9	807,000	123,000	6.6
Port Elizabeth	46,000	22,000	2.1	291,000	54,000	5.4
East London	30,000	23,000	1.3	116,000	53,000	2.2
Principal	156,000	78,000	2.0	1,138,000	420,000	2.7

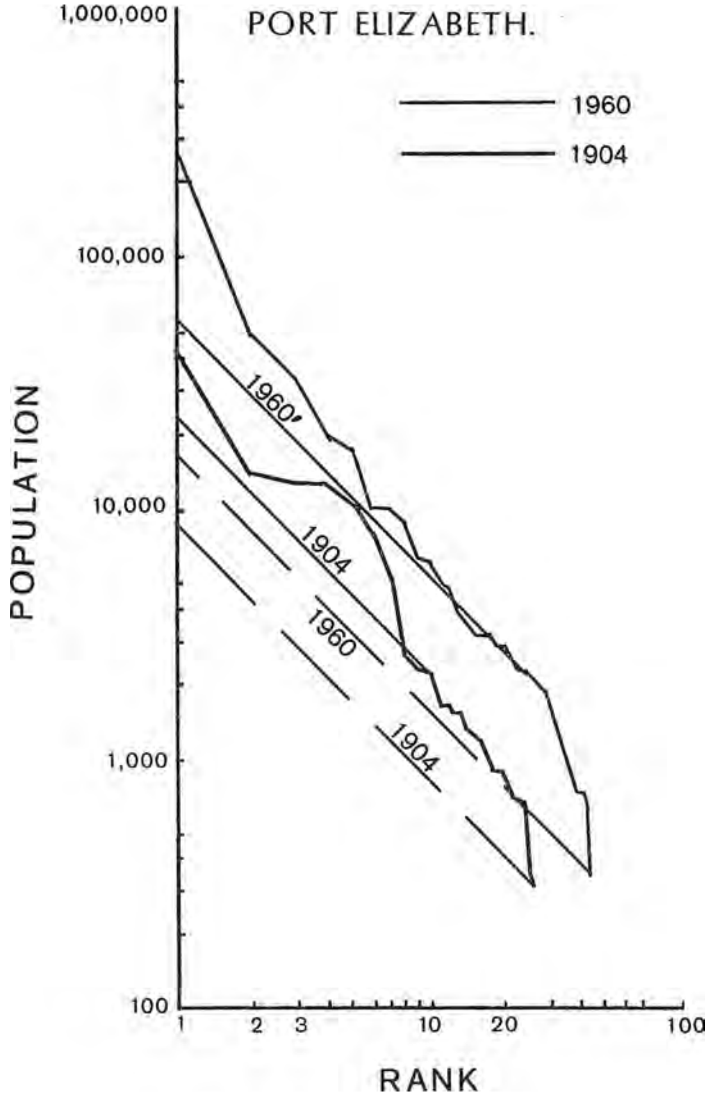
Note: For 1960 Johannesburg is taken as the largest city



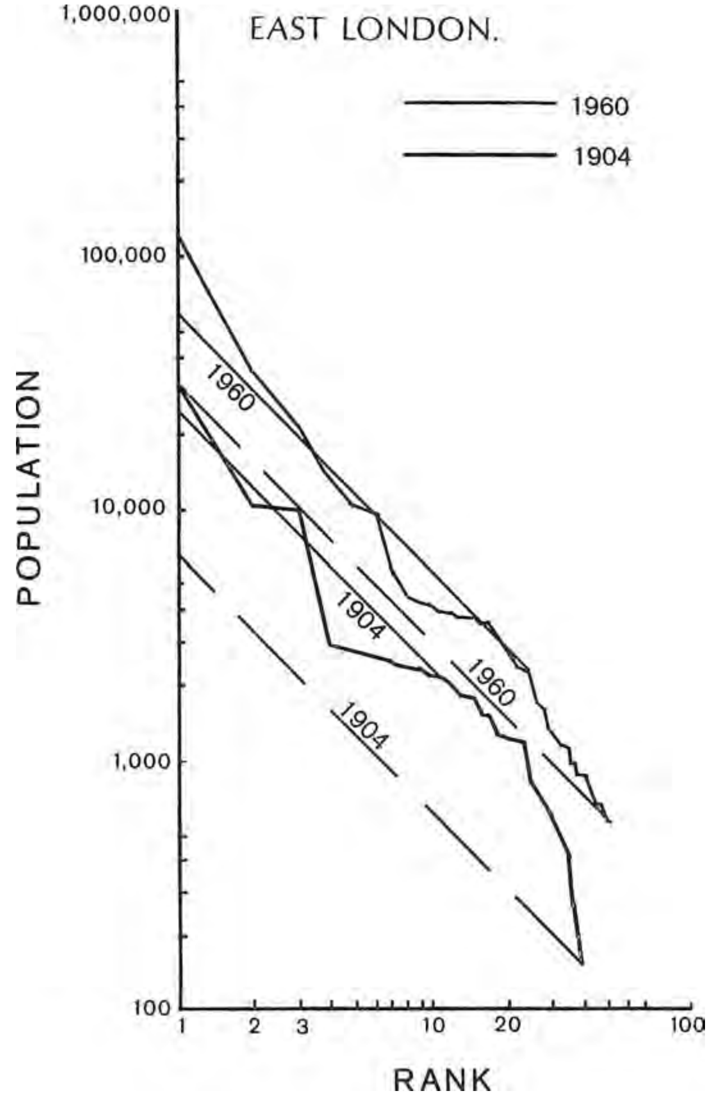
20a. RANK – SIZE DISTRIBUTION OF CITY SUBSYSTEMS 1904 & 1960



20b. RANK – SIZE DISTRIBUTION OF CITY SUBSYSTEMS 1904 & 1960



20c. RANK – SIZE DISTRIBUTION OF CITY SUBSYSTEMS 1904 & 1960



20d RANK – SIZE DISTRIBUTION OF CITY SUBSYSTEMS 1904 & 1960

Like Australia and Canada the South African national urban primacy index and rank-size distribution patterns reflect the development of regional city sub-systems each dominated by a large metropolitan city, which, within its own sub-system, may reflect a high level of regional primacy.

The structure is not incompatible with the framework suggested by Friedmann for the industrial stage of development. In the industrial stage economic activity tends at first to remain concentrated upon a few widely spaced major metropolitan cities which presumably are primate cities within their own nodal regions. The pattern persists until a stage is reached where the economy builds outwards to subordinate cities which then grow relatively more rapidly than the major city and so reduce the level of regional primacy and consequently also that of national primacy. The process is accompanied also by a higher level of integration within the city system.

RANK OVER TIME

The rank-size relationship within the city system may be viewed also in terms of variations in rank over time. The first 25 cities ranked by population size in 1904 together with their corresponding rank in 1960 are plotted in Table 13.

Despite shuffling of the ranks of individual cities in the 54 year period, 16 of the leading cities in 1904 retained rank within the first 25 cities of 1960. These cities have therefore continued to dominate the urban hierarchy and have, as will be shown, evolved in many cases from cities strongly influenced by mining and industrial development in the late transition and industrial stage of growth.

Apart from Kimberley and Grahamstown very little change has taken place in the ranking of the first 10 cities. Kimberley declined relatively because of the reduction in its growth potential after the development of the Witwatersrand, while Grahamstown, along with other cities not influenced by industrial development in the Cape Province, has suffered a strong relative decline in rank.

Rearrangement of rank has also been brought about by the growth of new mining centres, (Welkom, Virginia, Carletonville), the development of mining in older cities (Klerksdorp, Witbank, Nigel) and, by the growth of new industrial complexes such as Vereeniging - Vanderbijlpark.

TABLE 13.

CHANGE IN RANK OF SOUTH AFRICAN CITIES 1904 - 1960

City	Rank in 1904	Rank in 1960	Net Change
Witwatersrand	1	1	0
Cape Town	2	2	0
Durban	3	3	0
Port Elizabeth	4	5	- 1
Kimberley	5	10	- 5
Pretoria	6	4	+ 2
Pietermaritzburg	7	7	0
Bloemfontein	8	6	+ 2
East London	9	8	+ 1
Grahamstown	10	22	- 12
Middleburg (C)	11	71	- 60
Uitenhage	12	13	- 1
Paarl	13	17	- 4
Graaff-Reinet	14	40	- 26
Queenstown	15	21	- 6
King William's Town	16	29	- 13
Potchefstroom	17	16	+ 1
Oudtshoorn	18	32	- 14
Harrismith	19	42	- 23
Worcester	20	23	- 3
Cradock	21	36	- 15
Kroonstad	22	15	+ 7
Jaggersfontein	23	125	- 102
Ladysmith	24	29	- 5
Aliwal North	25	58	- 33

Note: For this table the cities of the Witwatersrand have been grouped together as a single unit. Only the first 25 cities in 1904 have been considered in the table.

Industrial growth in older cities (such as Paarl, Worcester, Uitenhage, Kroonstand and Ladysmith) on the other hand has meant that these cities have experienced only small relative decline in rank. Pietersburg (with a rise in rank) and Queenstown (with a relatively small drop in rank) have grown as regional foci of relatively large service hinterlands.

Cities such as Grahamstown, Graaff-Reinet, Cradock, Oudtshoorn and Harrismith, which formerly ranked high on size have declined sharply in rank. These cities have experienced a relative insufficiency of growth momentum as the major economic growth processes of the industrial stage have passed them by. In these cities mercantile growth processes, more characteristic of the 19th century, have persisted. This characteristic is consistent, more particularly for the cities of the eastern Cape province, with the shift in economic emphasis from the Cape to the north-east of the country after the mineral discoveries and the development of industry in the industrial growth stage.

Jagersfontoin, formerly an important mining centre has been subject to gross decline by the out-migration of mining workers and service population since 1904.

Analysis of rank-size variation at greater depth in the system would no doubt reveal interesting patterns of insufficient growth momentum among other cities within the system. Some light will be thrown upon this problem when analysing the growth component in the system in a later chapter.

DISTRIBUTION OF CITIES BY SIZE

The distribution of cities by size group in the regional city sub-systems is illustrated in Table 14a and 14b for 1904 and 1960.

Between 1904 and 1960 the number of cities in the system rose from 259 to 584[1] While no city sub-system experienced an absolute decline in number of cities, only the Johannesburg, Pretoria and Durban sub-systems enjoyed a relative rise in numbers.

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1) Note: These totals do not correspond to the totals given by the census tabulations which are 262 and 604 for 1904 and 1960 respectively [Table 7a] Re-arrangement of the data to include net urban areas with parent cities and the use of the East Rand, West Rand as agglomerations has been the cause of the differences.

TABLE 14a.

DISTRIBUTION OF CITIES BY CITY SUB-SYSTEM
BY SIZE GROUP, 1904

Size Groups	Cape Town	Port Elizabeth	East London	Johannesburg		Pretoria	Durban	Bloemfontein	Kimberley	Principal Sub-systems	
				(a)	(b)					(a)	(b)
<2,000	47	16	28	34	34	3	6	21	22	86	86
2,000-5,000	18	3	8	8	8	1	5	3	5	22	22
5,000-10,000	3	2	2	4	4	-	1	2	-	7	7
10,000-20,000	1	-	-	-	-	-	-	-	-	-	-
20,000-50,000	-	1	1	3	-	1	1	1	1	7	4
50,000-100,000	-	-	-	-	-	-	1	-	-	1	1
100,000-500,000	1	-	-	1	1	-	-	-	-	1	1
+ 500,000	-	-	-	-	-	-	-	-	-	-	-
Total	70	26	39	50	47	5	14	27	28	124	121

Notes:

1. (a): where the Witwatersrand is taken as 4 units (Johannesburg, East Rand, West Rand and Germiston).
   (b): where East Rand, West Rand, Germiston and Johannesburg are taken as a single unit.

2. Only cities with more than 500 persons in 1960 are considered in the table. All sub-urban places have been grouped with parent cities.

TABLE 14b.

DISTRIBUTION OF CITIES BY CITY SUB-SYSTEM
BY SIZE GROUP, 1960

Size Groups	Cape Town	Port Elizabeth	East London	Johannesburg		Pretoria	Durban	Bloemfontein	Kimberley	Principal Sub-systems	
				(a)	(b)					(a)	(b)
< 2,000	44	16	24	55	55	6	52	9	20	142	142
2,000-5,000	40	15	18		53	6	24	22	19	123	123
5,000-10,000	10	6	3	20	20	5	11	3	4	43	43
10,000-20,000	6	2	1	13	13	2	3	1	1	20	20
20,000-50,000	4	2	2	10	10	1	1	-	1	13	13
50,000-100,000	-	-	-	1	1	-	-	-	1	2	2
100,000-500,000	-	1	1	4	1	1	1	1	-	7	4
+ 500,000	1	-	-	1	1	-	1	-	-	2	2
Total	105	42	49	157	154	21	93	36	46	352	349

Conversely the Cape Town, Port Elizabeth, East London, Bloemfontein and Kimberley sub-systems experienced a drop in their proportion of the total cities in the national system.

In 1960, 42 per cent of the cities with more than 100,000 persons in the national system were located in the Johannesburg sub-system (5 out of 12 cities where the agglomeration of the Witwatersrand are considered as separate entities). Of the total number of cities in this size group 7 out of 12 were located within the Principal Sub-system. Only the Kimberley sub-system was focussed upon a metropolitan city with fewer than 100,000 persons.

The distribution of cities with more than 100,000 population and including Kimberley with 78,000 persons, is such that about 60 per cent of the country is situated within 150 miles (240 kilometres) of a metropolis. In the Southern Transvaal the large cities of the Witwatersrand, Pretoria and Vereeniging complex have grown into a closely integrated city region.

Cities with populations of 20,000 to 50,000 persons and 10,000 to 20,000 persons are also most heavily represented in the Johannesburg sub-system which possessed 23 out of a total of 50 cities in these size groups. The Principal Sub-system, furthermore, possessed 33 cities in these size groups. The Cape Town sub-system on the other hand, possessed 10 cities, Port Elizabeth 4 and East London 3 cities of these size groups.

In all sub-systems cities with fewer than 5,000 persons predominate and form the base of pyramidal size hierarchies.

URBAN POPULATION POTENTIAL

Harris (1970,186) has observed that "accessibility of people to other people is a major role of a city". Accessibility in a system of cities may be described as a function of density distributions within the system and the relationship may most satisfactorily be measured in terms of the population potential of the system.

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1) Population potential is expressed as:

$P = \Sigma \frac{p}{d}$ where P is the population potential;

If a point p is the population of each unit within the area and d is the distance of each unit from the point for which population potential is being calculated.

Population potential expresses what Harris has called the 'potential interaction' within the system and gives also a measure of the market potential for consumer-orientated goods (Harris 1954).

Urban population potential distribution for South Africa has been worked out by Haswell (1970) and is presented in Figure 12b.[1] The potential reaches its highest level (100 per cent) in the Witwatersrand, while the 50 per cent isoval very clearly describes the intensity of urban settlement in the Southern Transvaal with the development of a relatively closely spaced set of large cities in a city region (the Pretoria - Witwatersrand - Vereeniging complex). In the Southern Transvaal the Johannesburg and Pretoria city sub-systems interact closely and collectively these sub-systems form the core of the Principal Sub-system.

In 1960 the Southern Transvaal city region accounted for nearly 18 per cent of the total population of South Africa and for 34 per cent of the total White population.

From the peak in the Witwatersrand, urban population potential declines steeply at first reaching a level of 50 per cent within 30 to 50 miles of the peak level. At distances of 50 to 75 miles the potential drops to 30 per cent of the peak level and then declines more gradually towards the northern and north-eastern Transvaal and southwards in the Orange Free State. Gradients towards the west remain relatively steep. South-eastwards, on the other hand, the pattern tends to suggest the development of a ridge of moderately high levels extending between the Witwatersrand and Durban.

Three subsidiary peaks of urban population potential occur orientated about Durban, Cape Town and Port Elizabeth. These cities are the major foci of population and economic development in the coastal margin.

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1) The data for Figure 12b. were supplied by personal communication and have not yet appeared in published form. Acknowledgement should, however, be made to Haswell, R. M.A. Research Programme in course of completion. University of Southern Illinois, Carbondale.

Most of the Cape Province, including the hinterland of East London and the Transkei, northern Natal and Zululand, and the north-eastern, north and north-western Transvaal have low urban population potentials. These are areas in which occur much of the African reserve lands with weakly developed urban centres. The lowest urban population potentials occur in the arid sparcely populated north-west Cape.

The analysis reveals clearly that areas of greatest access to the urban population, and consequently the areas of greatest potential interaction within the city system, lie in the north-east of the country focussed upon the Witwatersrand and the Southern Transvaal mining-industrial complex. At the coast the Durban-Pietermaritzburg subsidiary peak is linked by a ridge of moderate population potential to the core area while the trace of the 15 per cent isoval effectively circumscribes the area within which the majority of the set of cities identified as the Principal Sub-system are located. The significance of a relatively high potential interaction within the Principal Sub-system is strongly emphasised by the distribution, and the role of the Johannesburg city-sub-system is particularly stressed. In the rest of the country only a narrow zone about Cape Town and to a lesser extent about Port Elizabeth is likely to enjoy a relatively high level of potential interaction with the city system.

C H A P T E R 4

THE ECONOMIC BASE OF SOUTH AFRICAN CITIES

CHAPTER 4.

THE ECONOMIC BASE OF SOUTH AFRICAN CITIES

INTRODUCTION:

Berry and Horton (1970, 107) have observed that 'specific geographic objectives are difficult to discern in the statements of purpose appearing in functional classifications of towns'. In most studies mere classification appears to be an end in itself. Thus the authors maintain that economic base studies should be concerned not only with pedagogic considerations which provide the 'differentiating characteristics' of a set of cities, but that they should lead on also to the identification of 'accessory characteristics'. Of the accessory characteristics, those which permit generalisations to be made about the relationships between economic base and the location of cities on the one hand, and those which examine the relationships between the economic base and the hinterland structures of cities on the other, appear to be most important. The classification which is adopted, furthermore, should be 'relevant to a well-defined problem or class of problems' (page 111).

In this study economic classification is directed towards the identification of cities which have a specialised representation in one or more economic functions on the one hand, and towards an examination of the spatial distribution of these cities in an attempt to explain location patterns on the other. It is intended that the findings of the analysis be related to those for other characteristics of the city system in the identification of its structural and spatial components as an essential part of the South African space economy.

While cities have been classified in terms of the functions in which they have varying levels of specialisation, no attempt has been made at this stage to derive functionally-distinct groups of cities (i.e. groups of cities in which the range and level of representation of functions is similar, and significantly different from other groups of cities). Such analyses, which are obviously of considerable importance in fully understanding the location of cities, will be taken up in future research.

In this study, city functional data has been included in a principal components analysis in which they are related to other variables of the city system to produce an integrative classification of cities in the system. The results of the analyses are examined in the next chapter.

THE DATA:

The analysis of the economic base of cities in South Africa has been made possible by the acquisition of special tabulations by industry group, by town, for the 1960 Census made available through the generosity of the Departments of Planning and Statistics. The tabulations are confined to those urban places which in 1960 had populations of over 2,000 persons. The set of unpublished data covers 305 urban places below the level of metropolitan area and the data from 12 of the 14 published metropolitan reports of the Department of Statistics have been integrated in the analysis. Data for cities below 2,000 persons were not available.

The unpublished tabulations present the number of persons employed in 65 industry groups by race and sex. In the present analysis no account has been taken, however, of race and sex. The economically-active population which forms the base for the analyses comprises 64 industry groups, and excludes the group of persons 'not engaged in industry, households... etc.' The 64 industry groups have been categorised to identify 11 industry divisions. The 4 divisions of Agriculture, Fishing and Forestry, Domestic Services, Industry Unspecified and Persons Unemployed, however, are not discussed. Absolute totals have been processed into percentages for the analyses of economic structure.

GENERAL ANALYSIS:

Summary results of preliminary analysis of the data are presented in Table 15.

The 12 cities identified in the Class A size category, represent particular groupings of larger urban places for which the economic data were available. These include the metropolitan areas of Johannesburg, Cape Town, Durban, Pretoria, Germiston, Port Elizabeth, Bloemfontein, Pietermaritzburg, East London and Kimberley, together with the grouped centres of the East Rand, West Rand and Orange Free State Goldfields as defined by the Department of Statistics. In this analysis Vereeniging and Vanderbylpark are considered as separate places, and consequently the number of cities with more than 100,000 and more than 50,000 persons differs slightly from the number quoted in an earlier chapter. Approximately 300 cities below 2,000 persons are excluded and the true base of the size group pyramid is thus not revealed.

The economically-active population, expressed as a percentage of the total population, gives the activity ratio for each city. The distribution of the 318 cities in 8 classes is approximately normal around a mean of 38.5 per cent and a median of 34.7 per cent.

TABLE 15.

DISTRIBUTION OF CITIES BY SIZE, SERVICE STATUS AND ACTIVITY RATIO, 1960

Size Class	Class Code	No. of Cities
500,000 +	AA	3
100,000-500,000	A	9
50,000-100,000	B	2
20,000-50,000	C	20
10,000-20,000	D	28
5,000-10,000	E	60
2,000-5,000	F	196
Hierarchy Class[1)]	**Code**	**No. of Cities[2)]**
Principal Metropolitan Area	1	1
Major Metropolitan Area	2	3
Metropolitan Area	3	8
Major Town	4	18
Town	5	54
Minor Town	6	145
Local Service Centre	7	45
Low Order Centre	8	40
Activity Ratio Class	**Code No.**	**No. of Cities**
80% +	I	10
70-79.99%	II	7
60-69.99%	III	12
50-59.99%	IV	10
40-49.99%	V	51
30-39.99%	VI	176
20-29.99%	VII	48
Below 20%	VIII	4

1) Hierarchical Service Status refers to 1966 (See Chapter 5).

2) The data available have prevented the use of the exact number of cities by order of place determined in Chapter 5.

ANALYSIS BY INDUSTRY DIVISION:

The results of analysing the set of 318 cities in terms of central tendency, deviation and the lowest quintile (or fifth percentile) value for each of 7 industry divisions are assembled in Table 16.

TABLE 16

URBAN MEASURES: ECONOMICALLY ACTIVE POPULATION BY INDUSTRY DIVISIONS, 1960

Measure	INDUSTRY DIVISIONS						
	Mining	Manufac-turing	Construc-tion	Electricity	Commerce	Transport	Services
Average %	5.84	13.76	9.17	1.09	11.36	5.84	15.44
Median %	0.21	9.39	8.70	0.69	11.65	4.54	16.06
Modal Class %	0-4.99	5-9.99	5-9.99	0-4.99	10-14.99	0-4.99	15-19.99
Standard Deviation	5.34	13.36	5.26	2.88	5.75	5.34	7.16
k value	0.00	0.44	0.34	0.00	0.82	0.36	1.61

The leading divisions in the national average urban economic structure are Services, Manufacturing and Commerce, while the frequency distribution in all but Commerce, Transport and Services are very positively skewed - the tails of Mining and Electricity in particular stretch far to the right. The *k* value for each of the divisions is the 5 per cent value calculated from the origins of the ranked lists of 318 cities. *k* value is below 1 per cent for all divisions except Services.

The measures in Table 16 form the bases for the primary classification of cities by economic function.

ECONOMIC CLASSIFICATION OF CITIES:

In this study the methodologies employed by Alexandersson (1956) and Nelson (1955) are used in the economic classification of the 318 South African cities. In addition the cities have been classified in terms of only two classes (above and below the mean), in each industry division.[1] Table 17 gives the number of places in the statistical categories of the three schemes by 7 industry divisions.

TABLE 17

DISTRIBUTION OF 318 CITIES ACCORDING TO THREE SYSTEMS OF CLASSIFICATION, BY INDUSTRY DIVISIONS, 1960.

Categories	NO. OF CITIES, BY INDUSTRY DIVISIONS						
	Mining	Manufac-turing	Construc-tion	Electric-ity	Commerce	Transport	Services
Above $\bar{X}$	46	106	146	67	166	105	175
Below $\bar{X}$	272	212	172	251	152	213	143
Total	318	318	318	318	318	318	318
> $\bar{X}$+3 S.D.	33	10	4	3	1	8	3
> $\bar{X}$+2 S.D.	3	7	8	1	8	7	6
> $\bar{X}$+1 S.D.	4	23	28	6	36	12	34
Other	278	278	278	308	273	291	275
Total	318	318	318	318	318	318	318
A	34	61	11	1	18	9	48
B	6	82	111	2	158	23	191
C	8	104	129	4	95	96	44
Other	270	71	67	311	47	190	35
Total	318	318	318	318	318	318	318

Notes: $\bar{X}$ stands for the Arithmetic mean value; S.D for standard deviation.

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1) The simplest of all functional classifications of cities is one that classifies each place according to the dominant single function - without reference to national means, deviation from means, or the percentage level reached by the dominant activity. Such a method is mutually exclusive (i.e. a city belongs to one and only one class) and exhaustive (in the sense, at any rate, that every unit is classified). The dominant single functions are noted in Table 18. If a threshold of 50 per cent of employment were imposed, 28 cities would be Mining and 11 Manufacturing; no places reach the 50 per cent level in any of the other 5 divisions considered in this study.

The simple dichotomous classification identifies the Mining and Electricity divisions as notably weak in number of places above the national means in these divisions. Services, Commerce and Construction are in balance, while Manufacturing and Transport are intermediate in distribution. A classification scheme of this type is obviously coarse, and for most purposes insufficiently discriminative.

The Nelson methodology employs an objective measure of variation from the means - the standard deviation *(S.D.)*. The *S.D.* values for the 7 industry divisions permit the isolation of three levels of specialisation identified by the national means plus 3 *S.D.*'s, plus 2 *S.D.*'s and plus 1 *S.D.* respectively. Cities which do not fall into one of these levels are by exclusion classified as not specialised - in other words, they are not notably positively dispersed from the central values. While the standard deviation method appears to be objective it should be remembered that its validity can be called into question by skew distribution of data.

Of the total of 318 cities, 62 are characterised by upper level specialisation ($\bar{X}$+ 3 *S.D.*) distributed over the 7 industry divisions, but the majority of cities are statistically undistinguished in any one of the divisions. There are relatively high levels of specialisation which distinguish the Mining division, explained by the inclusion in the set of cities of several mines with their associated settlement. The Electricity division on the other hand ranks very low on levels of specialisation.

In contrast to the $\bar{X}$ + 3 *S.D.* level, several cities score at the 1 *S.D.* and 2 *S.D.* levels in more than one division. The number of places ranked at these two levels, however, averages only 12 per cent of the total in Manufacturing, Construction, Commerce and Services, and is as low as 4 per cent in the remaining divisions.

The Alexandersson scheme identifies functional specialisation at A, B and C levels. The lowest statistical levels for these classes are 5, 10 and 20 per cent of the total economically-active in an industrial division plus the *k* value for that activity. The *k* value, referred to earlier, is said to indicate the proportion of any activity that is city-serving (or non-basic) as opposed to the proportion that is city-forming (or basic). It may also be referred to as a minimum requirement statistic. With the low *k* values in the 7 industry divisions of the present study (see Table 17), the lower limits of the classes A, B and C are, in fact, only slightly above the arbitrary 5, 10 and 20 per cent levels in the rankings.[1)]

Except in mining and electricity, the Alexandersson procedure classifies many more places in the upper classes than does Nelson's method. There are 182 A awards - though 10 cities achieve 'AA status' (three of them with the combination of Manufacturing and Services) - except in Electricity, Nelson's top towns are included amongst Alexandersson's A's. There are 573 B awards distributed over 252 cities; 26 cities achieve a rank of B in no less than 4 activities. At Alexandersson's C level, 480 rankings are noted for 261 cities. The C rank is dominant in Manufacturing and Construction, but yields first place to the B ranking Commerce and Services, both of which activities have but a few cities below C level. It is evident that Alexandersson's Scheme is less demanding than Nelson's but on the other hand it permits a more comprehensive statement concerning the industrial character of any place to be made.

CLASSIFICATION OF CITIES:

Table 18 lists the 318 cities in the set, and classifies each city in terms of Alexandersson's and Nelson's systems. Furthermore, each city is classified according to its population size, service hierarchy, status and activity ratio. No attempt will be made here to distil out combinations of rankings; several of the correlations evident are suggestive, however.

To illustrate the structure of the tabulation the first town in the group of metropolitan cities is explained. Johannesburg is classified A 1 W V: M i_C M_B C_B; C 1(C). This means that the city attains the highest rank in both size and service status order and is at the fifth level in activity ratio (see Table 15); Mining is at the C level, Manufacturing at the B level, Commerce at the

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1) Two comments should be made concerning the low k values in the South African studies. The inclusion of several mining settlements with their particularly low employment ratios in all but the mining division is partly responsible for the low k values. If places with mining ratios of more than 90 per cent are excluded from the set, the k values rise. For instance in the case of Manufacturing, the k value changes from 0.44 to 1.59 per cent. This would result in the loss of 2 places at the A level, a net loss of 11 B places and a net loss of 10 C places, while 23 places would join those that are not ranked. Since this procedure involves an arbitrary decision to omit certain places because of high levels of specialisation, their exclusion is subjective and probably not justified. The second comment is that the low k values for South African cities also result from the relative importance of Domestic Service - of the order of 20-30 per cent for most towns, this function thus reduces the ratio levels reached by the other divisions.

TABLE 18.

ECONOMIC CLASSIFICATION OF 318 SOUTH AFRICAN CITIES, 1960.

Key: After each city name there appears the code letter or number for Size Class, Service Hierarchy Status and Activity Ratio Class. These are followed by the rankings of the city on the Alexandersson classification (A, B and C) and (after the semi-colon) by the rankings on the Nelson scheme (plus 1 S.D., plus 2 S.D., and plus 3 S.D.). The last letter (in parentheses) indicates the dominant single function of the city.

The seven industry divisions are: Mi - Mining, M - Manufacturing, E - Electricity, C - Commerce, S - Services, T - Transport, CN - Construction

W - Part of Witwatersrand.

Johannesburg	A	1W	V :	Mi_C M_B C_B S_B	; C1 M	(C)
Cape Town	A	2	V :	M_A C_B T_C CN_C S_B	; C1	(M)
Durban	A	2	V :	M_A C_B T_C S_B	;	(M)
East Rand	A	1W	IV:	Mi_A M_B C_C S_C	; Mi3	(Mi)
Pretoria	A	2	V :	M_B C_B T_C CN_C S_A	; S3	(S)
West Rand	A	1W	III:	Mi_A M_C C_C	; Mi3	(Mi)
Port Elizabeth	A	3	V :	M_A C_B T_C CN_C S_B	; M1	(M)
Germiston	A	1W	V :	Mi_B M_A C_C T_C CN_C S_C	; Mi1 M1	(M)
O.F.S. Gold-fields	A	3	III:	Mi_A	; Mi3	(Mi)
Bloemfontein	A	3	V :	M_C C_B T_B CN_C S_B	; C1 T1	(C)
Pietermaritz-burg	A	3	V :	M_B C_B T_C CN_C S_A	; S1	(S)
East London	A	3	V :	M_B C_B T_C S_B	;	(M)
Kimberley	B	3	V :	Mi_B M_C C_B T_C CN_C S_B	; Mi1	(S)
Bethlehem	C	4	VI:	M_B C_B T_B CN_C S_B	; T1	(S)
Grahamstown	C	4	VI:	M_C C_B CN_C S_A	; S2	(S)
King William's Town and Zwelitsha	C	4	V :	M_A C_C S_B	; M1	(M)
Klerksdorp	C	3	V :	Mi_A M_B C_B T_C CN_B S_B	; Mi2	(Mi)
Kroonstad	C	4	VI:	M_B C_B T_B CN_C S_B	;	(S)
Ladysmith (N)	C	4	V :	M_A C_C T_B CN_B S_B	; T1	(M)
Nigel	C	5	III:	Mi_A M_C S_C	; Mi3	(Mi)
Orkney	C	6	III:	Mi_A	; Mi3	(Mi)
Oudtshoorn	C	4	VI:	M_B C_B CN_B S_A	; S1	(S)
Paarl	C	4	V :	M_A C_B CN_C S_B	; M2	(M)
Pietersburg	C	4	VI:	M_B C_B T_C CN_C S_B	;	(S)
Potchefstroom	C	4	VI:	M_B C_B CN_C S_A	; S2	(S)
Queenstown	C	4	VI:	M_C C_B T_C CN_C S_B	;	(S)
Rustenburg	C	4	VI:	Mi_C M_B C_A CN_C S_B	; C1	(C)
Stellenbosch	C	4	VI:	M_A C_B CN_C S_A	; S2	(S)
Uitenhage	C	4	VI:	M_A C_C T_C CN_C S_B	; M1	(M)
Upington	C	5	VI:	M_C C_B T_B CN_C S_B	; T1	(C)
Vanderbijlpark	C	4	V :	M_A C_C S_C	; M3	(M)
Vereeniging	C	3	V :	M_A C_C CN_C E_C S_C	; M2	(M)
Witbank	C	4	VI:	M_A C_C T_C CN_C S_B	;	(M)
Worcester	C	4	VI:	M_A C_B T_C CN_C S_B	; M1	(M)
Aliwal North	D	5	VI:	M_B C_B CN_C S_A	; S1	(S)
Beaufort West	D	5	VI:	Mi_C M_C C_B T_B CN_C S_B	; T2	(S)
Barberton	D	5	V :	M_B C_B CN_C S_A	; S1	(S)
Bethal	D	5	VI:	M_B C_B T_C CN_C S_B	; C1	(C)
Cradock	D	5	VI:	M_C C_B T_B CN_B S_B	;	(S)
De Aar	D	5	VI:	M_C C_C T_B CN_B S_B	; T2	(T)
Dundee	D	5	VI:	M_B C_C CN_C S_A	; S1	(S)
Ermelo	D	5	VI:	M_C C_B CN_B S_B	;	(S)
George	D	4	VI:	M_A C_B CN_C S_B	;	(M)
Graaff-Reinet	D	5	VI:	M_C C_B T_C CN_C S_B	;	(S)
Harrismith	D	5	VI:	M_A C_C CN_C S_B	;	(M)
Hartebeesfon-tein Mine	D	7	I :	Mi_A	; Mi3	(Mi)
Knysna	D	5	VI:	M_A C_B CN_C S_B	; M1	(M)
Lichtenberg	D	5	V :	M_A C_A CN_C S_B	; C1	(C)
Middelburg (T)	D	5	VI:	M_B C_B T_C CN_C S_A	; S1	(S)
Messina	D	6	- - - - NO DATA - - - -			
Mossel Bay	D	5	VI:	M_B C_B T_C CN_B S_B	;	(M)
Nelspruit	D	5	VI:	M_B C_B T_C CN_C S_B	; C1	(C)

Newcastle	D	5	VI:	Mi_B	M_B	C_C	CN_C	S_B	;	Mi1		(M)
Parys	D	5	VI:	M_A	C_B	CN_B	S_B		;			(M)
Potgietersrus	D	5	V :	M_B	C_B	CN_C	S_B		;	C1		(S)
Sasolburg	D	5	V :	M_A	CN_C	S_C			;	M3		(M)
Standerton	D	5	V :	M_A	C_B	T_C	CN_C	S_B	;			(M)
Stilfontein	D	5	II:	Mi_A					;	Mi3		(Mi)
Strand	D	5	VI:	M_A	C_B	CN_C	S_B		;	M1		(M)
Umtata	D	4	V :	M_C	C_B	CN_C	S_A		;	S1		(S)
Vryheid	D	5	V :	M_C	C_B	T_C	CN_C	S_B	;			(S)
Vryburg	D	5	V :	M_B	C_B	T_C	CN_B	S_B	;	C1		(C)
Wellington	D	5	VI:	M_A	C_C	CN_C	S_B		;	M2		(M)

Adelaide	E	6	VII:	M_C	C_B	T_C	CN_C	S_B	;			(S)
Bothaville	E	6	VI:	M_B	C_B	T_C	CN_B	S_B	;	C1		(M)
Brits	E	5	VI:	M_B	C_A	CN_C	S_B		;	C2		(C)
Burgersdorp	E	6	VI:	C_C	T_B	CN_B	S_B		;	T1		(S)
Calvinia	E	6	VI:	M_C	C_B	CN_B	S_B		;			(S)
Ceres	E	5	VI:	M_B	C_A	CN_B	S_B		;	C2		(C)
Charlestown	E	8	VI:	M_A					;	M1		(M)
Christiana	E	6	VII:	M_C	C_B	T_C	CN_B	S_B	;			(S)
Clydesdale	E	8	I :	Mi_A	E_C				;	Mi3		(Mi)
Despatch	E	6	VI:	M_A	C_C	T_A	CN_B	S_C	;	T3		(M)
Empangeni	E	5	IV:	M_A	C_C	T_C	CN_C	S_B	;	M1		(M)
Estcourt	E	5	IV:	M_A	C_C	T_C	CN_C	S_B	;	M1		(M)
Ficksburg	E	5	VI:	M_C	C_B	CN_C	S_B		;	C1		(C)
Fort Beaufort	E	6	VII:	C_C	CN_B	S_A			;	S1		(S)
Glencoe	E	6	VI:	M_C	C_C	T_B	CN_B	S_B	;	T1	CN1	(CN)
Greytown	E	5	VI:	M_B	C_C	T_C	CN_B	S_A	;	S1		(S)
Heidelberg (T)	E	5	VI:	M_B	C_C	T_C	CN_B	S_A	;	CN1	S1	(S)
Howick and Howick West	E	6	VI:	M_A	C_C	S_B			;	M2		(M)
Heilbron	E	6	VI:	M_B	C_B	T_C	CN_B	S_B	;	C1		(C)
Henneman	E	6	VI:	M_B	C_B	T_C	CN_B	S_B	;	CN1		(M)

Kirkwood	E	6	VI:	C_A	CN_C	S_C			; C1	(C)
Kokstad	E	5	V :	M_C	C_B	T_C	CN_B	S_A	;	(S)
Kuilsrivier	E	6	V :	M_A	C_B	T_C	CN_C	S_B	; M1	(M)
Kuruman	E	6	VI:	Mi_C	M_C	C_B	CN_C	S_B	;	(S)
Ladybrand	E	6	VI:	M_B	C_C	CN_C	S_B		;	(S)
Louis Trichardt	E	5	V :	Mi_A	M_C	C_C	CN_C	S_B	; Mi3	(Mi)
Lydenberg	E	5	VI:	M_C	C_B	T_C	CN_B	S_A	; S1	(S)
Mafeking	E	5	VI:	M_C	C_B	T_B	CN_C	S_B	; T2	(T)
Malmesbury	E	5	VI:	M_B	C_B	T_C	CN_B	S_B	; CN1	(S)
Meyerton	E	6	VI:	M_A	C_C	S_C			; M2	(M)
Middelburg(C)	E	5	VI:	M_C	C_B	CN_C	S_A		; S1	(S)
Modderfontein	E	1W	II:	M_A	CN_C				; M3	(M)
Montague	E	6	VI:	M_A	C_B	CN_C	S_B		;	(M)
Nababiep	E	7	V :	Mi_A					; Mi3	(Mi)
Noupoort	E	6	VI:	M_C	C_C	T_A	CN_C	S_B	; T3	(T)
Nylstroom	E	5	- - - - - - - - - -	NO DATA	- - - - - - - - - - - -					
Piet Retief	E	5	VI:	M_B	C_B	T_C	CN_C	S_B	;	(S)
Port Alfred	E	6	VII:	C_C	CN_C	S_A			;	(S)
Prieska	E	6	VI:	M_C	C_B	T_C	CN_B	S_B	;	(S)
Riversdale(C)	E	5	VI:	M_B	C_B	T_C	CN_B	S_A	; S1	(S)
Robertson	E	5	VI:	M_A	C_B	CN_B	S_B		; CN2	(M)
Schweizer-Reneke	E	6	VI:	M_B	C_B	CN_B	S_B		;	(S)
Senekal	E	5	VI:	M_B	C_B	CN_C	S_B		;	(M)
Somerset East	E	5	VI:	M_B	C_C	CN_C	S_B		;	(S)
Somerset West	E	5	VI:	M_A	C_B	CN_C	S_B		;	(M)
Stanger	E	5	V :	M_B	C_B	T_C	CN_B	S_B	; CN1	(M)
Stutterheim	E	6	VII:	M_B	C_C	CN_C	S_B		;	(M)
Thabazimbi	E	6	IV:	Mi_A	S_C				; Mi3	(Mi)
Theunissen	E	6	VI:	M_C	C_B	CN_B	S_B		;	(S)
Tongaat	E	6	VI:	M_A	C_C	CN_B	S_B		; M1	(M)
Touwsrivier	E	6	VI:	M_B	C_C	T_A	CN_C	S_B	; T3	(T)

Tzaneen	E	5	VI:	M_B	C_B	T_C	CN_C	S_B	;			(S)
Utrecht	E	6	VI:	Mi_A	S_B				;	Mi3		(Mi)
Vaal Reefs Mine	E	8	1 :	Mi_A					;	Mi3		(Mi)
Viljoensdrif	E	8	II:	Mi_A					;	Mi3		(Mi)
Volksrust	E	5	VI:	M_B	C_C	T_B	CN_C	S_B	;	T1		(T)
Vrede	E	6	VI:	M_C	C_B	CN_C	S_B		;	C1		(C)
Warmbaths	E	5	VI:	M_C	C_B	CN_C	S_A		;	S2		(S)
Warrenton	E	6	VII:	M_C	C_C	T_B	CN_B	S_B	;	T2		(T)
Waterval-Bo	E	6	VI:	M_C	C_C	T_A	CN_A	S_C	;	T3	CN2	(T)
Wolmaranstad	E	6	VI:	M_C	C_B	CN_C	S_A		;	S1		(T)
Winkelhaak and Evander	E	6	1 :	Mi_A	CN_C	S_B			;	Mi3		(Mi)
Zeerust	E	6	VI:	M_C	C_B	T_C	CN_B	S_B	;			(S)

Aberdeen	F	6	VII:	M_C	C_B	CN_B	S_B		;	CN1	(CN)
Afrikander Mine	F	8	IV:	Mi_A					;	Mi3	(Mi)
Alexander Bay	F	8	III:	Mi_A					;	Mi3	(Mi)
Alexandria	F	6	VI:	M_C	C_B	T_C	CN_B	S_B	;	C1	(C)
Alice	F	6	VI:	C_C	S_A				;	S3	(S)
Amersfoort	F	6	VI:	M_C	C_B	T_C	CN_B	S_B	;	CN1	(S)
Amsterdam	F	7	VI:	C_C	CN_C	S_A			;	S1	(S)
Ashton	F	7	VI:	M_A	S_C				;	M3	(M)
Balfour	F	6	VI:	M_C	C_B	T_C	CN_A	S_B	;	CN3	(CN)
Barkly East	F	6	VI:	M_C	C_B	T_C	CN_B	S_B	;		(S)
Barkly West	F	6	VI:	Mi_B	M_C	C_C	CN_C	S_B	;	Mi2	(Mi)
Bedford	F	6	VII:	M_C	C_C	T_C	CN_C	S_B	;		(S)
Belfast	F	6	VI:	M_B	C_B	T_B	CN_C	S_B	;		(S)
Berlin	F	7	VI:	C_C	S_C				;		(S)
Bethulie	F	6	VII:	C_C	CN_C	S_B			;		(S)
Blanco	F	8	VI:	M_A	C_B	CN_C	S_C		;		(M)
Bloemhof	F	6	VI:	M_B	C_B	T_C	CN_C	S_B	;	C1	(C)
Bonnievale	F	6	VI:	M_C	C_C	CN_C	S_B		;		(S)

Boshof	F	6	VII:	C_B	CN_C	S_B			;			(S)
Brandfort	F	6	VI:	M_C	C_B	T_C	CN_B	S_B	;			(S)
Bredasdorp	F	6	VI:	M_B	C_B	CN_B	S_B		;	C1	CN1	(C)
Breyton	F	7	VI:	M_C	C_C	T_A	CN_B	S_C	;	T3		(T)
Britstown	F	7	VI:	M_C	C_B	CN_B	S_B		;			(S)
Bronkhorst-spruit	F	6	VI:	M_C	C_B	S_B			;			(S)
Buffelsfon-tein G.M.	F	8	1 :	Mi_A					;	Mi3		(Mi)
Bultfontein	F	6	VI:	M_C	C_A	T_C	CN_B	S_B	;	C1		(C)
Butterworth	F	6	IV:	M_C	C_B	T_C	CN_C	S_A	;	S1		(S)
Cala	F	6	VI:	C_C	CN_C	S_A			;	S1		(S)
Caledon	F	5	V :	M_B	C_A	T_C	CN_B	S_B	;	C2		(C)
Calitzdorp	F	7	VI:	C_C	S_B				;			(S)
Carnarvon	F	6	VI:	M_C	C_B	T_C	CN_B	S_A	;	S1		(S)
Carolina	F	6	VI:	M_C	C_B	T_C	CN_B	S_B	;	CN1		(S)
Cathcart	F	6	VI:	M_C	C_C	T_C	CN_B	S_B	;			(S)
Clanwilliam	F	6	VI:	M_B	C_B	CN_C	S_A		;			(S)
Clewer	F	8	III:	Mi_A					;	Mi3		(Mi)
Clocolan	F	6	VI:	M_B	C_B	T_C	S_B		;			(S)
Colenso	F	7	V :	C_C	E_A	S_B			;			(E)
Colesberg	F	6	VI:	M_C	C_C	T_C	CN_C	S_B	;			(S)
Coligny	F	6	VI:	M_C	C_B	T_B	CN_B	S_B	;	C1	T2	(C)
Cookhouse	F	8	VII:	M_B	C_C	T_A	CN_B	S_C	;	T3		(T)
Cullinan	F	7	II:	Mi_A					;	Mi3		(Mi)
Dannhauser	F	6	- - - - - - - - - -NO DATA - - - - - - - - - - - - - - - -									
Darnall	F	7	VII:	M_A	C_C				;	M3		(M)
De Doorns	F	6	VI:	C_C	CN_C	S_C			;			(S)
Delareyville	F	6	V :	M_B	C_A	CN_A	S_C		;	C2	CN2	(C)
Delmas	F	6	VI:	M_B	C_B	T_C	S_B		;	C1		(S)
Dewetsdorp	F	6	VI:	M_C	C_B	CN_B	S_C		;			(C)
Dominion Reefs G.M.	F	8	III:	Mi_A					;	Mi3		(Mi)
Dordrecht	F	6	VI:	C_B	CN_B	S_B			;			(S)

Douglas	F	6	VII:	C_B	CN_C	S_B				;			(S)
Duiwelskloof	F	6	V :	M_A	C_B	CN_C	S_A			;	S1		(S)
Durnacol	F	8	- - - - - - - - - NO DATA - - - - - - - - - - - -										
Edenburg	F	6	VI:	M_C	C_C	T_C	CN_B	S_B		;	CN1		(CN)
Elliot	F	6	VI:	M_C	C_C	CN_B	S_B			;			(S)
Eshowe	F	5	IV:	M_C	C_B	CN_C	S_A			;	S1		(S)
Excelsior	F	6	VI:	M_B	C_B	S_B				;			(S)
Fauresmith	F	6	VI:	C_B	CN_B	S_B				;			(S)
Felixton	F	8	III:	M_A						;	M3		(M)
Frankfort	F	6	VI:	M_B	C_B	T_C	CN_B	S_B		;	C1		(C)
Fraserburg	F	6	VI:	M_C	C_B	CN_B	S_B			:	CN1		(CN)
Genadendal	F	8	VIII:	S_B						;			(S)
Grabouw	F	6	VI:	M_A	C_B	CN_C	S_B			;			(M)
Graskop	F	7	VI:	Mi_C	M_A	C_C	T_C	CN_C	S_C	;			(M)
Grasmere	F	8	VI:	M_A	C_C	CN_C	S_C			;	M1		(M)
Griquatown	F	7	VII:	C_C	CN_B	S_B				;	CN1		(S)
Groblersdal	F	6	V :	M_B	C_B	CN_B	S_A			;	S1		(S)
Great Brak River	F	7	VI:	M_A	C_C	S_C				;	M2		(M)
Hankey	F	7	VII:	C_C	S_B					;			(S)
Hanover	F	7	- - - - - - - - - NO DATA - - - - - - - - - - - -										
Harding	F	6	V :	M_B	C_C	T_C	CN_C	S_A		;	S1		(S)
Hartswater	F	6	V :	C_A	CN_B	S_B				;	C3	CN1	(C)
Heidelberg(C)	F	6	VI:	M_C	C_B	CN_B	S_B			;	C1		(C)
Hermanus	F	5	V :	M_C	C_B	CN_C	S_A			;	S2		(S)
Hofmeyer	F	7	VII:	C_C	CN_B	S_B				;			(S)
Hoopstad	F	6	VI:	M_B	C_B	CN_B	S_B			;			(S)
Hopefield	F	6	VII:	M_C	C_B	CN_B	S_B			;	CN1		(S)
Hopetown	F	6	VII:	C_B	CN_B	S_B				;	CN1		(CN)
Humansdorp	F	6	VI:	M_C	C_B	T_C	CN_B	S_A		;			(S)
Indwe	F	6	VI:	C_C	T_C	CN_C	S_B			;			(S)
Jagersfontein	F	6	VI:	Mi_B	C_C	CN_C	S_C			;	Mi1		(Mi)

Jansenville	F	6	VI:	C_C	CN_B	S_B			;	CN2		(CN)
Kiemoes	F	6	VI:	M_C	C_B	CN_C	S_B		;			(S)
Kieskamahoek	F	7	VI:	C_C	CN_C	S_B			;			(S)
Kendal	F	8	VI:	Mi_A	T_C	CN_B			;	Mi3	CN1	(Mi)
Kenhardt	F	6	VII:	M_C	C_B	CN_B	S_B		;			(S)
Klipplaat	F	7	VI:	C_C	T_A	CN_B	S_C		;	T3		(T)
Koffiefontein	F	6	VII:	M_C	C_B	CN_B	S_B		;	CN1		(CN)
Komatipoort	F	7	VI:	C_C	T_A	CN_B	S_C		;	T3		(T)
Komgha	F	6	VI:	M_B	C_C	CN_B	S_B		;	CN1		(CN)
Kookfontein	F	8	VI:	M_A	C_C	CN_C	E_C		;	M3		(M)
Koppies	F	6	VI:	M_B	C_A	CN_B	S_B		;	C1		(C)
Koster	F	6	VII:	M_B	C_B	T_C	CN_C	S_B	;	C1		(C)
Kromdraai	F	8	III:	Mi_A					;	Mi3		(Mi)
Kruisfontein	F	8	VII:	M_C	T_C	CN_B	S_B		;	CN1		(CN)
Ladismith (C)	F	6	V :	M_B	C_B	T_C	CN_A	S_A	;	CN2	S1	(CN)
Lady Grey	F	6	VI:	C_C	CN_C	S_B			;			(S)
Laingsburg	F	6	VI:	M_C	C_B	T_C	CN_B	S_B	;	CN1		(CN)
Lambertsbay	F	7	V :	M_A	C_C	CN_C	S_C		;	M1		(M)
Landau Colliery	F	8	I :	- - - - - - - - NO DATA - - - - - - - - - - -								
Leeudoringstad	F	7	VII:	M_C	C_A	T_C	CN_B	S_B	;	C2	CN1	(C)
Leslie	F	6	VII:	M_B	C_B	CN_B	S_B		;			(M)
Lindley	F	6	VI:	M_B	C_A	S_B			;	C1		(C)
Loriesfontein	F	7	VI:	M_C	C_C	CN_B	S_C		;			(CN)
Maclear	F	6	VI:	C_C	T_C	CN_B	S_B		;			(S)
Mamre	F	8	VII:	M_C	C_C	CN_C	S_A		;	S3		(S)
Mandini	F	7	III:	M_A					;	M3		(M)
Marburg	F	8	VI:	M_C	C_B	CN_B	S_B		;			(S)
Margate	F	5	V :	M_C	C_B	CN_C	S_A		;			(S)
Marquard	F	6	VI:	M_C	C_B	T_C	CN_C	S_B	;	C1		(C)
Matatiele	F	6	IV:	M_C	C_B	CN_B	S_B		;			(S)

Molteno	F	6	VII:	M_B	C_C	CN_C	S_B			;			(S)
Mooi River	F	6	V :	M_A	C_C	T_C	CN_C	S_B		;	M1		(M)
Moorreesburg	F	6	VI:	M_A	C_A	T_C	CN_B	S_B		;	C2		(C)
Mpolweni	F	8	VIII:	S_B						;			(S)
Murraysburg	F	7	VII:	M_C	C_B	CN_B	S_B			;			(S)
Naboomspruit	F	6	VII:	M_B	C_A	T_B	CN_C	S_B		;	C1		(C)
New Largo Colliery	F	8	II:	Mi_A	E_B					;	Mi3		(Mi)
New Spring-field Colliery	F	8	I :	Mi_A						;	Mi3		(Mi)
Ogies	F	7	VI:	M_B	C_B	T_B	CN_C	S_B		;		=	(CS)
Okiep	F	8	V :	Mi_A						;	Mi3		(Mi)
Pacaltsdorp	F	8	VI:	M_A	C_C	CN_B	S_C			;	M1		(M)
Park Rynie	F	6	VI:	M_C	C_C	T_C	CN_C	E_C	S_A	;	S2		(S)
Paulpietersburg	F	6	VI:	C_C	CN_A	S_C				;	CN2		(CN)
Pearston	F	7	VII:	C_C	CN_A	S_B				;	CN3		(CN)
Penge	F	8	I :	Mi_A	S_C					;	Mi3		(Mi)
Petrusburg	F	6	VII:	C_B	T_C	CN_B	S_A			;			(S)
Petrus Steyn	F	6	VI:	M_C	C_A	T_C	CN_B	S_B		;	C1		(C)
Philippolis	F	7	VI:	M_C	C_B	CN_B	S_B			;			(S)
Philipstown	F	7	VI:	M_C	C_C	CN_A	S_B			;	CN3		(CN)
Phoenix Colliery	F	8	II:	Mi_A						;	Mi3		(Mi)
Piketberg	F	6	VI:	M_B	C_B	CN_B	S_B			;			(S)
Pofadder	F	7	VII:	M_C	C_B	T_B	CN_C	S_B		;	T1		(S)
Porterville	F	6	VI:	M_B	C_B	CN_B	S_B			;	C1		(C)
Port Nolloth	F	7	V :	Mi_C	M_A	S_C				;	M1		(M)
Port Shepstone	F	5	V :	M_C	C_B	T_B	CN_C	S_A		;	T1	S1	(S)
Postmasburg	F	6	VI:	Mi_B	M_C	C_C	T_A	CN_C	S_C	;	Mi2	T2	(T)
Prince Albert	F	6	VI:	M_C	C_C	CN_B	S_B			;			(S)
Reddersburg	F	7	VI:	M_C	C_C	T_C	CN_B	S_A		;	S1		(S)
Reitz	F	6	VI:	M_C	C_A	CN_C	S_B			;	C2		(C)

Reivilo	F	7	VI:	M_A	C_C	CN_B	S_C			;	M1		(M)
Residensia	F	8	VI:	M_A	C_B	T_B	CN_B	S_B		;	M1	T1	(M)
Richmond (C)	F	7	VI:	M_C	C_C	CN_C	S_B			;			(S)
Richmond (N)	F	6	VI:	M_C	C_B	T_C	CN_C	S_A		;	S1		(S)
Roosboom	F	8	VIII:	M_B	T_C	CN_B	S_C			;			(M)
Rouxville	F	7	VII:	M_C	C_B	CN_A	S_B			;	CN2		(CN)
Sabie	F	6	VII:	M_B	C_B	CN_C	S_A			;	S1		(S)
Saldanha	F	7	V :	M_A	C_C	S_C				;	M1		(M)
Saron	F	8	VII:	M_C						;			(M)
Scottburgh	F	6	III:	M_B	C_B	S_A				;	S3		(S)
Sezela	F	8	V :	M_A						;	M2		(M)
Shakaskraal	F	7	V :	M_A	C_C	S_C				;	M3		(M)
Smithfield	F	6	VI:	M_C	C_B	CN_B	S_B			;			(S)
Springbok	F	6	V :	Mi_C	M_B	C_B	T_C	CN_B	S_A	;	S1		(S)
Springbok Colliery	F	8	I :	Mi_A						;	Mi3		(Mi)
Springfontein	F	7	VII:	C_C	T_B	CN_B	S_B			;	T2	CN1	(T)
Sterkstroom	F	6	VII:	C_C	T_C	CN_C	S_C			;			(S)
Steynsburg	F	6	VII:	M_C	C_C	CN_C	S_B			;			(S)
Steynsrus	F	6	VII:	M_B	C_B	CN_C	S_B			;	C1		(C)
Steytler-ville	F	6	VII:	M_C	C_B	CN_B	S_C			;	CN1		(CN)
Swartruggens	F	6	VI:	C_B	T_C	CN_B	S_B			;			(S)
Swellendam	F	6	VI:	M_B	C_B	CN_B	S_B			;			(S)
Tarkastad	F	6	VII:	M_C	C_B	CN_B	S_B			;	CN1		(S)
Trompsburg	F	7	VI:	C_B	T_B	CN_B	S_B			;	T1		(S)
Tweefontein Colliery	F	8	II:	Mi_A						;	Mi3		(Mi)
Tweespruit	F	7	VI:	M_A	C_B	CN_B	S_C			;	M1		(M)
Ugie	F	7	VII:	M_C	C_C	T_C	CN_C	S_A		;	S1		(S)
Ulco	F	8	IV:	M_A						;	M3		(M)
Umkomaas	F	6	IV:	M_A	C_C	T_C	S_A			;	S1		(S)
Umzinto	F	6	VI:	M_C	C_B	T_C	CN_C	S_B		;	C1		(S)

Uniondale	F	6	VII: C_B	T_C
Upper Kubusi	F	8	VII: M_B	
Valspan	F	8	VI: C_B	S_B
Vanrhynsdorp	F	6	VII: M_C	C_C
Velddrif	F	7	V : M_A	C_C
Ventersburg	F	6	VI: Mi_C	M_B
Ventersdorp	F	6	VI: M_B	C_B
Verulam	F	6	VI: M_B	C_B
Victoria West	F	6	VI: M_C	C_B
Vierfontein	F	7	III: Mi_A	E_B
Viljoenskroon	F	6	VI: M_B	C_B
Villiers	F	6	VI: M_A	C_B
Vredefort	F	6	VII: M_B	C_A
Vredenburg	F	6	V: M_B	C_B
Vredendal	F	6	VI: M_B	C_B
Wakkerstroom	F	7	VIII: C_C	CN_C
Warden	F	6	VI: M_C	C_B
Wasbank	F	7	VII: M_B	C_B
Weenen	F	7	V : M_C	CN_C
Wepener	F	6	VI: M_C	C_A
Wesselsbron	F	6	VI: M_C	C_B
White River	F	5	- - - - - - - -	
Williston	F	6	VII: M_C	C_B
Willowmore	F	6	VI: M_C	C_B
Winburg	F	6	VI: M_B	C_B
Windsorton	F	8	VII: Mi_A	S_C
Wolseley	F	6	VI: M_A	C_B
Wolwekrans Colliery	F	8	I : Mi_A	
Zastron	F	6	VI: M_C	C_B

CN_A	S_B		;	CN2		(CN)
			;			(M)
			;			(C)
CN_B	S_A		;	CN1	S1	(S)
S_C			;	M1		(M)
C_B	CN_B	S_B	;			(S)
T_C	CN_C	S_A	;	S1		(S)
T_C	CN_C	S_B	;	C1		(C)
CN_B	S_B		;	CN1		(S)
			;	Mi3		(Mi)
CN_C	S_B		;	C1		(M)
CN_C	S_B		;	M1		(M)
CN_B	S_B		;	C2		(C)
T_C	CN_B	S_B	;	CN1		(S)
CN_B	S_B		;			(S)
S_B			;			(S)
T_C	CN_B	S_C	;	C1		(C)
T_C	CN_C	S_B	;			(M)
S_C			;			(CN)
T_C	CN_B	S_B	;	C1		(C)
CN_B	S_B		;	C1		(C)
- NO DATA - - - - - - - - - - - - -						
T_C	CN_B	S_B	;	CN1		(CN)
T_C	CN_A	S_B	;	CN3		(CN)
T_C	CN_C	S_B	;			(C)
			;	Mi3		(Mi)
T_B	CN_C	S_B	;	T1		(M)
			;	Mi3		(Mi)
T_C	CN_C	S_B	;			(S)

B and Services at the B level; in the Nelson method the only specialisation that emerges is for Commerce at the level of $\bar{X} + 1$ *S.D.* The final letter indicates that the largest single function in Johannesburg is commerce. The W following upon the Service Hierarchy Order here indicates that the city is part of the Witwatersrand conurbation.

SPATIAL DISTRIBUTION:

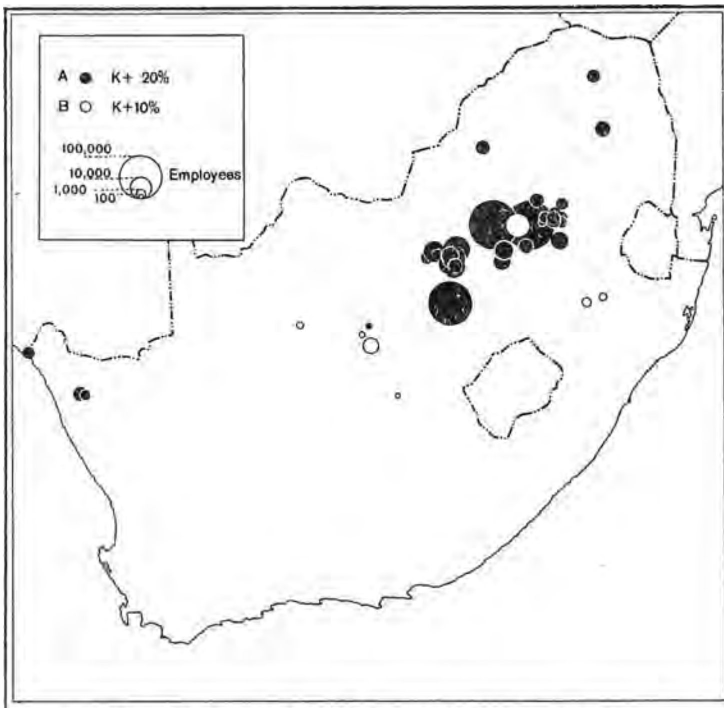
Figures 21 and 22 depict the distribution of cities ranked at the A and B levels of specialisation according to the Alexandersson scheme for four industrial divisions selected for analysis.

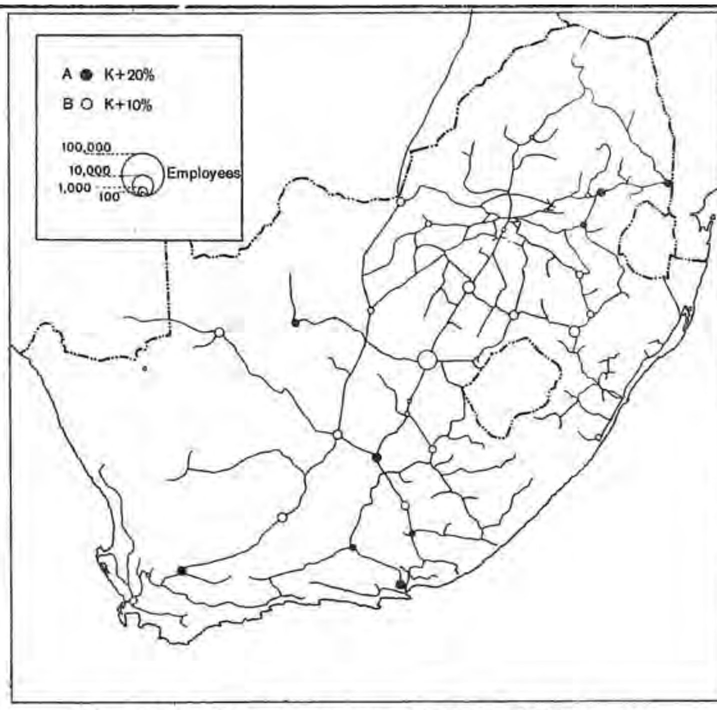
Mining cities by definition are cities associated with the distribution of developed mineral resources. Relatively few cities of more than 2,000 persons, however, qualify as mining centres, reflecting relatively low urban employment levels in this activity on the one hand, and the small size of many mining settlements *per se* on the other. Thus not infrequently mining activity with its associated residential development may be located beyond the statutory limits of recognised urban places. In Natal, for example, the cities of Vryheid, Newcastle and Dundee are by common consent classed as centres of the northern Natal coalfield. Only Newcastle and Utrecht, however, emerge as mining centres and at the B level.

The gold and coal mining cities of the southern and eastern Transvaal and the northern Orange Free State (part of the Johannesburg city sub-system) form the most prominent group of cities in which mining is a specialised activity. Significantly, however, Johannesburg does not reach a level of specialisation in mining - the city today functions principally as a commercial, financial, service and industrial centre and is the most important economic organising focus of the country. Mining employment is clearly most highly concentrated in the East and West Rand, Orange Free State goldfields and the Far West Rand in Klerksdorp and its neighbouring mining settlements.

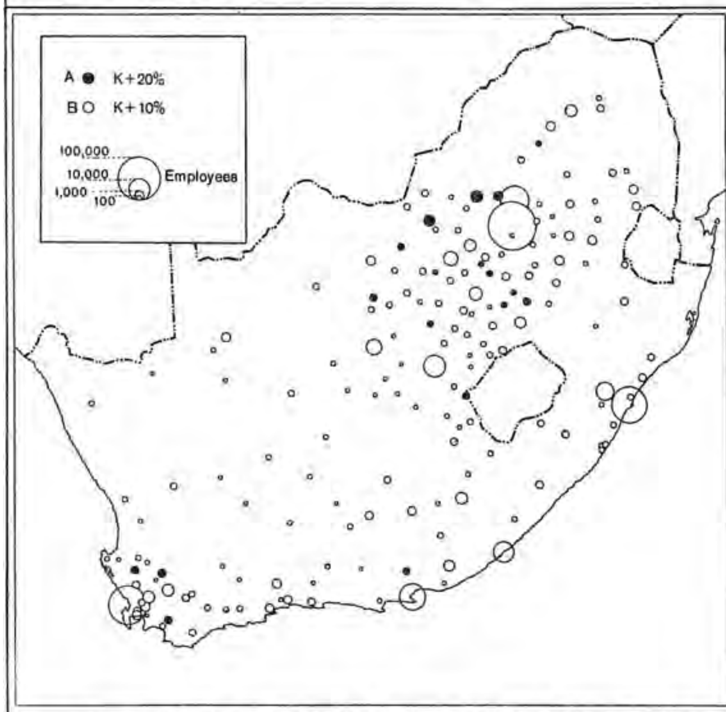
In the northern Transvaal lie the iron mining centre of Thabazimbi, the phosphate, iron and vermiculite complex of Phalaborwa and the copper mining city of Messina.

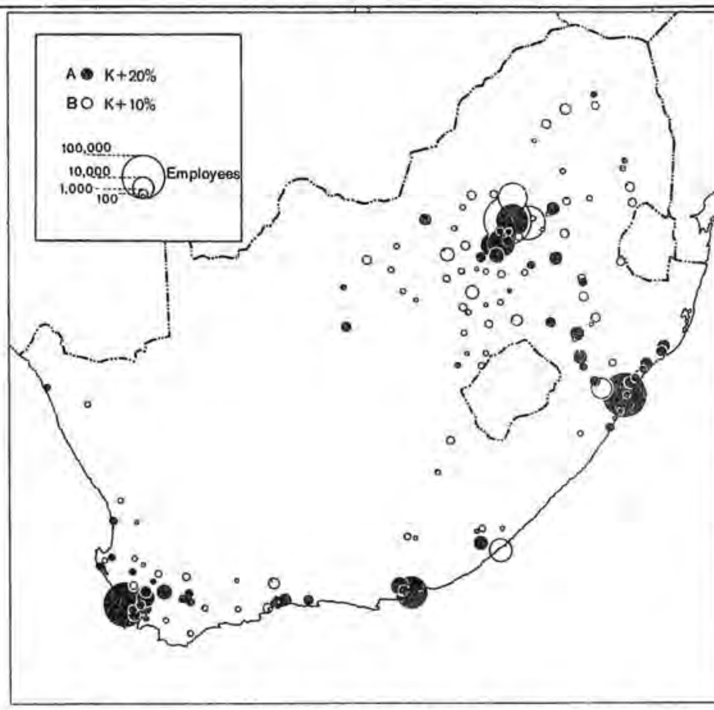
The north-west Cape Province has several mining cities based upon diamond and copper resources, while in the northern Cape focussed upon Postmasburg base mineral mining including manganese explains the small cluster of mining cities. In this area too is the diamond mining city of Kimberley.





21a DISTRIBUTION OF MINING CITIES 1960 21b DISTRIBUTION OF TRANSPORT CITIES 1960
AT THE A AND B LEVELS OF SPECIALISATION ACCORDING TO THE ALEXANDERSSON CLASSIFICATION. THE SYMBOLS ARE PROPORTIONAL TO THE
ALEXANDERSSON CLASSIFICATION. THE SYMBOLS ARE PROPTIONAL TO THE CUBE ROOTS OF EMPLOYMENT DATA FOR (A) MINING. AND (B) TRANSPORT





22a DISTRIBUTION OF COMMERCIAL CITIES 1960 22b DISTRIBUTION OF MANUFACTURING CITIES, 1960
AT THE A AND B LEVELS OF SPECIALISATION ACCORDING TO THE ALEXANDERSSON CLASSIFICATION. THE SYMBOLS ARE PROPORTIONAL TO THE
THE CUBE ROOTS OF THE EMPLOYMENT DATA FOR (A) COMMERCE AND (B) MANUFACTURING

The distribution of Manufacturing and Commercial cities is more widespread but localisation remains strongly apparent, more particularly for Manufacturing cities. A strong correlation between manufacturing and commercial specialisation is apparent for many cities in the distribution. This association contrasts with the pattern in the United States where the two functions have disparate distributions in both absolute and regional terms (Alexandersson 1956 and Nelson 1955).

Manufacturing cities are concentrated more particularly in the southern, south western and south eastern Transvaal, northern Orange Free State, and in a chain of places within the railway zone between Durban and the Witwatersrand. Less closely knit distributions occur in the northern Transvaal railway zone and the southern Lowveld. The locational distribution of Manufacturing cities in these areas, in qualitative terms, most nearly approaches the concept of a manufacturing belt as it has been identified in the north eastern United States. Within the so-called belt, however, employment in manufacturing is concentrated mainly in the metropolitan areas of the Witwatersrand, Pretoria, Vereeniging, Durban and Pietermaritzburg which contain 50.34 per cent of the total manufacturing employment in the country.

Smaller clusters of Manufacturing cities are focussed upon the metropolitan centres of the Cape coastal margin and the George-Knysna-Oudtshoorn area. Of these the cluster focussed upon Cape Town and its near hinterland is the most important.

Table 19 describes the distribution of Manufacturing cities by city sub-system and shows that 157 cities are located within the Principal sub-system, of which 79 are situated within the Johannesburg sub-system alone. It is interesting to note however, that the numbers of A cities in the Cape Town sub-system exceeds the number in the Johannesburg sub-system. A higher level of manufacturing specialisation by city in the Cape Town sub-system is apparent from this finding.

The Bloemfontein and Kimberley sub-systems are relatively poorly represented in the A and B classes of Manufacturing city.

In detail the location of Manufacturing cities produces patterns of considerable interest but work on location in depth will require further research. The manufacturing structure of South African cities, is, however, treated in some detail below.

TABLE 19

NUMBER OF MANUFACTURING CITIES BY
k LEVELS BY CITY SUB-SYSTEMS

k	Cape Town	Port Eliza-beth	East London	Johannes-burg	Pret-oria	Durban	Bloem-fontein	Kimb-erley	Principal sub-system
A	23	4	1	16	1	14	1	1	33
B	16	2	6	41	6	9	1	1	58
C	16	12	11	22	3	12	14	14	66
To-tal	55	18	18	79	10	35	16	16	157

Few cities are highly specialised in commercial activity but a considerable number are ranked at the B and C levels. The distribution of B rank Commercial cities as previously noted, is closely associated with that of Manufacturing cities. The distribution is, however, somewhat less localised. The metropolitan cities have a B rank except for the West and East Rand, Germiston and Vereeniging, which rank high in Manufacturing or Mining. In addition, the cities of the Durban-Witwatersrand railway zone rank as C places for Commerce, a feature explained by relatively high employment ratios in Manufacturing. In contrast to Manufacturing, Commerce is a prominent activity of cities situated in more peripheral localities - this is particularly apparent with respect to places in the Western Cape interior, the southern Orange Free State and southern Natal. The distribution of Commercial cities at the A and B levels is, as might be expected, a correlate of the density of the distribution of the White population of the country.

Specialisation in the transport and communications sector is related essentially to forces within the networks of transport and communication. Transport cities at the A and B levels of specialisation are important railway junctions, rail terminals or staging points on the rail system. The Transport cities are all country places and exclude the metropolitan centres, with the exception of Bloemfontein. The strength of development of other activities obscures the significance of the transport function in the port cities and other metropolitan nodes. Germiston, for example, the major national railway centre, is identified only at the C level.

THE MANUFACTURING COMPONENT:

Because of the importance of manufacturing industry in the contemporary phase of economic development in South Africa, a deeper analysis of manufacturing in South African cities appears to be particularly significant. Two aspects of manufacturing will be taken up. They are firstly, to present an overview of urban manufacturing and to identify industrial profiles of industrial cities, and secondly, to focus on the relationship between manufacturing and size of place.

DEFINITIONS AND DATA:

Manufacturing activities are widely taken to include the processing and fabrication or transformation of material inputs into new products. The assembly of inputs and certain types of repair work are also normally included. As used here, manufacturing embraces these activities, but the definition has been tightened in comparison with that used in the analysis of the general economic structure of South African cities presented above. Specifically, employment in the industry group 'general garages and workshops' has been extracted from the definition. Following the pattern adopted by the Department of Statistics for the census reports on the metropolitan areas, however, employment in 'specialised repair of motor vehicles' has been retained.

The analysis is based principally upon the unpublished employment data for individual cities drawn from the 1960 Population Census, and relates to persons employed in manufacturing in 22 individual groups that comprise that division. In contrast, data derived from the industrial census relate to employment in industrial establishments, and certain differences arise.[1)]

The national total of employment in manufacturing is larger in the population census, and though the totals in industry in the larger manufacturing centres do not differ much, in the smaller urban places industrial workers are recorded who would not, in fact, be enumerated in a census based on industrial establishments. Workers in the population census are

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1) The number of cities analysed is 314 and differs slightly from the number used in the earlier analysis of economic structure.

also enumerated by 'place of residence' rather than 'place of work'.

THE STRUCTURE OF URBAN MANUFACTURING: AN OVERVIEW:

The data presented in Table 20 afford an overview of urban manufacturing. According to the census, 90.8 per cent of all manufacturing is urban. The cities in the present analysis have 88.6 per cent of the national total (the 2.2 per cent difference being employment in urban places not included in the set of cities analysed). The metropolitan areas account for three-quarters of all manufacturing employment. With so large a proportion of manufacturing located in urban places the structure of manufacturing in the urban set (column b) is very similar to the national structure (a), though wood and cork and food industries are one or two per cent lower and metal products and clothing a little higher in the urban mix. Percentage differences between the manufacturing mix of metropolitan areas (c) and the urban set (b) as a whole tend to be larger, with food, textiles and petroleum products weaker in the metropolitan areas, and clothing and metal products stronger.

The proportion of the national totals of each of the 21 industry groups varies in the urban set (column d) from 99.2 per cent (printing) to 49.4 per cent (wood and cork), but only three groups are below the overall manufacturing percentage of 88.6 per cent. Eighteen of the groups are clearly overwhelmingly urban, and one (wood and cork) may claim to be as much rural as an urban industry. However, seven or eight groups, most notably wood and cork and petroleum products, are clearly not overwhelmingly metropolitan in location (e). The metropolitan proportion of the urban total (f) is no less than 84 per cent, and in nine industry groups the non-metropolitan cities in the set are left with less than 10 per cent of the urban totals. Petroleum, tobacco, food, wood and cork, and beverages alone have metropolitan percentages which are below 70 per cent of the urban total.

TABLE 20

MANUFACTURING EMPLOYMENT, 1960, BY INDUSTRY GROUP

Industry Group (& code letters)	Urban Total	Percentages (a)	(b)	(c)	(d)	(e)	(f)
Food: (F)	75,800	14.4	13.3	10.6	81.2	54.3	65.4
Beverages: (B)	10,535	1.9	1.8	1.5	90.4	61.3	67.9
Tobacco: (To)	4,730	0.8	0.8	0.6	92.8	60.0	64.5
Textiles: (Te)	32,488	5.3	5.7	4.8	94.6	66.9	70.7
Footwear: (Fw)	35,055	5.9	6.1	6.1	93.1	78.0	83.9
Clothing: (CL)	42,906	6.8	7.5	8.5	97.7	92.7	94.8
Wood and Cork: (WC)	14,221	4.5	2.5	2.0	49.4	32.3	65.5
Furniture and Fixtures: (Fu)	17,142	2.8	3.0	3.4	97.1	91.7	94.4
Paper and Paper Products: (P)	13,867	2.5	2.4	2.3	89.4	70.1	79.4
Printing and Publishing Products: (Pr)	24,709	3.9	4.3	4.7	99.2	91.1	91.9
Leather Products: (L)	4,288	0.7	0.8	0.8	93.0	79.0	85.0
Rubber Products: (R)	5,401	0.9	0.9	0.8	93.4	66.9	71.7
Chemical and Chemical Products: (C)	37,652	6.6	6.6	7.2	88.8	81.1	91.4
Petroleum Products: (Pe)	5,375	0.9	0.9	0.5	93.5	38.0	40.6
Non-Metalliferous mineral products: (NM)	38,315	8.4	6.7	6.4	70.9	56.6	79.9
Basic Metals: (BM)	39,875	6.5	7.0	7.9	94.9	90.2	95.1
Metal Products: (M)	57,742	9.3	10.1	11.4	96.0	90.6	94.4
Agricultural Machinery: (A)	16,082	2.6	2.8	3.1	96.2	88.0	91.5
Electrical Equipment: (E)	24,248	3.9	4.2	4.9	97.4	93.2	95.7
Transport Equipment & Specialised Repairs: (T)	58,670	9.6	10.3	10.2	94.6	78.9	83.5
Other (O)	12,416	2.0	2.2	2.5	96.6	92.1	95.3
TOTAL :	570,680	100	100	100	88.6	74.4	83.9

NOTES: The Urban Total comprises 14 metropolitan areas and 300 towns. Evaton and Mariannhill have been added to the metropolitan areas. The National totals for industry groups are given in Table 2 of Volume 6 of the 1960 Population Census. Table 1 breaks National totals into Urban and Rural - but for Industry Divisions only. By itself, 'Specialised Repairs' has an employment total of 6,328.

Key: (a) Percentage of the national manufacturing total.
(b) Percentage of the urban manufacturing total.
(c) Percentage of the metropolitan manufacturing total.
(d) Urban total for each group as percentage of national total for the group.
(e) Metropolitan total for each group as percentage of national total for the group.
(f) Metropolitan total for each group as percentage of urban total for the group.

MANUFACTURING CITIES:

Table 21 presents the essential industrial character or profile of each of the cities studied. It is possible here, however, to examine only manufacturing as a whole. Detailed groupings of cities by manufacturing composition will be undertaken in later research.

The number of cities where manufacturing as a whole is the dominant function is 54; 27 of these are from the smallest population size class, though it might be noted that this F class (2,000 - 5,000 persons) has 196 cities.

Manufacturing is of some importance in most of the cities analysed, being entirely absent in only three places, all colliery settlements. The median of the manufacturing ratios is 6.40 per cent and the average ratio is 10.92. Since the ratio is affected by several very high values (including three of over 70 per cent), the number of cities, above the mean ratio is only 95; 136 cities are below the 5 per cent level.

The actual degree of importance of manufacturing in the economic structure of cities in the set may be guaged from the application of a variety of criteria to the list of ratios. The Alexandersson functional classification identifies 51 A rank cities, 46 B cities and 78 C cities, where the k value is 0.30 per cent. The Nelson methodology yields 13 cities manufacturing specialisation at the level of $\bar{X} + 3$ $S.D.$, only 2 at $\bar{X} + 2$ $S.D.$, and 26 at $\bar{X} + 1$ $S.D.$, where the standard deviation is 13.10.[1)]

A further guide to the relative importance and level of concentration of manufacturing in cities within the set is provided by the Location Quotient. The quotient is calculated by dividing the manufacturing ratio for each city by its percentage share of the total employment in manufacturing in the

1) The average manufacturing ratio for the 318 cities discussed earlier was 13.76 per cent. The lower figure here results from the adjustment referred to in an earlier footnote. The reduction in the number of workers in the Manufacturing division has also affected the rankings of several cities. Table 20 does not exactly correspond therefore with the results listed in Table 18.

TABLE 21

MANUFACTURING PROFILES OF SOUTH AFRICAN CITIES, 1960

	a	b	c	d	e	f	g	h	i						j						k
Cape Town	1	AA	*	22.8	A	-	1.3	21	CL	20	F	13	Pr	9	CL	2.6	Pr	2.2	L	1.4	22.0
Durban	1	AA	*	23.8	A	-	1.4	21	F	15	C	14	T	11	C	2.1	Pe	1.8	Te	1.6	17.8
E. Rand	1	A	-	18.9	B	-	1.1	21	M	17	C	15	NM	9	C	2.3	A	2.2	P	2.1	27.5
Johannesburg	1	AA	-	19.2	B	-	1.1	21	M	12	CL	12	F	10	Fu	2.4	O	2.1	E	1.9	20.9
Germiston	2	A	*	30.1	A	1	1.8	21	M	17	T	13	NM	12	A	4.2	E	2.2	M	1.7	32.4
Port Elizabeth	2	A	*	29.6	A	1	1.7	21	T	25	F	14	FW	12	L	2.7	T	2.4	WC	2.3	25.5
Pretoria	2	A	-	16.7	B	-	1.0	21	BM	41	T	14	NM	9	BM	5.8	O	1.7	T	1.3	41.7
Vereeniging - Vanderbijlpark	2	A	*	49.3	A	3	2.6	21	BM	51	M	24	NM	11	BM	7.3	M	2.4	NM	1.6	62.0
East London	4	A	*	20.0	B	-	1.2	21	F	33	T	19	Te	18	Te	3.1	F	2.4	T	1.9	41.6
W. Rand	4	A	-	7.4	C	-	0.4	21	M	19	NM	18	F	12	NM	2.6	M	1.9	R	1.6	23.8
Bloemfontein	5	A	-	9.2	C	-	0.5	21	T	36	Pr	14	F	11	T	3.5	Pr	3.2	NM	1.6	41.1
Estcourt	5	E	*	36.3	A	1	2.1	17	P	44	F	43	Te	9	P	18.4	F	3.2	Te	1.5	73.8
Kimberley	5	B	-	9.5	C	-	0.6	20	T	24	CL	19	F	10	B	2.9	CL	2.7	T	2.3	35.6
King William's Town	5	D	*	33.2	A	1	1.9	19	Te	59	FW	15	L	7	Te	10.3	L	9.4	FW	2.5	68.8
Klerksdorp	5	B	-	9.0	C	-	0.5	19	F	33	T	16	M	11	A	3.5	F	2.5	B	2.0	39.9
Kroonstad	5	C	-	12.2	B	-	0.7	19	F	30	T	17	NM	11	B	2.4	A	2.4	F	2.3	37.3
Ladysmith (N)	5	C	*	20.1	B	-	1.2	19	Te	43	T	21	CL	18	Te	7.5	CL	2.4	T	2.1	58.1
O.F.S. Goldfields	5	A	-	2.1	-	-	0.1	19	M	24	F	16	A	16	A	5.5	M	2.4	R	2.4	38.7
Paarl	5	C	*	38.9	A	2	2.3	20	F	24	Te	18	To	17	To	20.1	B	6.5	Te	3.2	53.2
Pietermaritzburg	5	A	-	16.1	B	-	0.9	19	FW	25	T	20	F	10	L	4.7	FW	4.2	T	1.9	14.8
Sasolburg	5	D	*	55.9	A	3	3.2	15	Pe	86	C	12	F	1	Pe	91.2	C	1.8	F	0.1	90.1
Stellenbosch	5	C	-	21.8	A	-	1.3	19	B	30	WC	22	NM	14	B	16.6	WC	9.0	T	3.5	58.6
Uitenhage	5	C	*	32.8	A	1	1.9	19	T	53	Te	30	NM	3	Te	5.3	T	5.2	L	3.2	67.7
Wellington	5	D	*	41.6	A	3	2.4	20	F	41	Te	23	FW	12	L	12.0	Te	4.0	F	3.1	60.5
Witbank	5	C	*	19.8	B	-	1.2	18	BM	34	C	27	T	14	BM	4.8	C	4.1	T	1.4	51.0
Worcester	5	C	*	26.3	A	1	1.5	17	Te	40	F	34	B	5	Te	7.1	B	2.6	F	2.6	58.1
Ashton	6	F	*	55.8	A	3	3.2	5	F	98	T	1	WC	0.3	F	7.4	WC	0.1	T	0.1	85.0
Bethal	6	D	-	13.6	B	-	0.8	16	F	80	T	7	FW	2	F	6.0	R	1.9	B	1.2	67.4
Bethlehem	6	C	-	11.8	B	-	0.7	20	F	47	T	23	NM	6	F	3.6	T	2.2	B	2.0	52.4
Charlestown	6	E	*	36.7	A	1	2.1	11	CL	92	F	4	NM	1	CL	12.4	F	.3	NM	0.2	84.6
Despatch	6	E	*	23.6	A	-	1.4	18	T	73	FW	5	F	4	T	7.1	L	1.3	FW	0.9	6.92
Dundee	6	D	-	16.7	B	-	1.0	18	NM	45	F	34	FW	4	NM	6.7	F	2.6	B	1.4	60.5
Empangeni	6	E	*	27.8	A	1	2.2	13	F	91	T	4	A	1	F	6.9	R	0.5	T	0.4	78.2
Felixton	6	F	*	77.3	A	3	4.4	5	F	68	P	31	A	0.2	P	13.2	F	5.2	A	0.1	83.9
George	6	D	*	24.5	A	1	1.4	19	FW	48	WC	29	F	4	WC	11.8	FW	7.8	A	0.9	68.2
Grahamstown	6	C	-	6.4	C	-	0.4	17	F	29	NM	28	FW	12	NM	4.3	F	2.2	FW	2.0	48.7

	a	b	c	d	e	f	g	h	
Harrismith	6	D	-	19.0	B	-	1.1	13	Te
Howick	6	E	*	42.7	A	3	2.5	11	R
Kuils River	6	E	*	31.8	A	1	1.8	18	C
Knysna	6	D	*	26.0	A	1	1.5	13	WC
Lamberts Bay	6	F	*	27.0	A	1	1.6	6	F
Lichtenburg	6	D	-	15.5	B	-	0.9	16	NM
Mandini	6	F	*	78.0	A	3	4.4	2	P
Meyerton	6	E	*	40.2	A	2	2.3	16	NM
Mossel Bay	6	D	-	16.6	B	-	1.0	14	F
Nelspruit	6	D	-	12.5	B	-	0.7	18	WC
Newcastle	6	D	-	15.7	B	-	0.9	16	BM
Oudtshoorn	6	C	-	13.7	B	-	0.8	19	FW
Parys	6	D	*	19.1	B	-	1.1	18	Te
Pietersburg	6	C	-	7.7	C	-	0.4	20	F
Piet Retief	6	E	-	16.1	B	-	0.9	10	WC
Potchefstroom	6	C	-	9.0	C	-	0.5	20	B
Queenstown	6	C	-	6.5	C	-	0.4	17	F
Rustenburg	6	C	-	7.4	C	-	0.4	19	To
Sezela	6	F	*	41.6	A	3	2.4	1	F
Shakaskraal	6	F	*	54.7	A	3	3.2	10	F
Somerset West	6	E	*	21.2	A	-	1.2	19	C
Standerton	6	D	*	21.7	A	-	1.3	17	Te
Stanger	6	E	-	16.0	B	-	0.9	18	F
Strand	6	D	*	26.2	A	1	1.5	18	C
Tongaat	6	E	*	35.0	A	1	2.0	13	F
Ulco	6	F	*	77.6	A	3	4.5	3	NM
Vryburg	6	D	-	12.0	B	-	0.7	16	F
Aliwal North	7	D	-	11.9	B	-	0.7	17	F
Barberton	7	D	-	10.4	B	-	0.6	19	M
Beaufort West	7	D	-	6.1	C	-	0.4	15	T
Blanco	7	F	*	26.2	A	1	1.5	13	WC
Bloemhof	7	F	-	8.1	C	-	0.5	10	F
Bothaville	7	E	-	11.1	B	-	0.6	10	A
Bredasdorp	7	F	-	9.6	C	-	0.6	12	NM
Brits	7	E	-	8.8	C	-	0.5	14	NM

		i					j				k
67	F	21	WC	3	Te	11.7	F	1.5	WC	1.4	69.1
95	F	2	FW	1	R	100.1	WC	0.3	FW	0.9	93.6
44	M	13	T	12	C	6.7	T	1.2	A	1.0	42.4
83	Fu	7	F	2.7	WC	33.7	Fu	2.3	B	0.6	84.0
97	FW	0.9	T	0.9	F	7.2	B	0.2	FW	0.1	84.0
61	F	19	FW	6	NM	9.1	F	1.5	B	1.2	60.4
100					P	42.3					97.5
61	BM	23	M	10	NM	9.0	BM	3.3	M	0.9	69.8
64	T	12	FW	8	F	4.8	FW	1.4	T	1.2	55.0
37	F	18	T	8	WC	15.0	B	2.7	R	2.5	48.4
39	M	28	NM	12	BM	5.6	M	2.8	B	1.9	56.8
29	F	21	To	13	To	16.4	FW	4.8	B	3.0	50.8
23	CL	21	M	20	Pe	9.2	Te	4.1	CL	2.8	49.2
46	T	11	B	9	B	5.0	F	3.4	R	1.8	42.6
77	F	8	NM	5	WC	31.2	R	1.8	NM	0.8	75.7
26	F	24	FW	11	B	14.1	E	3.2	F	1.8	40.7
38	T	15	Pr	7	F	2.8	R	2.0	Fu	1.9	37.3
43	F	12	NM	9	To	51.5	B	2.4	R	1.4	47.5
100					F	7.6					86.7
95	Te	1	FW	1	F	7.2	Te	0.3	FW	0.2	82.0
41	F	16	T	13	C	6.2	T	1.3	Pr	1.2	40.1
57	F	22	T	5	Te	10.1	F	1.6	R	1.1	60.3
73	T	12	FW	3	F	5.5	R	1.4	T	1.1	61.8
51	F	17	T	9	C	7.8	F	1.3	WC	1.1	48.6
89	CL	3	WC	2	F	6.7	WC	0.8	O	0.5	75.4
99	O	0.5	FO	0.1	NM	15.0	O	0.3	F	0.01	92.7
50	B	16	T	9	B	8.6	F	3.8	A	1.1	60.9
65	NM	16	T	4	F	4.9	NM	2.4	B	1.3	62.2
19	F	18	FW	13	WC	3.2	B	3.0	R	2.6	34.1
53	NM	14	F	12	T	5.2	B	2.1			53.2
39	FW	37	CL	16	WC	15.9	FW	6.1	CL	2.1	76.3
44	B	26	NM	9	B	14.2	F	3.3	NM	1.3	58.2
63	F	14	T	8	A	22.5	F	1.1	WC	0.8	60.9
55	FW	12	F	9	NM	8.1	WC	2.0	FW	2.0	58.4
40	F	27	T	9	NM	6.0	R	2.8	B	2.2	53.6

	a	b	c	d	e	f	g	h	i						j						k
Ceres	7	E	-	11.4	B	-	0.7	11	F	78	FW	6	T	5	F	6.0	FW	1.1	WC	0.8	65.5
Clocolan	7	F	-	10.1	C	-	0.6	9	F	55	A	17	NM	16	A	6.0	F	4.2	NM	2.4	64.5
Cradock	7	D	-	5.0	-	-	0.3	17	T	22	F	22	NM	18	R	3.6	NM	2.6	T	2.1	40.9
Darnall	7	F	*	62.1	A	3	3.6	3	F	98	P	1	FW	0.7	F	7.5	P	0.4	FW	0.1	85.0
De Aar	7	D	-	8.2	C	-	0.5	13	T	62	NM	17	F	6	T	6.1	NM	2.5	R	1.8	61.4
Duiwelskloof	7	F	-	19.6	B	-	1.1	7	WC	85	NM	4	F	3	WC	34.5	NM	0.6	FW	0.5	82.6
Ermelo	7	D	-	6.4	C	-	0.4	18	F	30	NM	18	M	13	NM	2.7	R	2.6	F	2.3	36.4
Eshowe	7	F	-	7.2	C	-	0.4	18	F	43	Fu	9	T	9	B	3.3	F	3.3	Fu	3.0	50.5
Ficksburg	7	E	-	6.3	C	-	0.4	14	F	33	NM	26	T	13	NM	3.8	WC	2.8	F	2.5	58.6
Frankfort	7	F	-	8.2	C	-	0.5	11	F	61	FW	11	T	10	F	4.6	FW	1.8	T	1.0	51.9
Graaff Reinet	7	D	-	4.1	-	-	0.2	16	NM	20	Pr	13	F	13	Fu	3.4	B	3.2	NM	3.1	40.6
Glencoe	7	E	-	8.1	C	-	0.5	12	T	55	F	27	NM	6	T	5.4	F	2.0	NM	0.9	57.7
Grabouw	7	F	*	19.7	B	-	1.1	8	F	68	WC	22	FW	4	WC	9.1	F	5.1	T	1.1	74.1
Graskop	7	F	*	23.6	A	-	1.4	7	WC	95	T	2	FW	1	WC	38.4	FW	0.2	T	0.1	92.5
Grasmere	7	F	*	26.2	A	1	1.5	18	CL	28	FW	15	Fu	11	L	6.4	Fu	3.7	CL	3.7	42.0
Great Brak River	7	F	*	50.9	A	3	3.0	11	FW	75	WC	19	F	2	FW	12.2	WC	7.7	L	0.3	85.0
Greytown	7	E	-	7.2	C	-	0.4	15	F	31	WC	26	NM	13	WC	10.7	R	4.4	F	2.4	52.3
Harding	7	F	-	14.5	B	-	0.8	9	WC	69	F	20	T	3	WC	27.9	F	1.5	FW	0.5	73.7
Heidelberg (T)	7	E	-	10.3	C	-	0.6	17	F	31	A	11	T	10	A	3.8	WC	3.6	Fu	2.5	39.4
Heilbron	7	E	-	9.7	C	-	0.6	14	F	67	NM	12	T	6	F	5.0	NM	1.8	FW	0.9	59.2
Henneman	7	E	-	14.7	B	-	0.9	11	F	45	M	25	NM	13	B	4.5	F	3.4	A	3.3	59.9
Hermanus	7	F	-	5.6	C	-	0.3	11	F	38	T	19	B	12	B	6.6	F	2.8	WC	2.6	52.5
Kokstad	7	E	-	5.2	-	-	0.3	12	F	37	T	19	NM	12	R	3.8	F	2.8	B	2.7	45.0
Kookfontein	7	F	-	52.3	A	-	3.0	9	BM	53	M	27	NM	7	BM	7.6	M	2.7	A	1.5	66.7
Kuruman	7	E	-	4.1	-	-	0.2	12	F	41	T	17	NM	11	F	3.2	B	2.7	T	1.7	44.3
Koppies	7	F	-	9.5	C	-	0.6	8	F	69	M	10	T	9	F	5.1	M	0.9	T	0.8	56.0
Ladybrand	7	E	-	9.2	C	-	0.5	11	C	59	F	20	Pr	5	C	9.0	F	1.5	Pr	1.2	59.4
Louis Trichardt	7	E	-	4.7	-	-	0.3	13	WC	26	NM	24	F	24	WC	10.2	NM	3.6	F	1.8	52.8
Lydenburg	7	E	-	4.1	-	-	0.2	12	F	45	T	25	NM	6	F	3.4	T	2.4	WC	2.2	37.8
Mafeking	7	E	-	6.1	C	-	0.4	13	T	39	F	21	Pr	8	T	3.7	B	2.6	Pr	1.8	44.9
Malmesbury	7	E	-	11.6	B	-	0.7	16	F	61	FW	11	C	9	F	4.6	R	2.5	FW	1.9	56.0
Middelburg (C)	7	E	-	5.2	-	-	0.3	16	C	28	NM	17	B	11	L	6.0	B	5.7	C	4.2	44.7
Middelburg (T)	7	D	-	6.6	C	-	0.4	15	F	28	NM	16	M	12	NM	2.4	F	2.1	Pr	1.9	33.3
Molteno	7	F	-	11.3	B	-	0.7	8	F	86	FW	4	T	3	F	6.6	R	1.5	FW	0.7	72.7
Montagu	7	E	*	20.4	A	-	1.2	9	F	81	B	7	FW	3	F	6.0	B	3.9	WC	0.7	72.6
Mooi River	7	F	*	33.5	A	1	1.9	7	Te	73	F	22	T	1	Te	12.8	F	1.7	A	0.4	76.5
Moorreesburg	7	F	-	14.2	B	-	0.8	13	F	49	A	11	Fu	8	A	3.8	F	3.6	Fu	2.6	49.9

	a	b	c	d	e	f		h		i					j						k
Noupoort	7	E	-	7.1	C	-	0.4	7	T	77	NM	11	FW	6	T	7.5	NM	1.7	FW	0.9	71.1
Orkney	7	C	-	2.3	-	-	0.1	13	NM	47	BM	20	F	11	NF	7.0	BM	2.9	A	1.1	53.7
Pacaltsdorp	7	F	*	28.0	A	1	1.6	9	WC	43	FW	25	CL	20	WC	17.8	FW	4.2	L	3.1	75.4
Piketberg	7	F	-	11.4	B	-	0.7	8	A	58	T	11	NM	11	A	20.8	B	2.9	NM	1.7	63.1
Port Nolloth	7	F	*	26.8	A	1	1.6	6	F	92	T	6	FW	0.9	F	6.9	T	0.6	FW	0.2	78.9
Potgietersrust	7	D	-	9.6	C	-	0.6	18	F	39	A	18	NM	9	A	6.6	F	3.0	B	1.7	47.3
Port Shepstone	7	F	-	8.2	C	-	0.5	18	F	31	T	30	Pr	6	T	2.9	B	2.6	To	2.4	43.0
Reivilo	7	F	*	35.9	A	1	2.1	2	F	100					F	7.4	T	0.1			83.2
Residensia	7	F	*	26.6	A	1	1.5	16	BM	36	M	32	A	10	BM	5.2	A	3.5	M	3.1	58.2
Riversdale	7	E	-	6.3	C	-	0.4	15	NM	20	WC	18	F	17	WC	7.5	R	3.9	NM	3.0	46.8
Robertson	7	E	-	16.9	B	-	1.0	17	B	35	F	32	NM	9	B	19.3	F	2.4	NM	1.3	55.4
Schweizer-Reneke	7	E	-	9.0	C	-	0.5	8	F	67	B	9	NM	9	B	5.0	F	4.9	R	3.2	64.9
Sabie	7	F	-	10.4	B	-	0.6	9	WC	61	P	11	F	7	WC	25.1	P	4.8	To	2.0	69.4
Saldanha	7	F	*	35.4	A	1	2.1	7	F	96	CL	1	T	1	F	7.2	CL	0.1	E	0.1	82.6
Senekal	7	E	-	15.8	B	-	0.9	13	F	76	Pr	7	NM	4	F	5.7	Pr	1.7	NM	0.6	65.6
Somerset East	7	E	-	9.9	C	-	0.6	12	C	44	NM	19	F	14	C	6.7	NM	2.9	B	1.4	50.7
Stilfontein	7	D	-	1.3	-	-	0.1	12	M	49	BM	25	NM	6	M	4.8	BM	3.6	A	1.6	58.2
Stutterheim	7	E	-	9.7	C	-	0.6	11	Te	40	WC	35	NM	10	WC	14.3	Te	7.0	NM	1.4	70.7
Swellendam	7	F	-	9.1	C	-	0.5	16	WC	29	NM	13	A	10	WC	12.0	A	3.5	L	3.3	43.2
Theunissen	7	E	-	7.0	C	-	0.4	6	F	58	M	12	FW	12	F	4.3	FW	2.0	NM	1.5	56.6
Touwsriver	7	E	-	19.2	B	-	1.1	9	T	92	F	4	FW	2	T	8.9	FW	0.3	F	0.3	81.4
Tweespruit	7	F	*	26.6	A	1	1.5	8	F	89	B	3	M	3	F	6.7	B	1.9	A	0.7	77.4
Tzaneen	7	E	-	12.3	B	-	0.7	13	WC	43	F	12	T	7	WC	17.2	Fu	5.1	R	3.6	57.1
Umkomaas	7	F	-	25.2	A	1	1.5	10	P	87	F	6	T	2	F	36.7	BM	0.9	F	0.5	84.6
Umtata	7	D	-	6.7	C	-	0.4	18	WC	24	F	21	NM	14	WC	9.6	NM	2.0	R	1.8	41.7
Umzinto	7	F	-	7.1	C	-	0.4	10	F	60	FW	13	T	8	F	4.4	FW	2.1	WC	1.9	59.6
Upington	7	C	-	5.9	C	-	0.4	16	T	37	F	17	M	11	T	3.6	R	1.9	FW	1.7	37.4
Velddrif	7	F	*	28.5	A	1	1.7	6	F	89	T	8	C	1	F	6.7	To	0.8	O	0.5	75.7
Ventersdorp	7	F	-	9.9	C	-	0.6	10	B	38	NM	30	F	13	B	20.6	NM	4.5	R	2.3	61.2
Verulam	7	F	-	12.7	B	-	0.7	13	F	35	CL	21	FW	12	CL	2.8	F	2.6	P	2.3	44.1
Viljoenskroon	7	F	-	11.5	B	-	0.7	8	C	47	F	14	T	14	C	7.0	NM	1.7	T	1.4	51.5
Villiers	7	F	-	25.1	A	1	1.5	11	CL	83	F	5	T	4	CL	11.1	NM	0.5	F	0.4	75.1
Volksrust	7	E	-	9.9	C	-	0.6	13	T	44	F	22	NM	13	T	4.2	NM	1.9	F	1.7	48.2
Vrede	7	E	-	5.0	-	-	0.3	11	F	26	NM	21	T	15	R	3.7	NM	3.2	F	1.9	41.2
Vryheid	7	D	-	7.5	C	-	0.4	16	F	22	T	20	C	19	B	2.9	C	2.8	R	2.3	43.1
Waterval-Bo	7	E	-	5.3	C	-	0.3	3	T	92	F	5	FW	4	T	8.8	FW	0.6	F	0.4	81.3
Winburg	7	F	-	8.3	C	-	0.5	16	F	54	NM	18	FW	8	F	4.1	NM	2.7	FW	1.2	53.6
Wolseley	7	F	*	23.4	A	-	1.4	9	F	82	Fu	8	T	4	F	6.1	Fu	2.6	T	0.4	73.4

	a	b	c	d	e	f	g	h		i					j						k
Adelaide	8	E	-	3.8	-	-	0.2	10	C	31	Pr	18	T	15	C	4.5	Pr	4.1	WC	3.9	48.9
Balfour (T)	8	F	-	6.1	C	-	0.4	8	F	44	T	17	FW	11	F	3.4	A	2.6	FW	1.8	49.7
Barkly East	8	F	-	4.4	-	-	0.3	10	F	45	T	11	FW	10	WC	3.9	F	3.4	FW	1.5	47.1
Barkly West	8	F	-	4.9	C	-	0.3	7	F	77	T	10	FW	8	F	5.9	FW	1.3	To	0.9	64.0
Belfast	8	F	-	7.2	C	-	0.4	7	NM	34	WC	27	F	22	WC	10.9	NM	4.9	F	1.6	60.7
Breyton	8	F	-	6.1	C	-	0.4	6	T	50	NM	23	F	17	T	4.6	NM	3.4	WC	1.3	60.5
Brandfort	8	F	-	4.5	-	-	0.3	11	T	31	F	28	FW	13	T	3.0	WC	2.3	FW	2.2	49.1
Burgersdorp	8	E	-	3.3	-	-	0.2	9	T	32	F	17	NM	17	WC	3.6	B	3.4	T	3.1	46.9
Butterworth	8	F	-	5.7	C	-	0.3	9	F	46	NM	27	T	7	NM	4.2	F	3.7	WC	1.8	54.9
Caledon	8	F	-	5.6	C	-	0.3	15	F	18	FW	15	T	15	R	8.7	B	3.9	Fu	3.5	44.1
Calvinia	8	F	-	4.5	-	-	0.3	11	NM	46	T	14	Pr	10	NM	6.9	Pr	2.3	FW	1.4	52.3
Carolina	8	F	-	5.7	C	-	0.3	11	F	21	NM	19	M	15	B	4.8	WC	4.1	NM	2.8	41.5
Christiana	8	E	-	3.6	-	-	0.2	10	NM	44	F	21	T	15	NM	6.4	B	2.5	F	1.5	54.5
Clanwilliam	8	F	-	9.7	C	-	0.6	6	FW	43	F	24	WC	22	WC	8.9	FW	7.0	F	1.8	68.3
Colesberg	8	F	-	5.7	C	-	0.3	11	M	29	NM	19	T	16	M	2.8	NM	2.8	T	1.5	30.7
Coligny	8	F	-	5.8	C	-	0.3	7	T	35	FW	34	NM	12	FW	5.5	T	3.4	NM	1.8	58.4
Delareyville	8	F	-	5.0	-	-	0.3	9	M	55	T	17	FW	8	M	5.2	T	1.5	FW	1.3	53.5
Delmas	8	F	-	7.7	C	-	0.4	8	F	76	T	10	FW	7	F	5.6	FW	1.1	T	0.9	63.9
Excelsior	8	F	-	11.8	B	-	0.7	5	F	71	NM	17	T	5	F	5.6	NM	2.6	T	0.5	68.3
Fort Beaufort	8	E	-	2.4	-	-	0.1	10	F	35	NM	30	T	18	NM	4.4	B	2.9	F	2.6	55.3
Groblersdal	8	F	-	5.7	C	-	0.3	8	F	51	T	13	NM	13	R	4.7	F	3.9	B	2.3	52.7
Heidelberg (C)	8	F	-	4.7	-	-	0.3	14	M	31	FW	22	T	9	R	3.7	FW	3.5	M	2.9	43.7
Komga	8	F	-	9.7	C	-	0.6	7	F	49	NM	41	T	4	NM	6.2	F	3.8	FW	0.5	69.5
Koster	8	F	-	7.3	C	-	0.4	5	F	55	NM	20	T	15	F	4.2	NM	3.1	T	1.6	62.2
Ladismith (C)	8	F	-	8.1	C	-	0.5	5	F	43	B	26	FW	20	B	14.8	F	3.4	FW	3.3	68.3
Leslie	8	F	-	11.3	B	-	0.7	12	F	67	A	8	T	7	F	4.8	A	2.8	T	0.7	58.9
Lindley	8	F	-	8.3	C	-	0.5	7	F	73	T	11	NM	9	F	5.6	WC	1.5	NM	1.3	63.5
Marburg	8	F	-	6.1	C	-	0.4	14	F	26	CL	20	B	9	B	5.1	R	3.3	CL	2.6	42.1
Margate	8	F	-	6.9	C	-	0.4	15	F	36	Pr	11	M	11	O	2.9	F	2.6	Pr	2.4	37.5
Marquard	8	F	-	6.0	C	-	0.4	7	F	50	NM	16	T	16	F	3.8	NM	2.4	T	1.6	52.7
Matatiele	8	F	-	3.2	-	-	0.2	9	F	37	T	21	Pr	18	Pr	4.0	F	2.7	T	2.0	53.1
Ogies	8	F	-	8.4	C	-	0.5	7	F	55	T	13	FW	11	F	4.2	FW	1.9	T	1.3	50.8
Prieska	8	E	-	4.0	-	-	0.2	10	NM	49	FW	14	T	11	NM	7.3	To	2.8	WC	2.4	48.4
Reitz	8	F	-	4.3	-	-	0.2	11	F	31	NM	15	T	14	F	2.2	NM	2.2	Pr	1.8	43.3
Richmond (N)	8	F	-	8.0	C	-	0.5	9	WC	67	F	8	T	6	WC	26.2	R	1.6	Pr	1.0	65.0
Roosboom	8	F	*	15.0	B	-	0.9	11	Te	66	CL	7	C	6	Te	11.8	R	2.2	B	1.1	60.9
Scottburgh	8	F	-	7.6	C	-	0.4	13	F	49	T	14	P	9	F	3.6	P	3.6	T	1.4	46.4

	a	b	c	d	e	f	g	h	i						j						k
Springbok	8	F	–	4.2	–	–	0.2	8	T	33	R	21	F	19	R	22.7	T	3.2	L	2.6	58.5
Upper Kubusi	8	F	*	12.2	B	–	0.7	1	WC	100					WC	39.5					97.5
Ventersburg	8	F	–	7.4	C	–	0.4	12	F	26	NM	17	FW	15	FW	0.6	NM	0.5	F	0.4	36.5
Vredefort	8	F	–	9.1	C	–	0.5	9	NM	54	M	19	Fu	7	NM	8.3	Fu	2.4	M	1.9	61.7
Vredenburg	8	F	–	8.4	C	–	0.5	8	F	61	T	9	M	8	F	4.8	WC	2.2	C	1.0	50.4
Vredendal	8	F	–	6.4	C	–	0.4	10	B	51	F	10	T	8	B	28.8	R	6.2	WC	1.8	57.1
Warmbaths	8	E	–	4.1	–	–	0.2	12	F	39	T	15	M	10	R	4.6	R	2.9	Pr	1.5	36.9
Warrenton	8	E	–	5.7	C	–	0.3	9	F	50	T	20	NM	16	F	3.7	NM	2.3	T	1.9	65.2
Wasbank	8	F	–	15.1	B	–	0.9	9	F	46	Pe	36	FW	7	Pe	37.8	F	3.4	FW	1.1	69.0
Weenen	8	F	–	5.4	C	–	0.3	8	WC	64	F	21	FW	3	WC	25.8	F	1.6	FW	0.6	69.8
Wepener	8	F	–	4.3	–	–	0.2	10	NM	38	F	26	Pr	16	NM	5.7	Pr	3.6	F	2.0	55.9
Wolmaransstad	8	E	–	4.1	–	–	0.2	10	NM	31	F	25	T	17	NM	4.7	FW	2.1	F	1.9	50.6
Zastron	8	F	–	4.8	–	–	0.3	10	F	56	NM	18	T	8	F	4.1	NM	2.6	WC	1.5	56.1
Zeerust	8	E	–	3.8	–	–	0.2	11	NM	29	F	23	T	21	NM	4.3	T	2.1	F	1.7	50.5
Aberdeen	9	F	–	3.1	–	–	0.2	8	NM	35	F	19	FW	15	NM	5.5	WC	2.6	FW	2.5	55.2
Afrikander Mine	9	F	–	0.2	–	–	0.1	2	F	50	BM	50									79.7
Alexander Bay	9	F	–	0.1	–	–	0.1	2	F	50	NM	50			NM	3.0	F	1.0			80.0
Alexandria	9	F	–	1.3	–	–	0.1	4	T	67	FW	11	NM	11	T	5.0	FW	1.5	NM	1.5	65.8
Alice	9	F	–	3.9	–	–	0.2	9	Pr	34	F	26	NM	14	Pr	7.7	WC	3.2	L	2.6	56.6
Amersfoort	9	F	–	3.0	–	–	0.2	5	F	52	FW	19	T	19	T	2.0	T	1.8	FW	1.4	61.1
Amsterdam	9	F	–	1.5	–	–	0.1	5	F	45	FW	18	T	18	F	3.5	WC	3.5	P	3.5	65.4
Bedford	9	F	–	2.7	–	–	0.2	9	T	24	FW	17	O	14	O	6.6	WC	4.2	FW	2.8	59.5
Berlin	9	F	–	1.6	–	–	0.1	5	T	45	F	18	Te	18	B	5.0	T	4.5	Te	3.0	59.7
Bethulie	9	F	–	3.1	–	–	0.2	6	NM	67	FW	13	T	10	NM	10.4	To	4.2	FW	2.2	69.7
Bonnievale	9	F	–	5.7	C	–	0.3	6	B	40	F	24	NM	22	B	21.6	NM	3.3	F	1.9	56.3
Boshof	9	F	–	1.5	–	–	0.1	6	F	25	T	25	A	17	A	6.0	FW	3.0	T	2.5	56.5
Britstown	9	F	–	3.5	–	–	0.2	8	NM	44	F	18	T	12	T	11.3	NM	6.5	FW	2.0	50.7
Bronkhorstspruit	9	F	–	3.1	–	–	0.2	4	F	65	T	24	FW	6	F	4.8	T	2.3	FW	1.0	64.6
Buffelsfontein Mine	9	F	–	0.1	–	–	–	1	M	100											89.9
Bultfontein	9	F	–	3.3	–	–	0.2	8	F	31	T	29	NM	19	NM	3.0	T	2.9	F	2.4	50.7
Cala	9	F	–	3.4	–	–	0.2	6	F	25	FW	25	NM	21	FW	4.3	WC	3.5	NM	3.3	67.1
Calitzdorp	9	F	–	1.7	–	–	0.1	5	FW	50	WC	17	T	17	FW	8.5	WC	7.0	T	1.5	67.1
Carnarvon	9	F	–	3.6	–	–	0.2	7	F	28	NM	26	FW	17	NM	3.9	FW	2.9	F	2.1	50.6
Cathcart	9	F	–	3.5	–	–	0.2	7	NM	52	T	16	E	14	NM	7.5	E	3.3	Pr	2.0	65.4
Clewer	9	F	–	1.2	–	–	0.1	3	T	50	BM	39	F	11	BM	6.0	T	5.0	F	1.0	71.6
Colenso	9	F	–	2.7	–	–	0.2	7	M	52	B	13	FW	13	M	5.5	FW	2.3	Pr	1.0	60.3

	a	b	c	d	e	f	g	h	i						j						k
Clydesdale	9	E	–	0.1	–	–	0.1	4	Te	33	Pr	33	NM	17	Pe	37.0	Te	6.0	NM	3.0	79.7
Cullinan	9	F	–	0.2	–	–	0.1	5	F	33	Te	17	Pr	17	Pr	4.0	F	3.0	C	3.0	59.8
De Doorns	9	F	–	2.9	–	–	0.2	9	A	23	B	16	E	16	B	9.6	A	8.8	E	4.2	52.5
Dewetsdorp	9	F	–	2.4	–	–	0.1	6	NM	35	F	31	T	19	NM	4.6	F	2.2	T	1.8	54.3
Dominion Reefs Mine	9	F	–	2.1	–	–	0.1	1	BM	100					BM	13.8					93.0
Dordrecht	9	F	–	3.2	–	–	0.2	7	F	56	T	15	NM	15	F	4.1	NM	2.3	T	1.4	56.9
Douglas	9	F	–	1.8	–	–	0.1	6	FW	38	T	24	NM	19	FW	5.8	NM	2.5	B	2.5	62.8
Edenburg	9	F	–	4.3	–	–	0.2	10	T	32	F	21	FW	14	B	4.8	T	3.3	WC	2.6	50.8
Elliot	9	F	–	4.4	–	–	0.3	8	F	36	NM	19	M	15	NM	3.0	F	2.8	R	2.4	46.1
Fauresmith	9	F	–	2.1	–	–	0.1	7	NM	40	A	13	T	13	NM	5.3	A	4.0	FW	2.0	54.2
Fraserburg	9	F	–	3.5	–	–	0.2	6	Fu	32	NM	21	F	18	Fu	10.6	NM	3.2	FW	1.8	57.0
Genadendal	9	F	–	0.7	–	–	0.0	2	Pr	75	FW	25			Pr	12.0	FW	3.0			89.6
Griquatown	9	F	–	2.0	–	–	0.1	5	NM	40	WC	20	F	13	WC	7.0	NM	5.3	FW	2.0	61.1
Hankey	9	F	–	1.7	–	–	0.1	5	T	43	NM	29	WC	14	WC	7.0	NM	5.0	T	5.0	67.3
Hartebeesfontein Mine	9	D	–	0.2	–	–	0.0	7	M	26	A	22	WC	22	WC	8.8	A	7.8	M	2.5	67.6
Hartswater	9	F	–	1.1	–	–	0.1	5	F	23	FW	23	NM	15	FW	4.5	NM	2.5	T	2.5	53.5
Hofmeyr	9	F	–	0.9	–	–	0.1	3	T	60	NM	20	A	20	A	6.0	T	5.0	NM	3.0	80.2
Hoopstad	9	F	–	4.4	–	–	0.3	5	NM	51	T	23	F	21	NM	7.4	T	2.1	F	1.6	64.6
Hopefield	9	F	–	1.9	–	–	0.1	2	T	91	F	9			T	8.5	F	0.5			80.6
Hopestown	9	F	–	2.3	–	–	0.1	8	FW	39	F	22	T	11	FW	6.7	WC	2.3	A	2.0	49.6
Humansdorp	9	F	–	4.0	–	–	0.2	10	T	26	F	24	FW	13	B	4.8	T	2.5	FW	2.1	43.3
Indwe	9	F	–	3.6	–	–	0.2	6	NM	46	F	29	FW	9	NM	7.0	F	2.2	FW	1.5	60.3
Jagersfontein	9	F	–	3.2	–	–	0.2	5	F	37	NM	34	FW	18	NM	4.9	FW	2.9	F	2.6	63.6
Jansenville	9	F	–	2.8	–	–	0.1	4	NM	63	T	21	Pr	10	NM	10.3	Pr	2.7	T	2.3	73.4
Keimoes	9	F	–	4.5	–	–	0.3	6	F	74	FW	12	T	5	F	5.3	FW	1.8	O	1.0	66.8
Keiskammahoek	9	F	–	2.3	–	–	0.1	4	T	81	Fu	6	FW	6	T	7.3	Fu	2.0	FW	1.0	71.1
Kendal	9	F	–	3.2	–	–	0.1	4	F	52	T	35	FW	9	F	4.0	T	3.5	P	1.8	67.9
Kenhardt	9	F	–	2.0	–	–	0.1	6	F	50	T	19	FW	13	F	3.7	B	3.3	WC	2.3	59.8
Kirkwood	9	F	–	2.2	–	–	0.1	5	F	72	T	15	FW	8	F	5.3	T	1.4	FW	1.3	65.2
Klipplaat	9	F	–	2.7	–	–	0.1	5	T	44	NM	28	FW	17	T	4.7	NM	4.3	FW	3.0	65.8
Koffiefontein	9	F	–	5.5	C	–	0.3	8	F	48	NM	27	B	9	B	4.8	NM	3.9	F	3.5	62.4
Komatipoort	9	F	–	3.3	–	–	0.2	4	T	63	F	29	WC	4	T	6.5	F	2.3	WC	1.8	69.7
Kromdraai	9	F	–	0.2	–	–	0.0	3	C	33	NM	33	T	33	C	3.0	NM	3.0	T	2.0	76.4
Kruisfontein	9	F	–	2.6	–	–	0.2	5	T	38	NM	33	F	14	NM	4.5	T	3.5	F	1.0	55.4
Lady Grey	9	F	–	1.4	–	–	0.1	6	T	27	FW	18	NM	18	Pe	9.5	WC	3.5	FW	3.0	63.4
Laingsburg	9	F	–	3.4	–	–	0.2	7	E	30	T	30	FW	13	E	7.4	A	3.8	T	3.0	51.8

	a	b	c	d	e	f	g	h	
Leeudoringstad	9	F	-	3.5	-	-	0.2	5	NM
Loeriesfontein	9	F	-	3.6	-	-	0.2	7	NM
Maclear	9	F	-	3.0	-	-	0.2	9	NM
Mamre	9	F	-	7.1	C	-	0.4	13	F
Mpolweni	9	F	-	1.3	-	-	0.1	3	FW
Murraysburg	9	F	-	4.2	-	-	0.2	7	F
Nababeep	9	E	-	0.1	-	-	0.0	3	F
Naboomspruit	9	F	-	4.8	-	-	0.3	7	F
New Largo Colliery	9	F	-	0.5	-	-	0.0	3	M
New Springfield Co.	9	F							
Okiep	9	F	-	0.2	-	-	-	-	
Park Rynie	9	F	-	4.9	-	-	0.3	7	F
Paulpietersburg	9	F	-	1.3	-	-	0.1	3	F
Pearston	9	F	-	2.9	-	-	0.2	3	NM
Penge	9	F	-	0.4	-	-	0.0	2	F
Petrusburg	9	F	-	2.3	-	-	0.1	7	M
Petrus Steyn	9	F	-	4.6	-	-	0.3	8	F
Philippolis	9	F	-	2.1	-	-	0.1	5	NM
Philipstown	9	F	-	3.5	-	-	0.2	6	NM
Phoenix Colliery	9	F	-	-	-	-	-	-	
Pofadder	9	F	-	0.8	-	-	0.1	2	T
Port Alfred	9	E	-	2.1	-	-	0.1	8	F
Porterville	9	F	-	5.4	C	-	0.3	10	FW
Postmasburg	9	F	-	2.7	-	-	0.2	8	F
Prince Albert	9	F	-	5.3	-	-	0.3	7	To
Reddersburg	9	F	-	2.2	-	-	0.1	6	NM
Richmond (C)	9	F	-	4.1	-	-	0.2	10	T
Rouxville	9	F	-	4.7	-	-	0.3	8	NM
Saron	9	F	-	7.2	C	-	0.4	4	FW
Smithfield	9	F	-	1.6	-	-	0.1	5	T
Springbok Colliery	9	F	-	0.0	-	-	-	-	
Springfontein	9	F	-	4.1	-	-	0.2	6	F
Sterkstroom	9	F	-	2.2	-	-	0.1	5	NM
Steynsburg	9	F	-	3.3	-	-	0.2	6	NM
Steynsrus	9	F	-	6.0	C	-	0.3	7	NM

i					j						k
47	F	24	T	18	NM	7.0	F	1.7	T	1.7	57.9
27	FW	20	E	13	NM	4.2	FW	3.4	E	3.4	46.5
29	F	24	T	18	NM	4.1	Pe	2.7	WC	2.0	52.3
23	FW	17	CL	17	L	6.7	O	4.7	FW	2.9	43.8
33	WC	33	C	33	WC	7.0	FW	3.0	C	3.0	84.8
28	NM	24	T	20	NM	4.0	O	4.0	WC	3.5	52.4
33	FW	33	T	33	FW	3.0	T	2.0	F	1.0	70.3
41	FW	22	T	19	FW	3.8	F	3.3	T	2.0	53.9
44	E	44	NM	11	E	8.0	M	3.5	NM	1.5	79.0
											93.9
57	FW	16	T	8	F	4.7	FW	2.8	WC	2.3	58.0
67	T	27	Fu	7	F	4.3	T	2.3	Fu	2.0	73.4
43	M	43	T	14	NM	5.8	M	4.0	T	1.3	70.9
93	A	7			F	8.5	A	3.0			83.9
30	F	23	T	15	B	4.5	M	3.5	F	2.0	44.7
29	NM	29	T	15	NM	4.3	F	2.2	FW	1.8	50.1
36	T	21	FW	21	NM	6.5	A	6.0	FW	4.5	71.1
46	T	25	WC	13	NM	7.3	WC	5.3	A	3.0	71.3
											93.0
75	NM	25			T	5.0	NM	3.0			64.7
45	FW	16	T	14	F	3.7	FW	2.8	WC	2.3	50.8
25	T	21	B	14	L	14.6	B	7.3	FW	4.0	55.6
50	T	19	FW	15	F	4.0	FW	2.5	T	1.9	67.3
29	FW	22	T	14	To	35.2	Pe	12.7	WC	4.8	69.6
47	T	27	O	7	NM	6.0	O	2.7	T	2.3	65.1
23	F	20	WC	14	WC	6.0	Fu	4.0	L	3.8	46.6
62	T	18	Fu	5	NM	9.0	T	1.7	Fu	1.7	64.6
76	WC	12	F	9	FW	12.0	WC	4.8	F	0.7	79.3
31	FW	25	NM	25	FW	3.7	NM	3.3	T	3.0	58.2
											-
45	T	24	NM	18	F	3.3	R	3.2	NM	2.7	67.9
42	F	29	T	17	NM	6.5	F	2.3	T	1.8	59.7
45	T	26	FW	13	NM	7.4	T	2.8	FW	2.4	57.6
44	F	26	T	12	NM	6.5	F	2.0	FW	1.5	55.2

	a	b	c	d	e	f	g	h	i						j						k
Steytlerville	9	F	-	3.8	-	-	0.2	4	NM	70	T	22	FW	4	NM	10.5	T	2.3	FW	0.8	40.3
Swartruggens	9	F	-	3.1	-	-	0.2	6	F	38	NM	35	FW	12	NM	4.6	F	2.6	FW	1.8	59.4
Tarkastad	9	F	-	3.3	-	-	0.2	8	NM	39	M	21	FW	15	NM	5.7	FW	2.3	M	2.0	53.1
Thabazimbi	9	E	-	0.5	-	-	0.0	3	T	47	A	29	F	24	A	10.3	T	4.7	F	1.7	73.6
Trompsburg	9	F	-	2.1	-	-	0.1	5	T	60	NM	20	FW	7	T	5.0	NM	2.7	FW	1.0	63.6
Tweefontein Colliery	9	F	-	0.3	-	-	0.0	3	F	71	C	14	NM	14	F	7.0	C	3.0	NM	3.0	73.4
Ugie	9	F	-	3.8	-	-	0.2	6	NM	62	T	15	FW	11	NM	8.8	FW	1.8	T	1.4	65.8
Uniondale	9	F	-	1.8	-	-	0.1	6	T	29	FW	24	F	18	WC	4.7	Fu	4.0	FW	4.0	58.9
Utrecht	9	E	-	1.7	-	-	0.1	5	F	43	NM	30	T	13	NM	4.6	F	3.4	FW	1.8	60.2
Vaal Reefs Mine	9	E	-	0.1	-	-	0.0	3	M	50	BM	33	FW	13	BM	8.0	M	7.0	FW	3.0	71.8
Valspan	9	F	-	1.6	-	-	0.1	7	FW	30	F	22	Fu	17	Fu	6.0	FW	5.0	O	2.0	55.9
Vanrhynsdorp	9	F	-	2.8	-	-	0.2	6	T	31	NM	25	FW	12.5	NM	3.3	T	3.0	FW	2.0	50.0
Victoria West	9	F	-	3.0	-	-	0.2	4	T	38	FW	24	F	22	FW	4.3	Pr	4.0	T	4.0	66.0
Vierfontein	9	F	-	0.6	-	-	-	-													85.5
Viljoensdrif	9	E	-	0.8	-	-	0.0	8	M	32	BM	21	NM	21	WC	5.3	NM	3.3	M	3.3	64.4
Wakkerstroom	9	F	-	1.8	-	-	0.1	5	F	54	FW	15	NM	15	F	4.5	WC	3.5	FW	3.0	63.7
Warden	9	F	-	3.5	-	-	0.2	6	F	45	T	26	FW	5	F	3.6	T	2.7	FW	1.6	54.1
Wesselsbron	9	F	-	3.7	-	-	0.2	6	F	43	M	29	T	14	F	3.4	M	3.0	A	1.7	55.0
Williston	9	F	-	2.7	-	-	0.2	6	NM	25	T	25	F	20	NM	3.3	FW	3.0	T	2.3	58.3
Willowmore	9	F	-	3.0	-	-	0.2	8	NM	35	T	24	F	12	NM	5.2	T	2.3	A	2.0	40.3
Windsorton	9	F	-	0.7	-	-	0.0	4	FW	25	Fu	25	B	25	F	10.0	Fu	6.0	FW	3.0	82.4
Winkelhaak & Evander	9	E	-	0.1	-	-	0.0	2	M	75	A	25			A	6.0	M	1.0			87.1
Wolwekrans Colliery	9	F	-	0.1	-	-	0.0	1	NM	100					NM	16.7					-

Key: Column a (1-9) indicates the manufacturing size class of the city (see Table 22) and Column b which follows denotes the population size class (A-F)(see Table 23). Column d gives the manufacturing ratio (employment in manufacturing as a percentage of total economically active population) and an asterisk in Column c appears when manufacturing is the dominant economic function in a city. Columns e and f identify a city as A, B or C and/or 1, 2 or 3 in the Alexandersson and Nelson manufacturing classifications. Column g gives the Location Quotient for Manufacturing as a whole. Column h identifies the number of industry groups that are represented in the city (1-21). Column i gives the three leading industry groups, referred to by code letters (see Table 20) in the city. The percentages of the city's total manufacturing are shown. Column j identifies the leading industry groups in terms of Location values. The industry groups are defined by code letters (see Table 20). Column k shows the Index of Dissimilarity for each city.

set of cities. Twenty cities have Location Quotients *(lq)* values of over 2.0 and a further 40 places have a significant level of concentration with quotients of between 1 and 1.9. The remaining cities have quotient values below unity and a high proportion of cities (189) have quotients of less than 0.5.

A correlation of the A, B and C levels of cities in the Alexandersson classification with Location Quotient values shows that A cities have quotients above 1.20, B cities values between .60 and 1.19, and C cities values of .30 to .59. Cities with Location Quotients below .30 have low status as industrial places. The exact significance of the correlating Location Quotient values, however, is unclear at this stage. They have nevertheless been used as the framework for the construction of Figure 23 in which the relative importance and spatial distribution of the country's manufacturing cities with more than 100 employees have been identified.

The relative importance of urban places as manufacturing centres and as 'cities' may be visually gauged also by the construction of a '100 model' in which the size of manufacturing employment is compared to total city population [Figures 24 and 25]. In Figure 24 the total population of each city in the set is represented by a proportional sphere. In Figure 25 drawn to the same scale, manufacturing employment in each city is represented by a proportional sphere drawn to a scale such that the sum of the symbol volumes equals the corresponding sum of the population map.[1)]

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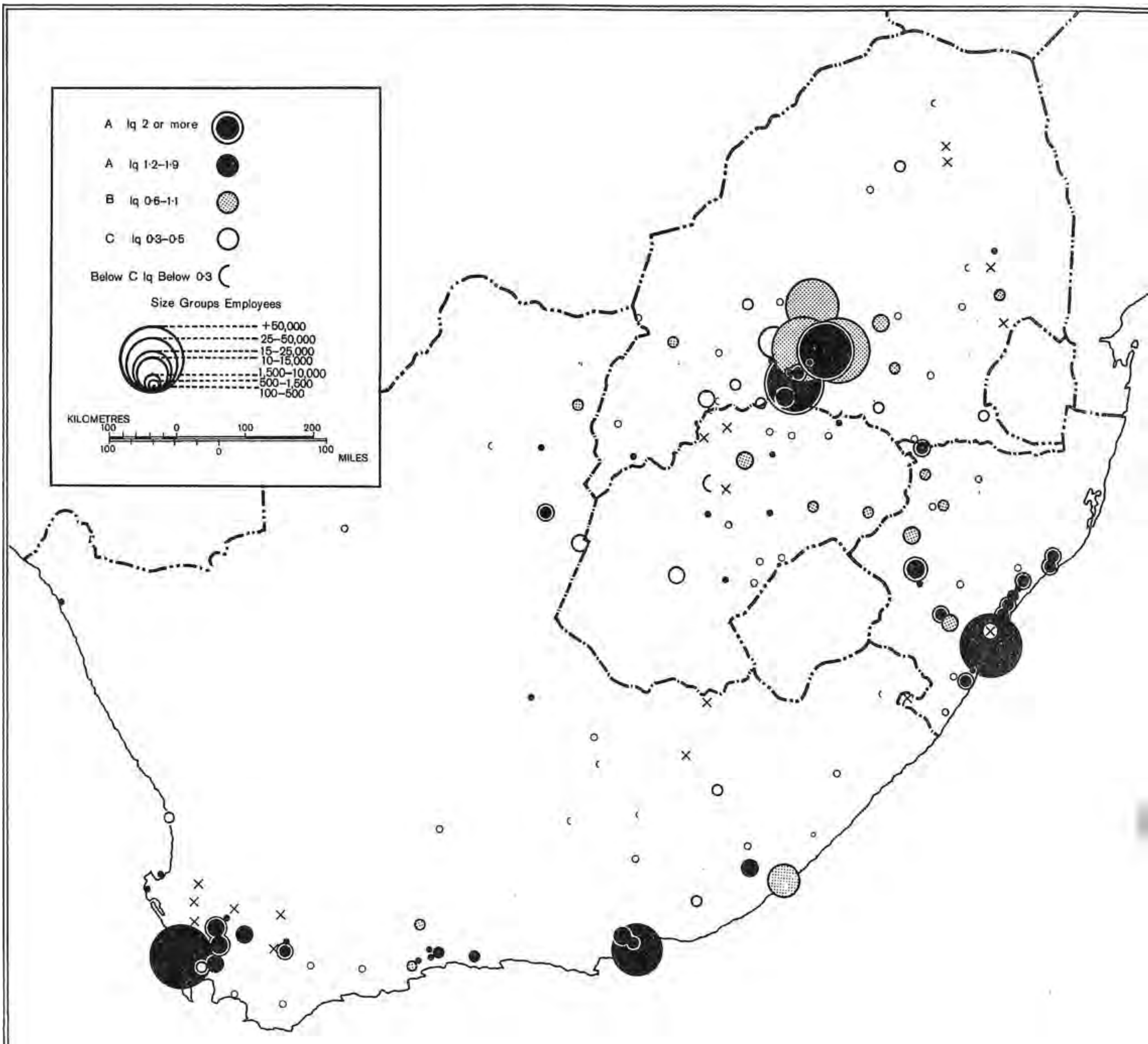
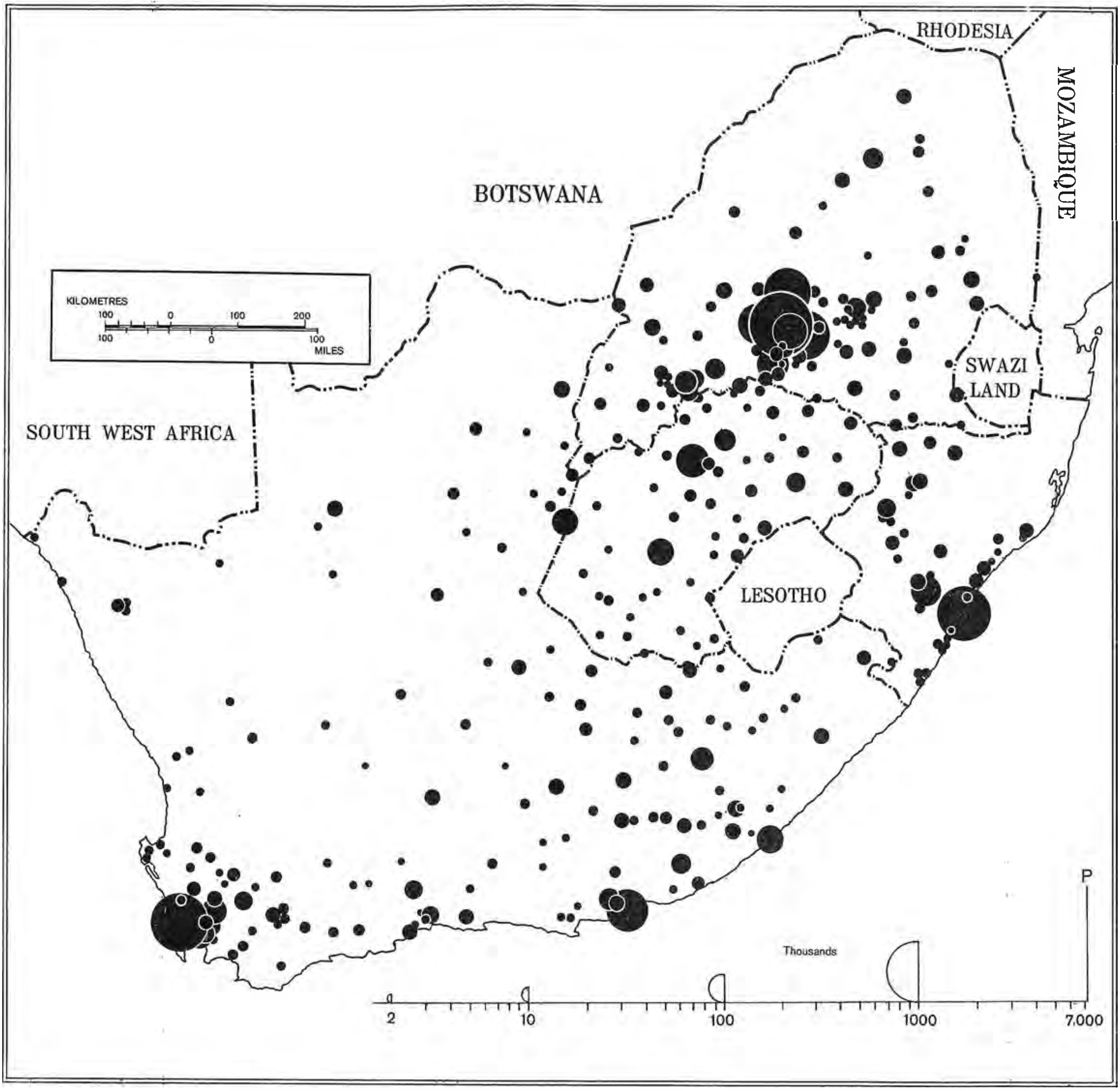
1) The diameter scale used for drawing the spheres on the population map is extended to the point P, representing the total urban population shown on the map. The same vertical distance is marked off on the diameter scale to be used for manufacturing employment at the point Pm representing the total employment in manufacturing. From point Pm the employment scale is constructed backwards. The proportional spheres of manufacturing employment should ideally be supported by Location Quotients in the form:

$$LQ = \frac{\frac{M_x}{M_r} \times 100}{\frac{P_x}{P_r}}$$

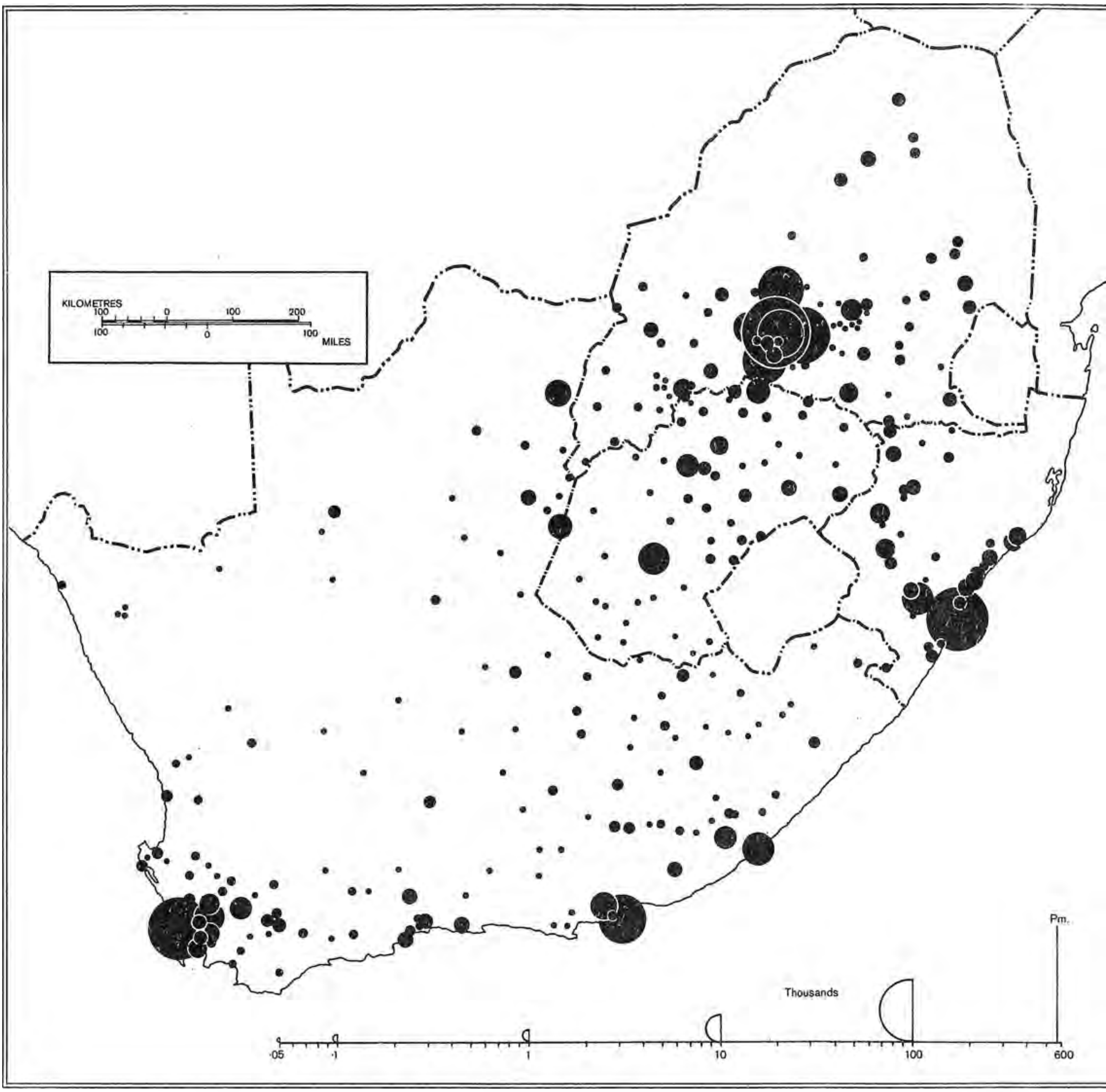
where M_x is the manufacturing employment in city X, M_r the manufacturing employment in all cities in the set, P_x the population of city X and P_r the total population in the set.



23 SOUTH AFRICAN MANUFACTURING CITIES, 1960.



24 THE DISTRIBUTION OF SOUTH AFRICAN CITIES BY TOTAL POPULATION, 1960.



25 THE DISTRIBUTION OF SOUTH AFRICAN CITIES BY EMPLOYMENT IN MANUFACTURING 1960

The comparative distribution of manufacturing employment and total population confirms the pattern produced by the Alexandersson classification and the Location Quotients based on the economically-active population.

The distributions in Figures 23, 24 and 25 draw attention to the existence of a central-north-east manufacturing zone of cities in the Transvaal, northern Orange Free State and the Natal railway zones on the one hand, and to smaller more localised concentrations of industrial cities focussed upon Cape Town, Port Elizabeth, East London and the southern Cape about George and Oudtshoorn as previously noted.

The number of persons in manufacturing in the smaller cities is, of course, relatively low, and manufacturing employment is concentrated in the larger centres. Table 22 shows that over a third of the cities have fewer than 50 persons in manufacturing, and these cities, which have been categorised as class nine places, account for less than 0.5 per cent of the total manufacturing employment in the set. Ten cities, on the other hand, together have more than 80 per cent of the total. The four class 1 cities in terms of employment in manufacturing (Cape Town, Durban, East Rand and Johannesburg) together account for nearly 54 per cent of the total employment in manufacturing.

While in absolute terms manufacturing employment is concentrated in larger cities, it is of interest to know if a tendency exists for manufacturing to concentrate in large or small cities in relative terms. To examine the level of urbanisation for manufacturing the relevant data were first arranged as in Table 23.

Location Quotients, with the exception of that for cities of 30,000 to 50,000 persons (class B) show a progressive decline from the largest to the smallest cities and suggest that manufacturing is relatively urbanised. The level of urbanisation, however, is moderate as is indicated by values of the Location Quotients and by an Index of Urbanisation which has a value of .13 where 0 indicates no urbanisation and 1 absolute concentration in the largest city class.[1)]

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1) The Index of Urbanisation takes the form:

$$I_u = \frac{(\Sigma X_{-1})(Y - \Sigma Y_{-1})(X)}{10{,}000}$$

where X is the percentage share of manufacturing employment and Y is the percentage share of economically-active population. The data are ranked by population size group.

TABLE 22

DISTRIBUTION OF CITIES AND MANUFACTURING EMPLOYMENT BY MANUFACTURING SIZE CLASS.

1960

Size Class	No. of Cities	%	No. of Employees	%
(1) 50,000 and over	4	1.3	305,912	53.52
(2) 25,000-49,999	4	1.3	127,660	22.33
(3) 15,000-24,999	-	-	-	-
(4) 10,000-14,999	2	0.6	24,309	4.25
(5) 1,500- 9,999	16	5.1	54,2 7	9.49
(6) 500- 1,499	38	12.1	32,547	5.69
(7) 100- 499	83	26.5	20,257	3.54
(8) 50- 99	52	16.6	3,9 5	0.70
(9) Less than 50	115	36.6	2,722	0.48

TABLE 23

PERCENTAGE EMPLOYMENT IN ALL ECONOMIC ACTIVITES AND IN MANUFACTURING BY POPULATION SIZE CLASS. 1960

SIZE CLASS	a TOTAL ECON. ACTIVE	b MANF.	a/b	Food.	Textiles	Basic Metals	Metal Prods.
AA	44.34	53.77	1.21	44.28	51.92	17.17	57.01
A	29.03	29.61	1.01	21.51	18.83	77.91	36.99
B	1.58	0.84	0.53	1.17	0.01	0.14	0.77
C	5.55	5.18	0.93	7.79	15.20	1.83	1.53
D	6.92	4.27	0.62	6.32	11.78	1.46	1.68
E	5.70	3.25	0.57	8.44	1.03	0.71	1.05
F	6.88	3.08	0.45	10.49	1.23	0.78	0.97

Key: AA - Over 500,000 persons.
A - 100,000 to 500,000 persons.
B - 50,000 to 100,000 "
C - 20,000 to 50,000 "
D - 10,000 to 20,000 "
E - 5,000 to 10,000 "
F - 2,000 to 5,000 "

The finding is supported by an Index of Concentration in which the percentage share of the city's employment in manufacturing of the total is related to its percentage share of the total economically-active population in the set, and where the data are ranked in terms of the ratio, percentage share of manufacturing to percentage share of economically-active population. The index has a value of .3 which is moderate in a scale which runs from -1 representing a negative relationship to the distribution of the economically-active population, through 0 representing a balanced relationship to +1 with absolute concentration in relation to the size distribution of economically-active population. In relative terms, therefore, manufacturing as a whole tends to be distributed in proportion to the size of the working population, and there is a moderate trend only for larger cities to have a disproportionate share of manufacturing in relation to their working population.

While this finding may be true for manufacturing as a whole, it masks considerable variation within individual industry groups [Table 23]. Discussion of inter-industry variations in levels of urbanisation and concentration must, however, be deferred to future research.

UBIQUITOUS AND SPORADIC INDUSTRIES:

Alexandersson (1956) has drawn attention to ubiquitous and sporadic industries, with reference to cities; and Estall and Buchanan (1961) have referred to a third major type of geographical pattern - that of the highly concentrated industry.[1)] The data in Table 24 permit an assessment of the patterns of manufacturing industries in these terms, but it should be remembered that the data are from the population census, and that any employment in a group has been accepted as evidence of the presence of that activity in any city.

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1) For Alexandersson, industries found in all cities may appropriately be labelled ubiquitous industries, but manufacturing industries characteristically have sporadic patterns: they occur in some towns, but do not occur at all in others. Estall and Buchanan's ubiquitous industries are 'found in almost every sizeable urban centre'; highly-concentrated industries are those in which 'a very large proportion of total capacity is limited to a few locations'; and sporadic industries are those for which some concentration may be observed but in which total capacity is more widely-spread than in the highly-concentrated group.

TABLE 24

DISTRIBUTION OF CITIES ACCORDING TO ABSENCE/PRESENCE OF INDUSTRY GROUP, 1960

Industry Group	Absent	Present
Food (F)	29	285
Beverages (B)	180	134
Tobacco (To)	261	53
Textiles (Te)	225	89
Footwear (Fw)	36	278
Clothing (CL)	218	96
Wood and Cork (WC)	229	85
Furniture and Fixtures (Fu)	177	137
Paper and Products (P)	251	63
Printing and Publishing Products (Pr)	162	152
Leather Products (L)	257	57
Rubber Products (R)	219	95
Chemical and Chemical Products (C) ...	153	161
Petroleum Products (Pe)	267	47
Non-Metalliferous Mineral Products (NM)	61	253
Basic Metals (BM)	206	108
Metal Products (M)	105	209
Agricultural Machinery (A)	173	141
Electrical Equipment (E)	162	152
Transport Equipment and Specialised ... Repairs (T)	18	296
Other (O)	182	132

Though no group is to be found in all the cities, four may be distinguished as ubiquitous. The local market, including the city and its immediate hinterland, is evidently an important factor in the widespread occurrence of the food, footwear, non-metallic mineral products, and transport equipment industries. The aggregation of activities into these groups masks the fact that it is, in fact, the bakery, shoe-repairers, stone, brick and cement block works, and the vehicle repair shops that are spread through the urban system from top to bottom. Metal products as a class of industry (including the blacksmith) are very nearly as ubiquitous.

Eight groups of industry are present in less than 100 places, and these suggest themselves as concentrated, though perhaps only petroleum, tobacco, leather and paper fully merit this description. Access to raw materials, transport economies and economies of scale have clearly influenced the concentration of these 4 groups.

The remaining 9 industrial groups are found in between 100 and 200 of the cities, and are therefore, sporadic. Their presence in the larger centres and absence in the smaller cities suggests the significance of the larger and local market of the larger urban labour pool and of economies of agglomeration or industrial linkage.

DOMINANT INDUSTRIES:

Table 20 shows clearly that in terms of employment urban manufacturing is dominated by half a dozen industry groups. The 3 dominant industries in each of the 314 cities are specified in Table 21. In Table 25 the material is re-assembled so that the frequency of each group as a leading urban industry can be reviewed. Outstanding is the food industry group, and it is noteworthy that this group ranks as frequently (at all three levels) in the small cities (employment size classes 8 and 9) as in places with a large labour force. Non-metallic mineral products and transport equipment industries are the only other groups with high scores at the first and second levels, with clothing represented as a second and third ranking industry group. Leather, petroleum, rubber and tobacco industries are seldom dominant groups in the urban economy.

VARIATIONS IN INDUSTRY STRUCTURE:

City to city variation in the structure of manufacturing is very considerable, as is shown by the application of an Index of Dissimilarity to the set of cities. The index is a measure of a city's overall divergence from the national urban manufacturing structure, and is shown in Column b, Table 20, and Figure 26.[1)]

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1) The Dissimilarity Index for a city is simply the sum of either the positive or negative deviations (for each of the 21 industry groups) from the national urban percentage values for each industry group. It is discussed by Duncan et al in 'Metropolis and Region,'1960. It should be noted however, that a high value may result from concentration in either one group or in two or more groups (e.g. Howick's value is solely from rubber, but Mooi River's index value is from the combination of food and textiles).

TABLE 25.

DISTRIBUTION OF CITIES BY DOMINANT INDUSTRIES, 1960

Industry Group	Frequency as a leading urban industry		
	Dominance level of industry		
	First	Second	Third
Food	124	68	35
Beverages	6	9	7
Tobacco	2	-	2
Textiles	10	6	2
Footwear	16	45	61
Clothing	4	9	4
Wood and Cork	17	13	9
Furniture and Fixtures	1	4	8
Paper and Paper Products	3	3	1
Printing and Publishing	3	6	9
Leather Products	-	-	1
Rubber Products	1	1	-
Chemical and Chemical Products	10	6	4
Petroleum Products	1	1	-
Non-Metalliferous Mineral Products	48	59	48
Basic Metals	9	7	1
Metal Products	18	14	17
Agricultural Machinery	3	12	5
Electrical Equipment	3	1	2
Transport Equipment and Specialised Repairs	50	75	67
Other	-	1	3

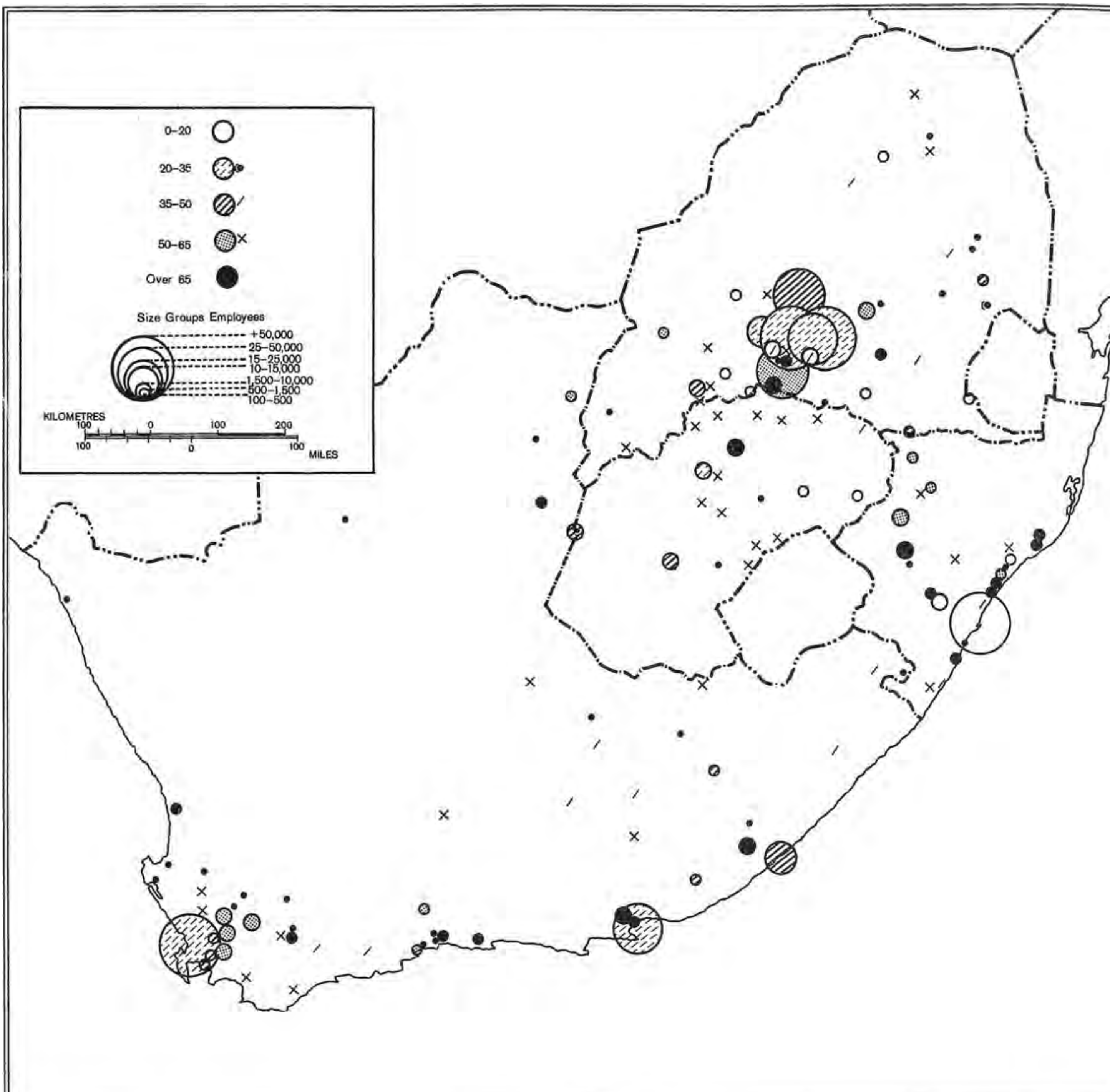
One or two features of the indices of dissimilarity for the South African cities are noteworthy (See Table 21). The average value of the index for 311 cities, (i.e. omitting the 3 collieries that have no emppployment in manufacturing) is 59.70, indicating that some 60 per cent of the employment in the 'average city' would have to be re-allocated amongst the 21 industry groups to bring the city into line with the national urban structure. This high level of dissimilarity is exceeded by 152 cities, and 34 places have indices over 80.0 with Upper Kubusi reaching 97.50. At the other end of the scale, Pietermaritzburg has an index of dissimilarity of 14.8.

As a group, the 14 metropolitan areas have an index of dissimilarity of the order of 32.0, ranging from 14.8 to 62.0 (in the case of Vereeniging-Vanderbiljpark with its marked concentration in basic metals). The averages for the manufacturing size classes 1 to 9 are: 22.05; 40.40; 32.70; 52.96; 65.00; 59.29; 55.45; and 64.17 respectively. The variation within the group is evident in the list in Table 21; these group averages suggest, however, that the larger the place in terms of manufacturing the nearer it is likely to be to the national urban structure. If the index is accepted as a measure of specialisation, then the general tendency is for the larger centres to be less specialised, i.e. more diversified.

In the set of cities considered, ranging in population size and manufacturing size from very large to very small, a considerable measure of diversification of industrial structure is to be expected. An index of diversity of structure that is not related to any average or norm is one based simply on the number of industry groups represented in each town's profile. Absolute diversification is 21 in the present case; maximum specialisation would be 1. Eleven of the cities have employment in all the groups of the manufacturing division, and another 33 have between 18 and 20 groups. Another sub-set of 79 cities is between 11 and 18; and no fewer than 146 places have index values of between 5 and 10. Three places have no manufacturing at all, and 43 have workers in fewer than 5 industry groups. If employment in a group is not counted unless it reaches some specified absolute or relative level, the manufacturing diversity of the bulk of the cities is reduced, though the larger cities still remain at the higher levels.

MANUFACTURING AND SIZE OF PLACE IN THE SOUTH AFRICAN CITY SYSTEM:

Published studies of the relationship between city size, urban economic structure and industrial composition that have contributed to the analysis of



26. THE SOUTH AFRICAN MANUFACTURING CITIES PLOTTED BY INDEX OF DISSIMILARITY

size relationships should be noted. Pownall (1953) based his New Zealand work on the assumption that it is logical to work with national means for groups of cities of approximately the same size, and his urban classification scheme was developed in terms of 7 size classes. Breaking down a set of 897 cities into 7 arbitrarily-selected size groups, Nelson (1955) in his service classification of American cities looked for correlations between size of city and the proportions of the labour force in each of 9 activity groups, including manufacturing. Morrisett's paper (1958) on American cities extended Alexandersson's (1956) investigation by estimating *k* values for cities of different sizes; with data arranged in 6 size classes. He also went on to examine sporadic and ubiquitous industries in terms of size of city. Winsborough (1959) contributed a study of relative urbanisation of the labour employed in the various groupings of industries in relation to the urban hierarchy model; two sets of size groups were employed - the larger one of 9 categories including 2 rural groups. In 'Metropolis and Region' Duncan et al. (1961) also dealt with manufacturing and the urban hierarchy, using a number of size of place classifications for their work with Location Quotients, other urban indices and census regions. In his paper dealing specifically with manufacturing, Duncan (1959) examined the proposition that when individual regions are considered the pattern of industry structure by city size is not an hierarchic one, and he used regression and residual analyses for each of 6 size classes. Maxwell (1965) introduced a four-class scheme for his calculations of minimum percentages employed in 13 different functions in Canadian cities, and this recalls the urban economic base work of Ullman and Dacey (1960) where a size classification of three groups of cities and three groups of metropolitan areas was used. The most recent pertinent study appears to be that of Morse et al. (1968) in which a locational taxonomy for industries is developed according to occurrence in places arranged in 6 size classes.

Whatever approach is adopted or hypothesis formulated, the analysis requires that some attribute of each place be accepted as a valid and reliable measure of its size. Total population (all races) is used in this study as the index of size, and the measurements are, as noted above, those from the 1960 Population Census. A second decision to be taken concerns the grouping of the individual units (i.e. cities) into size classes. The principal size class scheme employed here for the South African data is an arbitrary one - though not a capricious one - involving 7 size classes. The note to Table 26 gives the class limits, and the number of cities in the classes of the scheme is: AA:4; A:9; B:1; C:19; D:31; E:58; F:192. The size pyramid is obviously not perfect and is especially distorted in the B class, and the true base of the pyramid is not revealed since some 300 cities below 2,000 persons are excluded from the urban set. A 'perfect' pyramid results from a six-class scheme with 4, 10, 20, 40, 80, and 160 cities in classes P1 to P6, from largest to smallest.[1] A secondary system is a grouping into six classes with 52 units in each class E1 to E5, and 54 in E6, in descending order.[2]

In the analyses presented here discussion will be largely confined to relationships within the principal size class scheme, with some results of analyses in terms of the secondary P and E schemes given in footnotes. The value of working with the full set of cities as individual units has not been overlooked, however, and a number of product moment correlation co-efficients *(r)* have been included to indicate the existence, direction and degree of statistical association between variables. Those based on actual population or industry numbers over the entire set of cities are derived from decidedly non-normal distributions. The non-parametric contingency co-efficient *C* has also been computed.

CITY SIZE AND MANUFACTURING EMPLOYMENT:

In absolute terms there is, of course, concentration of urban manufacturing employment in the larger places in the city system. Table 26 indicates this concentration in terms of total share of each of the seven size classes of the urban total, the average percentage share of the urban total of a city in the class, and the extreme values in each class.[3]

---

1) The sizes of the largest and smallest cities in each of the classes P1 to P6 are, respectively: 1,149,273 and 504,513; 422,254 and 78,985; 48,519 and 19,541; 17,501 and 8,409; 8,349 and 4,025; 3,987 and 1,540.

2) The sizes of the largest and smallest cities in each of the classes,E1 to E6 are, respectively: 1,149,273 and 12,089; 11,980 and 6,192; 6,173 and 3,963; 3,956 and 2,854; 2,844 and 2,336; 2,334 and 1,540.

3) Percentage shares for the secondary size class schemes are: P1: 53.7; P2: 30.1; P3: 6.0; P4: 5.0; P5: 2.6; P6: 2.7; E1: 92.5; E2: 3.7; E3: 1.2; E4: 0.7; E5: 0.8; E6: 1.2.

TABLE 26.

URBAN MANUFACTURING EMPLOYMENT BY CITY SIZE CLASS

	AA	A	B	C	D	E	F
Per cent of total	53.7	29.6	0.5	6.0	4.0	3.0	3.2
Average	13.4	3.3	0.5	0.3	0.1	0.1	0.0
Highest	18.7	5.5	0.5	1.2	0.6	0.3	0.2
Lowest	9.1	0.4	0.5	0.1	0.1	0.0	0.0

Key: AA : 500,000 persons and over
A : 100,000 - 499,999
B : 50,000 - 99,999
C : 20,000 - 49,999
D : 10,000 - 19,999
E : 5,000 - 9,999
F : 2,000 - 4,999

Note: Percentages calculated on a national urban manufacturing total of 571,731; the size class averages in actual numbers are: 76,718; 18,780; 3,033; 1,799; 735; 291 and 99 persons respectively.

Relative to the distribution of the economically active population amongst the size classes, there is a moderate tendency for manufacturing to concentrate in the larger-size places, and the index of urbanisation has a value of only 0.13 (where zero indicates no tendency to concentrate in larger or smaller places)[1] The information assembled in Table 27 throws further light on the influence of city size on manufacturing as a whole. Employment in manufacturing by city size and manufacturing ratio by city size produce different patterns.

The average manufacturing ratio tends to decrease as city size falls, and the 13 largest centres (AA and A) have an average ratio more than double that of the 250 smaller cities (E and F). The lowest

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1) The index of urbanisation takes the form:

$$I_u = \frac{(\sum X_{-1})\ Y - (\sum Y_{-1})\ X}{10{,}000}$$

Where X is the percentage share of industry group employment whose urbanisation is being measured and Y is the percentage share of the standard variable.

TABLE 27

MANUFACTURING RATIOS, LOCATION QUOTIENTS AND k VALUES BY CITY SIZE CLASS

	AA	A	B	C	D	E	F
MANUFACTURING RATIOS							
Average	21.2	20.1	9.5	15.1	14.5	10.7	9.3
Highest	23.8	49.3	9.5	38.9	55.9	42.7	78.0
Lowest	18.9	2.1	9.5	1.3	0.1	0.1	0.0
LOCATION QUOTIENTS							
Average	1.2	1.1	0.6	0.9	0.8	0.6	0.5
Highest	1.4	2.6	0.6	2.3	3.2	2.5	4.5
Lowest	1.1	0.1	0.6	0.1	0.0	0.0	0.0
k VALUES	-	-	4.7	4.1	1.3	0.1	0.5

value in each size class also decreases in the same direction, and the influence of certain mining centres (with little or no employment in manufacturing) is evident in the four smaller classes. The extreme high value on the other hand trends upwards as city size falls, and it is clear that the several smaller places with very high ratios contribute substantially to the averages of the three smaller classes. The location quotient values behave very similarly to the manufacturing ratios, and the very specialised smaller places are responsible for keeping the averages as high as they are in the smaller size classes.[1] The median location quotients in the E and F size classes (0.4 and 0.3 respectively) emphasise that the distributions of quotients are positively skewed.

---

1) Manufacturing ratios and location quotients for the other size schemes are interesting: P1: 21.2 and 1.2; P2: 19.0 and 1.1; P3: 14.6 and 0.8; P4: 15.1 and 0.9; P5: 8.6 and 0.5; P6: 9.8 and 0.6. E1: 16.1 and 0.9; E2: 12.2 and 0.7; E3: 7.5 and 0.4; E4: 6.9 and 0.4; E5: 9.3 and 0.5; E6: 13.3 and 0.8.

Alexandersson's k values for the size classes show the expected fall with decreasing size. No value is shown for the cities in the AA and A groups, and the entry in the B cell of the table is, in fact, for the entire set of 14 larger cities: it is the value midway between the lowest and the second lowest values in the rank. The k for the C class was similarly derived, while the second value from the bottom and the value midway between the third and fourth values in the rankings were taken as the fifth percentile values for the D and E size classes respectively.[1)]

Correlation co-efficients (r) were computed to give further information about the relationship between city size and manufacturing as a whole. Those in the first row of Table 28 reveal the association between city size and the manufacturing variables throughout the whole set of 314 places: the co-efficients in the other rows measure the correlations of the variables within each size class.

The co-efficient for city size and manufacturing employment suggests that 96 per cent (r^2) of the city to city variation in employment is 'explained' by city to city variation in city size. Measured within each city size class however, the relationship is generally weak and variable. Classes D and E show virtually no relationship at all.

The overall association between city size and manufacturing ratio is revealed by the product-moment correlation co-efficient as positive but weak, and the same is true of the relationship between size and location quotient for manufacturing. Nowhere in the size classes are these relationships strong.

For the universe of 314 cities, the relationships between city size are differently described by contingency co-efficients. The respective C co-efficients are 0.70 and 0.35, and they should be interpreted in the light of upper limits of 0.82[2)].

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1) The procedure follows Morrisett (1958) p.243.

2) The co-efficients are based on 5 x 3 contingency tables (Five size classes and three employment and three ratio classes). They are not entirely comparable with the (r) values. For interpretation of C see, for example, Siegel (1956, 196-202).

TABLE 28.

CORRELATION COEFFICIENTS OF CITY SIZE WITH MANUFACTURING

	Employment in Manufacturing	Manufacturing Ratio	Location Quotient
314 Cities	0.980	0.128	0.125
AA	0.997	-0.143	-0.205
A	0.571	-0.073	-0.047
B	-	-	-
C	0.549	0.247	0.238
D	0.041	-0.110	-0.106
E	0.358	0.171	0.178
F	-0.040	-0.191	-0.189

It can be shown furthermore that when employment in manufacturing and manufacturing ratio are correlated, a slight positive association is evident in the whole set ($r = 0.180$) but there are strong positive results in the four smaller classes (exceeding 0.900). Employment numbers and location quotients are related in a very similar manner. Not surprisingly, ratio levels and quotient values show an almost perfect positive correlation (0.996), both throughout the system and within each size class.

THE STRUCTURE OF MANUFACTURING BY CITY SIZE:

The structure of manufacturing in each of seven population-size classes in terms of the component industry groups is presented in Table 29. Each column (size class) totals 100 per cent. Every size class has at least a few workers in every one of the 21 industry groups - though it should be recalled that the basic data relate to employment in industrial groups and not in industrial establishments. All size classes have two or three industry groups that exceed 10 per cent of the size class total and three or more industry groups in which the representation is less than one per cent. Classes A to E have six to eight groups with more than the column average percentage (4.76); the AA group has 10 and the F group only five industry groups above 4.76. Food is the leading group in four size classes (C, D, E and F) and ranks second in the AA category. The percentage of employment in Food industries becomes stronger as size class falls. Transport and Repairs leads in class B and ranks second in classes A and E, while several industry groups rank lowly

TABLE 29.

PERCENTAGE EMPLOYMENT IN CITY SIZE CLASSES BY INDUSTRY GROUP

Industry Group: Processing	Industry Group: Fabricating	AA	A	B	C	D	E	F
Food		11.7	9.7	10.0	19.5	23.0	33.0	41.0
Beverages		1.7	1.2	5.3	7.0	2.4	2.1	0.2
Tobacco		0.9	0.2	0.2	5.0	0.5	0.1	0.1
Textiles		5.5	3.5	0.1	18.0	10.0	1.8	2.4
	Footwear	6.7	5.3	4.1	6.0	7.0	3.3	5.8
	Clothing	11.9	2.1	19.9	2.0	1.6	3.6	2.6
Wood and Cork		1.8	2.2	1.5	2.3	8.2	5.4	6.9
	Furniture and Fixtures	4.3	1.7	5.9	1.2	1.6	1.0	1.6
	Paper and Paper Products	3.1	0.9	-	0.8	0.5	4.3	9.9
	Printing and Publishing Products	5.6	3.1	6.6	2.0	2.1	1.8	3.6
Leather Products		0.7	0.8	0.1	2.0	1.0	0.2	0.3
	Rubber Products	1.0	0.6	0.2	0.6	0.1	6.1	0.4
	Chemical and Chemical Products	9.1	3.7	1.6	2.0	5.7	5.5	1.3
Petroleum Products		0.6	0.2	0.0	0.1	12.9	0.1	0.1
Non-Metalliferous mineral products		4.9	9.1	7.7	6.3	8.6	10.6	10.5
Basic Metals		2.2	18.4	0.1	2.5	2.1	1.5	2.0
	Metal Products	10.7	12.7	8.2	3.2	3.2	3.3	3.8
	Agricultural Machinery	2.6	4.0	1.4	1.6	1.2	1.7	1.8
	Electrical Equipment	4.8	4.9	2.5	1.9	1.0	0.8	0.6
	Transport Equipment & Specialised Repairs	7.9	14.2	23.8	15.0	6.5	13.2	4.1
	Other	3.0	1.6	0.7	1.0	0.8	0.5	0.8

Note : The column totals from left to right, in rounded numbers are: 306,900; 169,000; 3,000; 34,200; 22,800; 16,900; 19,000.

in all seven size classes - these are industries with low employment totals, such as Tobacco, Leather, Rubber and Petroleum products.

The industrial composition of the largest city class (AA) is widely based and no single industrial group exceeds 12 per cent of the class total. Clothing is the leading industrial group at 11.9 per cent. In contrast, smaller city classes have one or two particularly prominent industry groups. In the A class Basic Metals (18.4 per cent) and Transport Equipment (14.2 per cent) stand out while in the B class Transport Equipment (23.8 per cent) and Clothing (19.9 per cent) are notable. Textiles (18.0 per cent) is close behind Food (19.5 per cent) in the C class where in addition Beverages and Tobacco each record their highest class totals. In the D size class Petroleum (12.9 per cent) follows Food (23.0 per cent) and Footwear at 7.0 per cent records its highest class total. In both the smaller size classes (E and F) employment in the manufacture of Food Products dominates the lists (33.0 and 41.0 per cent respectively). Transport and Non-Metalliferous mineral products are strong in the E class (13.2 per cent) while the breakdown of the F size class reveals strength in the Non-Metalliferous (10.5 per cent) and Paper and Paper Products (9.9 per cent) groups, the latter's share in the F class being more than double the share recorded against it in any of the larger size classes.

When the four leading groups in each city size class are considered together, they total 40.6 per cent of all employment in the AA class and 68 per cent in the F class. The top four groups average 58.7 per cent in the intermediate classes A to E.

Nine groups are identified in Table 29 as <u>processing</u> industries and twelve groups as <u>fabricating</u> industries.[1] In the smaller places, employment in processing industries is high, averaging

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1) The distinction between processing and fabricating industries rests on the nature of dominant inputs. and the definition is used in the same sense as by Winsborough, op. cit., p.122. Only the Paper and Paper Products industry group is not clearly either primarily processing or primarily fabricating. Industrial census data for the industries aggregated into this 'intermediate' group indicates that national employment in paper production is, in fact, rather less than that in fabricated paper products.

62.4 per cent for size classes C to F, and ranging from 54.8 (E) to 68.7 (D). Conversely the larger centres (AA to B) are characterised by high employment ratios in fabricating industries, averaging 66.8 per cent and ranging from 54.7 (A) to 75.0 (B).

INDUSTRY DISTRIBUTION AND CITY SIZE:

The percentage values in Table 30 indicate the relative distribution of total employment in each of the 21 industry groups in the Manufacturing division by seven city size classes. Each row (industry group) totals 100 per cent.

The variation in each column of Table 30 merits comment. The AA towns have less than 20 per cent of the total urban employment in the Basic Metals group and no less than 85 per cent of all the clothing workers. The A towns have as much as 40 per cent of the totals of Non-Metalliferous mineral products, Agricultural Machinery and Transport Equipment, and as little as seven per cent of the Tobacco and Petroleum Products workers. Only Beverage products exceeds the two per cent level in the one-town B class. The C towns have more than a third of the total urban employment in Tobacco products and notable shares of Beverages and Textiles; they are under one per cent in only one group. Petroleum Products in the D class reaches 58 per cent, while employment in the manufacture of Rubber Products stands out as a peak in the E column. The percentages in the smallest size class range from almost 12 (Paper and Paper Products) to 0.3. Treating the column data statistically, analysis of the variability within each size class shows that in absolute terms the deviation from the arithmetic average decreases with decreasing city-size. Relative measures emphasise that the variation - from industry group to industry group within a size class - is actually four or five times greater in the smaller size classes than in the AA and A size classes.[1)]

Industry groups in the fabricating category tend to have higher proportions of the total employment in each industry group in class AA cities than do processing industry groups. Aggregating employment numbers for the fabricating and processing industry

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1) The standard deviations run from 16.4 (AA) to 3.5 (F); the relative deviations from 25.0 (AA) to 80.0 (C to F); and the co-efficients of variation from 32.0 (AA) to 142.0 (F).

categories, it can be shown that the AA class of cities has 62.6 per cent of the total employment in fabricating and 40.0 per cent of the total employment in processing industries. Interestingly, the positbn is reversed in the A class where employment in fabricating is only 26.7 per cent of the total fabricating employment whereas employment in processing is 33.8 per cent of the processing total. Size classes C to F have relatively high proportions of the total employment in processing industries.[1)]

The data in the rows of Table 30 indicating the proportions of the urban total of each industry group that are found in each of the seven city size classes, may be analysed in terms of relative levels of urbanisation - i.e. the tendency of the employment of each group to concentrate in the larger cities. The index of urbanisation has extreme theoretical values of -1.0 and + 1.0, the former indicating great relative strength in the smaller cities while an index value of 0.0 indicates no urbanisation. Manufacturing as a whole, as noted earlier, has an index of 0.13.

In Table 31 two urbanisation indices are presented for each of the 21 component groups - the first index (a) reveals urbanisation relative to a second index (b) and summarises urbanisation compared with a standard of employment in all manufacturing. The two sets of urbanisation indices are almost identical in terms of the rank orders,[2)] and the ranges of the two sets are similar (6.46 and 6.76). The indices based on economically active population include, however, 12 that are greater than 0.10 and only five negative values, whereas the (b) indices have no less than 10 negative indices and only seven greater than 0.10. Clothing, Furniture and Chemicals are clearly relatively urbanised on both indices, while Petroleum, Wood and Cork Products and Basic Metals tend to be low in urbanisation.

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1) The percentages for the two categories by city size class are:

	AA	A	B	C	D	E	F
Processing:	40.0	33.8	0.5	9.2	7.1	4.2	5.2
Fabricating:	62.6	26.7	0.6	3.9	2.0	2.2	2.0

2) The value of the Spearman Rank Correlation Coefficient is 0.995.

TABLE 30

PERCENTAGE EMPLOYMENT IN INDUSTRY GROUPS BY CITY SIZE CLASS

Industry Groups								
Processing	Fabricating	AA	A	B	C	D	E	F
Food		44.8	21.5	0.4	8.8	7.0	7.4	10.3
Beverages		48.5	18.4	1.6	22.4	5.0	3.8	0.3
Tobacco		57.4	6.9	0.2	33.7	1.3	0.3	0.3
Textiles		51.9	18.8	0.0	20.3	6.8	1.0	1.2
	Footwear	58.6	25.6	0.4	6.1	4.8	1.8	2.7
	Clothing	85.3	8.2	1.4	1.6	0.8	1.5	1.2
Wood and Cork		39.5	25.8	0.3	5.5	13.5	6.0	9.2
	Furniture and Fixtures	76.3	16.5	1.1	2.3	1.4	1.0	1.4
	Paper and Paper Products	69.7	10.6	0.0	1.8	0.5	5.7	11.7
	Printing and Publishing Products	69.9	21.1	0.8	2.5	2.0	1.3	2.3
Leather Products		53.1	31.9	0.1	9.4	4.0	0.6	0.9
	Rubber Products	54.3	17.3	0.1	3.9	2.7	20.6	1.1
	Chemicals and Chemical Products	74.3	16.9	0.1	1.9	3.6	2.7	0.5
Petroleum Products		34.1	6.5	0.0	0.3	58.1	0.2	0.8
Non-Metalliferous Mineral Products		39.0	40.3	0.6	5.0	5.6	5.1	4.4
Basic Metals		17.2	77.9	0.0	2.1	1.3	0.7	0.9
	Metal Products	57.0	37.0	0.4	2.1	1.5	1.1	1.0
	Agricultural Machinery	49.2	42.2	0.3	3.1	1.8	1.9	1.6
	Electrical Equipment	61.6	34.0	0.3	2.4	0.9	0.6	0.3
	Transport Equipment & Specialised Repairs	41.2	41.0	1.2	8.7	2.7	4.1	1.1
	Other	73.2	21.8	0.2	2.4	1.1	0.7	0.7

TABLE 31

INDICES OF URBANIZATION FOR TWENTY-ONE INDUSTRY GROUPS

Processing	Fabricating	(a) P	(a) F	(b) P	(b) F	Rank Order (a)	Rank Order (b)
Food		-.041		-.163		18	18
Beverages		.038		-.098		16	15
Tobacco		.107		-.025		12	12
Textiles		.070		-.066		13	14
	Footwear		.172		.046	9	9
	Clothing		.416		.312	1	1
Wood and Cork		-.086		-.213		20	19
	Furniture and Fixtures		.347		.241	2	2
	Paper & Paper Products		.201		.101	8	7
	Printing and Publishing Products		.288		.170	5	5
Leather Products		.141		.006		10	10
	Rubber Products		.055		-.062	14	13
	Chemicals and Chemical Products		.322		.207	4	4
Petroleum Products		-.230		-.364		21	21
Basic Metals		-.076		-.249		19	20
Non-Metalliferous Mineral Products		-.005		-.145		17	17
	Metal Products		.211		.078	7	8
	Agricultural Machinery		.139		.000	11	11
	Electrical Equipment		.255		.127	6	6
	Transport Equipment and Specialised Repairs		.041		-.103	15	16
	Other		.336		.218	3	3

Note: The standard distribution for the (a) and (b) indices are noted in the text.

The twelve fabricating industry groups together have an a index of urbanisation of 0.227, that is they are more strongly urbanised than manufacturing as a whole. By contrast, processing industries as a category have an (a) index value of -0.021 which demonstrates a lower level of urbanisation than manufacturing as a whole and a distribution very similar to that of the total economically active population.[1)]

INDUSTRY GROUP AND CITY SIZE:

Four industries were selected for analysis of the influence of size on industry ratios. The industry ratio of a group in a town is the ratio of employment in that particular industry group to the total employment in the Manufacturing division expressed as a percentage. [Table 32]

The average Food ratio trends upwards as city size falls, but the averages for the remaining industry groups show no consistent relationship to size.[2)] The highest value in all industry groups increases as size falls most smoothly in Food while the lowest values decrease. The numbers of F size cities with zero employment in the selected industry groups are, it should be noted, 24, 158, 101 and 157 respectively. Furthermore, these numbers ensure that the k values (based on industry ratios) for the set of 314 cities are zero for the four groups.

The group k values for the size classes based on ratios using total <u>urban</u> manufacturing as the base, decrease with city size. The Food group k declines from 3.5 (AA, A and B together) to 2.43 (C) and 0.99 (D); it is zero in the E and F size classes. Clothing, Wood and Cork, and Basic Metals have k values of 0.22, 0.45 and 0.11 respectively in the large city classes (AA, A and B), and zero values for the smaller city classes (C to F).

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1) The b index values are +0.102 for the fabricating category and -0.159 for the processing industries.

2) The averages for P1 to P6 for the selected groups are: Food: 10.8 per cent; 12.0; 21.2; 23.6; 29.6; and 27.3. Clothing: 11.1 per cent; 3.3; 1.9; 1.2; 1.9; and 1.5. Wood and Cork: 2.0 per cent; 2.1; 2.1; 9.4; 3.7; and 6.0. Basic Metals: 2.5 per cent 10.8; 4.7; 1.8; 1.4; and 2.7.

TABLE 32

INDUSTRY RATIOS FOR FOUR GROUPS BY CITY SIZE CLASS

FOOD							
	AA	A	B	C	D	E	F
Average	10.8	12.2	10.0	21.2	26.1	22.3	29.2
Highest	14.9	32.5	10.0	47.2	79.6	80.5	99.9
Lowest	5.2	2.8	10.0	2.2	0.0	0.0	0.0
CLOTHING							
	AA	A	B	C	D	E	F
Average	11.1	1.5	19.9	2.0	1.4	2.4	1.4
Highest	19.6	4.6	19.9	17.6	11.5	92.1	82.6
Lowest	2.2	0.2	19.9	0.0	0.0	0.0	0.0
WOOD AND CORK							
	AA	A	B	C	D	E	F
Average	2.0	2.1	1.5	2.1	8.4	4.7	5.7
Highest	3.3	5.7	1.5	20.8	82.4	77.4	99.9
Lowest	1.3	0.2	1.5	0.0	0.0	0.0	0.0
BASIC METALS							
	AA	A	B	C	D	E	F
Average	2.5	12.0	0.1	5.0	2.2	1.8	2.3
Highest	8.1	50.8	0.1	33.6	38.9	32.5	99.9
Lowest	0.5	0.2	0.1	0.0	0.0	0.0	0.0

On an absence-presence basis and assuming ubiquity to occur at an arbitrary level where 75 per cent or more of the cities in a class possess employment in an industry group, the four selected groups are ubiquitous in classes AA to D. Only Food is ubiquitous in all city classes, however, and the other three industry groups are sporadic in classes E and F. In fact, in classes E and F the Clothing industry may be termed concentrated, if this is said to occur when less than 25 per cent of the cities have any employment in the industry. Basic Metals reaches this level of concentration in the F class.

Measuring ubiquity by a comparison of Alexandersson's k values (based on industry ratios) and levels equal to one-fourth of the national percentage of urban manufacturing in all cities,[1] Food emerges as ubiquitous in the AA, A and B classes (and as sporadic in the C to F classes) and Clothing, Wood and Cork, and Basic Metals are sporadic in all the size classes of the city system.

The evidence from the four industry groups suggests that as city size increases, more and more industries are classified as ubiquitous.

The r co-efficients in Table 33 (row one) indicate that the influence of size of place on absolute size of each industry group is very definite and positive, though the correlation with Basic Metals is only moderate. Within each size class, however, the relationship is less strong, and sometimes inverse.

The co-efficients that result from relating population and industry ratios are quite small for the whole system and generally weak throughout the size classes [Table 34]. When manufacturing employment is related to group employment and to industry ratios, the patterns are similar to those in Tables 33 and 34.

VARIATION IN MANUFACTURING STRUCTURE AND CITY SIZE:

City to city variation in the structure of manufacturing is very considerable. The index of diversity measures the diversification of structure and the index of dissimilarity indicates the degree of divergence from the national urban manufacturing structure. Table 35 assembles these measures in a

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1) See Morrisett (1958, 245)

TABLE 33

CORRELATION COEFFICIENTS OF CITY SIZE WITH EMPLOYMENT IN FOUR INDUSTRY GROUPS

	Food	Clothing	Wood & Cork	Basic Metals
314 Cities	0.927	0.878	0.792	0.351
AA	0.672	0.755	0.205	-0.396
A	0.352	0.324	0.378	0.358
B	-	-	-	-
C	0.467	-0.081	-0.064	-0.121
D	-0.318	0.022	-0.073	0.272
E	0.197	-0.169	0.181	0.079
F	-0.002	0.004	-0.039	-0.083

TABLE 34

CORRELATION COEFFICIENTS OF CITY SIZE WITH RATIOS IN FOUR INDUSTRY GROUPS

	Food	Clothing	Wood & Cork	Basic Metals
314 Cities	-0.106	0.138	-0.042	0.063
AA	0.229	0.516	-0.751	-0.692
A	-0.319	0.350	0.232	0.351
B	-	-	-	-
C	0.228	-0.077	-0.165	-0.255
D	-0.340	0.362	-0.092	0.221
E	-0.111	-0.206	0.118	0.109
F	0.113	-0.015	-0.047	-0.121

form that suggests how manufacturing structure varies according to city size, and there are evidently several regularities.

Absolute diversification is 21, and the larger centres are very diversified in structure. In the four smaller size classes there are also towns that reach high diversity levels - though it is necessary to emphasise again that <u>any</u> employment in a group is accepted as an indication of the presence of that group in that town. The drop in average diversity index value with decreasing town size is steep after the B size class, and amongst the E and F towns there are nearly 200 places with index values below 10. The national average diversity index value is 9.9.

The pattern of scores on the dissimilarity index is rather different. They increase strongly with decreasing city size. The larger centres approximate in structure to the national picture and the smaller places are two or three times more 'specialised'. Amongst the smaller places are to be found a number of towns that are extremely 'different' - though one or two of the largest cities in the country are very specialised also. When the four F size collieries with no manufacturing are included and given indices of 100,00, the average for the smallest size class increases to 63.3.[1)]

TABLE 35

DIVERSITY AND DISSIMILARITY INDICES BY CITY SIZE CLASS

	AA	A	B	C	D	E	F
DIVERSITY INDEX							
Average	21.0	20.6	20.0	18.0	15.6	10.8	7.2
Highest	21	21	20	20	20	19	18
Lowest	21	19	20	13	1	2	0
DISSIMILARITY INDEX							
Average	21.9	35.7	35.6	50.6	56.7	60.0	62.5
Highest	27.5	62.0	35.6	68.8	90.1	93.6	97.5
Lowest	17.8	14.8	35.6	37.3	33.3	36.9	30.7

1) The average Diversity and Dissimilarity indices for the secondary size-class schemes are respectively: P1: 21.0 and 21.9; P2: 20.5 and 35.7; P3: 17.9 and 50.1; P4: 15.2 and 58.0; P5: 10.1 and 58.7; P6: 6.6 and 63.6 (64.5 when four collieries are included). E1: 17.8 and 47.2; E2: 12.6 and 59.5; E3: 9.4 and 58.5; E4: 7.3 and 59.4 (61.0 when two collieries are included; E5: 6.7 and 64.2; E6: 5.9 and 67.2 (68.4 when two collieries are included)

Correlation analysis of population numbers with the two indices confirms the general direction of the relationship is positive with diversity and inverse with dissimilarity (row one, columns 1 and 2 of Table 36). Relating the indices to manufacturing ratios reveals a weak positive association.

TABLE 36

CORRELATION COEFFICIENTS OF CITY SIZE AND MANUFACTURING RATIO WITH DIVERSITY AND DISSIMILARITY INDICES

	With City Size		With Manufacturing Ratio	
	Diversity	Dissimilarity	Diversity	Dissimilarity
314 Cities	0.369	-0.340	0.278	0.288
AA	-	-0.548	-	-0.640
A	0.375	-0.124	0.429	0.467
B	-	-	-	-
C	0.268	-0.175	0.475	0.628
D	0.083	-0.177	0.329	0.446
E	0.429	-0.048	0.531	0.372
F	0.354	-0.213	0.081	0.400

The two indices are themselves negatively correlated (-0.448) in the system as a whole, and most strongly so in the D size class (-0.529).

VARIATION WITHIN CITY SIZE CLASS:

Size class averages and extremes have been presented in earlier tables. In Table 37 the variation of selected measures within each city size class is shown in terms of coefficients of variation, defined as the percentage ratio of the size class standard deviation to the size class mean. The trend throughout is increasing 'within size class variation' as city size class decreases larger cities are clearly more alike than are smaller cities.

CONCLUSIONS:

A high proportion of South African manufacturing is urban in location and in absolute terms is concentrated in the country's metropolitan areas which have 75 per cent of all manufacturing employment.

TABLE 37

VARIATION COEFFICIENTS FOR CITY SIZE CLASSES

	AA	A	C	D	E	F
Manufacturing Numbers	30	69	96	91	117	163
Manufacturing Ratio	12	73	74	80	102	150
Location Quotient	12	70	74	79	103	147
Diversity Index	0	4	13	24	38	50
Dissimilarity Index	19	38	19	26	22	26
Food Ratio	40	72	67	81	99	94
Clothing Ratio	64	112	218	166	531	510
Wood and Cork Ratio	46	80	211	201	265	273
Basic Metals Ratio	149	162	199	329	336	520

Nevertheless, manufacturing is an activity encountered to a greater or lesser degree in most South African cities. In relative terms the size of manufacturing employment in a city tends to be correlated with the size of its economically active population. While this finding may be true for the Manufacturing division as a whole, marked differences may be shown to exist in individual industry groups. Inter industry variations in levels of urbanisation are due to a wide range of factors, the explanation of which will require further research.

A relatively small number of South African cities may be classed as specialised manufacturing centres and these, with a few notable exceptions, tend in general to be smaller cities.

The industrial profile of cities in the set is subject to considerable variation and it is possible to identify ubiquitous, sporadic and concentrated groups of industry. Dissimilarity in profile from the national manufacturing structure is associated more particularly with smaller cities which tend to be more highly specialised in a few industry groups than larger cities. This pattern also reflects the tendency for larger cities to be duplicative rather than specialised in industrial structure.

The findings of the analyses of the relationships between size of city and manufacturing suggest that definite relationships exist, and the main points may be summarised as follows:

While in absolute terms employment is heavily concentrated in the larger city size classes (AA and A), the manufacturing component in smaller size classes is significant and the Index of Urbanisation is moderate (.13). Average manufacturing ratios decline with size class, as do location quotients and k values. These trends are confirmed by r and C co-efficients for 314 cities - though the interpretation of these values is not straightforward. The influence of city size is evident also in the wide base of manufacturing in the largest city size class (AA) and in the tendency for one or two industry groups to dominate manufacturing in the other size classes. There is a strong tendency for fabricating industries to dominate in the larger size classes, and the fabricating category is also more urbanised than the processing category. The evidence suggests that as city size increases more and more industries become ubiquitous and that the industry ratios of ubiquitous industries increase as city size falls. Cities in the larger size classes are more diversified and less 'specialised' in their manufacturing composition than smaller cities; and they are more alike than are cities in the smaller city size classes.

The relationship revealed and differences between city size classes established in this paper are generated by forces that have yet to be analysed in depth locally. Location theory, however, points particularly to the significance of agglomeration economies. The strongest of these advantages are economies external to individual industries and they are pronounced in urban centres. 'Urbanisation economies' or 'economies of urban concentration' include access to a larger market, to the larger labour market, to more and better industrial and social services and facilities and to a wider range of inputs. Not only are they strong in urban centres, but they improve with increasing city size, particularly for market-oriented consumer industries.

Manufacturing in the smaller cities is to be explained primarily in terms of competitive advantages in serving the local, if restricted,market, and advantages of access to raw material inputs for processing. Mining and large-scale processing activities have attracted fabricating industries to several smaller cities, and the process may be encouraged by official planning policies. Non-metropolitan centres in the growth zones that surround the major metropolitan concentrations and in the growth corridors lining such concentrations are favourably located for the further development of manufacturing.

Two further questions arising from the analysis deserve comment. The South African evidence has shown that the larger city size classes have a higher order of manufacturing than do the smaller city size classes. The differences in order are indicated by size of employment, location quotient, fabricating: processing ratio and diversity and dissimilarity indices. Values of these measures tend to graduate from the smallest city size class through intermediate size classes to the largest city size class. Does this hierarchical arrangement of manufacturing by city size class suggest that manufacturing is also hierarchically distributed from city to city within a rank-size system?

The results of correlation analysis between city size and size of employment in manufacturing in the whole set of 314 cities indicate a strong positive relationship and the possibility of a city to city hierarchy. The postulate collapses, however, when the relationship is examined within size classes where weak correlations (sometimes inverse associations) are found. Correlations between city size and location quotients and diversity and dissimilarity indices within size classes are equally weak and inconsistent. A hierarchical distribution of manufacturing measured on a city basis does not appear, therefore, to be acceptable. It follows too that an urban hierarchy model (based on population size) can have little relevance when it comes to predicting the volume of manufacturing for a city as it grows in size over time.

In terms of the detailed composition of manufacturing city by city, though there are positive relationships between city size and size of employment in particular industry groups in the whole set of 314 cities, the correlations for the size classes do not support the notion that city size is a good indicator of the numbers employed in individual groups in a city. One might speculate, furthermore, that if data in greater topical detail were available, concentration of employment in <u>types</u> of manufacturing in a few cities would be revealed - concentration both within the urban system as a whole and within city size classes.[1] The urban hierarchy model probably has no more relevance when it comes to predicting the composition of manufacturing in a city.

The nature of the relationships which exist between city size and population growth on the one hand, and manufacturing on the other will emerge more clearly when data from the 1970 population census become available. Meanwhile, analysis of the 1960 employment data for the cities in the South African urban system continues, the major concerns at the moment being regional patterns and characteristics and the identification of 'similar' cities and of 'similar' manufacturing industries. Regression, residuals and cluster analysis are amongst the techniques being used to assist in the quest for greater understanding of the urban system and the space economy.

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1) Clustering or concentration in a few cities is evident throughout the data. Concentration of manufacturing as a whole within city size classes: in AA, the largest manufacturing city has 35 per cent of the total class employment; A, three have 58; C, four have 53; D, five have 42; E, five have 35; and in F, seven cities have 28 per cent.

Notable concentrations in the four industry groups: Food, 51 per cent in two cities in A; and 37 in four in F. Clothing, 77 in two cities in A; 70 in two in C; and 52 in one in F. Wood and Cork, 77 in three in D; 47 in one in E. Basic Metals, 89 in two in A; 86 in one in E; 69 in one in C; and 52 in one in F.

C H A P T E R 5

THE SOUTH AFRICAN URBAN SERVICE HIERARCHY

CHAPTER 5.

THE SOUTH AFRICAN URBAN SERVICE HIERARCHY

Analyses of tertiary services provided by cities within a city system are today unquestionably one of the most active fields of research in theoretical and applied urban geography. The provision of services for their own populations and for the populations of other urban places and rural populations, is the raison d'être which underlies the existence of the majority of cities. Concern with the tertiary component of city functions, however, is not limited to the determination of levels at which cities provide services but rests also upon the role which the service component plays in the functional and spatial organisation of the economy and society. The importance of the service structure of a city system to development strategies has therefore been repeatedly stressed in planning studies in recent years.

Services provided by cities range in importance from low-order frequently-required convenience services with low thresholds of entry and a small range, to high-order services with high thresholds of entry and large range. It follows that high-order services will be located in a relatively few and widely-spaced cities, serving relatively large populations, and that low-order services will be more widely distributed over a large number of cities, serving relatively small populations. The grading of services is reflected in the emergence of concomitant graduations of cities within the city system. Cities with high-order services normally also provide services of a low-order, and it may be assumed therefore that cities with a high service rank will be functionally more complex and will serve larger complementary regions than cities of a lower service rank.

The grading of cities by service rank implies that the city system will be organised either on a continuum or in hierarchical classes. Evidence from the majority of empirical and theoretical studies in the field point to the acceptance of an hierarchical arrangement. The assumption is based on the principle that an hierarchical class system of cities provides an orderly framework for the organisation of functional interdependence between cities in the provision of services on the one hand, and an equally orderly basis for the most economical spatial distribution of service centres on the other.

These principles are inherent in the classical central place theory first postulated by Christaller (1933) and later by Lösch (1954). A considerable volume of more recent research on the central place theory now exists and is reviewed in an extensive bibliography prepared by Berry and Pred (1965).

It is the objective of this chapter to apply central place theory to an analysis of the South African city system - but at this stage to confine attention to the Christaller models. Later research may facilitate an analysis of the city system within the Lösch framework.

DETERMINATION OF AN URBAN HIERARCHY

The first step in the analysis of the service structure of a city system is to establish a methodology for the recognition of the urban service hierarchy. A wide choice of methods exists ranging from simple qualitative statements to the application of sophisticated quantitative techniques. Work on South African city system has concerned the application of the functional basis methodology postulated by Berry and Garrison (1958a, b, c) on the one hand, and the development of an index method, employing simple methods, and directed towards a procedure which may be used for the rapid updating of an urban hierarchy, on the other. A review of other methods employed in recent research together with a detailed statement of the Berry and Garrison and index methods is included in Appendix A. Only the principal elements of the procedures will be outlined here.

THE DATA

The universe of cities considered in the analysis was 601 places classified as urban in the 1960 population census (Republic of South Africa, Bureau of Statistics, 1963). Places which on available evidence appear to form integral parts of larger urban places and which for census purposes have been separately listed, have been combined into single agglomerations. The most important agglomeration is that which has grouped together Johannesburg and those cities with which it is functionally related to form the Witwatersrand conurbation. The grouping has been necessary, primarily because of the difficulty of separately distinguishing from the sources of data available the functional bases of the cities of the Witwatersrand. All urban places forming part of other metropolitan areas or smaller cities, also, have been included with the parent cities.

Measures of the centrality of cities have been defined by a variety of criteria. Most workers agree that population size alone is an unsatisfactory determinant and centrality is more customarily defined by an index derived from the range of service functions present in a city. These include administration, cultural, health and social services, services associated with the organisation of economic and social life, finance, trade, service industries, labour and traffic movements.

Service data for each selected city in the analysis were extracted from secondary sources from which complete enumerations of service units may be made. The sources include in particular, Braby's Commercial Directory (1966); Provincial Telephone Directories (1967); medical, professional and library registers, the South African Railway time-table (1967); and official lists supplied by government, provincial and local authorities and by private organisations. The listings were subject to field checks in a sample of South African cities to test the reliability of the secondary sources. The use of secondary sources has necessitated the exclusion of a limited number of urban places which are not separately listed in either telephone directories or official lists.[1)]

All places classified as metropolitan cities by the Bureau of Statistics in 1960 were treated separately due to the complexity of extracting detailed service data from secondary sources. The metropolitan areas have, however, been included in the analysis but have been classified on the basis of more formal statistical data such as size, functional structure and selected details provided by secondary sources. This procedure has meant that the statistical treatment of the data in the analysis has excluded the metropolitan cities. The results of statistical tests, therefore, refer only to cities below metropolitan level except where, in the case of Vereeniging and Klerksdorp, these cities have been graded with the metropolitan centres on the grounds of their service complexity.

While initially all service functions were recorded an examination of the worksheets showed that the full complement of services may profitably be reduced by grouping closely similar types of service under generic heads. This procedure reduced the total number of services recorded to 55 (Table 38).

TABLE 38

CENTRAL FUNCTIONS

(a) Attribute Functions	Score
Magistrate	20
Library	20
Newspaper	20
S.A. Police	10
Post Office	10
Postal Agency	5
Railway	5
Money Order Office	5

Contd/

1) These include in particular: Valspan (4,610), Zoar (1,673), Louis Roodt (1,623), Mngqesha (1,518).

	District Surgeon	2
	Bantu Administration	2
	Roads Department	2
	Road Motor Transport	2
(b) <u>Variate Functions</u>		
EDUCATION		
	University (All Races)	40
	Training College (All Races)	30
	High School (All Races)	20
	Secondary School (All Races)	15
	Primary School (All Races)	10
	Other Administration	2
FINANCIAL		
	Bank Branch	5
	Bank Agency	2
	Building Society Branch	3
	Building Soceity Agency	1
	Insurance Office	1
	Other Financial Office	1
PROFESSIONAL		
	Medical Specialist	20
	General Practioner	10
	Dentist	10
	Lawyer and Solicitor	10
	Accountant/Auditor	10
	Estate Agent/Auctioneer	10
	Other Professional .	10
SOCIAL		
	Hospital	20
	Clinic	10
	Church	10
	Cinema	10
	Mission Church	5
COMMERICAL		
	Department Store	10
	Licensed Hotel	10
	Boarding House	5
	Wholesaler	5
	Produce Buyer	5
	Speciality Shop	5
	Engineering	2
	Electrician/Plumber	2
	Building and Cartage	2
	Other Service	2
	Butcher	1
	Baker	1
	Dairy	1
	Tearoom	1
	Bottle Store	1
	Hardware	1
	Motor Garage	1
	Other Provision Store	1
	General Dealer	1

Services have been broadly classified as attributes and variates as defined by Berry and Garrison (1958a). Attributes are services of which only one or no units may occur in a city, while variates are services of which more than one unit may occur in an individual city.

If it is assumed that services differ significantly in importance it is possible, though not simple, to derive a measure whereby the differences may be quantified and used as determinants of hierarchical status. A scale of weighted scores, derived after discussion with social scientists and officials of government and commercial institutions was decided upon as a measure to distinguish between the relative importance or quality of services. Field checks were undertaken to determine the reliability of the weighted scores. Each service has been assigned a score value in a scale ranging from one to forty (Table 38). A centrality index of a city may then be determined by the sum of weighted scores.

THE URBAN HIERARCHY

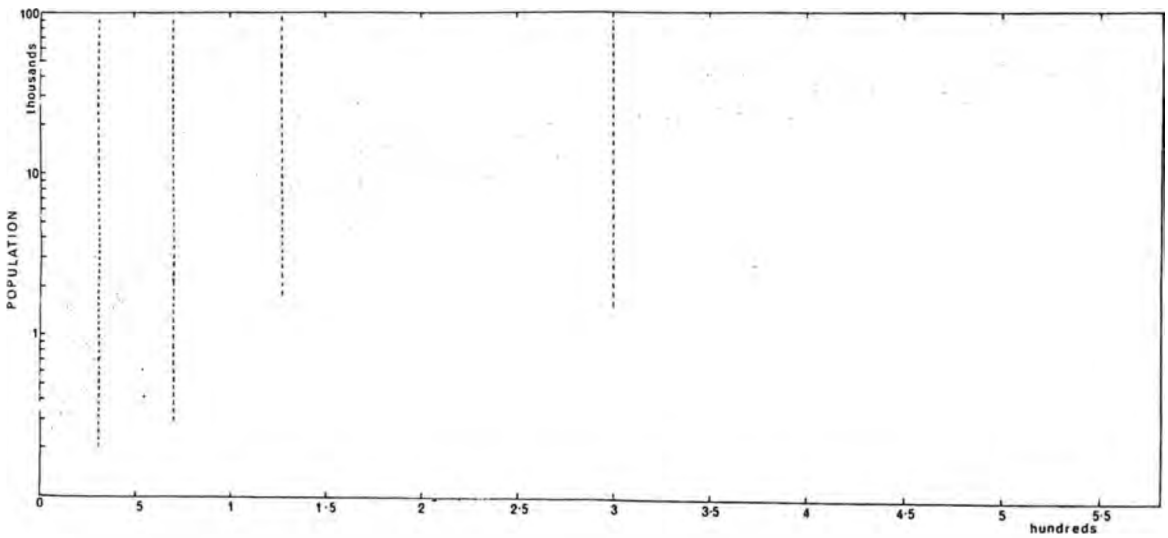
Population and the Total Number of Functional Units

The relationship between the number of functional units and population provides a first measure of the existence of an hierarchy. The measure is crude since each unit is given equal weight.

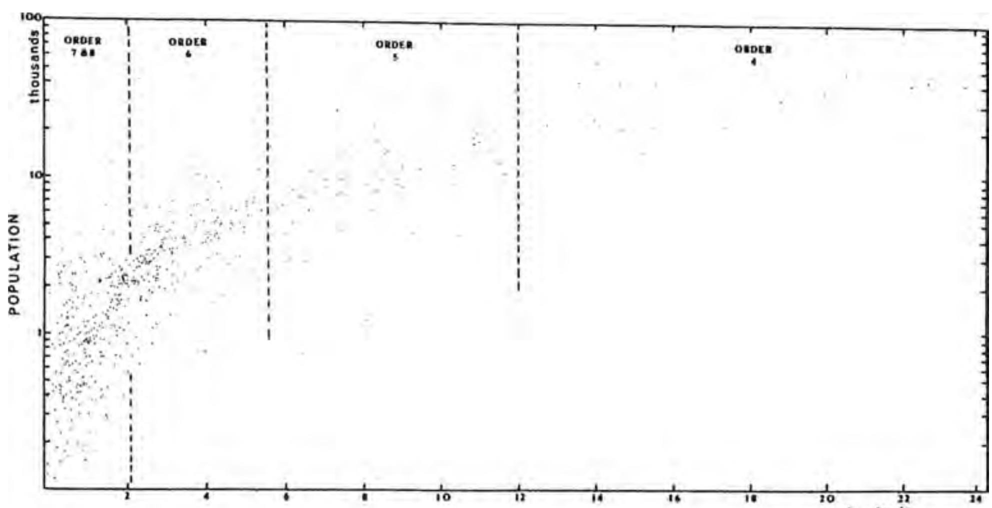
By inspection of the graph (Figure 27) which for reasons previously stated includes only cities below the level of metropolis, five classes of city may be identified at breaks in the angle of slope of the curve. The divisions could be substantitated by fitting regression lines to portions of the curve occupied by each order of urban place. The intersects could be expected to correlate with the between-class breaks already noted. The slope of each line would be significantly different from that of any other. It should be remembered, however, that a regression line may be drawn to fit any chosen grouping, and is not in itself an indication of the existence of a group. The grouping remains to be statistically substantiated.

Further examination of the distribution shows that a curvilinear relationship between population and number of units is evident when plotted on semi-logarithmic paper. The correlation coefffficient has a value of .90 and compares closely with correlations calculated by Stafford (1963) for Southern Illinois (r = .93) and Iowa (r = .93).

The regression equation: $y = 26.62 + 0.01x$ indicates that on average a change in city size of 1,000 persons will result in the existence of 10 additional units.



27. GRAPHICAL RELATIONSHIP BETWEEN NUMBER OF CENTRAL FUNCTIONAL UNITS AND TOTAL POPULATION OF CITIES



28 GRAPHICAL RELATIONSHIP BETWEEN CENTRALITY INDEX AND TOTAL POPULATION OF CITIES

The Relationship of a Centrality Index and Population

Figure 28 displays the graphical relationship between population of cities below metropolitan status and centrality index scores based upon 55 functions. The distribution, plotted on semi-logarithmic paper, shows a strong curvilinear relationship between centrality index and total population. The correlation coefficient, $r = 0.92$, suggests that in the South African city system population size may be used as a reasonable indicator of centrality - though naturally the classification would give no evidence of the functional make-up of cities in the system.

By inspection of the distribution of nearest neighbour distances between points in a rank order of scores, six orders of cities may be identified.[1] The centrality indices of Vereeniging and Klerksdorp (3,359 and 3,252 respectively) are very widely separated from the next highest score of 2,363 (Paarl) and the two cities have in consequence been grouped as Order 3 cities. This decision places the two cities in the lowest rung of the metropolitan centres. Their position is marginal and transitional.

Marked breaks in the curve of centrality index scores enables 5 additional orders of cities to be identified. (Figure 28.) .

While the main breaks in the distribution of cities are reasonably clear from a visual inspection of the curve they are nevertheless subjective. It may be argued that the distribution, far from representing a clear delimitation of cities in discrete categories, may represent a functional continuum. Such a continuum would not be unexpected in a situation where some cities are in a process of transition from one level of service to another. The tendency for discrete groups to emerge in such circumstances would be masked. Careful examination of the distribution of points on the curve will show, furthermore, that more refined categories could possibly be identified, either as independent orders or sub-orders of those groupings already suggested. The significance of such sub-groups, however, is likely to be lower than that for the principal groups identified. It is necessary therefore that the 5 orders of cities below metropolitan status be confirmed by statistical tests.

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1) Note In theory within-group differences in centrality is zero, but in reality the ideal stratification of cities with identical centrality indices is unlikely to occur. Thus it has become customary to regard a group as significant if the between-group differences in centrality scores are greater than within-group differences for any selected orders of cities. The 6 orders distinguished here are tested for significance at a later stage in this chapter.

The high-ranking metropolitan cities have previously been set off from cities of a lower rank and have not been subjected to statistical testing. The metropolitan orders have been sub-divided into three groups of cities on the basis of size and functional complexity. The classification of Pretoria and Cape Town proved difficult. These cities are the seats of the administrative and legislative functions of the central government respectively, and function as central places serving the whole of the Republic. The two cities do not, however, compare with the Witwatersrand in complexity in a wider range of functions, and fall more conveniently into the Order 2 level of Major Metropolitan Areas. The hierarchy is headed by the Witwatersrand as the principal Metropolitan Area, and is followed in Order 2 by the Major Metropolitan Areas of Cape Town, Durban and Pretoria. The third order Metropolitan Areas include Port Elizabeth, Bloemfontein, Pietermaritzburg, East London, Kimberley, the Orange Free State Goldfields, Vereeniging and Klerksdorp.

The remaining orders of cities identified by breaks in the curve of centrality index scores were subjected to testing for statistical significance.

The preliminary recognition of Orders 4 to 8 was substantiated by the application of the Tarrant (1968) method of grouping and involved generalisations ranging between 6 per cent and 42 per cent (Table 39).

TABLE 39

GROUPING OF CITIES

Order	No.of Cities	Tarrant Generalisation
4	19	41.9
5	57	27.6
6	173	18.7
7	140	6.4
8	200	7.05
7 & 8 Combined	340	13.5

A Student t test showed that for places in Orders 4, 5, 6 and 7 and 8 combined, the suggested grouping was statistically significant at the 0.01 level (i.e. the differences between the mean scores of pairs in these groups is significant and the selected breaks between the orders may be accepted as being reasonable). No significant difference was found, however, between Orders 7 and 8 which form a continuum, and the division between these orders must be taken as arbitrary.

It is important to note that the division between Orders 6 and 7 may be based on either of two statistically-significant breaks in the rank order of centrality index scores. The upper break distinguishes 65 Order 6 places while the lower break isolates 173 places of this order. Concomitantly, the number of Order 7 cities rises or falls with the selection of either the upper or lower break to distinguish Order 6 cities. It is a matter of arbitrary decision at this stage as to which break is the most significant from a functional rather than a statistical point of view. A final decision on the alternative breaks in Order 6 will require additional research. At this stage the order may be distinguished at an upper and lower level (Order 6a and 6b).

It is important to note that the hierarchy derived by relating the total number of functional units and the total population of each urban place graphically proved to be practically identical in terms of the order of cities (94 per cent absolute correspondence). The finding is interesting and suggests that a complex system of weighted scores is unnecessary in hierarchical determination when a wide range of services is considered.

The Functional Identity of the Urban Hierarchy

Having established the existence of 5 orders of city below the level of metropolitan area, the data may be further tested to establish that the 5 orders are functionally distinct.

Berry and Garrison (1958a) have described a methodology whereby the functional identity of levels of cities in a hierarchy may be established. Briefly stated the method includes :

1. The calculation, ranking and grouping of threshold population for each variate function. Threshold populations may be derived by determining the regression calculated to fit a distribution of the exponential growth type $y = a. b^x$.

2. The calculation, ranking and grouping of point bi-serial correlation coefficient (r_{pb}) for each attribute function. Determination of threshold populations and point bi-serial correlation coefficients is discussed in Appendix A.

Four groups of attribute and five of variate functions was achieved by the application of the Tarrant method of generalisation to the r_{pb} and threshold population values (Tables 40 and 41).

TABLE 40

POINT BI-SERIAL CORRELATION COEFFICIENTS FOR ATTRIBUTE FUNCTIONS

Attributes	r_{pb} values	Generalisation when grouped
Library	0.63	19.0%
Newspaper	0.53	
District Surgeon	0.37	0.1%
Magistrate	0.365	
Bantu Administration.	0.32	10.6%
Railway	0.31	
Roads Department	0.27	
South African Police	0.19	16.0%
Road Motor Transport	0.12	
Money Order Office	0.11	
Post Office	0.00	0.0%

The functional identity of cities was determined using a sample of 99 cities selected from the five orders of city with a sampling fraction of 100, 35, 12, 10 and 14 per cent respectively. The sampling fractions represent all cities in Order 4, and 20 cities drawn randomly from each of the remaining orders.

The analysis of functional identity was carried out by determining the number of establishments in each group of functions, in each sample city by order. Mean values for each group of functions was then calculated and divided by the number of functions in each group. A value of 1.0 indicates that every centre of the particular order of city tends to have one establishment of each function within the functional group. The functional identity of the five orders of cities is shown in Table 42.

TABLE 41.

THRESHOLD POPULATIONS FOR VARIATE FUNCTIONS.

	Parameters a	Parameters b	Threshold Population	Mean pop. for one unit.	
Building Society Branch	4.3471	0.0056	22,580	20,989	
Department Store	3.6069	0.3104	8,266	16,101	
Cinema	3.6684	0.2439	8,172	8,677	
Bakery	3.4970	0.2156	5,159	6,044	
Wholesaler	3.4828	0.2203	5,048	6,358	
'Other' Professional	3.5562	0.0541	4,077	5,190	
Dairy	3.2959	0.2707	3,686	4,748)	
Bottle Store	3.3197	0.2387	3,617	3,648)	
Engineering	3.4402	0.1043	3,503	3,773)	
'Other' Financial	3.3495	0.1918	3,477	6,470)	
Clinic	3.1999	0.3307	3,393	4,449)	13.8%
Lawyer & Solicitor	3.4254	0.0985	3,341	3,090)	
Electrician	3.4140	0.1015	3,277	3,688)	
Mission	3.3178	0.1675	3,057	2,964)	
Hardware	3.4150	0.0616	2,996	2,860)	
Estate Agent	3.3096	0.1441	2,843	3,571)	
Tea Room	3.4347	0.0048	2,751	1,748)	
Produce Buyer	3.2560	0.1703	2,669	2,439)	17.0%
Hospital	2.9846	0.4367	2,638	4,981)	
Insurance Company	3.3375	0.0527	2,457	2,477)	
Bank Agency	2.6583	0.6687	2,173	2,818)	
Speciality Shop	3.3004	0.0307	2,143	1,799)	
'Other' Food	3.2387	0.0872	2,117	2,670)	
Butcher	3.2010	0.1085	2,039	1,655)	
Accountant/Auditor	3.0727	0.2273	1,993	5,493)	9.6%
Building and Cartage	3.0547	0.2431	1,986	3,431)	
Boarding House	3.1614	0.1362	1,985	3,845)	
Doctor	3.1471	0.1194	1,805	1,653)	
Bank Branch	2.9590	0.2488	1,614	3,265)	
Church	3.0801	0.1121	1,557	1,792)	
Licensed Hotel	3.0236	0.1672	1,552	2,270)	
'Other' Service	3.1103	0.0343	1,395	1,516)	9.0%
Garage	3.0011	0.1178	1,315	1,024)	
Building Society Agency	2.9141	0.1848	1,256	2,358)	

Note: Percentage values represent levels of generalisation in grouping threshold populations.

TABLE 42

NUMBER OF FUNCTIONAL UNITS BY ORDER OF CITY

Functions	Order 4	Order 5	Order 6	Order 7	Order 8
Variates:					
Group 1	1.84	0.74	0.37	0.13	0.00
Group 2	5.32	2.73	1.18	0.32	0.15
Group 3	8.59	4.32	1.53	0.54	0.19
Group 4	12.59	5.44	1.81	0.66	0.35
Group 5	14.85	7.54	2.93	1.30	0.64
Attributes:					
Group 1	1.00	0.80	0.50	0.03	0.00
Group 2	0.84	0.65	0.43	0.23	0.10
Group 3	0.95	0.65	0.50	0.33	0.33
Group 4	1.00	0.98	0.93	0.86	0.77

An analysis of variance shows that a significant association (at the .01 level) exists between the groups of functions and the five orders of city. It may be assumed therefore that there are significant variations in the functional bases of the five orders of city, and that these variations are not the result of chance. The hierarchy determined by the centrality index score method may therefore be accepted as reasonable.

The identification of an eight-tier hierarchy by numerical labels is abstract, and it appears desirable to develop a graded nomenclature whereby the orders of cities may be qualitatively described.

Terms such as village, hamlet and sub-town as used in Britain, or village, small city, county seat, regional city and regional metropolis have not formed a part of customary usage in South Africa. Local terms are confined to such labels as metropolitan area, city and town in English, or to metropolitaanse gebied, stad, dorp and dorpie in Afrikaans. These terms provide the basis for the derivation of a nomenclature to describe the graded levels of cities in the South African urban hierarchy. It is suggested that the following terminology describing a gradation in degree of complexity be used for the South African city system :

Order 1. Principal Metropolitan Area (the Witwatersrand conurbation)

Order 2. Major Metropolitan Area (Cape Town, Durban and Pretoria).

Order 3. Metropolitan Area (Port Elizabeth, Bloemfontein, Pietermaritzburg, East London, Kimberley, Orange Free State Goldfields, Vereeniging and Klerksdorp).

Order 4. Major Country Town.

Order 5. Country Town.

Order 6. Minor Country Town.

Order 7. Local Service Centre.

Order 8. Low-order Service Centre.

The distribution of cities by hierarchical order is listed in Table 68 (in Appendix A) where a comparison between the hierarchy and an index hierarchy may be made.

THE CHARACTERISTICS OF THE SOUTH AFRICAN URBAN HIERARCHY

Structure

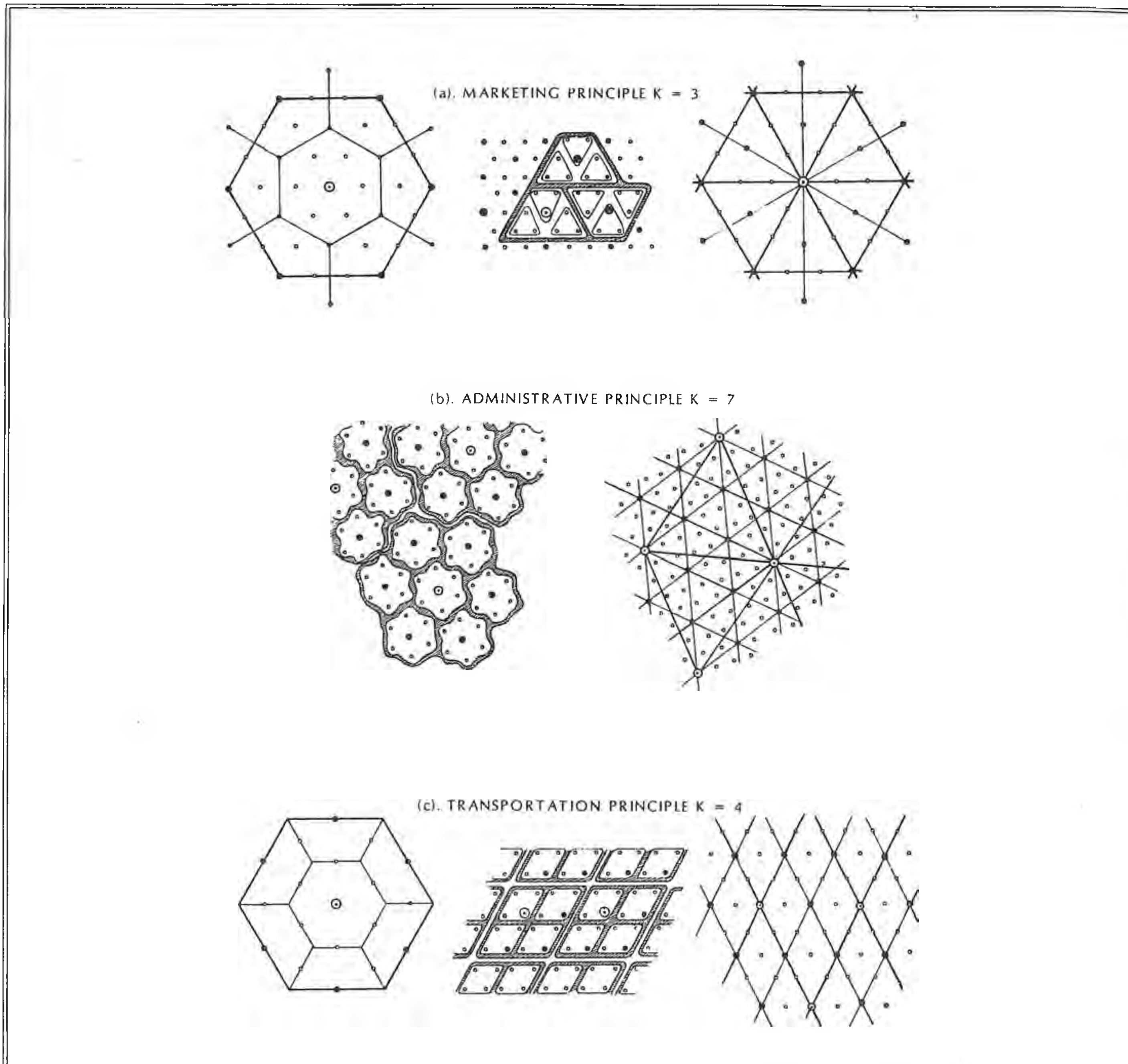
Christaller (1933) distinguished three principles upon which the number, size and spatial organisation of cities within a hierarchy depend. These are :

1. The market or supply principle,
2. The transport principle,
3. The administrative principle.

The theoretical organisation of the hierarchy by the three principles is illustrated in figure 29.

In the market principle a system of cities evolves to provide the maximum range of central services through the smallest or most economic number of cities. Cities tend to arrange themselves in a lattice where k (the number of settlements served by each central place) = 3. This is to say, where the number of central places in each successively lower order of the hierarchy increases threefold.

The transport principle lattice provides that the maximum number of higher-order cities are located on major transportation routes. The lattice has a $k = 4$ value where the number of cities in each successively lower order increases fourfold.



29. THE SYSTEM OF CENTRAL PLACES AFTER THE MARKETING PRINCIPLES

The administrative principle demands demarcation of individual hinterlands within which higher-order places have full administrative control over all lower-order centres within their sphere of influence. Cities will arrange themselves in a lattice where $k = 7$, and where each higher-order place has administrative control over 6 lower-order cities.

Table 43 demonstrates the structure of the South African urban hierarchy in comparison with the theoretical models postulated by Christaller. The hierarchy compares closely with the $k = 3$ model in terms of the number of cities by order of place. Bearing in mind that urban hierarchies are subject to imperfections in reality the degree of correspondence in the number of places from Order 1 to Order 5 is striking. Only in orders 7 and 8 combined is the number of places smaller than expected from the model.

TABLE 43

COMPARISON OF THE SOUTH AFRICAN URBAN HIERARCHY WITH THE CHRISTALLER THEORETICAL MODEL

Order	South Africa H_1	South Africa H_2	$k = 3$	$k = 4$	Index Hierarchy
1	1	1	1	1	1
2	3	3	2	3	3
3	8	8	6	12	8
4	19	19	18	48	17
5	57	57	54	192	61
6	65	173	162	768	178
7 & 8	448	340	486	3072	333
Total =	601	601			601

H_1 = Hierarchy based on higher break in centrality between Order 6 and 7.

H_2 = Hierarchy based on lower break in centrality between Order 6 and 7.

The Index Hierarchy is briefly discussed in Appendix A.

As previously noted, Order 6 cities in the hierarchy may be distinguished by the use of one of two statistically-significant breaks in the centrality index values. If the lower break is selected it isolates Order 6 cities at a level where their number corresponds closely to the expected value of 162 on the Christaller $k = 3$ model. The upper break on the other hand, while reducing the number of Order 6 cities to well below the expected level, yields 200 places in Order 7. If, as has been suggested, Orders 7 and 8 (253 cities) are combined, a total of 448 places is obtained. This number is close to the value of 486 places predicted by the $k = 3$ model for Order 7.

These observations suggest that either the South African hierarchy possesses an abnormally low number of Order 6 places (Minor Towns) and a number approaching the expected level of lower-order service centres, or a near-expected number of Minor Towns and an under-representation of lower-order service centres (Order 7 and 8). Whatever level is used to distinguish Order 7 and 8 cities from Order 6 places, the number of cities in these categories is lower than predicted by the $k = 3$ model. Furthermore, if Order 7 and 8 are considered as a single group, the South African hierarchy lacks the bottom tier of the $k = 3$ model.

With its less-intensive settlement and rural development pattern, South Africa has never produced or required the dense network of villages and hamlets which have characterised Europe. A pattern of fewer and more widely-spaced cities is more common, and the relatively small number of low-order places is not unexpected in reality.

The degree of correspondence in terms of the number of cities between the hierarchy and the $k = 3$ model is consistent with findings obtained by Scott (1963) in Tasmania, Skinner (1964) in China and Gunerwardena (1964) in Ceylon. Abiodun (1967) suggests that the Ijebu (Nigeria) hierarchy is $k = 3$ in structure over the first 3 orders of cities. The explanation appears to lie in the economy of central places which the $k = 3$ (marketing principle) hierarchy provides. It is interesting to note also that the $k = 3$ structure appears, from the evidence, to exist under varying economic situations and not only under agrarian conditions. On the other hand South Africa's industrial economy is of very recent date, and the existing national hierarchy may simply represent an inherited situation dating from the period prior to 1933 when the economy was essentially based on primary activity. The growth of new industrial cities may in the future change the hierarchical structure in detail.

In general, however, it may be stated that South Africa possesses a reasonably balanced service hierarchy of cities at the national level numerically most nearly approaching a system where the marketing principle has played a dominant role. In reality, however, it is unlikely that the influence of transport and administration among other factors has been entirely negative. The arrangement is more likely to be a compromise between the forces underlying the basic principles but with the marketing principle playing the major role. The spatial distribution of the hierarchy is illustrated in Figure 30.

The Structure of the Urban Hierarchy by Regional City Sub-Systems

Table 44 illustrates the distribution of the national hierarchy within the regional city sub-systems identified by the analysis of networks. Not unexpectedly there is considerable variation from sub-system to sub-system in response to historical patterns of settlement, restraints imposed by regional economic development patterns, the unequal distribution of physical resources, and of transportation and communications networks.

Table 44 - see Page 176.

The city sub-systems of Johannesburg, Cape Town and Durban are the largest, and each contain more than 100 cities. Pretoria has the smallest city sub-system with only 24 cities, and reflects the sparsity of settlements in the fringe zones in the north-western, northern and north-eastern Transvaal.

In general the city sub-systems have an hierarchical pyramidal structure of cities grouped by order. The Pretoria and Bloemfontein sub-systems, however, are hierarchically poorly evolved and rest upon a narrow base of lower-order centres. In each sub-system the 'regional' primate role of the metropolitan cities is strongly evident, and in the Cape Town, Bloemfontein, Kimberley, East London, Johannesburg and Pretoria sub-systems the metropolitan cities are separated by a void in order from the next lower order of cities.

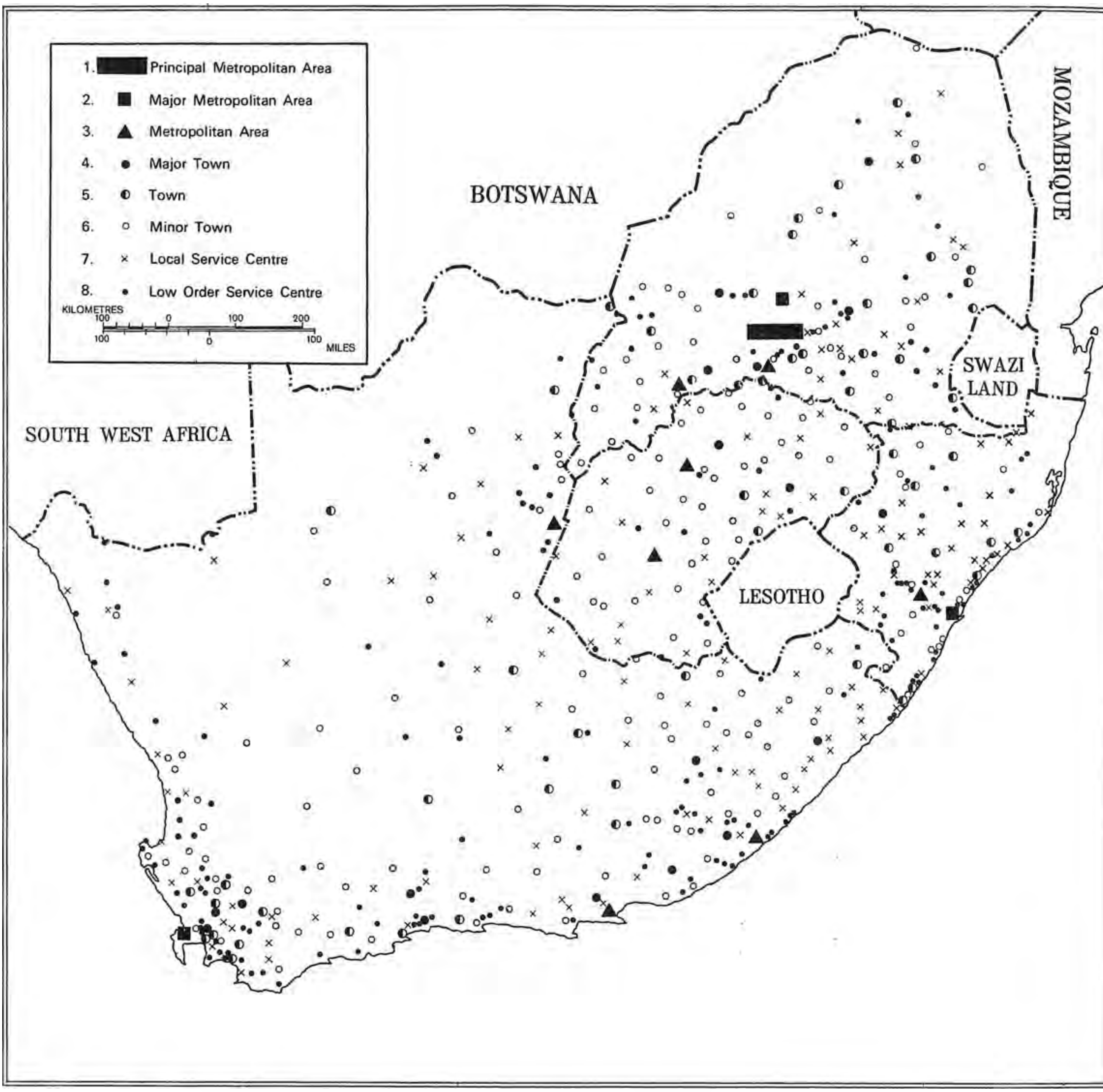
The structure of the sub-system hierarchies is in each case imperfect when compared to theoretical models. Nevertheless, there is a tendency for the sub-systems of Johannesburg, Port Elizabeth, Durban, Kimberley, East London and Bloemfontein to resemble a $k = 3$ model at least in the first two or three orders if these sub-systems are independently ranked. The Cape Town sub-system on the other hand more closely resembles a $k = 4$ model.

The structure of the Principle Sub-System with 361 out of the total of 601 cities in the set, is not unexpectedly similar to that of the national city system but has greater perfection in terms of a $k = 3$ distribution in its first three orders. The sub-system provides a favourable hierarchical structure which underpins the organisational framework of the economy in the northern two-thirds of the country. The dynamics which underlie the structure of the regional sub-system hierarchies are obviously highly complex, and detailed research is required to explain the differences in structure. It is clear, however, that the variation in the proportion of cities in each order

TABLE 44

URBAN SERVICE HIERARCHY BY REGIONAL CITY SUB-SYSTEMS 1966

Order	Cape Town	Port Elizabeth	East London	Johannes-burg	Pretoria	Durban	Bloem-fontein	Kimberley	Principal Sub-System	Total	$k = 3$
1	-	-	-	1	-	-	-	-	1	1	1
2	1	-	-	-	1	1	-	-	2	3	2
3	-	1	1	3	-	1	1	1	6	8	6
4	5	2	3	7	1	1	-	-	9	19	18
5	12	4	-	20	6	11	2	2	41	57	54
6	33	14	21	46	6	20	20	13	105	173	162
7 & 8	79	24	40	62	10	80	17	28	197	340	486
Total	130	45	65	139	24	114	40	44	361	601	



30 SPATIAL DISTRIBUTION OF THE SOUTH AFRICAN URBAN HIERARCHY 1966

may reflect significant differences in levels of economic development and opportunity. The distribution of the available levels of the national hierarchy within the regional sub-systems clearly also has important implications in the identification of the national space economy. This is more particularly the case in the distribution of centres of Order 5 or higher which are the key points of growth in the economy and have important influences over the rate and level of economic development in the areas in which they occur.

City Size.

While the numerical structure of the South African hierarchy most nearly approaches the $k = 3$ model the hierarchy does not compare with that model in terms of the mean size of cities by order (Table 45). This is particularly true of Orders 1, 2 and 3 in which the South African cities are considerably larger than the value suggested by the $k = 3$ model. In Orders 4, 5, 6 and 7 and 8 on the other hand a reasonable, though not exact, correspondence may be observed. It should be noted, however, that the mean size of cities in the lower orders of the South African hierarchy (combining Orders 7 and 8) in general increases by a factor approaching three between orders, which tends to support the assumption of a $k = 3$ structure.

TABLE 45

COMPARISON OF THE SIZE OF SOUTH AFRICAN CITIES WITH THE $k = 3$ HIERARCHY

	Mean Population		
Order	South Africa (1)	(2)	$k = 3$
1	2,180,914	2,180,914	1,000,000
2	637,097	637,097	300,000
3	131,488	131,488	100,000
4	30,896	30,896	30,000
5	11,884	11,884	9,000
6	3,864	6,023	3,500
7 & 8	1,135	2,117	1,500

(1) Hierarchy based on lower break in rank order of centrality index between Orders 6 and 7.

(2) Hierarchy based on upper break in rank order of centrality index between Orders 6 and 7.

Higher population values for South Africa are at least partly explained by the use of the total population of cities in the calculations. A marked disparity exists in the purchasing power between White and Black groups of the population which may significantly affect the service structure of the country's cities. Populations weighted by levels of disposable income would possibly yield more satisfactory results. [1)]

THE FUNCTIONAL BASIS OF THE SOUTH AFRICAN HIERARCHY

It has been previously shown that the orders of cities identified in the South African hierarchy are functionally distinct in terms of selected groups of functions. It is appropriate, however, to examine the functional structure of the hierarchy in greater detail and to compare the functional structure with those determined for other countries. The differences in the basic data and variations in the nature of services provided, however, make close comparisons with other countries difficult. It should be noted, furthermore, that the analysis cannot proceed beyond the level of Order 4 cities (Major Country Towns) since the detailed extraction of the service structure of the hierarchy has not been extended to the metropolitan cities. The discussion will refer in particular to Tables 42, 45 and 46.

Low-Order Service Centres (Order 8).

In South Africa Order 8 cities have mean populations of approximately 1,000 persons, possess from 4 to 30 functional units, and provide an average of 15 different functions.

A post office (with money order facilities) and a police station are basic attributes, while road motor services are also normally available in these cities. Characteristically, these functions are ranked in the lowest grouping of r_{pb} values. The possession of a magistrate in Order 8 cities of the Transkei is perhaps indicative in particular of their role as administrative centres in that territory.

[1)] Median incomes for the economically-active population 1960 were: Whites R1,550; Asiatics R427; Coloureds R209 and probably lower values for Africans for whom data are not available. (Bureau of Statistics, Population Census 1960, Personal Income, Vol. 5, 1967.) The use of weighted populations may also reduce the apparent disparity in the relationships between centrality indices and population evident in Figure 30.

TABLE 46

MEAN NUMBER OF FUNCTIONAL UNITS BY ORDER OF ENTRY IN THE SOUTH AFRICAN URBAN HIERARCHY

	FUNCTIONS	Order 4	Order 5	Order 6a	Order 6b	Order 7	Order 8
(a)	Attributes						
	Post Office	1	1	1	1	1	1
	Money Order Office	1	1	1	1	1	1
	Road Motor Trans.	1	1	1	1	1	1
	S.A. Police	1	1	1	1	1	1
	Railway	1	1	1	1	*	*
	Magistrate	1	1	1	1	1	*
	Roads Department	1	1	*	*		
	Library	1	1	*			
	Bantu Admin.	1	1	*			
	District Surgeon	1	*				
	Newspaper	1	*				
(b)	Variates						
	General Dealer	43	19	11	9	6	4
	Motor Garage	15	9	5	3	2	2
	Other Services	43	18	7	3	1	1
	Tea Room	14	7	5	2	2	1
	Butcher	11	5	3	2	2	1
	Primary Educ.(W)	5	3	1	1	1	*
	Licensed Hotel	6	4	2	1	1	*
	Bank Agency	1	0	0	0	0	*
	Church	13	7	3	2	1	*
	Doctor	14	4	3	2	1	*
	Clinic	3	2	1	0	0	*
	Other Admin.	16	7	3	1	2	
	Speciality Shop	46	18	8	3	1	
	Bldg.Society Agency	27	5	4	2	1	
	Insurance Office	17	8	4	2	1	
	Other Provision Shop	14	6	2	1	1	
	Lawyer/Solicitor	8	3	2	2	1	
	Mission Church	5	3	2	1	1	
	Bank Branch	5	3	2	2	1	
	Building/Cartage Contractor	8	3	1	1	*	
	Hardware Shop	14	7	2	1		
	Engineering	7	5	2	1		
	Estate Agent	6	3	2	1		
	Bottle Store	5	3	1	1		
	Primary Educ.(B)	3	2	1	1		
	Baker	2	1	1	1		
	Secondary Educ.(W)	5	3	1	1		
	Boarding House	3	3	1	*		
	Produce Buyer	3	2	1			
	Electrician/Plumber	8	4	1			
	Other Professional	8	3	1			
	Dentist	4	2	1			
	Dairy	3	2	1			
	Secondary Educ.(B)	4	1	*			
	Other Financial	3	2	*			
	Accountant/Auditor	5	2				
	Wholesaler	3	1				
	Cinema	2	1				
	Department Store	1					
	Bldg.Society Branch	1					
	Medical Specialist	1					
	Higher Education (W)	1					

NOTE: A single establishment of the functional type occurring in half the urban places of an order is indicated by an asterisk

Representatives of the lower groups of variates and, in particular general dealers' stores, motor garages, a tea-room and a butcher are common services in the order. Some cities may possess also a primary school for Whites, a licensed hotel, a bank agency, church and a resident doctor.

The services of Order 8 cities are ubiquitous in higher-order cities and comparison with findings elsewhere shows, that these cities are most closely comparable with villages in Tasmania (Scott 1963); Wisconsin (Brush, 1954); Iowa (Berry, 1967) and with third order central villages described by Bracey (1954) in Southern England. A general store, primary school, church and motor garage are common to these orders of cities.

Local Service Centres (Order 7).

The 140 Order 7 cities in South Africa have a mean population of approximately 1,500 persons each and have an average of 35 functional units spread over a mean of 21 functions. The cities have 4 of the 11 attributes (post office, money order office, police station and the facility of road motor services). A magistrate may be found in roughly half of the Order 7 cities.

Variate services are provided at greater depth and in greater variety than in Order 8 nodes, and include in particular the additional services of primary school (for Whites), hotel, doctor, speciality shop (frequently a chemist shop), and better financial institutions. Health services and educational facilities for Africans among higher-order services are as weakly developed as they are in Order 8 cities.

The significance of Order 7 cities in the African Reserves of the country is of particular note, more particularly as administrative and as educational centres. On the other hand financial facilities and specialist shopping services are less well represented than elsewhere in the country.

Minor Country Towns (Order 6).

Order 6 cities in South Africa number 173 places and may, on centrality index scores, be sub-divided into 2 sub-divisions : orders 6a and 6b. The cities of the Order as a whole have an average population of approximately 3,900 persons. For the Order as a whole also the nodes on average possess 76 functional units spread over 33 types of service.

Orders 6a and 6b tend to present a similar range of services, but these are provided in greater depth at the order 6a level. Six attribute functions are represented, and the nodes have railway facilities and a magistrate in addition to the attributes of lower-order cities. In more progressive Order 6a cities, library facilities may also be encountered.

Significant increments of services to the range of variate functions include secondary education (for Whites), primary education (for Blacks) and a bakery. Nodes at the Order 6a level include in addition, dental services, and dairies among other services.

The depth to which services are provided in Order 6 is important. While many higher-order services may be represented by a single unit, the presence of these services is particularly significant in those parts of the country such as the sparsely-populated areas of the western Cape interior, the north-eastern Cape, the Transkei, north-western Cape and southern Orange Free State, where cities of Order 6 are frequently called upon to perform higher-order services in the absence of higher-order cities.

Some comparisons may be made with the Towns recognised by Brush (1954) in south-western Wisconsin, though not all South African Minor Towns provide the same variety of retail establishments. Order 6 nodes may also be regarded as transitional between Minor Towns and Towns as defined by Scott (1964) for Tasmania.

While Order 6 nodes in the Transkei tend to follow the pattern of South Africa as a whole, the depth to which services are provided is generally shallower. Furthermore, some services common to the South African nodes are absent including hardware shops, estate agents, building and cartage contractors, bottle stores, produce buyers and boarding houses. At Order 6b also primary and secondary schools for Whites occur in fewer than half the nodes of the Transkei. These findings appear to indicate the significant differences in levels of economic development between the White-occupied areas of the country and those occupied by the African reserves.

Country Towns (Order 5).

Order 5 cities (Towns) in South Africa provide almost the full range of functions (an average of 45 services) and have a mean population of approximately 12,000 persons. A far larger variety of establishments, the number ranging from 126 to 300, provide goods and services for large tributary areas. The importance of Order 5 cities is reflected, in particular, by the existence of wholesale establishments in the majority of these centres. Their relative importance in comparison with Order 6 places is associated also with the provision of professional services. Order 5 cities have a wider range of each of the general professional and more specialized services, e.g. architects, and surveyors. Cinemas with daily programmes are also typical of this order of city.

Certain Order 5 cities provide all the attribute functions, though approximately half do not have a district surgeon, nor do they publish a newspaper. Specialized retail and service functions reflect the regional importance of Order 5 cities, for they have an average of 18 'other' services, 18 speciality shops (including women's clothing and furniture), 7 hardware and 6 'other' provision stores.

Inspection of listed functions in Towns in the United States of America as recognised by Berry, Barnam and Tennant (1962) and for major towns in Tasmania (Scott, 1964) indicates a high degree of similarity in type of function provided. There is, however, a greater degree of specialization present in the two Tasmanian major towns described by Scott.

The role of Order 5 cities in the less-densely populated parts of the country is similar to that described for Order 6 centres.

Major Country Towns (Order 4).

Order 4 cities in South Africa have a mean population of about 31,000 persons. The 19 Major Towns are clearly differentiated from lower orders of city by the presence of four important variate functions. These are higher educational facilities for Whites, a departmental store, a branch of one of the building societies, and on occasion at least one medical specialist.

All other services are present in Order 4 cities and are represented at greater depth than in either Order 5 or Order 6 cities. Shopping facilities and personal services provided are also more highly specialized. Between 300 and 600 establishments were recorded for Order 4 cities with a mean of 396 units.

Most Order 4 cities have all the attribute functions, and on average, 51 out of the 55 possible services recorded were present. It is interesting to note that bank agencies re-appear in the high-order places. Agencies are supplementary to a bank branch and in Order 4 cities serve to spread banking facilities over the larger urban areas associated with the order. Order 4 cities also provide all functions listed by Berry, Barnum and Tennant (1962) as typical of a City.

While the determination of the urban hierarchy has involved the use of a multivariate technique, the powerful analytical tool provided by Principal Components Analysis adds a further dimension to the study of the city system. Thus a Principal Components Analysis of the system is taken up in the chapter which follows.

THE SPATIAL IDENTITY OF THE URBAN HIERARCHY.

Marshall (1969), in a penetrating study of central place methodology, has questioned the relevance of urban hierarchies determined by examination of functional complexity alone. Because of the inherent relationship between functional complexity and the orderly placement of an hierarchy in space demanded by the theoretical hierarchical models, he has called for hierarchical determinations to be validated through tests of their spatial expression. Thus far in the present study the statistical procedures for the determination of an urban service hierarchy have been completed, but spatial tests remain to be undertaken.

In examining the space pattern of a hierarchy, Marshall has noted that 'rigid adherence to the precision of models is inappropriate in evaluating a real world system' (page 91). Thus, given the complexities of the real world, an orderly placement of categories of cities should not be taken to imply absolute geometrical precision in the distribution of actual cities. Rather, one should look for an expression in which one or other of the spatial arrangements inherent in the theoretical models can be recognised. By relaxing the rigidity of spatial arrangement in the models, the lattice within which a city system will be distributed, will of necessity be stretched or distorted with extra cities in some interstices and with cities missing from others. Thus in the same sense that it is possible to recognise an imperfect hierarchy in terms of the numerical pyramid of cities, so also an imperfect spatial expression of a hierarchy may be accepted.

The analysis which follows will take two steps. The first is an attempt to establish the degree of regularity in placement of cities which may be expected in the system, and the second will concern an examination of the form of the lattice within which the South African hierarchy is distributed, in an effort to seek confirmation of the hierarchy determined by statistical examination of centrality index values. It should be pointed out, however, that analyses of the spatial patterns of cities in the South African hierarchy are still in a preliminary stage and much research is still required before a final statement on the geometrical structure of the hierarchy can be made. The spatial distribution of the urban hierarchy is illustrated in Fig.30.

Preliminary results of analyses to establish the degree of spatial regularity in the city system examined at the level of Order 6a cities shows the distribution for the country as a whole to be near random. Employing nearest neighbour statistic techniques a value of .95 is derived in a scale which ranges from 0(indicating maximum agglomeration) through 1 (representing a random distribution) to 2.15 (representing a perfectly regular distribution.) It is unrealistic, however, to assume that the cities in South Africa are completely randomly distributed over the country. It is more probable that a balance of the forces of localisation within the system exists, and that variations in the spacing of cities is more closely related to the potentialities of the environment and resource base in the support of varying densities of urban places.

Carrying out a nearest neighbour analysis test in an area where distortion in the intensity of the mesh of cities is minimised by relatively uniform resource base and environment shows that distributions which possess a significantly regular component may be observed. The test was conducted for part of the eastern plateau area of South Africa and was based upon the distribution of 120 cities irrespective of hierarchical rank. The test yielded a nearest neighbour statistic of 1.56 for the area indicating a regular component in the distribution. This finding has been confirmed by the application of tests postulated by Dacey(1964) and by Medvedkov (1967), the results of which are summarized below. [1]

The Medvedkov (1967) test gave a regular-to-random ratio of 13:7 suggesting that of the 120 cities in the test area 78 were distributed in a random, and 42 in a regular, pattern. In other words, 35 percent of the distribution may be described as regular. The Medvedkov test is very rigorous in that it requires a perfect geometrical pattern to describe a distribution as regular. The ratio probably represents the minimum degree of regularity that may be expected to exist in the study area.

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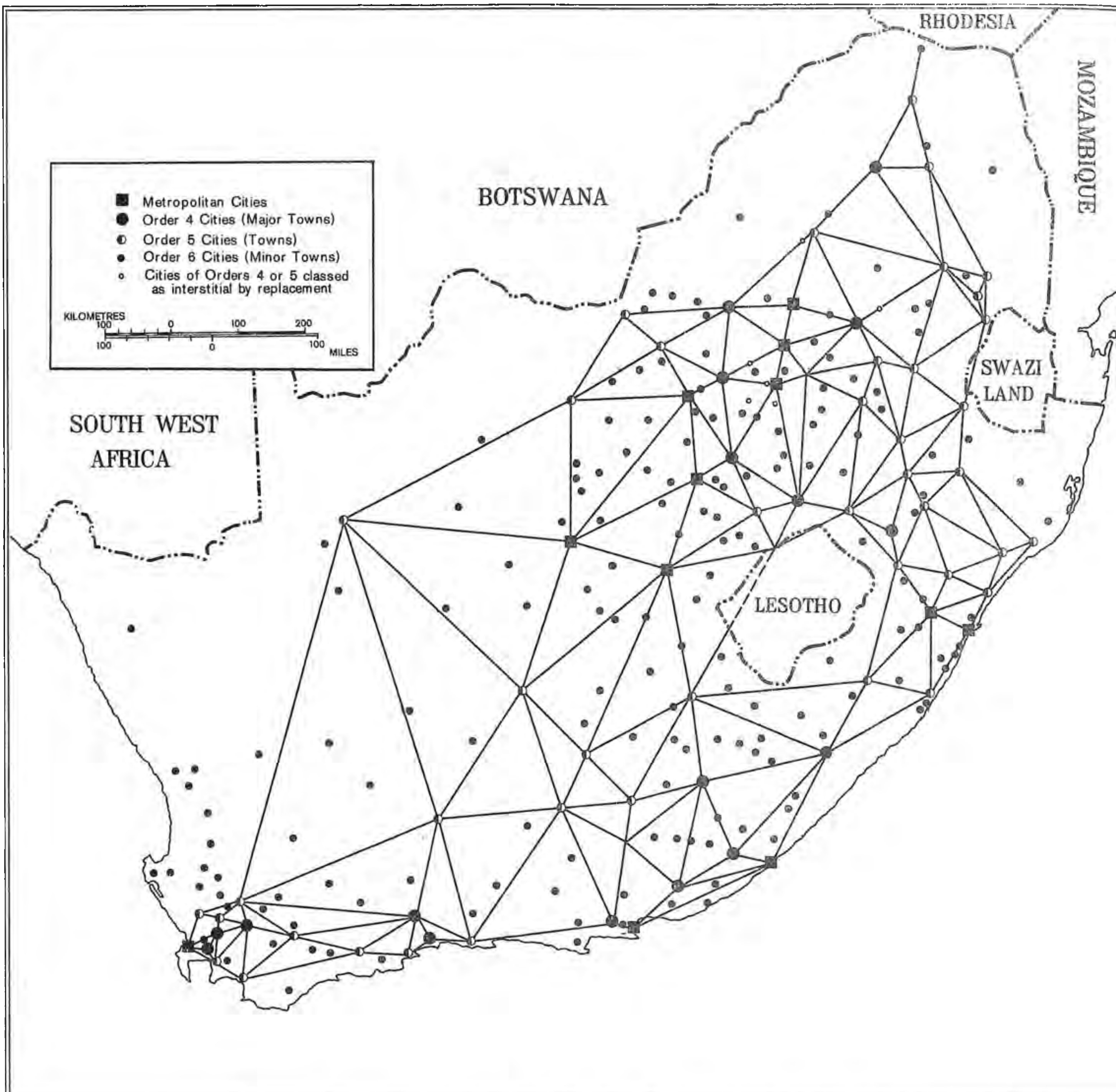
[1] The test area was defined by co-ordinates: 27 degrees south, 24 degrees east; 27 degrees south, 30 degrees east; 32 degrees south, 24 degrees east; 32 degrees south, 30 degrees east.Those parts of the territories of Lesotho and the Transkei which fell within the rectangle defined were excluded from the analysis.

In the Dacey (1964) test the estimator $\hat{p}$ gives an indication of the degree of regularity in the distribution. In the test area $\hat{p}$ has a value of .668 which represents a pattern in which 67 per cent of the distribution may be described as regular. The value may be considered to represent the maximum degree of regularity that may be expected to occur in the study area.

If it is assumed that the results from the two tests represent extreme possibilities, then it may be suggested that between 35 per cent and 67 per cent of the cities in the test area are distributed in a regular pattern. While similar tests have not as yet been extended to other parts of the country a significant level of regularity in the distribution of South African cities may reasonably be expected despite the lack of an isotropic surface.

The Nearest Neighbour, Dacey and Medvedkov tests indicate only the degree to which a distribution of cities can be described as being regular or random. They give no indication of the actual geometrical pattern of the distribution, and it is to this problem, which is in effect a further test of the existence of the hierarchy, that we now turn.

Marshall (1969) has developed a method whereby the spatial expression of the hierarchy may be tested. While the method is essentially subjective, it provides a reasonably rapid procedure upon which judgement may be exercised. The method involves the simultaneous application of two criteria - that of discrete stratification of centrality on the one hand, and of interstitial placement of orders of cities, on the other. Marshall observes that 'The second of these criteria is unique in that it cannot be translated into objective numerical terms in empirical work; it can be expressed only as a requirement that the spatial patterns of central places must "strongly resemble" one or other of the theoretical models'. (page 130). The mechanics of the procedure involves the plotting of cities, starting with the highest ranking city on centrality index, one by one on a map, seeking evidence of spatial distribution reminiscent of the theoretical placement of cities in the models. On the other hand a check is constantly kept on the rank centrality index value which may suggest breaks in functional complexity in the city system. The result of the experiment applied to the South African city system is presented in Figure 31 in which the basic lattice of the central place system is illustrated. The ideal theoretical placement of cities suggested by the Christaller models, on the other hand, has previously been demonstrated in Figure 29.



31. THE BASIC LATTICE OF THE SOUTH AFRICAN URBAN HIERARCHY

The South African city system in terms of groupings of centrality index values has been shown to be a relatively balanced hierarchy which most closely corresponds to the numerical pyramid of the Christaller $k = 3$ (the marketing principle) model; evidence of the spatial expression of a $k = 3$ distribution will therefore be sought in the analysis which follows.

In the South African city system the Witwatersrand may immediately be set off as the Principal Metropolitan Area. It is followed in complexity by the cities of Cape Town, Durban and Pretoria. These four cities together form a macro-triangle within which Johannesburg is an asymmetrical focus and the apices are represented by Pretoria, Durban and Cape Town. This is a triangle which has previously been observed to be of major significance in the overall organisation of the city system.

The addition of the remaining metropolitan cities, which are themselves set off from the upper ranking metropolitan centres and from lower order cities by a strong break in centrality index, produces a set of relatively smaller triangles on the plateau surface about the Witwatersrand. Larger triangles are produced by rays to the coastal cities. Collectively the set of triangles provides the lattice within which cities of a metropolitan order are distributed. The distribution of metropolitan cities is not perfectly regular, and the lattice is understandably distorted.

Continuing down the list of rank centrality indices and commencing with the next highest ranking city (Paarl), a fourth order lattice of cities may be gradually built up by the placement of cities within the metropolitan lattice. The plot of the cities to a rank marking the lowest level of the fourth order cities intensifies the lattice, but the distribution of these cities is localised in the north-east of the country, in the western Cape, the eastern Cape and in the George-Oudtshoorn area. It is only within these areas, therefore, that evidence of an emerging recognisable sub-national lattice arrangement of the city system begins to emerge. The bulk of the country, however, remains unserved at this level, and it is necessary to continue with the plot through the Order 5 centrality indices.

Completion of the plot to the lowest level of Order 5 centrality indices, at which stage a marked break with statistical significance occurs, produces a basic lattice which is illustrated in Figure 31.[1]

The placement of cities to the lowest level of Order 5 centrality index values identifies a lattice of triangles of varying size consistent with potentialities of the environment and the resource base, and reflecting the density of settlement within the country. Thus, in the north-east of the country surrounding the metropolitan cities of Johannesburg, Pretoria, Vereeniging, Klerksdorp, the Orange Free State Goldfields, Durban and Cape Town, the intensity of distribution of places is greatest. Elsewhere in the country the spacing of cities, placed within the lattice, is more considerable and the sides of triangles within the lattice are long.

While considerable distortion in shapes of triangles occurs, on the one hand, and a number of cities varies from the ideal postulated by the model, on the other, the distribution is strongly suggestive of a $k = 3$ expression.

Continuing further down the rank lists of centrality index values, the interstices in the lattice are progressively filled by centres of a lower order. It may be observed also that there is a distinctive tendency for interstitial cities to be located within the triangles of the lattice rather than along their sides, and that their distribution is reminiscent of the marketing principle arrangement.

While considerable further research will be required to examine the geometrical arrangement of cities in greater detail, it is believed that sufficient evidence exists from these preliminary tests to accept the hierarchy determined by formal statistical means as valid. It is interesting to note, however, that in obtaining the basic lattice of the city system, it has

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1) In the plotting of cities with centrality indices related to Order 4 cities previously determined, 8 cities have been specifically excluded because of their placement. These cities are Carletonville, Brits, Margate, Stilfontein, Parys, Sasolburg, Vanderbijlpark and Middleburg (Transvaal). With the exception of Middleburg these cities are all economically specialised and possibly of less significance as true central places. Their placement within the lattice consequently is suspect, and it has been considered advisable not to consider them as elements of the basic lattice. In addition, the closely spaced cities of Heidelberg (Transvaal) and Nigel have been grouped as a single unit in the distribution. The same grouping could, in fact, have been undertaken for Stilfontein and Klerksdorp, Vanderbijlpark with Vereeniging, and for that matter Port Elizabeth and Uitenhage.

been necessary to combine the levels of Order 4 and Order 5 cities (Major Towns and Towns). It would appear from the placement analysis that the two groups of cities are variants in degree rather than kind, and that they form the basic set of service centres in South Africa below the level of the metropolitan cities. The role of Order 5 cities, more particularly in the remote parts of the country, with widely-dispersed populations and purchasing power, is of particular importance.

CHAPTER 6

PRINCIPAL COMPONENTS ANALYSIS OF THE CITY SYSTEM

CHAPTER 6.

PRINCIPAL COMPONENTS ANALYSIS OF THE CITY SYSTEM

In previous chapters individual structural measures of the city system - size relationships, the economic base and the service hierarchy - were examined, largely independently of one another. It is now necessary to view the structure of the city system in a multivariate integrated framework. This is provided by the powerful tool of principal components analysis in which the structures and patterns produced by individual components may be integrated and collapsed into a small number of dimensions.

The application of principal components analysis requires the availability of critical variables that are scaler in nature. Apart from population totals by race and sex, however, no comprehensive demographic, social or economic data are available as measures of the structure of the population of South African cities, other than for 14 major urban areas for which special census reports have been published. In consequence multivariate analysis of the city system suffers from a basic data restraint.

The analysis presented here has selected data from the following chief sources:

1. The special tabulation of the industries of the population for a set of 318 cities which has previously been used in the analysis of the economic base of the city system.

2. The population of the cities by race and sex in 1960, (Republic of South Africa, Bureau of Statistics, 1963)

3. The official South African Municipal Year Book (1960-61) prepared by the United Municipal Executive of South Africa.

4. Extraction of data from secondary sources drawn from national telephone directories, Braby's Provincial Directories, other trade directories, and lists presented by government, provincial and local authorities.

Population data drawn from official census reports perhaps with the exception of African figures which are known to be under-enumerations, and data on the number of tertiary service units drawn from directories of various types, are reasonably complete for the whole set of cities in the system. All other data on the other hand is relatively poor in terms of the depth to which it can be traced in the city system. It is for this reason that it has been possible to assemble data for a principal components analysis for only 212 cities in the set. For the 212 cities it was possible to extract 13 variables. The analysis, therefore, is based upon approximately one-third of the total number of cities in South Africa, but it includes practically all the more important centres with the exception of Stilfontein (12,997), Sasolburg (11,890), Tongaat (9,051), Nylstroom (6,669) Riversdale (5,104), and White River (2,901). All minor urban places are excluded.

Due to lack of comparable data, furthermore, the principal components analysis is confined to levels of cities below metropolitan areas. A companion principal components analysis by magisterial district of volume of economic development and of economic welfare has shown, however, that districts containing the country's metropolitan areas emerge as the poles of economic volume and welfare. It may be assumed from these results that were the data available for the analysis of the entire city system, the metropolitan areas would emerge with very high component scores. (Board, Davies and Fair, 1970)

The 13 variables used in the principal components analysis may be grouped under heads which describe volume or size, service and economic structure, demographic characteristics and growth:

Volume and Service Structure

1. Total population 1960.
2. Percentage of the population employed in primary activities 1960.
3. Percentage of the population employed in manufacturing 1960.
4. Percentage of the population employed in professional and administrative services 1960.
5. Percentage of the population employed in other services 1960.
6. Percentage of the population employed in domestic service 1960.
7. Percentage of the population employed in transport 1960.
8. Total number of tertiary services 1966.
9. Units of electricity sold per head 1960.
10. Ratable value of land and buildings 1960.

Demography:

11. Sex ratio of the population 1960.
12. Percentage of the population which is White 1960.

Growth:

13. Percentage growth rate of the population 1951-1960.

Four vari-max rotated dimensions were extracted from the principal component analysis of the 13 variables for 212 cities. The four dimensions accounted for 66.23 per cent of the total variance. (Table 47).

TABLE 47

PRINCIPAL COMPONENTS ANALYSIS OF 212 SOUTH AFRICAN CITIES

Variable	Communality	Loadings on Components I	II	III	IV
1	95.55	0.95	-0.01	0.16	-0.14
2	86.83	0.08	-0.19	0.91	-0.08
3	65.47	0.30	0.36	-0.25	-0.61
4	55.22	0.10	0.70	0.11	0.20
5	63.69	-0.13	0.78	0.06	0.09
6	53.94	-0.18	0.21	-0.14	0.67
7	20.80	-0.03	0.18	-0.33	-0.26
8	94.21	0.94	0.22	-0.04	-0.09
9	68.36	0.34	0.65	-0.07	-0.38
10	93.19	0.94	0.09	0.09	-0.18
11	84.96	0.12	0.14	0.84	-0.33
12	36.10	0.21	0.54	-0.16	-0.05
13	42.57	0.09	-0.10	0.26	-0.58
Variance Accounted for (%)	Total (1-4) 66.23	23.19	16.42	14.37	12.25

Component I which accounted for 23.19 per cent of the variance, showed a high association with total population, total number of tertiary services and the ratable value of land and buildings in 1960. In each case the correlations of the variables with the component were above 0.9. Component I is, in essence, a component of volume or size.

Component II which accounted for 16.42 per cent of the total variance, showed a high association with employment in professional and administrative services, other services, the number of units of electricity sold per head and the percentage of the population which is White. These variables have moderately high component loadings which range from .54 to .78. Component II is essentially a volume of service component, and it is interesting to see that the percentage of the population which is White correlates highly within this component. It is normally accepted that Whites in South Africa are most strongly associated with white-collar occupations concentrated in the service categories of the economy.

Component III, correlates high levels of primary activity with the demographic variable of sex ratio of the population. These variables are naturally closely correlated. The component accounts for a further 14.37 per cent of the total variance, and the two variables load at levels between .84 and .91. This component may be defined as a primary activity dimension.

Component IV is a growth dimension in which population growth rate and proportion of the population employed in manufacturing correlate closely. The proportion of the population employed in domestic service loads moderately high in this component, while the number of units of electricity sold has a moderate component loading of .38. Component IV accounts for 12.25 per cent of the total variance, and may be named an industrial-growth dimension.

The analysis was completed by assigning a score on each component to each of the 212 cities in the set. The component scores permit the results of the analysis to be examined spatially. The scores are standardized to zero mean and unit variance.

A rank distribution of component scores on Component I largely confirms the relationship between Population size and Service hierarchical rank of a city previously noted. The inter-correlation matrix provided by the first step in the principal components analysis, for example, showed that the value of r between population and number of service units was equal to .91.

A high ranking group of cities distinguished by a level $\bar{x}$ + 1 σ contains 16 of the Order 4 cities (Major Towns) out of the total of 19 Order 4 cities identified in the service hierarchy. The cities excluded by Component I scores below $\bar{x}$ + 1 σ are Ladysmith, Umtata and Kingwilliam's Town, which were among the lower ranking Order 4 cities in the service hierarchy distributions. Cities included in the high ranking group by Component I scores, are Upington, Strand and Nigel which are among the highest-ranking Order 5 cities on the service hierarchy. Upington is a city in a peripheral location frequently called upon to perform higher-order service, Strand is an important resort centre, and Nigel is peripheral to the Witwatersrand and possesses a relatively high population.

Thirty-nine cities have Component I scores between $\bar{x}$ and + 1 σ. Of these, 33 are Order 5 cities, 3 are Order 4 cities and 3 cities have Order 6a level. The 3 Order 4 cities have previously been noted and the order 6a cities include Orkney, a mining town with a relatively high population, Hermanus, a resort city, and Ladybrand, serving an extensive regional area in the Eastern Orange Free State.

The number of places in Order 5 defined by the urban service hierarchy was 57, and thus there are 21 cities in that order which have negative scores on Component I, and consequently lack size or volume. (It should be remembered, however, that 5 of these cities were not included in the analysis for lack of data). While the 16 remaining cities lack volume on Component I they generally rank high in score on Component II, the service component. Thus while these cities do not measure up in relation to size they do in relation to the service component.

With the exception of three Order 6a cities, all other Order 6 places included in the analysis have low volume on Component I.

The distribution of scores in Component II largely confirms the findings made in the economic base classification of the city system. Thus of the 24 cities with component scores greater than $\bar{x} + 1\sigma$ 17 cities are basically service centres in which the dominant function has been previously listed as services.

A summary assessment of volume on Components I and II may be obtained by plotting the orthogonal component scores graphically. This procedure identifies 4 major groupings of cities:

1. Cities with high volume on Component 1 (+ 1.3σ) (+ 1.3σ to 4.0σ) and moderate volume on Component II (0 to + 1.0σ).

2. Cities with moderate volume on Components I and II (0 to + 1.5σ).

3. Cities with moderate volume on either Component I or Component II (0 to + 1.0σ), but with low volume on one component (0 to - 1.0σ).

4. Cities without volume on either component (0 to - 1.0σ).

The relationship between the four volume groupings thus identified and the urban service hierarchy levels between Order 4 and Order 6b is illustrated in Table 48. Relatively few cities of high ranking service order also possess high volumes on both Components I and II, but most Major Towns (Order 4) have high volume on Component I and moderate volume on Component II. The majority of cities of Minor Town status (Order 6) have low volumes on both components. Cities in the intermediate order of Towns (Order 5) tend to have volume on one but not both components. The findings emphasize the significance of Major Towns and Towns (Orders 4 and 5) as foci of economic development and service, and as the organising centres at levels below the metropolitan areas within the city system.

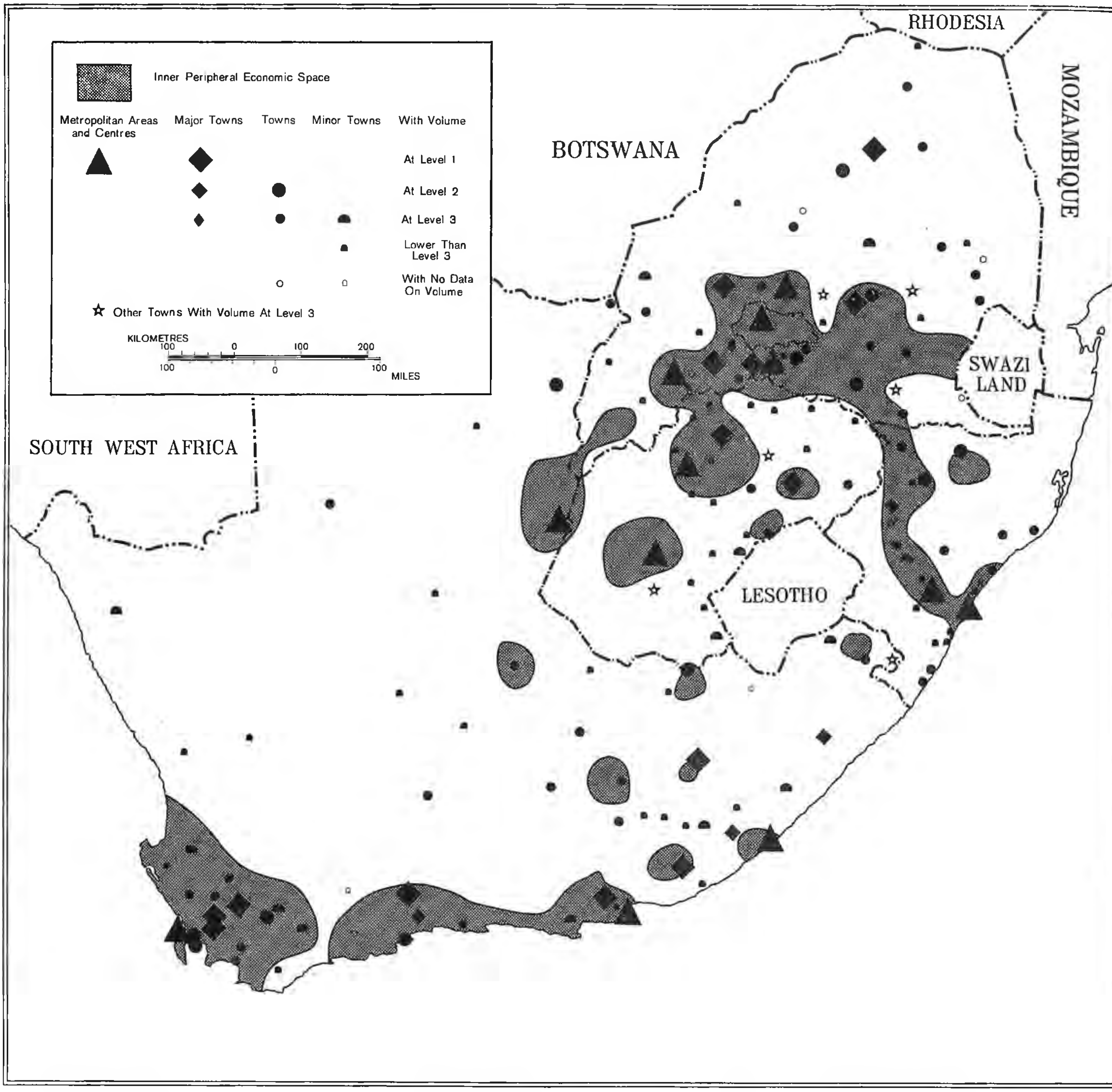
TABLE 48

RELATIONSHIP BETWEEN SERVICE HIERARCHY AND VOLUME OF ECONOMIC ACTIVITY

Order Title	Volume groupings.				
	1	2	3	4	Total
4 Major towns	14	5	0	0	19
5 Towns	0	12	38	0	50
6a Minor towns (upper tier)	0	0	18	39	57
6b Minor towns (lower tier)	0	0	1	83	84
Total	14	17	57	122	210*

* Two places, Klerksdorp and Vereeniging, have been classified as metropolitan centres.

The spatial pattern of the results of the groupings of Component I on Component II scores is illustrated in Fig.32. A discussion of the implications of the patterns, however, is deferred to the conclusion of the report.



32. URBAN HIERARCHY AND VOLUME OF ECONOMIC ACTIVITY RELATED TO SOCIO ECONOMIC SURFACES

C H A P T E R 7

GROWTH WITHIN THE CITY SYSTEM

CHAPTER 7.

GROWTH WITHIN THE CITY SYSTEM

Growth, expressed in terms of population change, is one of several indices which measure the dynamics of change within a city system. In South Africa, indeed, with its dearth of trend series data for cities, it is the only quantitative parameter of change which is available for the entire city system. While population change, on its own, is a poor measure of economic health in cities it is a useful aid in the identification of development patterns. Despite the availability of comparative population data in historical time series, it is suprising to find, therefore, that few research projects have been undertaken in the study of the growth patterns of national systems of cities.

The determination of growth patterns of cities is a relatively simple matter. The isolation of the factors which influence growth pattern, however, is more difficult. In this chapter we will be concerned primarily with a brief analysis of urban population demographic potential and with the classification of characteristic city growth patterns in the South African city system. Preliminary correlative analyses between growth and a selected range of measurable variables will also be made. In addition the results from the principle components analysis, on Component IV, which included a growth variable will be referred to.

The four aspects of population growth in cities to be considered are:

(a) A general analysis of the demographic potential of urban population.

(b) An analysis of growth rate and growth rate patterns between 1921 and 1960.

(c) relative spatial change in the shape of urban population within the city sub-systems.

(d) changes in the distribution of population measured in terms of the relative size of gains or losses in population by city sub-systems compared to national rates of growth between 1904 and 1960.

THE DEMOGRAPHIC STRUCTURE OF THE URBAN POPULATION

The age-sex structure of a population summarises the demographic history of the population at any point in time, and forms a biological structure upon which functional organisation is built. Hawley (1950) and Thomlinson (1965) suggest that there is hardly a phase of social, economic and political life that escapes the influence of the age-sex structure of the population. Thus an analysis of the demographic structure of the urban population is important as a background against which the growth patterns within the city system may be viewed.

The analysis presented here concerns the age structure of all population groups on the one hand and a study of the age-sex structure of the White population group on the other. Age-sex analyses of other population groups must at this stage await later research. The analyses are designed primarily to display spatial patterns of the demographic variables and particular attention is paid to a measure of the demographic 'quality' of the population.

Age Structure of the Population

Sundbärg (1907) early in the Twentieth Century, observed certain empirical relationships between age structure and the rate of population growth. He identified three types of population:

(a) progressive, having a high proportion of children and a high rate of growth;

(b) stationary, having moderate proportions of children and aged persons with slow growth of stationary numbers;

(c) regressive, having a high proportion of aged persons and declining numbers.

Sundbärg established the following modal proportions of the various age groups in his three types of populations:

	Per cent of population		
	Under 15 years	15-49 years	50 years and over
Progressive	40	50	10
Stationary	26.5	50.5	23
Regressive	20	50	30

The progressive-regressive scale though addmitedly a crude measure, nevertheless provides a convenient means whereby the growth potential of a population may be estimated and it serves as a demographic summary of the population. The scale is difficult to apply in practice, unless ranges within the limits set by the modal proportions are used. Few populations conform satisfactorily to the modal limits.

Population age quality has in consequence been measured by a parameter based upon deviations in age from national means calculated for the Sundbärg age groups 0-14, 15-49 and over 50 years. The identity of a population is defined by a formula which describes the deviation in each age group measured against standard deviations. Whereas it is possible to level theoretical criticism against the use of the S.D., as a parameter the measure is statistically acceptable and degrees of variation may be compared in cases where both large percentages and small numbers are dealt with.

In the South African rural and urban populations sixteen deviation permutations may be identified and ranked from populations with trends toward youth to ageing populations with a lower growth potential. Youthful populations tend to have positive deviations in the 0-14 and 15-49 age groups, while ageing populations have positive deviations in the over 50 years age group. To avoid tedious analysis and descriptions of each population type 16 deviation formulae of the scale may be grouped into 9 categories. The scale is shown in Table 49.

TABLE 49

POPULATION PROGRESSIVE - REGRESSIVE SCALE
BY AGE DEVIATION FORMULAE

CATEGORY	DEVIATION BY AGE IN YEARS		
	0-14	15-49	+ 50
1.	+ 0	0 +	- -
2.	+ 0 0	0 + 0	0 0 -
3.	0	0	0
4.	+	-	0
5.	- -	+ +	0 -
6.	0	-	0
7.	-	0	0
8.	0 - 0 +	0 0 - -	+ + + +
9.	-	-	+

Note

0 Deviation is less than 1 S.D. away from the national mean.

\+ Deviation is positive and more than 1 S.D. away from the national mean.

\- Deviation is negative and more than 1 S.D. away from the national mean.

The national means for the rural and urban populations of South Africa for all population groups and for the White population by age groups are shown in Table 50.

TABLE 50

NATIONAL MEANS FOR THE RURAL AND URBAN POPULATION OF SOUTH AFRICA. ALL POPULATION GROUPS AND WHITE POPULATION BY AGE GROUPS 1960

POPULATION	ALL POPULATION GROUPS					
	AGE GROUPS: PER CENTS			AGE GROUPS: S.D.		
	0-14	15-49	+50	0-14	15-49	+.50
RURAL	45.95	42.02	12.03	3.11	4.14	1.57
URBAN	33.38	54.53	12.08	6.95	8.89	3.44
TOTAL	40.08	47.87	12.05			
	WHITE POPULATION					
RURAL	33.03	43.40	23.56	5.88	4.95	9.18
URBAN	32.21	49.29	18.50	4.74	5.76	6.76
TOTAL	32.34	48.31	19.33			

The total population of South Africa is essentially progressive measured on the Sundbärg scale while the White population is near stationary.

The national means reveal the essential differences between urban and rural populations and the influence which ethnic variations in the populations have upon age structure. Comparing the means with the values in the Sundbärg scale the rural population (all groups), is over represented in the 0-14 age group and is near progressive in the over 50 age group. Underrepresentation occurs, however, in the 15-49 group and gives an indication of the possible extent of rural urban migration of the younger working age group. In the rural White population on the other hand the 0-14 and over 50 age groups are within the stationary range and underrepresentation occurs in the 15-49 group.

The urban population (all groups), is over represented in the 15-49 age group and is within the stationary range in the 0-14 age group, but within the progressive range in the over 50 years group. The White urban population is transitional between a stationary and a progressive population on the Sundbärg scale.

The percentage distribution of magisterial districts on the population age structure scale is shown in Tables 51 and 52.

In the distribution of the rural population 43 percent of the districts fall within the mean range and contain 53 percent of the total population. Districts with populations tending towards youth (categories 1 and 2), represent 20 percent of the total and contain 18 percent of the rural population, while those with ageing populations represent 19 percent of the districts and contain 18 percent of the total rural population. Approximately 63 percent of the districts have rural populations in scale categories 1, 2 and 3 and contain 72 percent of the population.

The distribution of the White rural population follows a similar pattern. Only 9 percent of the districts (containing 9 percent of the population), however, tend towards youthful populations but 54 percent of the districts with 78 percent of the total White rural population falls within scale categories 1, 2 and 3. Districts with ageing populations (categories 7, 8 and 9), represent 28 percent of the total and contain 10 - 11 percent of the total rural White population.

The distribution of urban population (all Groups), shows a relatively low proportion of districts with youthful populations (scale categories 1 and 2). These districts represent 10 percent of the total and contain only 8 percent of the urban population. The effects of rural-urban migration and lower birth rates upon age structure, are probably the major reasons for the distribution. Of the total, 28 percent of the districts fall in scale categories 7, 8 and 9, and contain 12 percent of the total urban population. The majority of the urban population, however, falls within districts in scale categories 1, 2 and 3 - 43 percent of the districts but 71 percent of the population. Scale category 5 with strong positive deviations in the 15-49 age group is characteristic of 9 percent of the districts which hold 13 percent of the total urban population.

The White urban population is relatively strongly represented in scale categories 1 and 2 - 24 percent of the districts and 16 percent of the White urban population. The proportion of districts in scale categories 1, 2 and 3, is 48 percent containing 78 percent of the population. Category 5 has 19 percent of the districts but only 3 percent of the total White population. While the proportion of districts in categories 7, 8 and 9, is similar to the distribution of rural population (27 percent), 17 percent of the White urban population is found in these categories as against 11 percent in the rural population.

Spatial Distribution Patterns

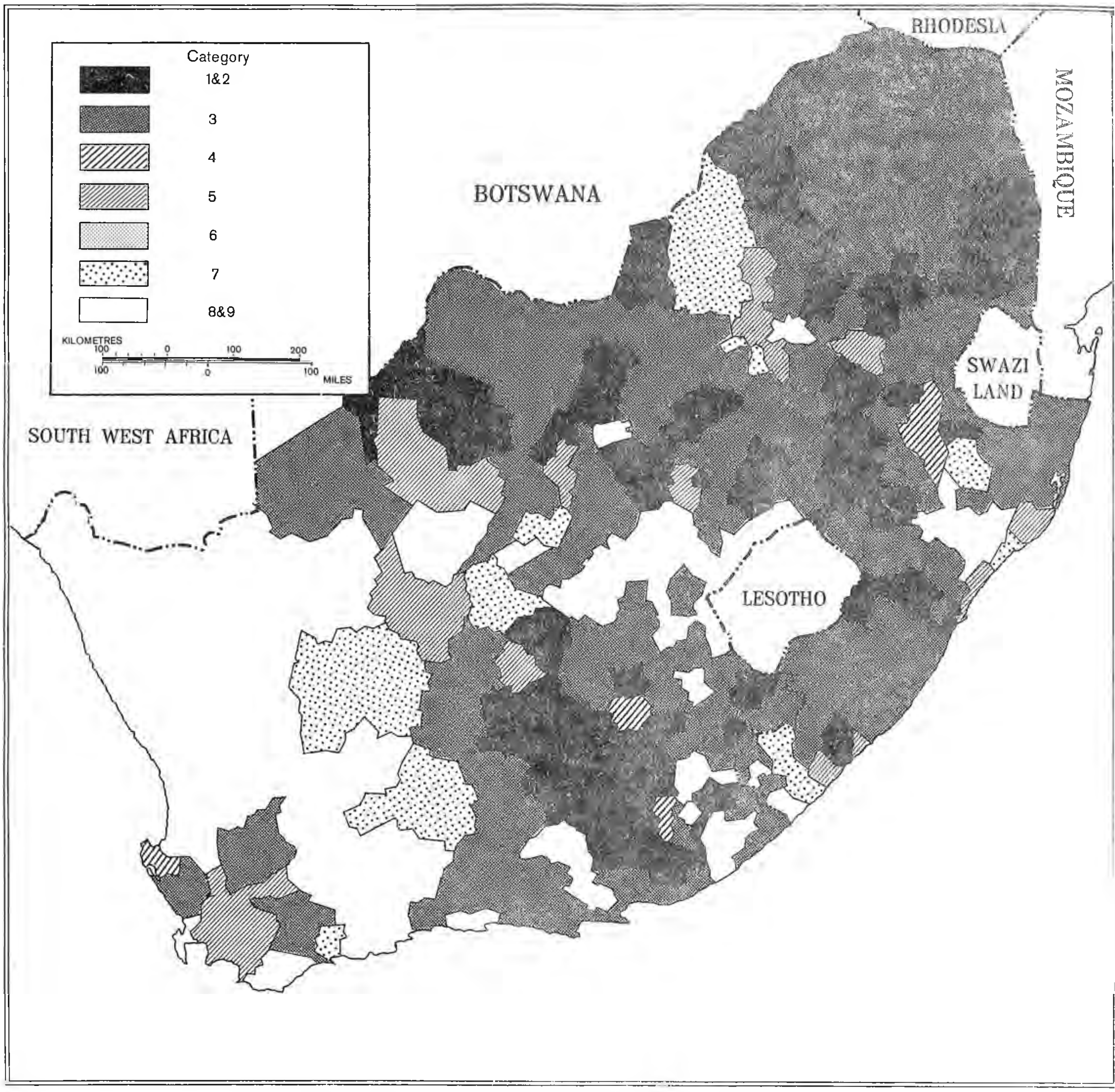
Figures 33, 34, 35 and 36, show the distribution of the rural and urban populations by magisterial districts classified on the age structure scale. In each case the distribution of scale categories is not random but is not necessarily easily explained. Age Structure is influenced by a wide range of factors which form complex interrelationships and are not easily unravelled. Explanations of distribution patterns must at this stage be tentative and subject to verification. There can be little doubt, however, that economic factors have played an important role in determining the spatial arrangement of demographic characteristics in the population.

The Rural Population

1. All Population Groups. Fig.33

The distribution of rural populations is strongly influenced by the distribution of the African population - the largest rural population group and the least urbanised. The eastern portion of the country, with high African populations has rural populations which fall in the mean range or in categories 1 and 2 tending towards youthful populations. The western part of South Africa on the other hand has rural populations, which are generally lacking in youth.

Category 8 populations occur most strongly in the W. Cape interior, S. Cape, S. and E. Orange Free State, the Border and Central Zululand. These areas have relatively low African populations, or have a low rural economic product and potential. Their rural employment potential is probably low, and the population has positive deviation in the +50 age group. The influence of special resource development areas on age structure is shown in the distribution of populations in category 5 with strong positive deviations in the 15-49 age group. The W. Cape, Orange River irrigation areas, Vaal-Hartz irrigation area, the surrounds of the Orange Free State gold fields, the districts surrounding the Witwatersrand and the Natal North Coast in particular are areas of this type. They have a relatively high rural economic product and are attractive to the younger working age groups. If all populations with positive deviations in the 15-49 age group are included the pattern is emphasized.



33. RURAL POPULATION ALL GROUPS BY AGE STRUCTURE SCALE

TABLE 51

PERCENTAGE DISTRIBUTION OF MAGISTERIAL DISTRICTS BY POPULATION AGE STRUCTURE SCALE. RURAL POPULATION ALL GROUPS AND WHITES ---------1960

ALL GROUPS

CATEGORY	NO. DISTRICTS	PER CENT	CUMULATED PERCENT	PERCENT OF TOTAL POPULATION	CUMULATED PERCENT
1.	4	1.50	1.50	2.86	2.86
2.	50	18.73	20.23	16.18	19.04
3.	114	42.70	62.93	53.25	72.29
4.	6	2.25	65.18	1.05	73.34
5.	30	11.24	76.42	8.40	81.74
6.	0	0.00	76.42	0.00	81.74
7.	13	4.87	81.29	6.04	82.78
8.	50	18.73	100.00	12.05	99.83
9.	0	0.00	100.00	0.00	100.00

WHITES

1.	6	2.27	2.27	0.63	0.63
2.	18	6.82	9.09	8.10	8.73
3.	119	45.08	54.17	69.41	78.14
4.	6	2.27	56.44	1.83	79.97
5.	31	11.74	68.18	3.38	83.35
6.	10	3.79	71.97	5.43	88.78
7.	41	15.53	87.50	6.10	94.88
8.	33	12.50	100.00	4.38	99.26
9.	0	0.00	100.00	0.00	100.00

TABLE 52.

PERCENTAGE DISTRIBUTION OF MAGISTERIAL DISTRICTS BY POPULATION AGE STRUCTURE SCALE. URBAN POPULATION ALL GROUPS AND WHITES ---------1960

ALL GROUPS

CATEGORY	NO. DISTRICTS	PER CENT	CUMULATED PERCENT	PERCENT OF TOTAL POPULATION	CUMULATED PERCENT
1.	3	1.14	1.14	0.41	0.41
2.	25	9.47	10.61	7.72	8.13
3.	85	32.20	42.81	62.42	70.55
4.	49	18.56	61.37	4.35	74.90
5.	24	9.09	70.46	13.40	88.30
6.	2	0.76	71.22	0.16	88.46
7.	2	0.76	71.98	0.03	88.49
8.	74	28.03	100.00	11.50	100.00
9.	0	0.00	100.00	0.00	100.00

WHITES

1.	23	8.71	8.71	7.61	7.61
2.	40	15.15	23.86	8.47	16.08
3.	64	24.24	48.10	61.92	78.00
4.	48	18.18	66.28	2.74	80.74
5.	2	0.76	67.04	0.54	81.28
6.	15	5.68	72.72	1.83	83.11
7.	5	1.89	74.61	7.82	90.93
8.	56	21.21	95.82	8.35	99.28
9.	11	4.17	100.00	0.71	100.00

The fact that rural populations in the Transkei fall mainly in the mean range is surprising as the area is subject to age selective emigration of African workers in the 15-49 age group. The characteristics of category 8 (+ - +), were expected. Conditions of that type occur for example in comparable areas in the African reserves of central Zululand.

Rural Whites: Fig.34

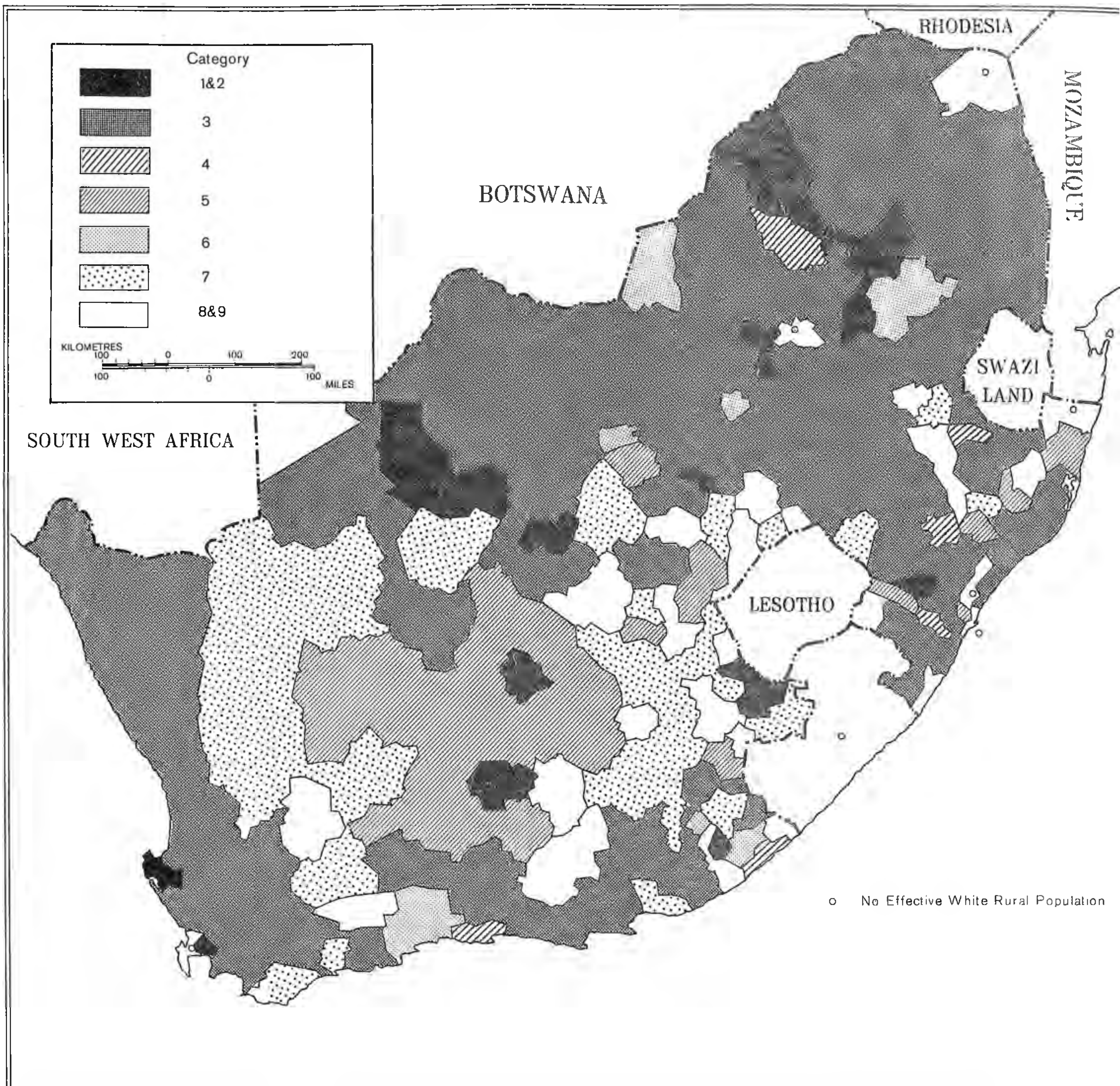
The high frequency of populations in category 3 (45 percent of the districts and 69 percent of the population), suggests at first sight that the greater part of the country possesses White rural populations with a satisfactory growth potential. The national means for rural Whites, however, are low in the age groups 0-14 and 15-49 years and many districts in category 3 may reflect populations in the stationary range of the Sundbärg scale. Only populations in categories 1 and 2 with 9 percent of the population may be regarded as progressive.

The distribution of populations in categories 1, 2 and 3, however, demonstrates that the growth potential of the White rural population is highest in the Transvaal, N. Cape, Natal and in areas peripheral to the coastal cities of the Cape Province. The pattern is probably related to a greater potential for rural economic development in these areas and points to the emergence of rural demographic imbalance in the remaining parts of the country as a result of economic backwardness.

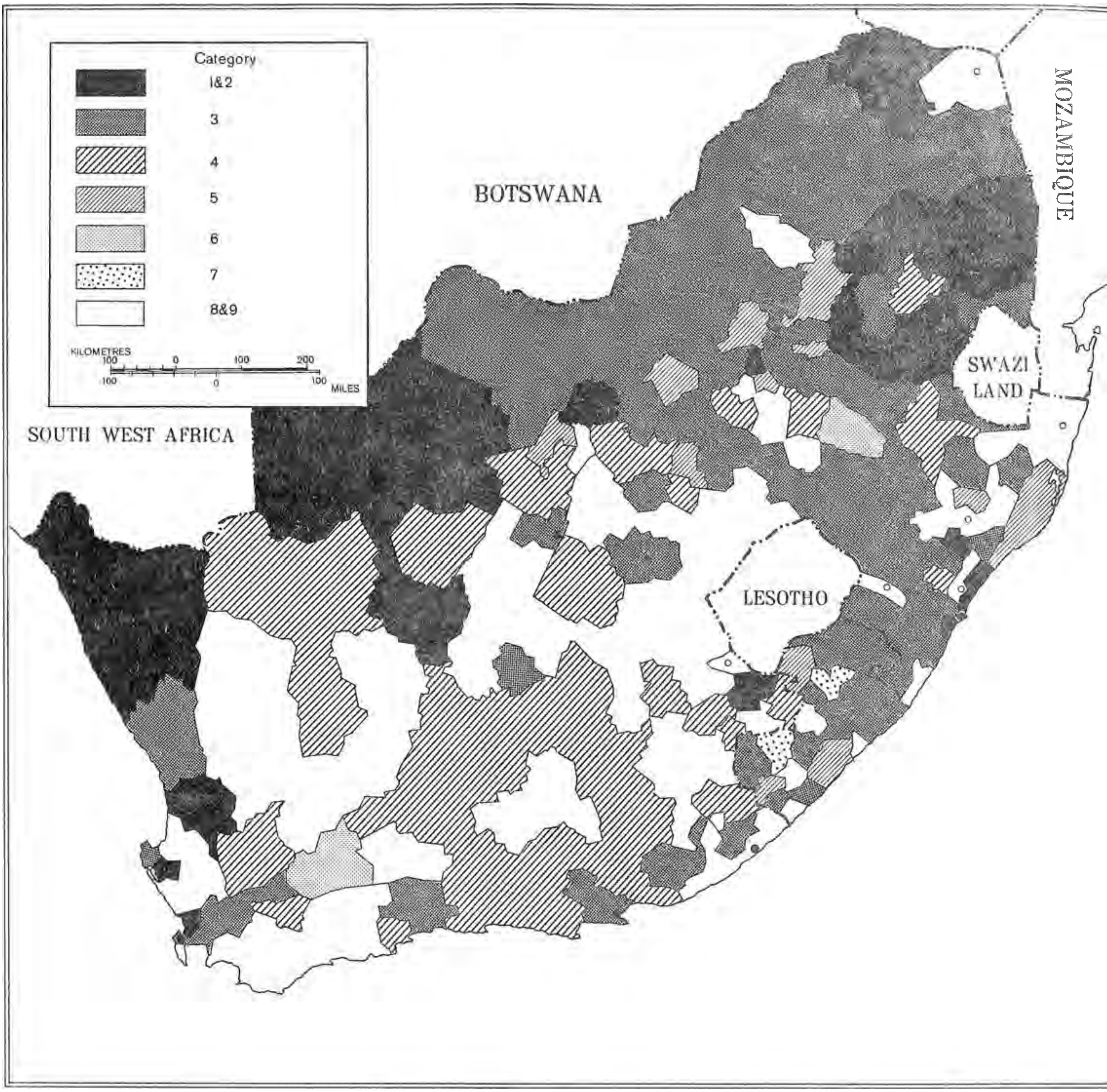
Apart from the Central Karoo with category 5 populations, the interior of the Cape Province, Border, S. Orange Free State, have populations in categories 7 or 8 reflecting regressive trends. The occurrence of strong positive deviations in the 15-49 age group in the Central Karoo is related to a high gross domestic product from agriculture (pastoralism), derived in the area.

Urban Population all groups: Fig.35

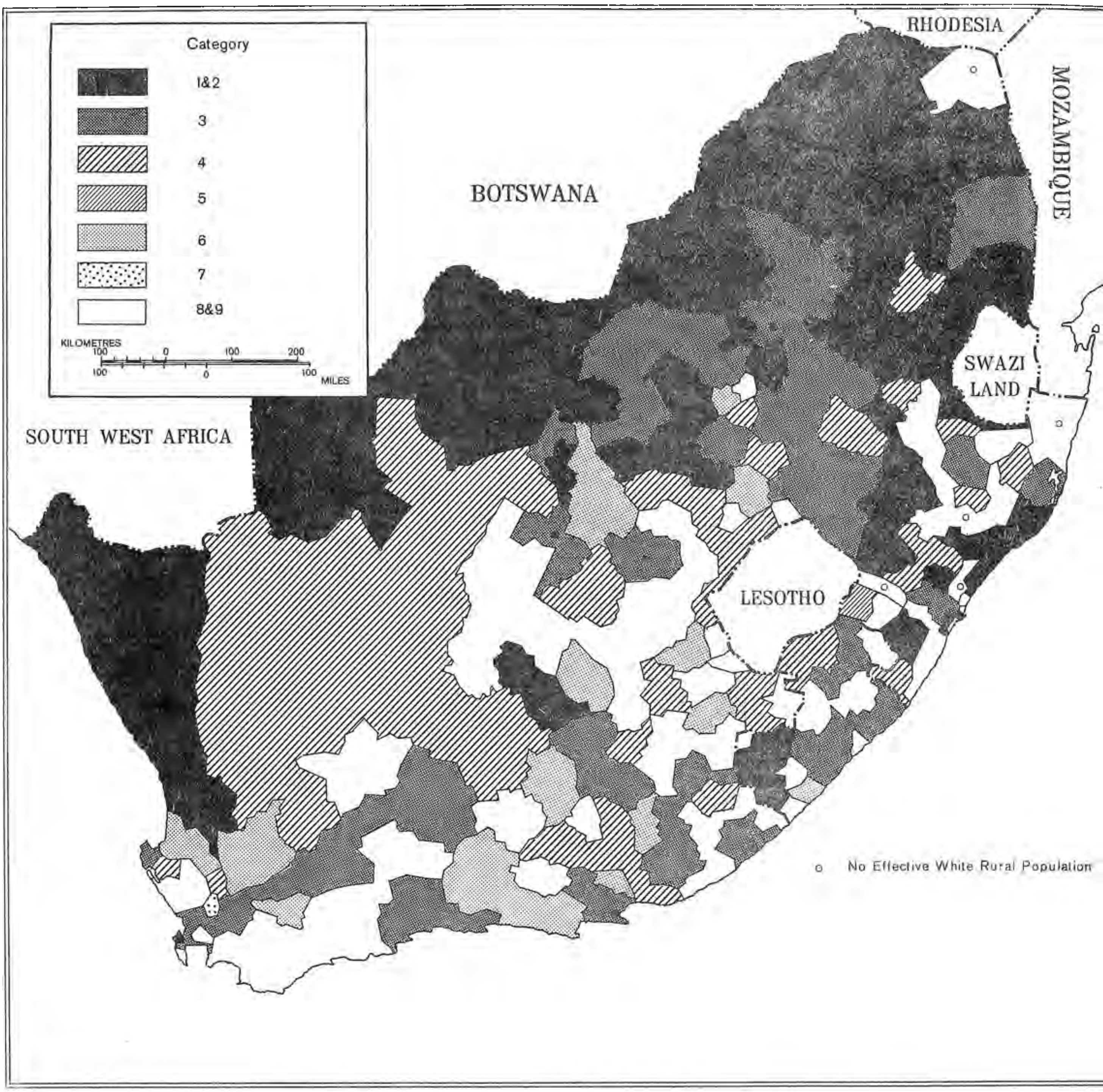
The distribution of urban population is markedly influenced by the distribution of urban economic potential. Populations in categories 1, 2 and 3, mainly progressive in trend, are contained in 43 percent of the districts which have 71 percent of the urban population. They are concentrated in the Transvaal, N. Orange Free State, N. Cape, Natal, and Coastal areas about the metropolitan cities of the Cape Province. These areas also contain populations in category 5 with positive deviations in the 15-49 year age group, centered upon the special resource areas previously listed.



34 RURAL WHITE POPULATION BY AGE STRUCTURE SCALE



35. URBAN POPULATION – ALL RACES BY AGE STRUCTURE



36. URBAN WHITE POPULATION BY AGE STRUCTURE SCALE

Populations in categories 4 and 8 which may either have a high proportion of the population in the 0-14 or the over 50 age group, and in many cases under-representation in the 15-49 age group, occur in the interior of the Cape Province, S. Cape, Border and the S. Orange Free State.

The distribution strongly suggests that demographic potential has been strongly influenced by migration and the evolution of the South African space economy. The industrial and mining regions of the S. Transvaal and N. Orange Free State, the mineral crescent in the N.W. of the country and the intermetropolitan link between the Port of Durban and the Witwatersrand have formed the basis for a progressive urban population. The widespread occurrence of populations in categories 1, 2 and 3, in these areas is associated with the outward growth of economic opportunity and resource development in the city sub-systems of Johannesburg Pretoria and Durban. The pattern is possibly also the basis for the distribution of the higher categories of rural White populations which in these regions is more highly integrated with the city system.

Figure 36 shows the Urban White population by age structure scale according to magisterial districts. Analysis of it is taken up below.

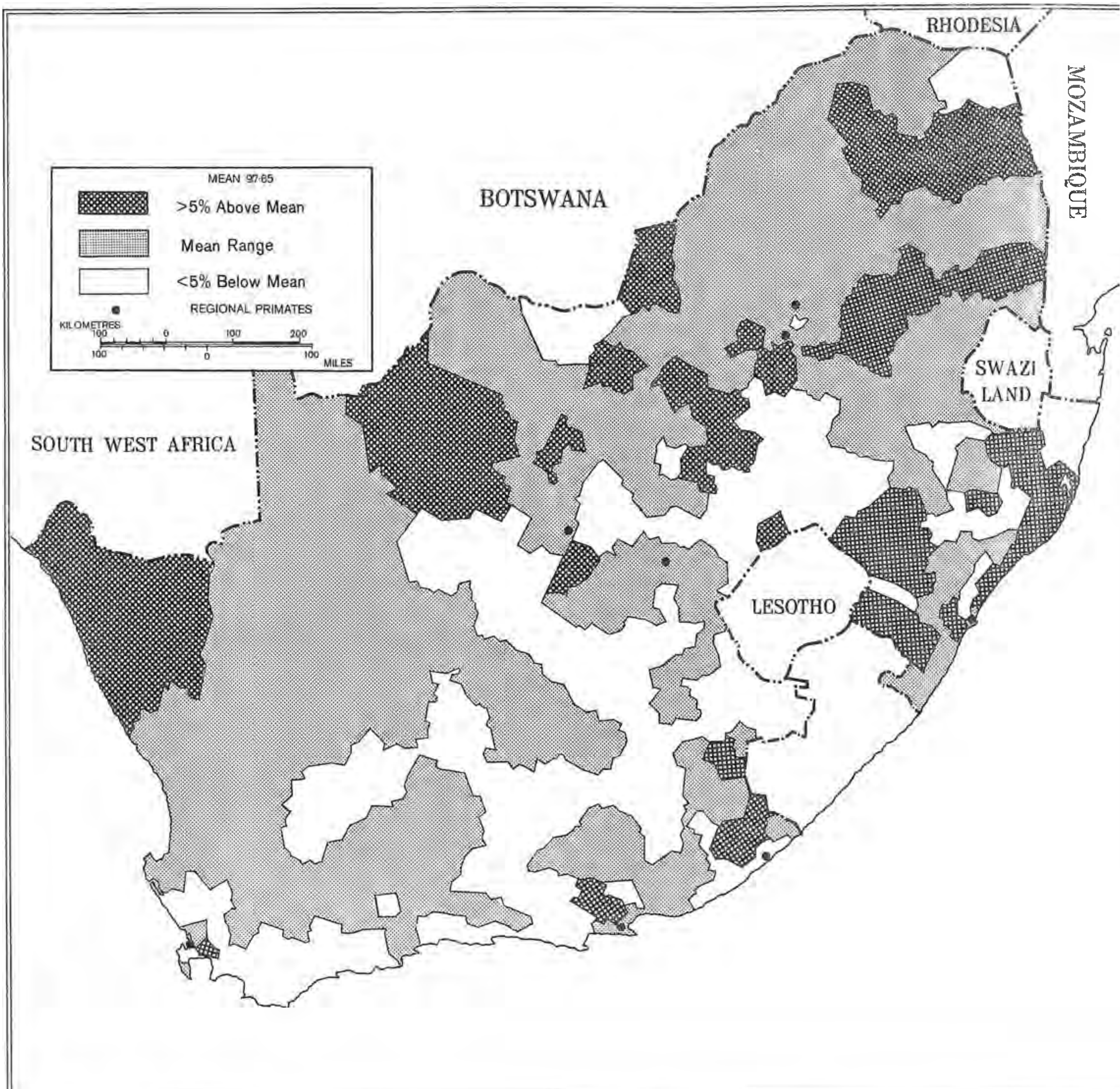
Analysis of the Age-Sex Structure of the White Urban Population.

The analysis will examine spatial differences in sex ratio, the distribution of the young working age groups (15 - 19 and 20 - 39 years), and a classification of the population on the progressive-regressive age structure scale suggested by Sundbärg (1907).

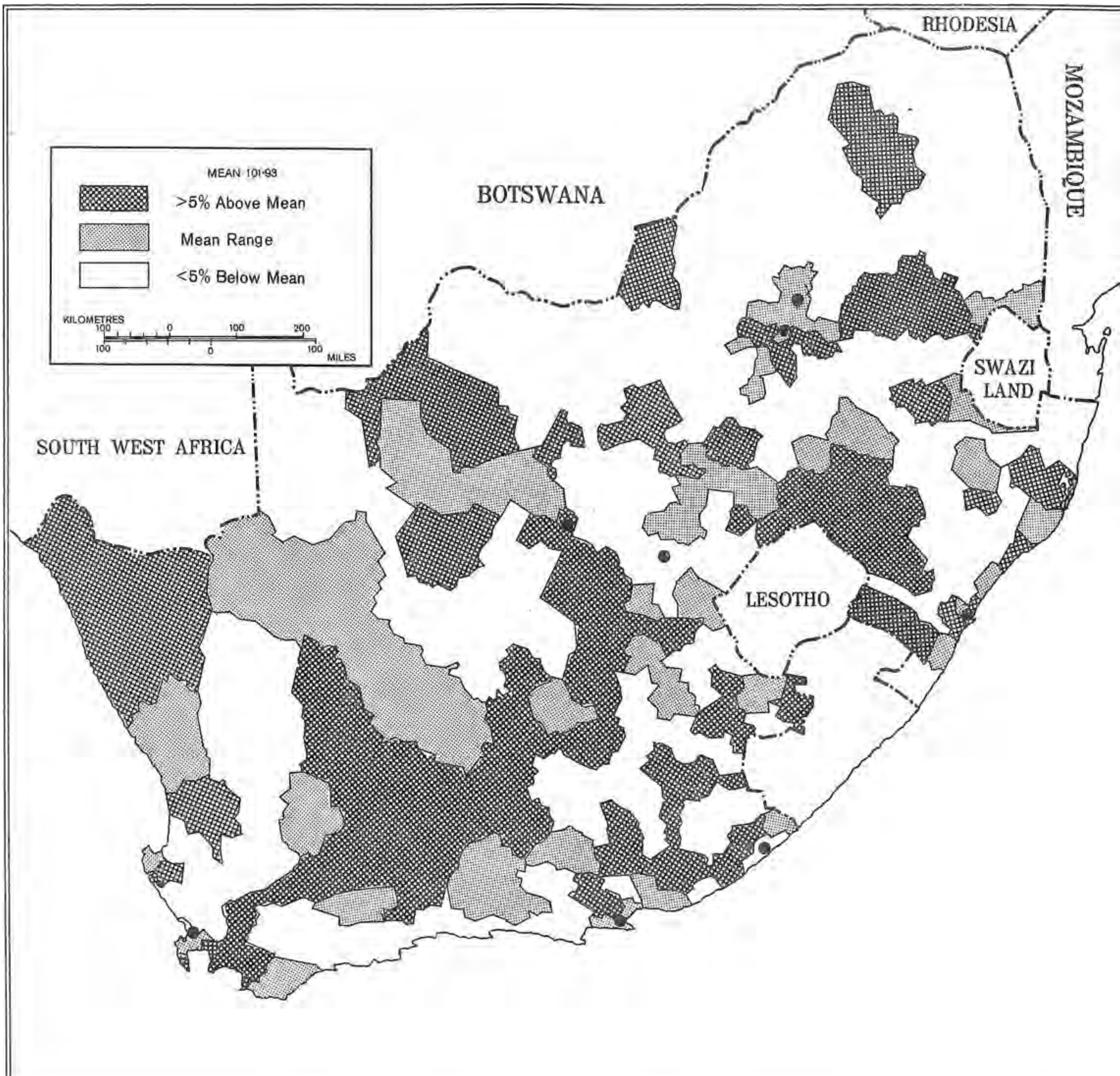
Sex ratio patterns.

The sex ratio of the White urban population of South Africa as a whole was 0.9765 in 1960. This may be expressed as a masculinity rate of 97.65. Considerable variation occurs from this mean value, area by area, ranging from 71 to more than 120 for all age groups, and varying over a wider range for individual age groups.

The analysis of the spatial distribution of the sex ratio is facilitated by the use of a three-tier scale using the mean, more than 5 per cent above, and less than 5 per cent below the mean, as class intervals for the data. The White urban sex ratio distribution for all age groups is shown in Figure 37. From the figure it will be seen that districts containing regional primate cities, have sex ratios at the mean level, or below it. This is expected.



37. SEX RATIO OF WHITE URBAN POPULATION ALL AGES 1960



38. SEX RATIO OF WHITE URBAN POPULATION 15–19 YEARS AGE GROUP 1960

The heavily urbanised mining districts on the outer rim of the Witwatersrand have high ratios. Thus a high sex ratio is apparent in the P-W-V complex.[1] This is also the case in the area occupied by the Durban, Kimberley and Cape Town city sub-systems. The pattern reflects areas of economic opportunity attractive to males. Industrialised districts close to the cities of Cape Town and Port Elizabeth also have high sex ratios.

Districts with low sex ratios occur in all nodal regions, but are particularly characteristic of the southern Cape sector of the Cape Town nodal region; in peripheral zones of the Port Elizabeth and East London and Bloemfontein regions; and in a sector covering the north-eastern Free State in the Johannesburg region.

The sex ratio distributions, while indicative of spatial demographic variations, produce an over-generalised picture, and require qualification by age groups.

The distributions of sex ratios in the young working age group of 15 - 19 years and 20 - 39 years, are of particular interest. The population in these age groups is probably the most mobile and most sensititve to economic forces. The sex ratio patterns are as a result strongly regional or zonal in distribution:

In the 15 - 19 age group, sex ratio distributions may be reduced to two or three spatial variants. From Figure 38 these are:-

(a) A pattern of roughly concentric zones, distorted by directional influences surrounding the cities of Cape Town, Port Elizabeth, East London and Bloemfontein.

The cities have mean or low sex ratios. In the nodal regions of these cities an outward gradation occurs through an inner zone of mean and high ratios, an intermediate zone of low sex ratios, and an outer zone of mean and high sex ratios. The distribution can only partially be explained by the occurrence of specific forms of economic activity in urban areas in the different zones, and is probably related to patterns of differential migration by sex within the age group.

---

1) Pretoria, Witwatersrand and Vereeniging city region.

The inner zones of high sex ratio may be subject to either an inflow of males to more intensively developed economies, and/or to an outflow of females to the neighbouring cities. It is difficult to account for the patterns of the intermediate and outer zones, except to suggest that females in the age groups appear to migrate over greater distances from the hinterland towards the cities. It is unlikely that intervening opportunities in the intermediate zone will attract a higher female population.

(b) A sectoral pattern of high sex ratios is characteristic of the Durban, Johannesburg, and Kimberley nodal regions. These sectors are flanked by sectors of low sex ratio. Levels of economic activity and opportunity appear to be the underlying influence, with an early migration of males from the less favoured sectors to urban places in the sectors of greater opportunity. The attractive sectors are the eastern Transvaal railway sector, the south-western Transvaal and Orange Free State goldfields sector, the Natal main-line railway, and North Coast sectors, and the railway sector linking Kimberley to the mining areas of the northern Cape.

While a relatively high proportion of the districts in all nodal regions have populations with a low sex ratio in the 15 - 19 age group, the Johannesburg and East London regions have more than 50 per cent of their districts in this category. Table 53 illustrates details of these observations. The distributions suggest a relatively high rate of migration of males to economically more attractive parts of the nodal regions.

Sex ratio distributions in the 20 - 39 year old age group differ from those in the 15 - 19 year old group, and possibly reveal relationships between demographic and economic variables more clearly. In this age group, sex ratios in the metropolitan cities are above average or within the mean range. The proportion of districts with above average sex ratios in the Johannesburg, Pretoria and Durban nodal regions is particularly striking, and suggests strong migratory movements of males towards urban areas in these nodal regions. See Table 54. The nodal regions of the coastal cities of the Cape Province and the Bloemfontein region have a higher proportion of districts with below average sex ratios, suggesting that the migration of males towards the north and east of the country has major origins in these nodal regions.

Within each of the nodal regions, the distribution of sex-ratio patterns is strongly sectoral, and is associated in particular with inter-metropolitan belts of communication and areas of economic opportunity. Figure 39 should be consulted.

The relatively high percentage of districts with high sex ratios in the Johannesburg - Pretoria and Durban nodal regions suggests a strong economic influence over demographic patterns, and is indicative of relatively low urban employment opportunities, particularly of young males, in the nodal regions of the Cape Province and southern Orange Free State.

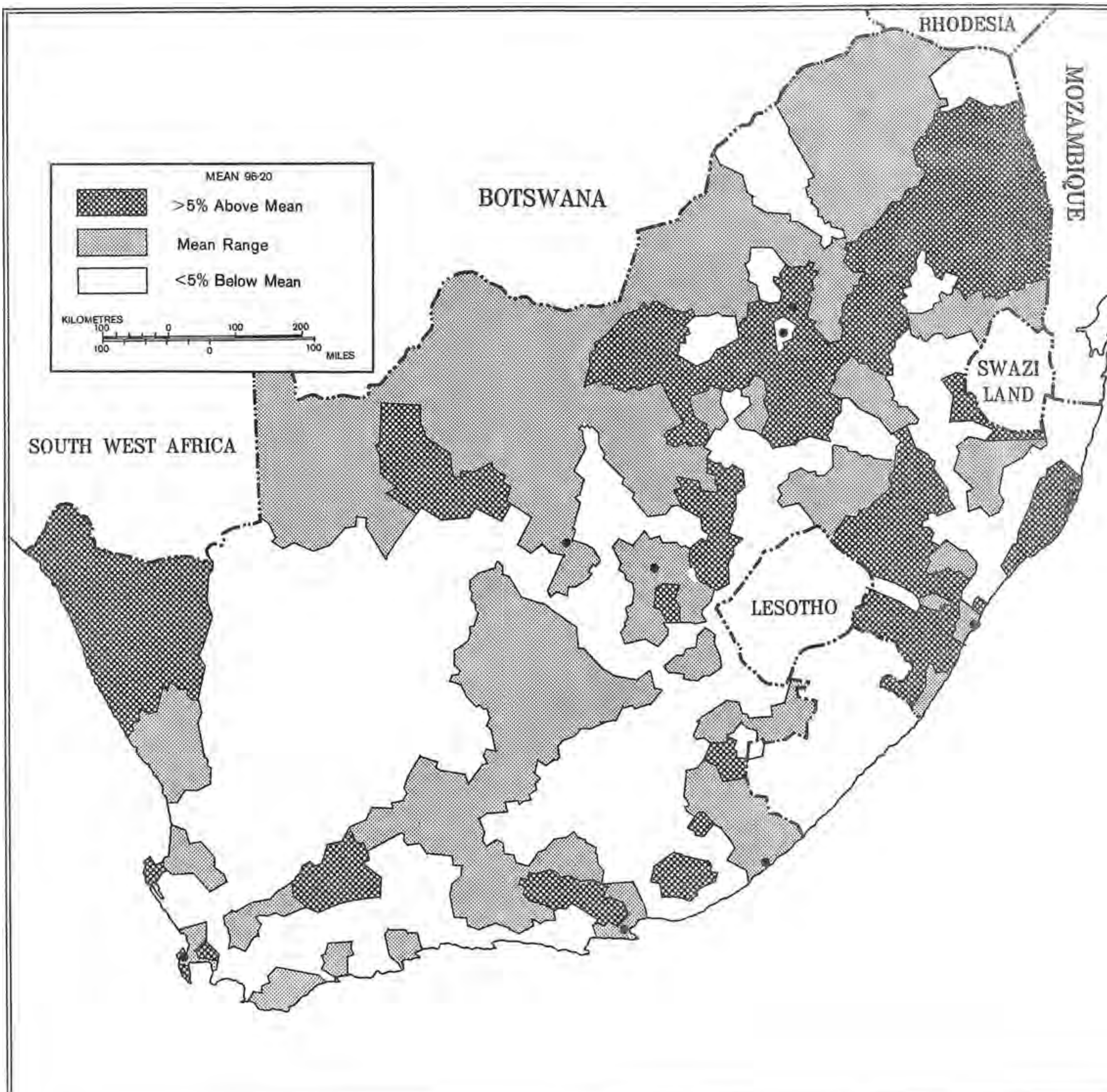
The differences in demographic structure between the nodal regions of the Cape and southern Orange Free State on the one hand, and the Johannesburg, Pretoria and Durban nodal regions on the other, is emphasised by the distribution of the White urban population aged 65 years and over. Figure 40 and Table 55 provide details. In the Johannnesburg - Pretoria and Durban nodal regions, 81 and 62 per cent respectively of the districts have below average proportion of the population above 65 years. Out of the remaining nodal regions, only Kimberley is remotely comparable to this position. These patterns are probably of considerable significance in assessing the need for development planning in the less favoured nodal regions, and in particular in the regions of East London and Bloemfontein.

TABLE 53

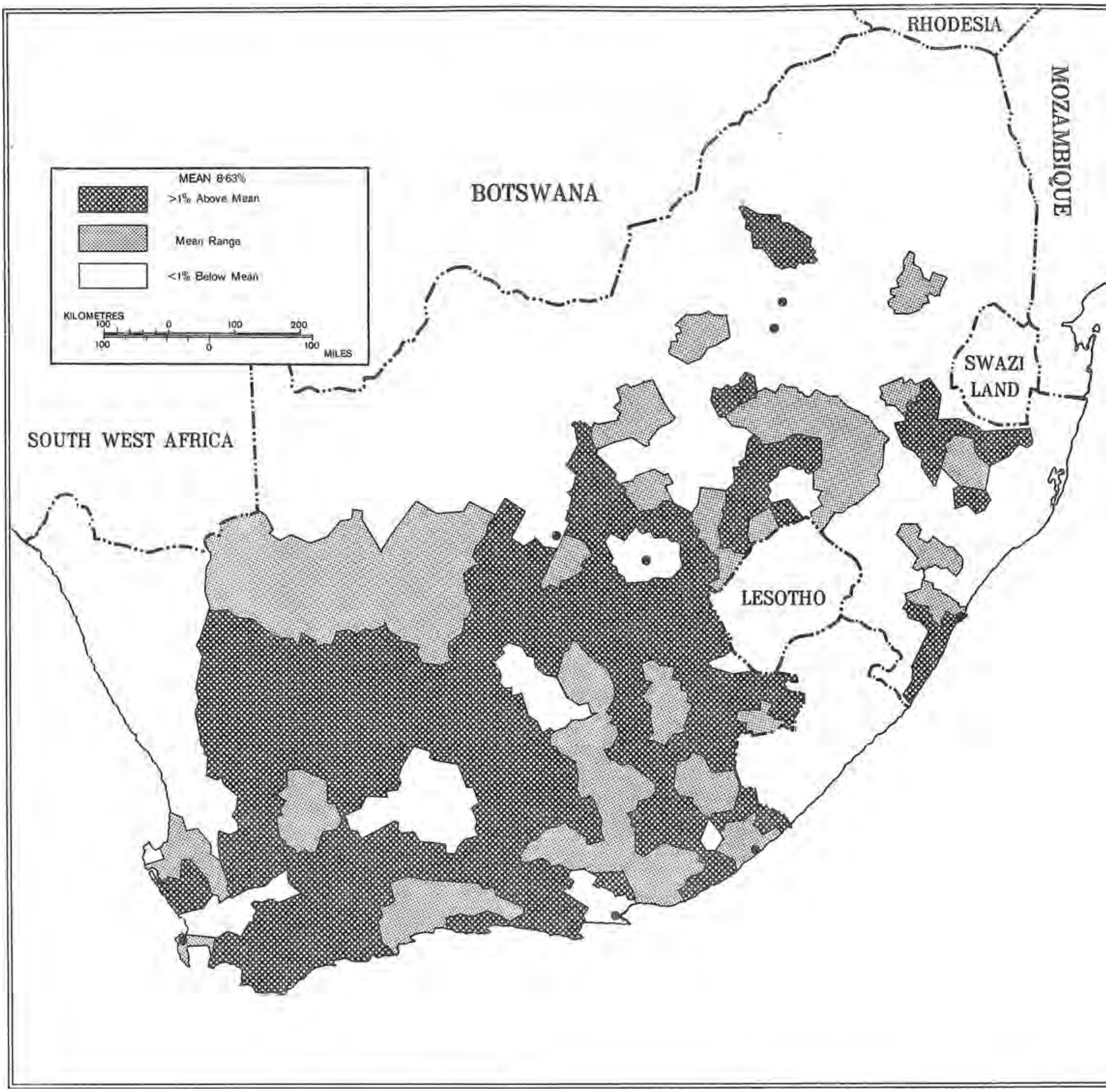
CLASSIFICATION OF THE POPULATION IN THE NODAL REGIONS OF THE REGIONAL PRIMATE CITIES: WHITE URBAN POPULATION BY MAGISTERIAL DISTRICTS, GIVING THE DISTRIBUTION OF SEX-RATIOS FOR THE 15-19 YEAR OLD AGE GROUP, SOUTH AFRICA 1960

NODAL REGIONS	PERCENTAGE DISTRIBUTION OF DISTRICTS			
	SEX-RATIOS FOR 15-19 YEAR OLDS			TOTAL
	$\bar{x}$ -(75%)	$\bar{x}$ ±5%	$\bar{x}$ +(75%)	
Cape Town	41.03	25.64	33.33	100.00
Port Elizabeth	43.48	26.09	30.43	100.00
East London	52.38	9.52	38.10	100.00
Bloemfontein	42.86	25.71	31.43	100.00
Kimberley	47.06	17.65	35.29	100.00
Johannesburg-Pretoria	50.72	21.74	27.54	100.00
Durban	45.95	16.22	37.84	100.00

NOTE: The Transkei has been excluded from the analysis and the Johannesburg and Pretoria nodal regions have been grouped.



39 SEX RATIO OF WHITE URBAN POPULATION 20–39 YEAR AGE GROUP



40 PERCENTAGE OF WHITE URBAN POPULATION OVER 65 YEARS

TABLE 54

CLASSIFICATION OF THE POPULATION IN THE NODAL REGIONS OF THE REGIONAL PRIMATE CITIES: WHITE URBAN POPULATION BY MAGISTERIAL DISTRICTS, GIVING THE DISTRIBUTION OF SEX-RATIOS FOR THE 20-39 YEAR OLD AGE GROUP, SOUTH AFRICA 1960

NODAL REGIONS	PERCENTAGE DISTRIBUTION OF DISTRICTS			
	SEX-RATIOS FOR 20-39 YEAR OLDS			TOTAL
	$\bar{x}$ -(75%)	$\bar{x}$ ±5%	$\bar{x}$+(75%)	
Cape Town	61.54	25.64	12.82	100.00
Port Elizabeth	56.52	30.43	13.04	100.00
East London	52.38	38.10	9.52	100.00
Bloemfontein	60.00	28.57	11.43	100.00
Kimberley	29.41	58.82	11.76	100.00
Johannesburg-Pretoria	17.39	39.13	43.48	100.00
Durban	21.62	21.62	56.76	100.00

NOTE: The Transkei has been excluded from the analysis and the Johannesburg and Pretoria nodal regions have been grouped.

TABLE 55

CLASSIFICATION OF THE POPULATION IN THE NODAL REGIONS OF THE REGIONAL PRIMATE CITIES: WHITE URBAN POPULATION BY MAGISTERIAL DISTRICTS, GIVING THE DISTRIBUTION OF THE PERCENTAGE AGED 65 YEARS AND OVER, SOUTH AFRICA 1960

NODAL REGIONS	PERCENTAGE DISTRIBUTION OF DISTRICTS			
	% OF WHITES AGED 65 + YEARS			TOTAL
	$\bar{x}$-(> 1%)	$\bar{x}$ ± 1%	$\bar{x}$ +(> 1%)	
Cape Town	25.64	23.08	51.28	100.00
Port Elizabeth	13.04	30.43	56.52	100.00
East London	0.00	28.57	71.43	100.00
Bloemfontein	8.57	20.00	71.43	100.00
Kimberley	47.06	23.53	29.41	100.00
Johannesburg-Pretoria	81.16	13.04	5.80	100.00
Durban	62.16	16.22	21.62	100.00

NOTE: The Transkei has been excluded from the analysis and the Johannesburg and Pretoria nodal regions have been grouped.

The White urban population on a progressive-regressive demographic scale.

To facilitate analysis, the number of categories in the progressive-regressive scale used above has been reduced to six by grouping. The six categories may be listed as follows :

Scale	Category
1	Progressive populations
2	Near progressive populations
3	Stationary populations
4	Sub-stationary populations
5	Stationary populations with definitely regressive tendencies
6	Regressive populations.

The percentage distribution of the White urban population on the scale, by magisterial district, is shown in Table 56 below

TABLE 56.

DISTRIBUTION OF THE WHITE URBAN POPULATION OF SOUTH AFRICA, BY MAGISTERIAL DISTRICT, ONTHE PROGRESSIVE - REGRESSIVE SCALE. 1960

Progressive-regressive Scale	No. of Magisterial Districts	%	Cumulated %
1	72	27.27	27.27
2	25	9.47	36.74
3	50	18.94	55.68
4	42	15.91	71.59
5	16	6.06	77.65
6	59	22.35	100.00
TOTAL	264	100.00	-

The distribution takes the form of a curve with a peak in the stationary and near-stationary categories, falling in opposing J curves rising to secondary peaks in the two extreme categories. The distribution confirms the general tendency of the population to fall into the three basic categories. Forty-four percent of the districts have populations which fall below the stationary category, and 22 per cent have regressive types of populations.

The spatial distribution of the types of population is shown in Table 57 and Figure 41.

The distribution confirms previous findings, and emphasises the correlation between the economy and relative demographic potential. The Johannesburg-Pretoria and Durban nodal regions, and the Kimberley region in particular, emerge as areas of relatively high demographic potential. The demographic potential of the Cape Town, Port Elizabeth, East London and Bloemfontein nodal regions is, by comparison, less satisfactory.

The intensity of agricultural, mining and industrial activity in the Johannesburg-Pretoria, Durban and Kimberley regions, forms the basis for more progressive urban population patterns. Furthermore, the greater spatial spread of populations in more progressive categories, particularly in the Johannesburg-Pretoria and Durban regions, is probably related also to an outward spread of economic opportunity into peripheral areas of the respective nodal regions.

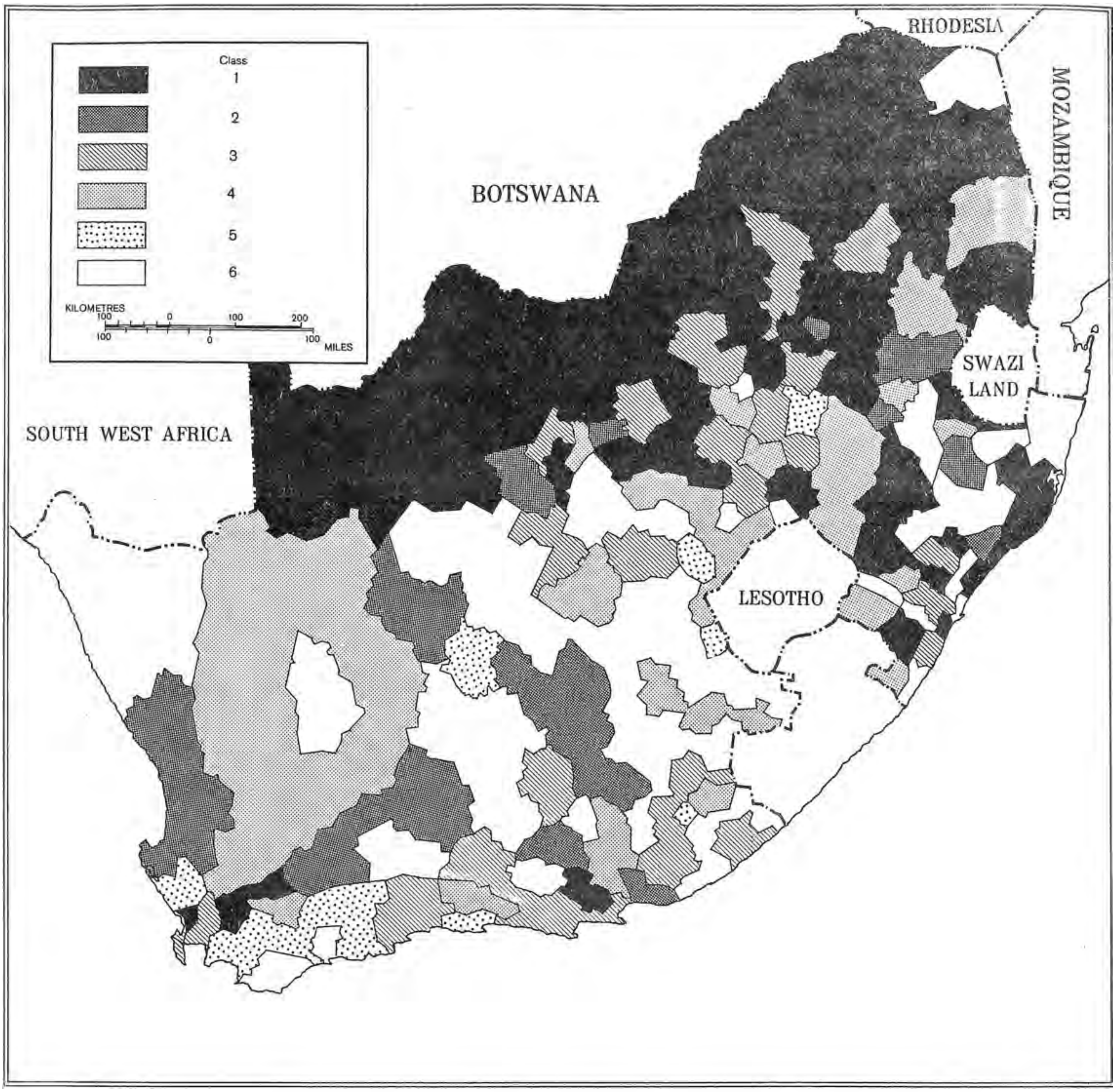
These nodal regions have probably advanced further in the industrial stage of development than other nodal regions in South Africa. Thus a multi-nuclear pattern, in which lower order cities in the nodal regions share economic growth with the regional metropolis is suggested by the distribution.

The significance of inter-metropolitan corridors between the metropolitan cities and areas of resource potential are also strongly evident in the distribution.

In the nodal regions of Cape Town, Port Elizabeth, East London and Bloemfontein, the metropolitan cities and their immediate surroundings have populations classed in the near-progressive categories. From these focal areas radial sectors of moderate demographic potential follow inter-metropolitan corridors of communication. The west coastal sector of the Cape Town nodal region is related to resource potential based upon mining and fishing - attractive to male workers, and has previously been shown to have a high sex ratio in the 20 - 39 year age category.

Intervening between the sectors of moderate demographic potential are sectors of low potential, more particularly in the southern Cape, and western Karoo in the Cape Town nodal region, and much of the East London and Bloemfontein nodal regions. Populations in these areas give rise to concern.

The spatial form of the economy in these nodal regions has probably not progressed beyond the stage where it is dominated by a simple primate core, surrounded by a stagnant or backward periphery. The demographic patterns tend to confirm this picture.



41 WHITE URBAN POPULATION PROGRESSIVE – REGRESSIVE CLASSIFICATION

TABLE 57

CLASSIFICATION OF THE POPULATION BY NODAL REGIONS: WHITE URBAN POPULATION, GIVING THE PERCENTAGE DISTRIBUTION OF MAGISTERIAL DISTRICTS ACCORDING TO THE PROGRESSIVE-REGRESSIVE POPULATION SCALE, SOUTH AFRICA, 1960.

Progressive Regressive Scale	PERCENTAGE DISTRIBUTION OF MAGISTERIAL DISTRICTS													
	CAPE TOWN		PORT ELIZABETH		EAST LONDON		BLOEMFONTEIN		KIMBERLEY		P-W-V		DURBAN	
	%	Cumulated %	%	Cumulated %	%	Cumulated %	%	Cumulated %	%	Cumulated %	%	Cumulated %	%	Cumulated %
1	6.82	6.82	8.70	8.70	0.00	0.00	2.94	2.94	25.00	25.00	65.23	65.23	36.11	36.11
2	15.91	22.73	17.39	26.09	0.00	0.00	2.94	5.88	18.35	43.75	5.80	71.03	11.11	47.22
3	29.55	52.28	26.09	52.18	23.81	23.81	8.82	14.70	18.75	62.50	14.49	85.52	19.44	66.66
4	20.45	72.73	13.04	65.22	14.29	38.10	32.35	47.05	6.25	68.75	10.14	95.66	16.67	83.33
5	15.91	88.64	0.00	65.22	4.76	42.86	8.82	55.87	6.25	75.00	1.45	97.11	0.00	83.33
6	11.36	100.00	34.78	100.00	57.14	100.00	44.13	100.00	25.00	100.00	2.90	100.00	16.67	100.00
TOTAL	100.00		100.00		100.00		100.00		100.00		100.00		100.00	

CONCLUSION

Demographic potential in South Africa has been shown to vary spatially in relation to levels of economic development. Regional primate cities too, have exercised an important influence over the orientation of demographic potential.

The relative economic strength of the Johannesburg, Pretoria and Durban nodal regions in particular is closely related to high demographic potential. These regions contrast sharply with those of the Cape Province (excluding Kimberley), and with the Bloemfontein nodal region. Other non-economic factors, have no doubt played roles of varying importance, but their significance is not clear from the statistical evidence available.

The findings suggest the need for research into the spatial dynamics of population distribution in South Africa, and the development of a national planning policy to take account of apparent social imbalance in the spatial demographic structure of the country.

ANALYSIS OF GROWTH RATES OF CITIES.

Growth Patterns.

Growth patterns have been analysed for the intercensal periods 1921-36, 1936-51 and 1951-60 which cover the last decade of transition and the contemporary industrial stages of economic growth.

Annual growth rates have been calculated using a computer programme based upon the normal exponential growth formula; $R = e^{rn}$ where R is the population at later date over population at earlier date, r the annual rate of growth, n is the number of years and e the Naperian logarithm.

Calculations were based upon the total population of cities on the hypothesis that, while obvious differentials exist between the levels of the contributions made by the various ethnic groups to the economy of a city, its total economy and growth depend upon the participation of all inhabitants and not merely upon one or two individual groups. It is realised that more detailed partial analyses of the influence of the individual ethnic groups upon city growth are of considerable importance to the present study but such work must await later research.[1)]

The Pattern of Growth of South Africa's Cities.

The mean annual growth rate of South Africa's cities remained remarkably constant between 1921 and 1960, and ranged from 2.03 per cent between 1921 and 1936 to 2.17 per cent between 1936 and 1951 and between 1951 and 1960 [2)].

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1) a. Calculations were based upon the total population of 590 cities with more than 150 persons in 1960. The value of 150 was selected as the base for calculations since below that level many cities extant in 1960 were not classified as urban in 1936 and growth rates could consequently not be calculated.

b. All new cities not in existence in 1936 were excluded from the calculations. In the majority of cases new cities have been characterised by relatively rapid growth at least in their initial development stages.

2) The mean annual growth rate has been calculated on the basis of the growth rates of individual cities and not upon the growth rate of the urban population of South Africa.

If the cities are grouped into two categories of positive and negative growth rates for each intercensal period, it is disquieting to find that the proportion of cities with negative growth rates steadily increased between 1921 and 1960 from 7.8 per cent to 13.5 per cent of all cities.

TABLE 58

PERCENTAGE OF CITIES WITH POSITIVE AND NEGATIVE GROWTH RATES 1921 TO 1960

PERIOD	% CITIES WITH NEGATIVE GROWTH	% CITIES WITH POSITIVE GROWTH	TOTAL %
1921-36	7.8	92.2	100.00
1936-51	9.1	90.9	100.00
1951-60	13.5	86.6	100.00

The finding suggests that it may be profitable in an analysis of city growth to pay particular attention to declining cities, or what may be termed problem cities, if it is assumed that a problem city is one that experiences negative growth. Attention will be focussed upon such cities at a later stage in the chapter.

Classification of Cities by Growth-Rate Pattern.

In order to avoid a tedious description of growth by intercensal periods, the growth rates of South Africa's cities may profitably be grouped firstly according to patterns of growth over the three intercensal periods as follows::

Growth Pattern		Nature of Pattern
1	a	Continuous positive rate above the mean and accelerating.
1	b	Continuous positive rate, but decelerating to or below the mean.
2	a	Continuous but uniform rate between 2 and 3 per cent per annum - the mean.
2	b	Continuous but uniform rate below the mean and not varying more than 1 per cent.
2	c	Continuous but uniform rate above the mean and not varying more than 1 per cent.
3	a	Continuous decreasing rate with a steady regression from positive to negative growth.
3	b	Continuous increasing rate with a steady progression from negative to positive growth.
4	a	Variable rate but between 1951 - 1960 an increasing rate above the mean.
4	b	Variable rate but between 1951 - 1960 a decreasing rate to less than - .5 per cent.
4	c	Variable rate but between 1951 - 1960 an increasing rate to 2-3 per cent (the mean).
4	d	Variable rate but between 1951 - 1960 an increasing rate from .5 per cent to 2 per cent.
4	e	Variable rate but between 1951 - 1960 a static growth rate (i.e) between - .5 per cent and +.5 per cent per annum.
5		Static rate at all times (i.e.) -.5 per cent to +.5 per cent per annum.

Secondly the 13 growth pattern categories may, in order to simplify the analysis further, be grouped into four basic growth pattern categories which describe the general degree of 'health of a city in terms of population change'. The categories are:

1. Positively 'healthy' cities (categories 1a, 2a, 2c, 3b, 4a, 4c).

2. Moderately 'healthy' cities (categories 2b, 4d).

3. Decelerating cities (category 1b).

4. 'Unhealthy' cities (categories 3a, 4b, 4e, 5).

The concept of degrees of 'health' used must be carefully defined. Health may be viewed on one hand from the standpoint of the city itself and on the other from the point of view of the regional or national space economy.

In relation to the city itself, it can be reasonably assumed that, in an industrial society, a continuous positive increment of population is indicative of existing or growing opportunity and therefore 'health'. Negative growth rates and rates which are below the average for all towns in the system, on the other hand, possibly indicate restricted or declining opportunity giving rise to various degrees of 'ill health' within the city. It is in this sense that the terms are used here.

Considered in relation to the regional or national economy it may be to the benefit of the economy as a whole, and therefore healthy, that some and perhaps many cities, do not grow at more than a somewhat below average rate at a level where they exist in a natural balance with their hinterlands in terms of services required and rendered. Excessive growth in such cases could, unless export of excess goods and services to beyond the hinterland is possible or demanded, lead to diminishing returns and an imbalance of the local economy. It is doubtful, however, whether actually declining cities can in any sense be regarded as a healthy development since they give rise to wasting infrastructure, locally unbalanced demographic and social structures, lethargy, hopelessness and social decay generally. Such cities should be either totally removed or carefully planned reduction should be undertaken. In either sense a policy similar to those already in existence in the United Kingdom and the United States for redundant or declining cities is required.

CORRELATIVE ANALYSES OF CITY GROWTH AND SELECTED MEASURABLE VARIABLES

Correlation of Growth Rate and Size of Place.

Two aspects of the relationship between growth and size of place will be considered. These are a correlation of actual growth rate and size for cities of over 10,000 persons, and a correlation of the size hierarchy with the growth pattern of all cities.

No significant correlation exists between actual growth rate and size of place for cities of over 10,000 persons in the intercensal periods between 1921 and 1960. In other words, the rank of a city by size is not correlated positively with its rank by growth rate in any intercensal period. (Table 59.)

TABLE 59.

SPEARMAN'S RANK CORRELATION COEFFICIENT VALUES FOR GROWTH RATE AND CITY SIZE (CITIES OVER 10,000) POPULATION 1921 - 1960*

	PERIOD	S.R.C.	SIGNIFICANCE LEVEL
Cities over 10,000 in 1921	1921-36	.39	.05
Cities over 10,000 in 1936	1936-51	.07	Not at .10
Cities over 10,000 in 1951	1951-60	-.07	Not significant

* All cities in existence in 1936.

It is interesting to note that the correlation coefficient decreases progressively between 1921 and 1960 which appears to suggest that, for the larger cities of South Africa, growth has become progressively independent of size. The trend is perhaps not unexpected since cities with over 10,000 persons vary widely in economic resource base and function, and are likely to possess variable growth rates, in which size alone is only one of many factors at work.

Whether a similar relationship exists between size and growth rate for cities below 10,000 persons has yet to be determined, but an inspection of the data suggests that it is likely that size and actual growth rate for the intercensal periods are not closely related in the case of smaller cities.

Growth Pattern by Size of Place.

Whereas the actual growth rate, as previously shown, is not correlated significantly with size of place, it is apparent from Table 60 that a very strong correlation exists between the growth pattern over the three intercensal periods and size of cities.

TABLE 60.

GROWTH PATTERN (1921-60) BY SIZE OF PLACE IN 1960*
PERCENTAGE VALUES

SIZE	UNHEALTHY	DECELE-RATING	MODERATELY HEALTHY	HEALTHY	TOTAL
+500,000	0.00	33.33	0.00	66.67	100.00
100-500,000	12.50	25.00	0.00	62.50	100.00
50-100,000	14.29	42.86	0.00	42.86	100.00
20- 50,000	0.00	10.00	10.00	80.00	100.00
10- 20,000	0.00	21.43	3.57	75.00	100.00
5- 10,000	0.00	21.05	15.79	63.16	100.00
2- 5,000	9.36	12.87	20.47	57.16	100.00
1- 2,000	15.15	16.16	19.19	49.49	100.00
< 1,000	39.64	15.32	13.51	31.53	100.00

* All cities in existence in 1936

The Large Cities of Over 50,000 Population.

The largest cities have healthy growth patterns with the exception of Johannesburg, which up to 1960 had a decelerating pattern. The degree of growth health declined progressively with size and cities of 50,000 to 100,000 persons had only 43 percent of their number in the positive health growth category.

The decelerating growth pattern of Johannesburg is not unexpected as there is a general tendency for large cities to reach a plateau or for their growth rate to level off or decelerate as they reach a mature stage of development and as increments of population beyond their boundary detract from growth within it. Despite a decelerating growth rate, such cities do however have large annual increments of population in absolute terms because of their size.

The relatively high proportion of cities with between 50,000 and 500,000 persons which fall in the decelerating category appears to suggest that a similar trend in growth is now beginning to affect smaller cities as well.

The groups of cities with populations between 50,000 and 500,000 persons in addition possess distinct degrees of actual ill-health. Half the cities in size groups between 50,000 and 500,000 persons are to some degree unhealthy and, with the exception of East London, all the ill-health falls within the Pretoria-Witwatersrand-Vereeniging region where declining mining activity has in more recent years markedly affected the potential for economic growth. Benoni and Brakpan in particular have distinctly unhealthy growth patterns (negative growth between 1951 and 1960) and clearly require urgent economic planning if they are to remain as viable growth points.[1)]

Cities with Fewer than 50.000 Persons.

A strong correlation exists between growth pattern and size of place in cities with populations below 50,000 persons. The proportion of cities with healthy growth patterns declines rapidly from 80 per cent (20,000 to 50,000 persons), to 31 per cent for cities with fewer than 1,000 persons.

Cities between 20,000 and 50,000 persons and between 10,000 and 20,000 persons, taken as a group, are clearly the cities with the most healthy growth patterns in South Africa. The majority of the cities are central places with regional service centre status. In contrast, the smaller cities, below 5,000 persons, are the least successful group, and contain relatively high proportions of unhealthy cities.

It is evident that as a result of increasing population and economic mobility and centralised economic opportunity, the functional basis of the smaller central places may be being reduced or removed.

A similar phenomenon has been observed also in the United States by Northam (1963). He notes that there may well be a metamorphosis of the urban hierarchy in the sense noted. Stewart (1958) in recognising this phenomenon states :- 'Eventually the lowest order practically disappears, and its place in the town function pyramid is taken by the next lowest order, which loses some of its functions but manages to survive. This at least is the picture in the United States and Britain, where many service villages and small towns have lost their economic functions and survive, if at all, only as a cluster of houses.'

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1) See news item Sunday Times, 9th July, 1967. In the period since 1960 the development of industry on the East Rand is likely to have improved the situation considerably.

It is clear that the same phenomenon of declining functional bases is now beginning to affect the town hierarchy in South Africa, and that a redundant or problem city category, as previously noted, may be emerging.

It may be significant to note further that the size groups between 1,000 and 10,000 persons now possess relatively high proportions of cities which are either decelerating or possess moderately healthy growth patterns. Could this possibly mean an even greater shift in potential for development than previously noted? That is, is centralised economic opportunity now beginning to affect the medium-sized central places as well as the smaller cities? It may be that a noticeable degree of ill-health in the medium-sized cities can be expected in the future if the trend continues.

Since size of place and rank in the Service Hierarchy are closely correlated, it may be assumed that growth rate and service hierarchy order are similarly related and that the problem of declining service centres exists. Research in this field should be extended.

Correlation between Growth Pattern and Employment in Services, Commerce and Finance and Manufacturing.

The relationship between employment in services, commerce and manufacturing, which are major forces in the urbanisation process, and the rate at which cities grow, is perhaps one of the most important correlations which may be made in the present study. The implications for economic planning are considerable.

For this analysis a random sample of cities has been drawn from the special tabulation of the industries of the population for cities of over 2,000 in 1960. No comparable statistics are available for earlier census dates, and correlation between growth rate and employment must be confined to the intercensal period 1951 to 1960. The results are nevertheless revealing.

The calculation of a rank correlation coefficient between the variables and growth rates of the sample cities between 1951 and 1960 yields the results tabulated in Table 61.

TABLE 61.

SPEARMAN'S RANK CORRELATION COEFFICIENT VALUES FOR INDUSTRY CATEGORIES AND GROWTH RATE OF A SAMPLE OF CITIES 1951 - 60.

Industry Category	S.R.C.	t Test	Significance Level
Per cent employed in services	-.05	-.43	-
Per cent employed in commerce	.22	1.83	.100
Per cent employed in manufacturing	.26	2.19	.025

No significant correlation exists for the intercensal period between growth rate and percentage employed in services. A correlation, significant at the .10 level exists between employment in commerce and growth rate, but is not significant at the .05 level. It appears therefore, that in modern times the role that services and commerce have to play in promoting strong positive growth in South Africa's cities is somewhat restricted.

A strong positive correlation exists, however, between growth rate and employment in manufacturing which clearly emerges as the single most important force in the promotion of healthy growth within cities at present. The finding is not unique, and applies equally well to most industrialised countries of the world. It is important to make the point, however, that it is no longer possible to rely upon services and commerce alone for growth in South Africa's cities. The point is particularly relevant in small cities which at present do not possess any significant degree of industrial development.

This finding is confirmed by the association between population growth rate and employment in manufacturing on Component IV of the Principle Component Analysis. Both variables load high on the industry growth component.

It is interesting to note that cities which had 6 per cent or more of their employment in manufacturing in 1960 enjoyed an overwhelmingly healthy growth rate in the intercensal period 1951 to 1960. (Table 62.)

TABLE 62

GROWTH RATE 1951 - 60 OF CITIES BY PERCENTAGE EMPLOYED IN MANUFACTURING 1960

Per cent in Manufacturing	PERCENTAGE OF CITIES			Total
	GROWTH RATES			
	Unhealthy < ½%	Moderately Healthy ½ - 2%	Healthy > 2%	
< 6%	20	24	56	100
+ 6%	0	6	94	100

Although it is hazardous to draw any definite conclusions on the basis of the analysis it may be stressed that under present conditions it would appear that a city should attempt to build up its industrial employment to at least 6 per cent of its total economically active population in order to achieve or ensure a healthy growth pattern. The value of 6 per cent, however, applies only to conditions in the recent past and perhaps the present, and would be subject to change relative to the change in the employment structure of the national system of cities in time.

A CORRELATIVE ANALYSIS OF THE GROWTH PATTERN OF CITIES AND SELECTED SPATIAL VARIABLES.

Research thus far completed will allow some assessment to be made of the relationship between growth patterns of cities and certain surfaces including rainfall distribution, agro-economic patterns and facilities for development areas. (Fair and Green 1962.)

Growth Pattern and Rainfall Zones.

A chi-square test and a contingency coefficient applied to the relationship between growth pattern categories and rainfall zones show that rainfall and growth pattern are significantly correlated at the .05 level. On inspection, the correlation, however, is not in the expected direction; i.e. that the wetter zones of the country possess the greatest proportion of towns with healthy growth patterns. The reverse is true and there is a general trend for the proportion of positively healthy towns to decline with increasing rainfall. While most rainfall zones have more than 50 per cent of their cities in positively healthy growth categories, the moister zones with more than 25 inches per annum have fewer than 50 per cent of their cities in the positively healthy growth pattern category. The driest zones, those with less than 10 inches per annum, have the highest proportion of cities with positively healthy growth patterns.

The percentage of cities with decelerating and moderately healthy growth patterns by rainfall zones is variable, but it may be significant that the higher rainfall zones (> 25 inches per annum), also possess relatively higher proportions of decelerating cities than the drier zones.

The relationships are not entirely expected, and it must be stated immediately that, while a strong statistical relationship exists, it is most unlikely that a higher rainfall is the direct cause of ill-health in the growth of cities. It is as an indirect factor that rainfall is important. The better watered areas in general are also the more highly developed areas, with a denser network of cities. They do also, however, possess in general, a more highly evolved system of transport and communications which may have resulted in a change in relative importance of cities as suppliers of central services as previously noted. A second factor is that the majority of the Bantu reserve lands lie in the better watered areas, and no doubt cities within those zones contribute, to a considerable degree, to the higher levels of urban ill-health encountered in the wetter areas.

The drier areas on the other hand have a less dense network of cities and less developed transportation systems and most existing cities, it may be suggested, therefore, tend to retain their importance and health as service centres irrespective of size and status. Furthermore, the proportion of low income African population in these areas is small and incomes per head are consequently higher than in many moister areas of the country. Growth in the drier areas can consequently be expected to be generally healthy.

The Agro-Economic Divisions and Growth Patterns.

The agro-economic divisions of South Africa very largely reflect rainfall patterns, and provide a refinement of the analysis based upon rainfall totals alone. Table 63 shows a more complex association of variables and indicates in particular the variation in the degree of urban positive health and ill-health which occurs among the better watered farming regions of the country.

TABLE 63.

GROWTH PATTERN BY AGRO-ECONOMIC REGIONS

A.E.R.	Unhealthy	Decelerating and Moderately Healthy	Healthy	Total
A.	14.06	33.79	54.05	100.00
B.	15.15	37.88	46.96	100.00
K.	19.35	35.48	45.16	100.00
V.	19.35	35.48	45.16	100.00
H.	10.53	33.34	56.13	100.00
E.	28.07	28.07	43.86	100.00
C.	7.89	26.32	65.79	100.00
D.	20.83	20.83	58.33	100.00
F.	17.24	41.38	41.38	100.00
M.	10.00	30.00	60.00	100.00
S.	14.47	19.74	65.79	100.00
TOTAL	15.82	30.83	53.35	100.00

The most significant features brought out by the table are:

1. The relatively high proportion of cities with positively unhealthy growth patterns in the eastern plateau diversified region (E), the grazing areas of the eastern plateau highveld (D), and areas of the south western Cape region (K,V). These regions also have relatively lower proportions of cities with positively healthy growth patterns.

2. The low proportions of cities with unhealthy growth patterns and relatively high proportions of cities with healthy growth patterns in the coastal belt (H), the drier marginal diversified area of the plateau (C), and the drier cattle and sheep grazing areas (M & S).

3. The average degrees of health and ill-health among cities found in the plateau cropping region (B), and the irrigation areas (A).

4. Region (F), the thornveld of Natal and the Transkei, has a relatively high proportion of cities with decelerating or moderately healthy growth patterns.

CORRELATION OF GROWTH PATTERNS AND FACILITIES FOR DEVELOPMENT AREAS.

A chi-square test and contingency coefficient show that a positive correlation exists between growth pattern and facilities for development areas at the .05 level of significance. Table 64 shows the percentage occurrence of degrees of health for cities in four re-grouped facility areas.[1)]

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1) Green and Fair (1962)

1. Areas within 50 miles of urban centres with populations of over 150,000 persons

2. Areas within 35 miles of urban centres wih populations of between 50,000 and 150,000 persons.

3. Areas with good power, water and rail and road motor service facilities and within 25 miles of towns with populations of between 10,000 and 50,000 persons

4. Areas with access to three of the four basic facilities.

5. Areas with access to two of the four basic facilities

6. Areas with access to one facility, often either railways or water supplies.

7. Areas possessing none of the basic facilities

It has been necessary to re-group the seven areas into four categories in order to obtain frequency tabulations which can be used with some reliability. Regions 1 and 2, 3 and 4, and 6 and 7, have been grouped together in Table 64.

TABLE 64.

GROWTH PATTERNS BY FACILITY FOR DEVELOPMENT AREAS
PERCENTAGE VALUES

Fac.Area	Unhealthy	Decele-rating	Moderately Healthy	Healthy	Total
1.	11.36	22.73	10.23	55.68	100.00
2.	16.03	16.03	13.74	54.20	100.00
3.	18.72	16.58	21.39	43.32	100.00
4.	7.06	10.59	17.61	64.71	100.00

Observations previously made are confirmed by the table. The highest degree of positive health and the lowest degree of ill-health in cities occurs in region 4 - i.e. the areas with access to one or none of the four basic facilities, and also the areas which are less intensively developed and drier. Region 1, with maximum facilities, has a relatively low proportion of cities with unhealthy growth patterns, but only a relatively moderate proportion of cities with positively healthy growth patterns. The intermediate regions 2 and 3 have relatively high proportions of cities with unhealthy growth patterns, and relatively high proportions of cities which are decelerating or have moderately healthy growth patterns.

The findings suggested by the results are:

1. That size of place in South Africa is no guarantee of a particular growth rate but is nevertheless closely correlated with growth pattern.

2. A strong functional relationship exists between employment in manufacturing and growth rate, typical of most industrialised societies. However, all cities cannot hope to become equally industrialised, and most places will continue to serve as central service centres. In view of the relatively low degree to which services alone appear to promote growth, however, the life pattern of the country's service centres and more particularly its smaller cities will need to be carefully watched.

3. It is apparent that a definite need exists for an official planning policy to govern the life of problem or declining towns. Jagersfontein is already the subject of a project of the Department of Planning, but there are many other towns in a similar situation.

Since unhealthy towns appear to cluster in distinct localities, it may be profitable to undertake detailed research into a declining town region. The findings could have important implications for growth point analysis and planning in the future.

GROWTH RATE ANALYSIS FOR THE PERIOD 1951-1960.

The analyses discussed in previous paragraphs refer to generalisations of growth patterns measured over three intercensal periods between 1921 and 1960. It is important, however, to examine growth within the most recent intercensal period for which data is available - 1951-60 - to establish contemporary growth conditions within the city system. Table 65 demonstrates the growth of cities with more than 2,000 persons.

TABLE 65

GROWTH PATTERNS OF CITIES WITH MORE THAN 2,000 PERSONS BY CITY SUB-SYSTEM - 1951-60

Sub-System	High Positive Growth	Positive Growth > Mean	Mean Range	Static Range	Negative	Total
Cape Town	4	15	29	12	1	61
Port Elizabeth	1	6	17	1	-	25
East London	1	6	14	3	1	25
Johannesburg	25	32	32	12	-	101
Pretoria	1	11	-	2	-	14
Durban	3	16	9	6	1	35
Bloemfontein	-	4	15	8	-	27
Kimberley	2	8	10	4	-	24

The largest proportion of cities with high positive and positive growth rates above the mean, between 1951 and 1960, were located within the three city sub-systems focussed upon Johannesburg, Durban and Pretoria. In these city sub-systems 58 per cent of cities with more than 2,000 persons fell in the two categories.

In the principal sub-system, incorporating the sub-systems of Johannesburg, Pretoria, Durban, Bloemfontein and Kimberley, 51 per cent of cities were classed in the two upper-growth categories. It is apparent, therefore, that the sub-systems of Bloemfontein and Kimberley contributed relatively small proportions of cities with high growth rates in the period. The Bloemfontein sub-system in particular possessed a high proportion of cities with more than 2,000 persons in the mean range and static categories of growth.

The sub-systems of Cape Town, Port Elizabeth and East London had only between 28 and 32 per cent of their cities, with more than 2,000 persons, in the two upper-growth categories. The growth rate of the majority of cities in these sub-systems fell within the mean and static range of growth.

THE SPATIAL DISTRIBUTION OF CITIES ACCORDING TO THEIR GROWTH PATTERN.

The spatial distribution of cities by growth pattern categories between 1921 and 1960 is shown in Figure 42, while the growth patterns between 1951 and 1960 are shown in Figure 43.

An analysis based on nearest neighbour methods shows that there is a tendency for cities with positively unhealthy growth patterns to cluster. Cities which fall in all other growth pattern categories, however, tend to have a random distribution spatially.

Figure 42 shows that clusters of unhealthy cities occur in particular in the east-central Karroo, southern Cape, north-west Cape, south-west Orange Free State, north-east Cape and the Transkei, all areas which form part of the Cape Town, Port Elizabeth and East London city sub-systems. Smaller clusters occur, however, in the north and north-east of the country and more particularly in East Griqualand and south-western Natal, north-eastern Orange Free State, the southern Transvaal (including the low-growth cities of the Witwatersrand) and in the northern Cape.

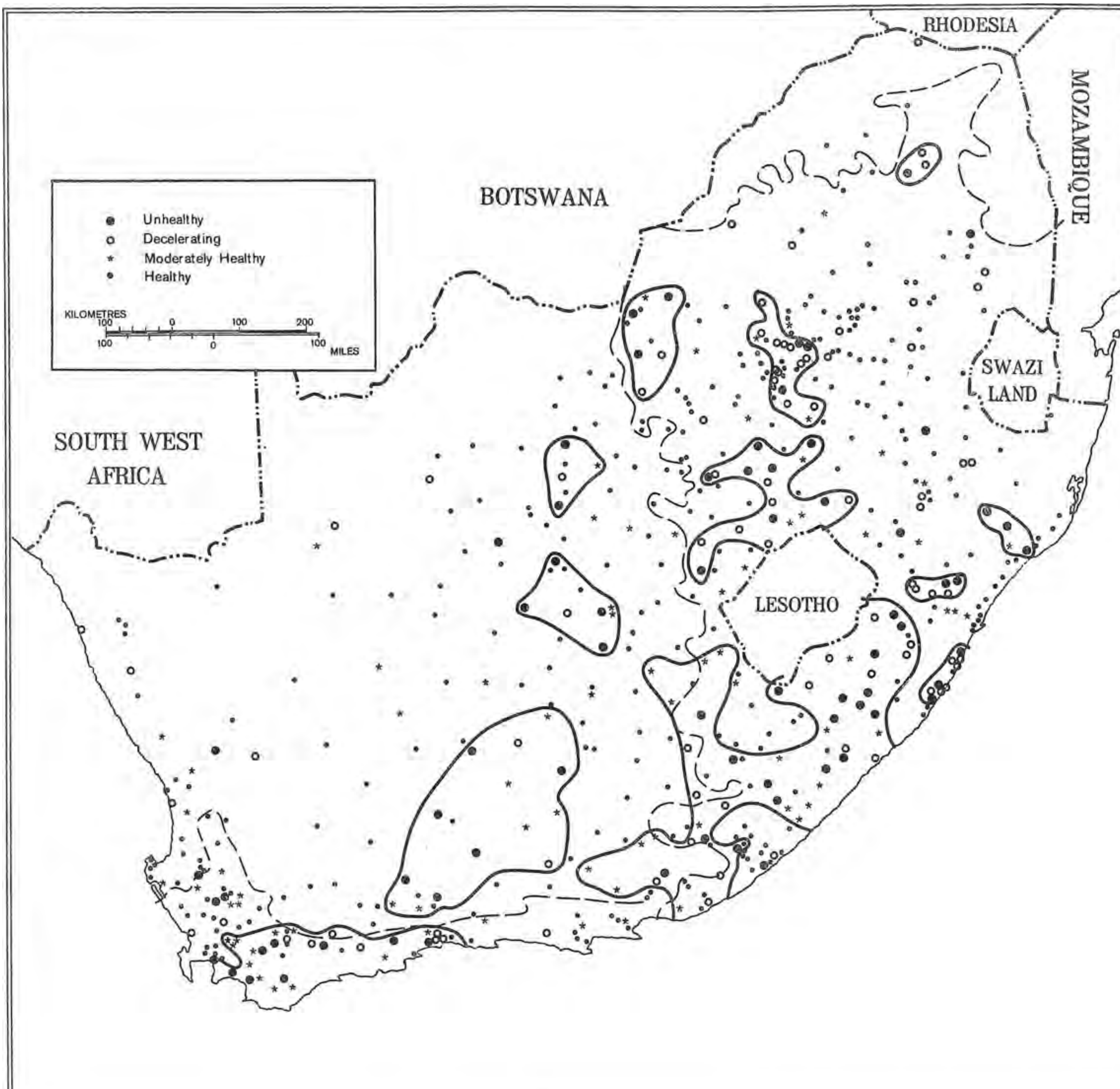
The reasons for the existence of local clusters of relatively unhealthy cities between 1921 and 1960 are not clear at this stage, and further research is needed to provide adequate explanations.

Figure 43 demonstrates in particular the concentration of cities with high-growth rate patterns between 1951 and 1960 in the Johannesburg, Pretoria and Durban city sub-systems, confirming trends in existence since 1921 (Figures 42 and 43). Local clusters of cities with poor growth performance are again evident.

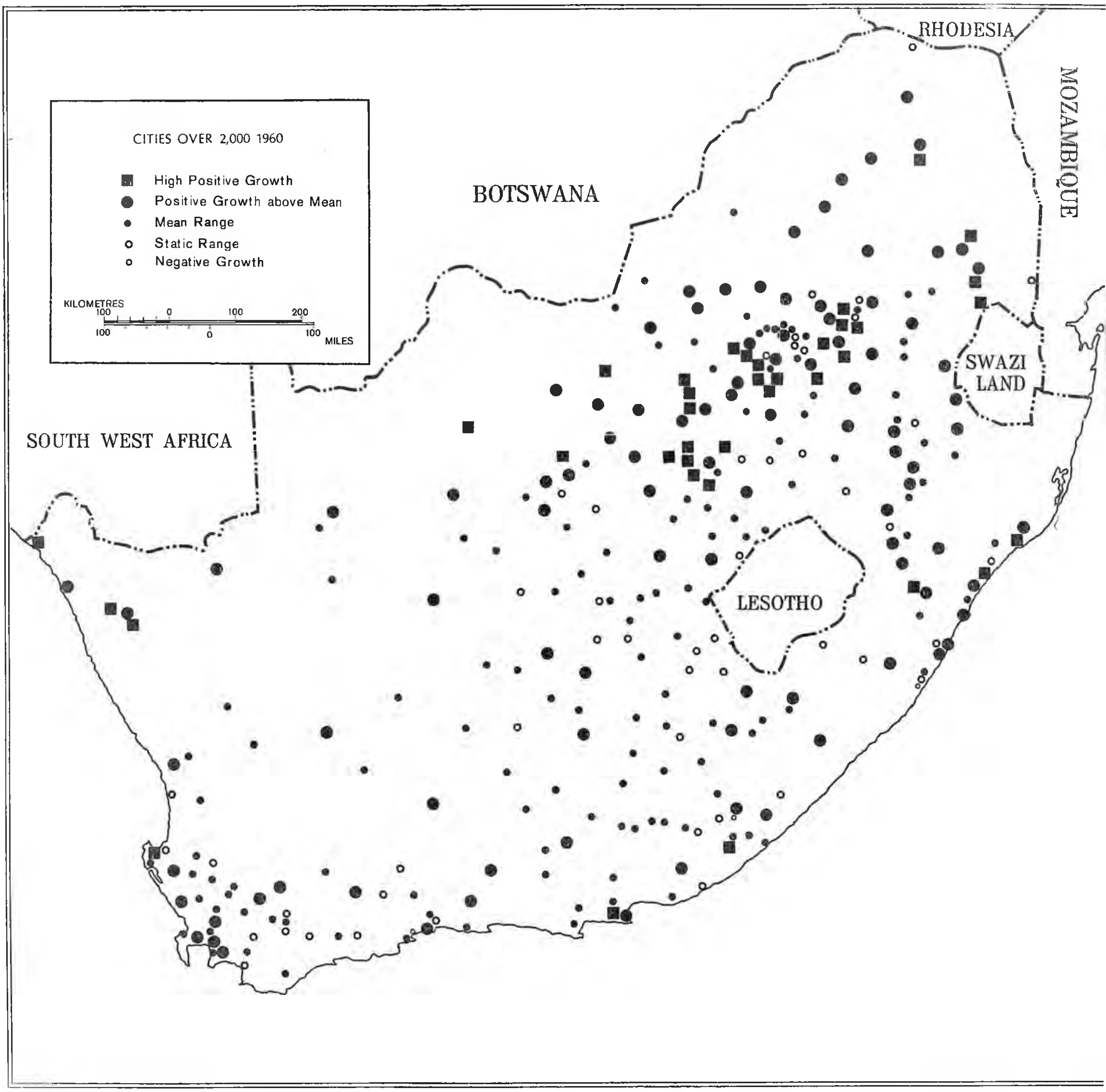
Relative Changes in Population Growth 1904-1960.

While the previous section of this chapter has concerned itself with an examination of the growth pattern of cities in terms of growth rates, it is important also to examine growth in 'relative terms' in this case for the periods 1904 to 1936 (the late transition phase) and 1936 to 1960 (the industrial stage of development).

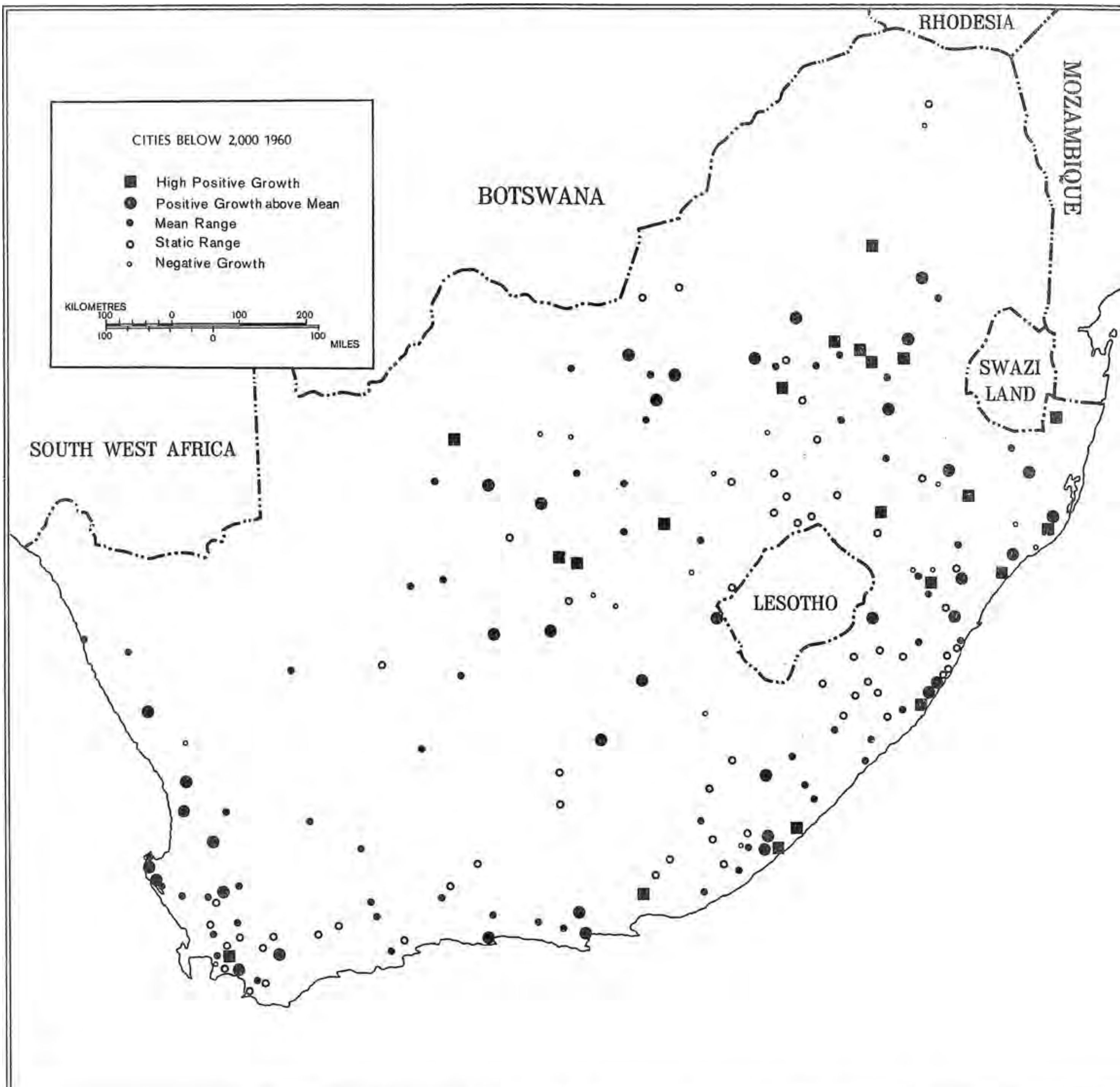
The analysis of relative changes in population was first employed in South Africa by Fair (1965) in examining regional population trends in relation to economic development. Two methods were suggested. The first indicated the percentage distribution or share of the South African population in each region, and the second method employed the so-called 'shift' technique as used by Perloff (1960). This method shows the relative size of the gains or losses in population against a national mean. Fair (1965 p.70) notes that 'the method aims at appreciating the relative size of the gains or losses among the areas being compared by combining both percentage and absolute changes. It helps to avoid the distortion apparent when percentage figures alone are used, e.g. an increase of 100 per cent, whether it be from 1,000,000 to 2,000,000 or from 10 to 20.' An example of the calculations using the method is illustrated in Fair (1965) and need not be repeated here.



42. DISTRIBUTION OF CITIES BY GROWTH RATE PATTERN 1921–1960



43a. DISTRIBUTION OF CITIES BY GROWTH RATE PATTERN 1951– 60



43b. DISTRIBUTION OF CITIES BY GROWTH RATE PATTERN 1951–60

Percentage Distribution of Population by City Sub-Systems.

In 1904, 55 per cent of the urban population was concentrated in the Cape Town and Johannesburg city sub-systems (26.8 per cent and 27.9 per cent respectively). The Durban and Port Elizabeth city sub-systems each possessed from 10 to 11 per cent of the urban population. The principal sub-system at that time also held 55 per cent of the total urban population.(Table 66.)

TABLE 66.

DISTRIBUTION OF THE URBAN POPULATION BY CITY SUB-SYSTEMS 1904 AND 1960

Sub-System	Pop. 1904	1904 % of Sub-System	% of Total	Pop. 1960	1960 % of Sub-system	% of Total
Cape Town	188,761	58.7	15.7	807,211	64.8	10.8
Rest of S.S.	132,687	41.3	11.1	438,690	35.2	5.9
Total Sub-System	321,687	100.0	26.8	1,245,901	100.0	16.7
Port Elizabeth	45,796	35.4	3.8	290,693	56.4	3.9
Rest of S.S.	83,445	64.6	6.9	225,054	43.6	3.0
Total Sub-System	129,241	100.0	10.7	515,747	100.0	6.9
East London	29,869	32.2	2.5	116,056	40.5	1.6
Rest of S.S.	63,036	67.8	5.3	170,335	59.5	2.3
Total Sub-System	92,905	100.0	7.8	286,391		3.9
Witwatersrand	249,703	74.6	20.8	2,152,302	65.1	28.8
Rest of S.S.	85,028	25.4	7.1	1,156,621	34.9	15.5
Total Sub-System	334,731	100.0	27.9	3,308,923	100.0	44.3
Pretoria	39,081	88.9	3.3	422,590	78.7	5.7
Rest of S.S.	4,856	11.1	0.4	114,219	21.3	1.5
Total Sub-System	43,937	100.0	3.7	536,809	100.0	7.2
Durban	69,903	58.0	5.8	696,782	63.6	9.3
Rest of S.S.	50,659	42.0	4.2	399,001	36.4	5.4
Total Sub-System	120,562	100.0	10.0	1,095,783	100.0	14.7
Bloemfontein	33,883	43.5	2.8	145,273	56.7	2.0
Rest of S.S.	44,107	56.5	3.7	111,158	43.3	1.5
Total Sub-System	77,990	100.0	6.5	256,431	100.0	3.5
Kimberley	43,709	55.3	3.6	79,031	36.4	1.1
Rest of S.S.	35,388	44.7	3.0	138,087	63.6	1.8
Total Sub-System	79,097	100.0	6.6	217,118	100.0	2.9
Total	1,199,911		100.0	7,463,103		100.0

Between 1904 and 1960 considerable changes in the distribution of the urban population took place. The Johannesburg, Pretoria , and Durban city sub-systems each increased their relative proportions considerably. Thus the Johannesburg sub-system contained no less than 44 per cent of the total urban population, while the Durban sub-system contained 15 per cent and the Pretoria system 7 per cent. The three sub-systems together held 66 per cent of the total urban population in 1960.

The relative proportion of the urban population contained in the Cape Town, Port Elizabeth, East London, Bloemfontein and Kimberley city sub-systems, on the other hand, declined considerably.

The proportion of the population resident in the focal cities of Cape Town and the Witwatersrand in 1904 was 16 per cent and 21 per cent of the total urban population of South Africa respectively. Durban contained 5.8 per cent, Kimberley 3.6 per cent, Pretoria 3.3 per cent, Port Elizabeth 3.8 per cent and East London 2.5 per cent of the total. By 1960, on the other hand, the Witwatersrand contained nearly 29 per cent of the total, while the proportion in Cape Town had declined to nearly 11 per cent. The proportion of the total urban population resident in Durban, on the other hand, had increased to over 9 per cent, and in Pretoria to nearly 6 per cent. In all the remaining focal cities the percentage of the total had declined considerably, except for Port Elizabeth which had retained its position with 3.9 per cent of the total urban population. The changes in the distribution of the urban population clearly reflect patterns of economic development which have previously been discussed.

In all city sub-systems, with the exception of the Pretoria and Kimberley sub-system, a general trend towards the concentration of urban population in the focal cities is apparent. In the case of the Kimberley sub-system the relative decline of the city may be explained by the opening of new mining areas in its hinterland. In the Pretoria sub-system on the other hand new cities have been established in the hinterland and older cities such as Pietersburg have enjoyed considerable growth in recent times. The agglomeration of urban population within the major metropolitan cities has previously been referred to in examining levels of urban primacy within the city sub-systems

<u>Percentage Distribution of Net Shifts of Urban Population within the City System.</u>

In the period 1904-1936, 62 cities experienced a net upward shift (or what Fair has termed extra growth) while 197 cities experienced a net downward shift of population.

Of the cities with a net upward shift of population, 29 were located in the Johannesburg sub-system, 4 in the Durban sub-system, 5 in the Pretoria sub-system, 5 in the Bloemfontein sub-system, and 3 in the Kimberley sub-system. Thus the principal sub-system contributed 46 of the total of 62 cities with net upward shifts of population in the period.

Between 1904 and 1936 the principal sub-system contributed no less than 98.7 per cent of the total net upward shift of population. The Johannesburg sub-system alone contributed 76 per cent, Durban 15 per cent and Pretoria over 2 per cent. By contrast the principal system contributed 36 per cent of the total net downward shift of population in the period. It should be noted, however, that the largest proportion of the net downward shift was contributed by the Bloemfontein and Kimberley sub-systems which collectively experienced a 23.7 per cent net downward shift.

The contribution of the Cape Town, Port Elizabeth and East London city sub-systems to the net upward shift of population was only just over 1 per cent but their collective contribution to net downward shifts of population was over 62 per cent.

Not unexpectedly the relative net upward shift of population is greatest in the category of cities with more than 100,000 persons. Thus in the principal city sub-system the cities of Johannesburg, Pretoria, and Durban, contributed 91 per cent of the total net upward shift in population, as against 98 per cent for the entire sub-system. In the period 1904-1936 the cities of Cape Town, Port Elizabeth, East London, Pietermaritzburg and Bloemfontein all had net downward shifts of population. Whereas 7 out of 12 cities with more than 100,000 persons experienced net upward shifts, only 20 - 34 per cent of cities in smaller size categories enjoyed net upward shifts in population.

The contribution to net downward shift made by cities of more than 100,000 was approximately 28 per cent. It is clear, therefore, that it is within the smaller size categories that downward shifts were particularly concentrated. (Table 67.)

TABLE 67

CONTRIBUTIONS TO NET UPWARD AND DOWNWARD SHIFTS IN POPULATION BY CITY SIZE GROUPS - 1904-36 AND 1936-60

Size Group	1904-36		1936-60	
	% Up	% Down	% Up	% Down
+ 500,000	36.93	17.42	10.10	15.26
100 - 500,000	54.32	10.33	56.30	23.79
50 - 100,000	0.00	9.72	0.00	1.83
20 - 50,000	1.62	12.42	10.37	6.42
10 - 20,000	1.81	11.00	6.02	9.47
5 - 10,000	2.22	10.64	9.52	9.12
2 - 5,000	2.80	19.47	5.54	24.08
1 - 2,000	0.24	5.00	1.56	7.12
500 - 1,000	0.05	3.94	0.73	3.93

Between 1936 and 1960, 146 cities experienced a net upward shift of population, while 341 cities experienced net downward shifts.

In a pattern similar to that which had occurred in the period 1904 - 1936 the major concentration of cities with net upward shifts of population occurred in the principal city sub-system. Thus the sub-systems of Johannesburg, Pretoria and Durban alone contributed 105 of the cities with net upward shifts, while the sub-systems of Bloemfontein and Kimberley contributed a further 11 cities. In the Cape Town, Port Elizabeth and East London city sub-systems, on the other hand, a total of only 30 cities experienced net upward shifts in population.

The percentage of the net upward shift in population accounted for by the principal city sub-system between 1936 and 1960 was nearly 92 per cent with the Johannesburg, Pretoria and Durban city sub-systems on their own contributing over 90 per cent.

Between 1936 and 1960, however, the principal sub-system contributed a relatively larger proportion to the net downward shift of population (50 per cent) than it did in the previous period. Of the total, the Johannesburg city sub-system contributed the largest proportion of the net downward shift in population (42.6 per cent). This sub-system also contributed a relatively lower proportion to the net upward shift than it did in 1904 to 1936. In the period 59.5 per cent of net upward shifts were concentrated in the Johannesburg city sub-system as against 75.9 per cent in the period 1904 to 1936. The Pretoria city sub-system experienced the greatest relative gain in terms of proportion of net upward shift increasing from 7.3 per cent in 1904 - 1936 to 17.16 per cent in the period 1936 - 1960. The Cape Town and Port Elizabeth city sub-systems also experienced an improvement in their relative contribution to net upward shifts in the period, while Durban's contribution remained constant.

In the period 1936 - 1960 a distinctive change took place in the relative contributions to net upward shifts of population by size of cities. Thus, of the cities with more than 500,000 persons in 1960 only Durban had experienced a net upward shift in population between 1936 and 1960. Both Johannesburg and Cape Town, on the other hand, had experienced net downward shifts. The major contribution to net upward shifts in population in the period was contributed by cities with 100,000 to 500,000 persons. Of the total nearly 41 per cent was contributed by cities of this size within the Johannesburg city sub-system. It is important to note, however, that this group of cities also contributed a relatively high proportion to the net downward shift in the period. Thus Johannesburg contributed 12 per cent and cities with 100,000 to 500,000 in the Johannesburg city system a further 19.6 per cent of the total of nearly

50 per cent downward shift. Cities with downward shifts were located principally on the Witwatersrand.

The cities in size groups between 5,000 and 50,000 persons in each case considerably improved their proportions contributed to net upward shift. This trend is particularly apparent in cities with populations between 20,000 and 50,000 persons, which, in the period 1904 - 1936 generally contributed a low proportion to net upward shifts in population. In the previous analysis these cities were noted for their relatively healthy growth patterns and these findings may suggest evidence for the outward growth of economic development from the major metropolitan centres.

CHAPTER 8

SUMMARY AND CONCLUSIONS

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While a full understanding of the structure and spatial dynamics of the South African city system must await the development of an urban systems' theory model for the country, the present study provides an initial basis from which theoretical work may commence.

The historical evolution of the system has shown that processes of growth in terms of the number of cities and of levels of urbanisation are reflected in sequential stages of growth and circular and cumulative development processes in the South African economy. In the first 220 years of growth from 1652 to 1870, the country passed through three industrial and early transitional stages of development. While the formative elements of much of contemporary South Africa were created in this time, the city system was small and poorly integrated. Coastal port centres, as the major points of interchange, encouraged circumferential development and the growth of regional economies of which the ports became the foci. Levels of integration with the interior periphery were generally weak.

The discovery of minerals, first at Kimberley and later on the Witwatersrand, introduced a major economic multiplier effect and in the mid and late transitional phases between 1870 and 1933 the expansion of the economy is reflected in the contribution of the largest increment of new urban places in South Africa's history. Kimberley, Johannesburg and other gold-mining cities of the Witwatersrand were established in this time and grew rapidly to provide new major urban foci in the interior about which the economy and networks of association were soon re-orientated. The level of urbanisation rose from an estimated 16 per cent (for the total population) in 1870 to 33 per cent in 1936. During the same period the White population resident in urban areas rose from an estimated 30 per cent in 1870 to 67 per cent in 1933.

From 1933 industrial growth has provided an additional multiplier effect and the contemporary economy falls within the industrial stage of sequential growth. Spatially, the growth of the economy and changes in population distribution have proceeded at different rates in different areas. Few new urban places have been established since 1933 and the process of urbanisation has resulted in the rapid expansion of large cities and major country towns. Today approximately 50 per cent of the total population is resident in urban areas. The White, Asiatic and Coloured population groups are most highly urbanised while the African population with a 35 per cent resident in urban areas is the least urbanised, but has experienced the most rapid rate of urbanisation in the late transitional and industrial stages of growth. Today more than 76 per cent of the urban population is resident in cities with more than 20,000 persons. While low levels of economic development may be identified in several areas occupied by the White population group, development has generally been least in the still partly subsistent African reserves. The disparity between advanced and less advanced areas has generated considerable movement of capital and people which have had a marked effect on the contemporary form not only of the economy but also of the city system.

Fundamentally the nodal structure which underpins the space economy at the national level is that of a principal metropolitan centre supported by a graded system of sub-national metropolitan cities resting upon tiers of cities of lower orders.

The city system has been shown to possess a rank-size distribution which while not conforming to a distribution predicted by the rank-size rule, occupies an intermediate position which is nearest rank-size between the limiting cases of primacy and log normality. The size relationship possesses a steplike formation in which the middle range of cities is separated from metropolitan cities by a considerable population gap. This structure, it has been suggested may reflect residual regionalism or a lack of full spatial integration with the city system at the present stage. The level of national primacy in the system is moderate, but the concentration of economic activity and the associated concentration of urban population on the Witwatersrand and in the major port cities is largely responsible for the degree of primacy present in the system. Thus, although the structure is reasonably balanced, it is headed by a set of nodally-dominant metropolitan centres of varying size which are duplicative rather than complimentary - a pattern not dissimilar to that found in Australia, New Zealand and Canada. The intermediate distribution of the city system suggests a structure characteristic of states in which the city system has evolved over a considerable period of time, and has been influenced by a complex of economic and social forces (Berry, 1961: 583 - 584).

The Witwatersrand complex of economically-integrated cities with overlapping and common service hinterlands focussed upon Johannesburg is the largest of the metropolitan nodes. It is followed by Cape Town, Durban, Pretoria, Port Elizabeth, East London, Bloemfontein, Pietermaritzburg, Kimberley, Vereeniging, Klerksdorp and the Orange Free State Goldfields metropolitan area.

Size of place and rank in an urban service hierarchy in the South African city system has been shown to be highly correlated. Thus the balanced form of rank-size distribution of cities is confirmed by a graded service hierarchy which conforms most closely to the Christaller $k = 3$ model (the marketing principle). The hierarchy is headed by the principal metropolitan centre, the Witwatersrand, and possesses in addition two levels of metropolitan cities and four orders of lower-ranking nodes. The hierarchical orders have been shown to be functionally distinct. While the numerical pyramid of the hierarchy and its spatial placement identified as an imperfect structure the findings suggest that the South African system supports the theoretical frameworks postulated by Christaller. It would appear that theoretical research on the spatial dynamics of the hierarchy would be highly profitable.

In the analyses of the economic base of the city system the economic profile of each South African city was identified. The spatial distribution of cities with high levels of specialisation in different economic sectors was shown to be non-random. The distribution of mining, and industrial cities in particular was shown to be highly localised and concentrated in particular within the principal city sub-system (an integrated set of city sub-systems including the Witwatersrand, Pretoria, Durban, Bloemfontein, and Kimberley). Local concentrations of manufacturing cities were identified also within the city sub-system of Cape Town and focussed in particular on the metropolitan cities in the Port Elizabeth and East London sub-systems.

Rank-size, economic base and service hierarchy analyses provided three distinct structural measures of the city system. An additional dimension has been added by the extraction of four rotated components in a principal components analysis of 212 cities in the system. Components 1 and 2 which accounted for approximately 40 per cent of the variants were identified as components of volume, and services. The components are distinguished by high component loadings on variables such as total population, number of central services, rateable value of property, employment in services and the number of units of electricity sold per head. Plotting component scores of component 1 on component 2 showed that relatively few cities of high ranking service order also possess high volumes of economic activity on both components. Most Major Towns (Order 4 cities), however, have high volume on component 1 and moderate volume on component 2. The majority of cities of minor town status (Order 6) have low volumes of economic activity. Cities in the immediate tier of towns (Order 5) tend to have volume on one but not both components. The findings, it was stressed, emphasised the significance of Major Towns and Towns (Orders 4 and 5) as the foci of economic development and economic concentrations in city levels below that of metropolitan city. Throughout the relative strength of the principal city system in comparison to those of Cape Town, Port Elizabeth and East London was revealed.

The analysis of growth within the city system in terms of demographic potential, absolute distribution of population and relative shifts in urban population over time all point to the prominence of the principal city sub-system as the most dynamically developing set of cities within the country.

South Africa as a whole is served by a balanced hierarchically-organised city system headed by a set of metropolitan cities of which the Witwatersrand is undoubtedly the most significant. The distribution of metropolitan cities is sufficiently balanced such that 59 per cent of the country lies within 150 miles of any of these cities. However, in those areas falling beyond that distance nodes of a low order are the main urban foci and assume roles more important than their hierarchical level may suggest. Cities of this type may occur singly or in small groups and examples are the George - Oudtshoorn and Nelspruit - Barberton groups of cities together with Upington, Pietersburg, Beaufort West, De Aar and Middleburg (Cape).

Of a total of 21 cities with populations greater than 50,000 persons, 13 are located within the Southern Transvaal (Pretoria-Witwatersrand-Vereeniging area) city region. Ten of these cities form part of the Witwatersrand principal metropolitan centres. This agglomeration of larger cities, on the one hand, introduces the measure of spatial imbalance in the city system ignored by formal rank-size analysis. On the other hand, it creates an economic environment of city interdependence and integration of considerable strength which is reflected in the summit of economic volume and welfare forming the principal focus of the national space economy.

The national focus of the Witwatersrand is supported by a distribution of cities of higher population, service rank and volume of economic activity which collectively constitutes a primary urban mesh. The mesh, which is near rank-size in distribution, includes the metropolitan cities of the Southern Transvaal, together with Durban, the Orange Free State Goldfields, Bloemfontein, Pietermaritzburg, Kimberley, Vereeniging and Klerksdorp.

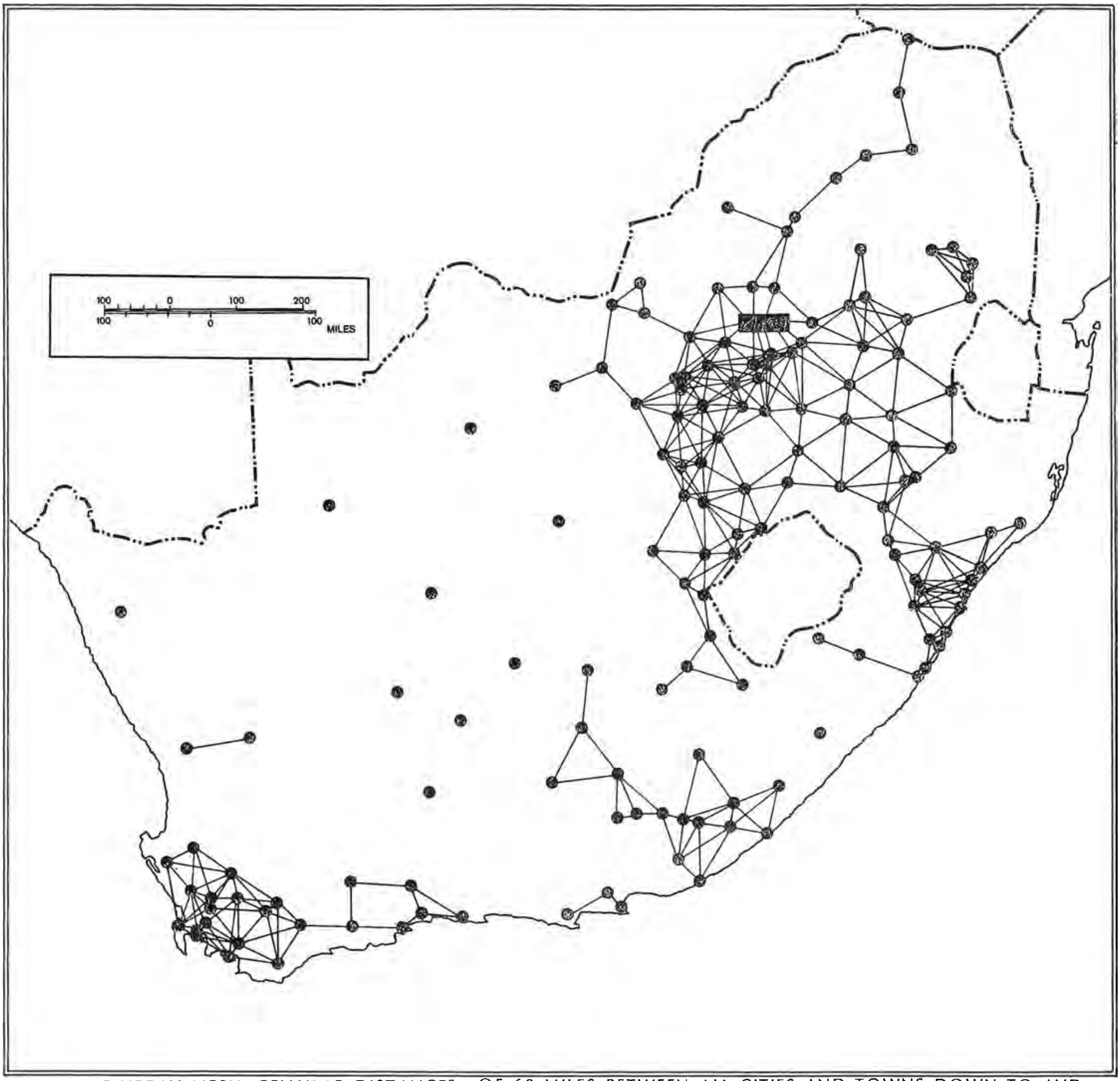
On the upper surfaces of South Africa's economic landscape, the maximum distances separating cities within the mesh at the level of Order 6A is 60 miles. In other words, the mesh on these surfaces has a 'cellular distance' equal to or less than 60 miles, and the mean distance to nearest neighbour at the Order 6A level is 26 miles.

The parts of the primary mesh which lie beyond the limit of the high and upper socio-economic surfaces are less strongly developed. Northwards the mesh is isolated in a single chain of high-ranking nodes in the central and northern Transvaal. Southwards and westwards the structure of the sub-system is characterised by a higher incidence of low-ranking cities becoming progressively less dense with distance from the Witwatersrand, so much so that in the vicinity of Bloemfontein and Kimberley higher order functions are focussed only in these metropolitan cities.

The primary mesh is supported by urban economies in which manufacturing and commerce play dominant roles. Manufacturing, furthermore, has been shown to be closely correlated to urban growth.

A highly localised secondary mesh occupies the south-west Cape and forms the inner zone of the Cape Town city sub-system. While not possessing a rank-size distribution, the mesh in the south-western Cape is closely knit and comprises a system of higher-ranking cities with relatively high populations and volumes of economic activity. The mesh is closely correlated to high levels of socio-economic development and has a maximum cellular distance measured at the Order 6A level of 40 miles. The mean distance to nearest neighbour at the Order 6A level is 25 miles. Urban economies with high levels of manufacturing and commerce reinforce the nodal strength of the mesh. At its margins the mesh declines steeply in level and in density within the remaining parts of the Cape Town city sub-system. A small localised set of cities, while tied in to the Cape Town metropolitan focus, is situated on the divide between the Cape Town and Port Elizabeth city sub-systems and comprises George, Oudtshoorn, Mossel Bay and Knysna.

The city sub-systems of Port Elizabeth and East London produce a relatively weak urban mesh commensurate with their lower levels of economic development. The mesh is particularly weak in the African reserve areas which form part of the East London city sub-system. In this respect also the marginal areas occupied by African reserves in the Durban city sub-system are comparable.



44 THE URBAN MESH: CELLULAR DISTANCES OF 60 MILES BETWEEN ALL CITIES AND TOWNS DOWN TO AND INCLUDING THE UPPER TIER OF MINOR TOWNS

In conclusion, while this report has presented some picture of the urban geography of South Africa (both presenting new material and pulling together previously published papers on the subject by the writer), it cannot be regarded as the final word on the subject. Important gaps in our knowledge, also serious gaps in our statistical data in South Africa, are evident.

The question of the urban geography of the Republic is not only of theoretical but also of applied significance (especially for planners), so that further research clearly is required. There are in particular, several major areas of concern (both microcosmic and macrocosmic in scale.) of which the main one appears to be an intensive detailed examination of the metropolitan structure of the country based on special population census fabrications. It is to be hoped that it will prove possible to obtain such tables for the 1970 census.

In a nutshell, this report is only part of a vast task, and it is hoped that it will spur research on.

A P P E N D I X A

APPENDIX A.

Concern in this appendix is with a review of methodology and procedures associated with the determination of urban hierarchies. Three principal aspects will be considered. These are a review of procedures used in the determination of centrality indices, the calculation of threshold population, and mention of procedures used in determining an index hierarchy.

Centrality Indices:

Christaller's (1933) pioneering work on the determination of an urban hierarchy employed an index derived from the relationship between the number of telephones and population in a city and its surrounding sphere of influence. The relationship is expressed in the formula

$$T_z = E_z \left(\frac{T_q}{E_q} \right)$$

where T_z is equal to number of telephones in a city, E_z is equal to the population of the city, T_q equals number of telephones in the sphere of influence, and E_q equals population of the sphere of influence of the city.

Ullman (1951), in reviewing the use of telephone data in hierarchical calculations, suggested that the telephone no longer represents an adequate measure of centrality as its use for domestic communication has become ubiquitous in more developed countries. The number of telephone calls between cities has, however, been recently used as an index of centrality, Nysteun and Dacey (1961) and Davies (1968).

Green (1948-1955) working in the United Kingdom and Western Europe used characteristics of bus services in the determination of an urban hierarchy. In South Africa the South African Railways Road Motor Transport Service provides bus services for passengers and goods to and from many urban places in the Republic. In this country, however, bus services are generally complementary to rail services, and furthermore, the differential use of bus services by White and non-White population groups introduces a complicating element.

Siddall (1961) used an index based on wholesale-retail ratios for each city. While this method holds promise the sophisticated data required is not available in South African statistical sources.

Some workers have suggested the use of a limited range of key services in determining centrality indices. Smailes (1944), working on the cities of England and Wales, used a set of key services which are in themselves specially significant as measures of different degrees of urban importance. Data on the services, furthermore, were readily and widely available. The services selected included banks, post offices, and the occurrence of Woolworths Stores, secondary schools, hospitals, cinemas, and newspapers. A centrality index based upon arbitrary groupings of the selected services permitted the identification of a 5-tier hierarchy, ranging from sub-towns to major cities. The hierarchy of England and Wales was confirmed by the work of Smith (1968) which showed that the hierarchy had remained relatively stable over time.

Bracey (1954) used 15 key services to determine an urban hierarchy in southern England. The method employed in this case, however, concerned the use of questionnaires to determine the level to which urban centres provided services for the respondents. The method enabled 2 main orders of city to be identified.

In South Africa the work of Davies (1967) has shown that the use of a set of 12 selected services, weighted by quality, may be used in the determination of an urban hierarchy for the Republic. Further reference will be made to this index hierarchy at a later stage in the appendix.

The advantages of using a limited range of key services appear to lie in the reduction of work required to determine an urban hierarchy, and the facility which it provides to rapidly update the hierarchy periodically. The major disadvantages, however, are associated with the selection of key services which of necessity is likely to be an arbitrary process.

The most satisfactory methods of determining a centrality index are those based upon the use of the total number of services in cities. The work of Brush (1953) is an early study in which an index was derived for small urban places in south-west Wisconsin using the total number of business and service establishments in each place. In 1955 Brush and Bracey undertook a comparative analysis of urban centres in south-west Wisconsin and south-east England using questionnaires to establish the functional relationship of cities.

King (1961) derived a classification of New Zealand cities employing the concept of threshold populations for 51 services. He found close correlations between the number of service units and population in cities. Scott (1964), working in Tasmania, used simple regression analysis in measuring the relationship between the number of services and number of service units. The method enabled six orders of city to be established for the island.

Davies (1967) developed an index in which the amount of centrality contributed by each function to a city, is taken to be proportional to the number of establishments of that function present in the city, with the total number of establishments of that function in the entire system having a combined centrality value of 100. The centrality value of a single establishment of any function is termed the <u>location coefficient</u> of that function. The location coefficient is defined as $C = 100\frac{t}{T}$ where t is unity, representing one establishment of function t; and T is the total number of establishments of function t in the set of cities.

The total centrality of a city is derived by summing the centrality contributed by each function. Centrality indices derived by this method have the merit of taking into account variations between cities in both numbers of functions and numbers of establishments. It distinguishes effectively between ubiquitous functions and rare functions and in essence attempts to achieve the same ends as does a functional weighted scoring system.

The most rigorous methods used thus far have been employed by Berry and Garrison (1958a, b, c) using the functional basis technique which was used in the determination of the South African hierarchy, on the one hand, and factor analysis used by Berry (1967), on the other.

<u>Threshold Population.</u>

The minimum number of consumers necessary to support the supply of a particular service is termed its threshold value. Closely related to the concept of threshold population is that of the range of the service. The lower limit of the range coincides with the area enclosing the threshold population. The upper limit is, under ideal conditions, the maximum possible radius attained, but more realistically extends as far as the zone in which competition from another centre becomes overwhelming.

Ideally, the calculation of threshold populations should be based on the population of the city together with its sphere of influence. Populations of hinterland areas are very difficult to determine, however, more particularly where an entire country is being studied. The calculation of thresholds, using only the city population, has been justified on the grounds that the city population comprises a very high proportion of the total population served by a city service. Furthermore, threshold populations in this study have not been used to determine absolute levels, useful in such fields as market research, but as parameters in the classification of hierarchical levels.

The methods used in the determination of threshold values are those suggested by the work of Berry and Garrison (1958a) which enable the relationship between the number of units of a service and the population of a city, to be determined.

The properties of attribute and variate services necessitate the use of two different procedures in the manipulation of the data. In the case of attributes two possiblities exist. Either one service unit exists in a city or else it does not. Under these circumstances the number of occurrences may be regarded as a section of the normal distribution which takes only two values into account vide: 0 and 1. The point-biserial correlation coefficient is suggested by Berry and Garrison to be the most satisfactory parameter for obtaining discrete values for each of the attribute services. The calculated values have the characteristic that as fewer attributes occur, and as they occur with more variates, so the correlation coefficient assumes steadily-increasing values. The point-biserial correlation coefficient may be obtained by the application of the formula:

$$r_{pb} = \frac{(\bar{x}_1 - \bar{x}_2)(pq)^{\frac{1}{2}}}{\sigma x}$$

where x_1 is the total population of cities possessing an attribute, x_2 is the total population of cities without the attribute, p is the true proportion of the values of N, $q = 1 - p$, and sigma equals sample variates:

vide $\sqrt{\frac{\Sigma(x^2)}{N-1} - \bar{x}^2}$; n, is the number of cities which possess the attribute and n_2 the number of cities without the attribute.

The application of the technique is applicable only where binomial distribution exists for it involves a comparison between the means of two samples of the population. The values of the point-biserial correlation coefficients for 11 attributes recorded for the South African city system appear in Table 40. Ranking of the r_{pb} values appears to support the weights assigned to attributes in assessing their quality.

TABLE 68

Comparison of the 1966 Comprehensive and the Index Hierarchies.

Comprehensive Hierarchy Rank of urban place	Index Hierarchy Urban places corresponding in order	Shifts in Order of places in the Index Hierarchy Shift Upwards	 Shift Downwards
ORDER 1			
Witwatersrand	Witwatersrand		
ORDER 2			
Cape Town	Cape Town		
Durban	Durban		
Pretoria	Pretoria		
ORDER 3			
Port Elizabeth	Port Elizabeth		
Bloemfontein	Bloemfontein		
Pietermaritzburg	Pietermaritzburg		
East London	East London		
Kimberley	Kimberley		
O.F.S. Goldfields	O.F.S. Goldfields		
Vereeniging	Vereeniging		
Klerksdorp	Klerksdorp		
ORDER 4			
Paarl	Paarl		
Kroonstad	Kroonstad		
Potchefstroom	Potchefstroom		
Worcester	Worcester		
Pietersburg	Pietersburg		
Uitenhage	Uitenhage		
Grahamstown	Grahamstown		
Stellenbosch	Stellenbosch		
Queenstown	Queenstown		
Vanderbijlpark			
Oudtshoorn	Oudtshoorn		
George	George		
Rustenburg			
Witbank			
K. Williams Town	K. Williams Town		
Carletonville			
Bethlehem	Bethlehem		
Ladysmith	Ladysmith		
Umtata	Umtata		
		Graaff Reinet	
		Cradock	
ORDER 5			
			Van der Bijl Park
			Rustenburg
			Witbank
Upington	Upington		
Nelspruit	Nelspruit		
Ermelo	Ermelo		
Cradock			
Strand			
Standerton	Standerton		
Graaff Reinet			
Dundee	Dundee		
Port Shepstone	Port Shepstone		
Somerset West	Somerset West		
Mosselbay	Mosselbay		
Lichtenburg	Lichtenburg		

Nigel	Nigel		
Beaufort West	Beaufort West		
Potgietersrus	Potgietersrus		
Eshowe	Eshowe		
Wellington	Wellington		
Estcourt	Estcourt		
Louis Trichardt			—
Sasolburg			—
Aliwal North	Aliwal North		
Vryburg	Vryburg		
Heidelberg (T)	Heidelberg (T)		
Stanger	Stanger		
Newcastle	Newcastle		
Knysna	Knysna		
Mafeking	Mafeking		
Tzaneen			—
Middelburg (T)	Middelburg (T)		
Empangeni	Empangeni		
Parys	Parys		
Malmesbury	Malmesbury		
Kokstad	Kokstad		
Bethal	Bethal		
Middelburg (C)	Middelburg (C)		
De Aar	De Aar		
Somerset East	Somerset East		
Vryheid	Vryheid		
Greytown	Greytown		
Harrismith	Harrismith		
Hermanus			—
Ficksburg	Ficksburg		
Stilfontein			—
Piet Retief	Piet Retief		
Brits			—
Robertson			—
Barberton	Barberton		
Ceres	Ceres		
Senekal	Senekal		
Margate			—
Lydenburg	Lydenburg		
Volksrust	Volksrust		
Riversdale	Riversdale		
Caledon	Caledon		
White River			—
Nylstroom			—
Warmbaths			—
		Humansdorp	
		Fort Beaufort	
		Ladybrand	
		Vrede	
		Stutterheim	
		Winburg	
		Calvinia	
		Matatiele	
		Alice	
		Victoria West	
		Willowmore	
		Tarkastad	
		Uniondale	
		Barkley East	
		Colesburg	
ORDER 6			
			Strand
			Louis Trichardt
			Sasolburg
			Tzaneen
			Hermanus
			Stilfontein
			Brits
			Robertson

				Margate
				White River
				Nylstroom
				Warmbaths
				Carletonville
Humansdorp				
Fort Beaufort				
Orkney				
Heilbron	Heilbron			
Zeerust	Zeerust			
Swellendam	Swellendam			
Verulam	Verulam			
Kuruman	Kuruman			
Bothaville	Bothaville			
Ladybrand				
Butterworth	Butterworth			
Vrede				
Ventersdorp	Ventersdorp			
Howick	Howick			
Springbok	Springbok			
Bredasdorp	Bredasdorp			
Zastron	Zastron			
Wolmaranstad	Wolmaranstad			
Stutterheim				
Schweizer-Reneke	Schweizer-Reneke			
Theunissen	Theunissen			
Frankfort (O)	Frankfort (O)			
Vredendal	Vredendal			
Port Alfred	Port Alfred			
Scottburgh	Scottburgh			
Winburg				
Reitz	Reitz			
Viljoenskroon	Viljoenskroon			
Adelaide	Adelaide			
Glencoe	Glencoe			
Carolina	Carolina			
Calvinia				
Matatiele				
Delmas	Delmas			
Tongaat				
Montagu	Montagu			
Umkomaas				
Wepener	Wepener			
Groblersdal	Groblersdal			
Burghersdorp	Burghersdorp			
Clocolan	Clocolan			
Despatch				
Umzinto	Umzinto			
Mooreesburg	Mooreesburg			
Kuilsrivier				
Alice				
Carnarvon	Carnarvon			
Hartswater	Hartswater			
Koppies	Koppies			
Mooi River	Mooi River			
Piketberg	Piketberg			
Messina	Messina			
Colesburg				
Meyerton				
Prieska	Prieska			
Henneman	Henneman			
Ixopo	Ixopo			
Thabazimbi	Thabazimbi			
Barkley East				
Thaba Nchu	Thaba Nchu			
Ladismith	Ladismith			
Wesselsbron	Wesselsbron			
Victoria West				
Sabie	Sabie			

Bedford	Bedford		
Richmond (N)	Richmond (N)		
Delareyville			—
Vredenburg	Vredenburg		
Dewetsdorp	Dewetsdorp		
Belfast	Belfast		
Fochville	Fochville		
Bronkhorstspruit	Bronkhorstspruit		—
Uvongo			
Warrenton	Warrenton		
Douglas	Douglas		
Kirkwood	Kirkwood		—
Evander			—
De Doorns			
Bethulie	Bethulie		
Grabouw	Grabouw		
Warden	Warden		
Christiana	Christiana		
Bloemhof	Bloemhof		
Willowmore		—	
Mt. Frere	Mt. Frere		
Porterville	Porterville		
Brandfort	Brandfort		
Dordrecht	Dordrecht		
Sannieshof	Sannieshof		
Coligny	Coligny		
Koster	Koster		
Cathcart	Cathcart		
Bergville	Bergville		
Bultfontein	Bultfontein		
Heidelberg (C)	Heidelberg (C)		
Maclear	Maclear		
Waterval Boven	Waterval Boven		
Elliot	Elliot		
Jan Kemp Dorp	Jan Kemp Dorp		
Lindley	Lindley		
Molteno	Molteno		
Clanwilliam	Clanwilliam		
Vredefort			—
Hoopstad	Hoopstad		
Harding	Harding		
Amersfoort	Amersfoort		
Jaggersfontein	Jaggersfontein		
Engcobo	Engcobo		
Petrus Steyn	Petrus Steyn		
Aberdeen	Aberdeen		
Balfour (T)	Balfour (T)		
Marquard	Marquard		
Keimoes	Keimoes		
Komgha	Komgha		
Peddie	Peddie		
Phalaborwa	Phalaborwa		
Sutherland	Sutherland		
Plettenberg Bay	Plettenberg Bay		
Mtubatuba			—
Villiers	Villiers		
Laingsburg	Laingsburg		
Postmasburg	Postmasburg		
Duiwelskloof	Duiwelskloof		
Dannhauser			—
Jansenville	Jansenville		
Klawer			—
Alexandria	Alexandria		
Steynsburg	Steynsburg		
Frasersburg	Frasersburg		
Tarkastad		—	
Albertinia	Albertinia		
Edenburg	Edenburg		
Leslie	Leslie		
Idutywa			—

Smithfield	Smithfield		
Noupoort	Noupoort		
Koffiefontein	Koffiefontein		
Prince Albert	Prince Albert		
Boshof	Boshof		
Ventersburg	Ventersburg		
Indwe	Indwe		
Uniondale			
Tulbagh	Tulbagh		
Barkley West	Barkley West		
Bonnievale	Bonnievale		
Wolseley	Wolseley		
Citrusdal	Citrusdal		
Sterkstroom	Sterkstroom		
Ottosdal	Ottosdal		
Morgenzon	Morgenzon		
Naboomspruit	Naboomspruit		
Joubertina	Joubertina		
Hopetown	Hopetown		
Fauresmith	Fauresmith		
Kenhardt	Kenhardt		
Groot Marico	Groot Marico		
Hopefield	Hopefield		
Swartruggens			
Vanrhynsdorp	Vanrhynsdorp		
Cala			
Tsolo			
Excelsior	Excelsior		
Paulpietersburg	Paulpietersburg		
Steytlerville	Steytlerville		
Petrusburg	Petrusburg		
Williston	Williston		
Steynsrus	Steynsrus		
Utrecht	Utrecht		
Nongoma	Nongoma		
Touwsriver			
Lady Grey	Lady Grey		
		Richmond (C)	
		Kestel	
		Rouxville	
		Trompsburg	
		Reddersburg	
		Pofadder	
		Olifantshoek	
		Philippolis	
		Calitzdorp	
		Hanover	
		Breyton	
		Griquatown	
		Weenen	
		Wakkerstroom	
		Villiersdorp	
		Murraysburg	
		Hofmeyr	
		Hendrina	
		Fouriesburg	
		Edenville	
		Jamestown	
		Garies	
		Hertzogville	
		Britstown	
		Taungs	
		Springfontein	
		Amsterdam	
		Dealesville	
ORDER 7			
			Orkney
			Tongaat
			Umkomaas

			Kuilsrivier	
			Meyerton	
			Delareyville	
			Despatch	
			De Doorns	
			Vredefort	
			Mtubatuba	
			Dannhauser	
			Klawer	
			Idutywa	
			Swartruggens	
			Cala	
			Tsolo	
			Touwsriver	
Richmond (C)		—		
Port St. Johns	Port St. Johns			
Trichardt			—	
Kestel		—		
Melmoth	Melmoth			
Willowvale	Willowvale			
Rouxville		—		
Trompsburg		—		
Reddersburg		—		
Lusikisiki	Lusikisiki			
Pofadder		—		
Oogies	Oogies			
Colenso	Colenso			
Olifantshoek		—		
Philippolis		—		
Velddrif	Velddrif			
Kranskop	Kranskop			
Nqeleni	Nqeleni			
Calitzdorp		—		
Philipstown	Philipstown			
Paterson			—	
Cedarville			—	
Hanover		—		
Louriesfontein	Louriesfontein			
Breyton		—		
Rawsonville			—	
Griquatown		—		
Marble Hall			—	
New Hanover	New Hanover			
Winterton			—	
Tweespruit	Tweespruit			
Kinross			—	
Weenen		—		
Wakkerstroom		—		
Darling	Darling			
Qumbu	Qumbu			
Franschoek	Franschoek			
Port Nolloth	Port Nolloth			
Shakaskraal			—	
Villiersdorp		—		
Murraysburg		—		
Leeudoringstad	Leeudoringstad			
Hofmeyr		—		
Lady Frere			—	
Jacobsdal			—	
Hendrina		—		
Fouriesburg		—		
Nottingham Road			—	
Napier	Napier			
Venterstad	Venterstad			
Edenville		—		
Bizana	Bizana			
Flagstaff	Flagstaff			
Brandvlei	Brandvlei			
Ugie	Ugie			

Jamestown		—	
Mapumulu	Mapumulu		
Pongola			—
Patensie	Patensie		
Komatipoort			—
Cullinan	Cullinan		
Garies		—	
Pearston	Pearston		
Hertzogville		—	
Great Brak River	Great Brak River		
Bulwer	Bulwer		
Petrusville	Petrusville		
Britstown		—	
Mtunzini	Mtunzini		
Taungs		—	
Springfontein		—	
Saldanha			—
Camperdown	Camperdown		
Amsterdam		—	
Dealesville		—	
Machadadorp			—
Gansbaai	Gansbaai		
Louwsburg	Louwsburg		
Paul Roux	Paul Roux		
Libode	Libode		
Nqamakwe	Nqamakwe		
Wasbank	Wasbank		
Riebeek West	Riebeek West		
Kentani	Kentani		
Keiskamahoek	Keiskamahoek		
Nababiep			—
Ingwavuma	Ingwavuma		
Hartbeesfontein	Hartbeesfontein		
Barrydale	Barrydale		
Underberg	Underberg		
Vierfontein			—
Gordons Bay			—
Cofimvaba	Cofimvaba		
Tweeling	Tweeling		
Elliotdale	Elliotdale		
Nkandhla	Nkandhla		
Pilgrimsrest	Pilgrimsrest		
Memel	Memel		
Kareedouw	Kareedouw		
Hankey	Hankey		
Gingindhlovu			—
Rosendal	Rosendal		
Mqanduli	Mqanduli		
Lambertsbay	Lambertsbay		
Mt. Fletcher	Mt. Fletcher		
Mhlabatini	Mhlabatini		
Seymour	Seymour		
Reivilo	Reivilo		
Graafwater	Graafwater		
Klipplaat	Klipplaat		
Sibasa	Sibasa		
Berlin	Berlin		
Perdekop			—
Graskop			—
Himeville	Himeville		
Sundra			—
Magudu	Magudu		
Wartburg	Wartburg		
Riviersonderend	Riviersonderend		
Hobhouse	Hobhouse		
Mandini	Mandini		
Tsomo	Tsomo		
Soekmekaar			—
Ramsgate			—
St. Lucia			—

Niekerkshoop	Niekerkshoop		
Marydale			—
Strydenburg	Strydenburg		
Cornelia	Cornelia		
Ashton			—
Danielskuil	Danielskuil		
De Rust	De Rust		
Haenertsburg			—
Tugela Ferry	Tugela Ferry		
Dalton			—
Sterkspruit	Sterkspruit		
Greylingstad			—
Devon			—
Hibberdene			—
Darnall			—
Mt. Ayliff	Mt. Ayliff		
Lutzville	Lutzville		
		Ubombo	
		Umzimkulu	
		Balfour (C)	
		Van Wyksvlei	
		Greyton	
		Vosburg	
		Stella	
		Stanford	
		Kamieskroon	
		Babanango	
		Merweville	
		Nieuwoudtville	
		Cookhouse	
		Charlestown	
		Tabankulu	
		Riebeekkasteel	
		Steinkopf	
		Nuwerus	
		Van Wyksdorp	
		Annerley	
		Rietbron	
		Whittlesea	
		Umbumbulu	
		Riebeek East	
ORDER 8			
			Uvongo
			Evander
			Trichardt
			Paterson
			Cedarville
			Rawsonville
			Marble Hall
			Winterton
			Kinross
			Shakaskraal
			Lady Frere
			Jacobsdal
			Nottingham Road
			Pongola
			Komatipoort
			Saldanha
			Machadadorp
			Nababiep
			Vierfontein
			Gordons Bay
			Gingindhlovu
			Perdekop
			Graskop
			Sundra
			Soekmekaar
			Ramsgate
			St. Lucia

				Marydale
				Ashton
				Haenertsburg
				Dalton
				Greylingstad
				Devon
				Hibberdene
				Darnall
Marikana	Marikana			
Sishen	Sishen			
Wilderness	Wilderness			
Loxton	Loxton			
Ubombo		—		
Umzimkulu		—		
Verkeerdevlei	Verkeerdevlei			
Balfour (C)		—		
Van Wyksvlei		—		
Stilbaai	Stilbaai			
Greyton		—		
Vosburg		—		
Kwambonambi	Kwambonambi			
Kleinmond	Kleinmond			
Luckoff	Luckoff			
Stella		—		
Donnybrook	Donnybrook			
Stanford		—		
Kamieskroon		—		
Babanango		—		
Merweville		—		
P. Alfred Hamlet	P. Alfred Hamlet			
Creighton	Creighton			
Nieuwoudtville		—		
Cookhouse		—		
Charlestown		—		
Biesiesvlei	Biesiesvlei			
Tabankulu		—		
Eloff	Eloff			
Moolman	Moolman			
Riebeekkasteel		—		
Dullstroom	Dullstroom			
Roedtan	Roedtan			
Steinkopf		—		
Koringberg	Koringberg			
Genadendal	Genadendal			
Jeffreys Bay	Jeffreys Bay			
Cato Ridge	Cato Ridge			
Nuwerus		—		
Bathurst	Bathurst			
Eendekuil	Eendekuil			
Franklin	Franklin			
Makwassie	Makwassie			
Middeldrif	Middeldrif			
Hlabisa	Hlabisa			
Whites	Whites			
Gonubie	Gonubie			
Amalia	Amalia			
O'Kiep	O'Kiep			
Rosetta	Rosetta			
Brackenfell	Brackenfell			
Van Wyksdorp		—		
Hogsback	Hogsback			
Pomeroy	Pomeroy			
Ohrigstad	Ohrigstad			
Van Dyksdrift	Van Dyksdrift			
McGregor	McGregor			
Gouda	Gouda			
Penge	Penge			
Sedgefield	Sedgefield			
Ottoshoop	Ottoshoop			

Dendron	Dendron		
Oranjeville	Oranjeville		
Port Edward	Port Edward		
Arlington	Arlington		
Lothair	Lothair		
Modderrivier	Modderrivier		
Van Reenen	Van Reenen		
Chrissiemeer	Chrissiemeer		
Davel	Davel		
Eersterivier	Eersterivier		
Alicedale	Alicedale		
Umtentweni	Umtentweni		
Kei Road	Kei Road		
Blanco	Blanco		
Keimouth	Keimouth		
Southport	Southport		
Frankfort (C)	Frankfort (C)		
Impendhle	Impendhle		
Henley-on-Klip	Henley-on-Klip		
Dibeng	Dibeng		
Amatikulu	Amatikulu		
Langebaan	Langebaan		
Mamre	Mamre		
Sir Lowrys Pass	Sir Lowrys Pass		
Aurora	Aurora		
Redelingshuis	Redelingshuis		
Windsorton	Windsorton		
Annerley			
Leipoldtville	Leipoldtville		
Saron	Saron		
Eendrag	Eendrag		
Shakas Rock	Shakas Rock		
Soutpan	Soutpan		
Clarens	Clarens		
Sezela	Sezela		
Ndwedwe	Ndwedwe		
Herbertsdale	Herbertsdale		
Delportshoop	Delportshoop		
Rhodes	Rhodes		
Nieu Bethesda	Nieu Bethesda		
Deneysville	Deneysville		
Kendal	Kendal		
Southbroom	Southbroom		
Kwelera	Kwelera		
Mkuze	Mkuze		
Sonop	Sonop		
Kenton-on-Sea	Kenton-on-Sea		
Krakeelrivier	Krakeelrivier		
Vanstadensrus	Vanstadensrus		
Lions River	Lions River		
Kingsley	Kingsley		
Rietbron			
Boetsap	Boetsap		
Kidds Beach	Kidds Beach		
Umlaas Road	Umlaas Road		
Haarlem	Haarlem		
Umdhloti	Umdhloti		
Keurboomstrand	Keurboomstrand		
Charl Cilliers	Charl Cilliers		
Whittlesea			
Hattingspruit	Hattingspruit		
Elim	Elim		
Stompneusbaai	Stompneusbaai		
Campbell	Campbell		
Dysselsdorp	Dysselsdorp		
Rosmead	Rosmead		
Hawston	Hawston		
Daleside	Daleside		
Onrusrivier	Onrusrivier		
Bot River	Bot River		

Firgrove	Firgrove		
Hertzog	Hertzog		
Hermon	Hermon		
Philadelphia	Philadelphia		
Sea Park	Sea Park		
Rayton	Rayton		
Umbumbulu			
Paternoster	Paternoster		
Ouseepkrans	Ouseepkrans		
St. Marks	St. Marks		
Riebeek East			
Tylden	Tylden		
Richards Bay	Richards Bay		
Lidgetton	Lidgetton		
Suurbraak	Suurbraak		
Bakerville	Bakerville		
Rossouw	Rossouw		
Kaapsehoop	Kaapsehoop		
Migdol	Migdol		
Grassmere	Grassmere		
Bell en Bodiam	Bell en Bodiam		
Klein-Brakrivier	Klein-Brakrivier		
Hutchinson	Hutchinson		
Kleinsee	Kleinsee		
Pacaltsdorp	Pacaltsdorp		
Cedara	Cedara		
Rooigrond	Rooigrond		
Longlands	Longlands		
Vioolsdrif	Vioolsdrif		
Matjiesfontein	Matjiesfontein		
Clever	Clever		
Geysdorp	Geysdorp		
Sheepmoor	Sheepmoor		
Hamburg	Hamburg		
Ottowa	Ottowa		
Pniel	Pniel		
Iswepe	Iswepe		
Bettys Bay	Bettys Bay		
Drummond	Drummond		
Ulco	Ulco		
Witsand	Witsand		
Tweedie	Tweedie		
Klaarstroom	Klaarstroom		
Waterford	Waterford		
Kromdraai	Kromdraai		
Morgans Bay	Morgans Bay		
Haga-Haga	Haga-Haga		
Goedemeod	Goedemeod		
Struisbaai	Struisbaai		
Boesmanskop	Boesmanskop		
Slurry	Slurry		
Albert Falls	Albert Falls		
Boesmansrivier	Boesmansrivier		
Hondeklipbaai	Hondeklipbaai		
Macleantown	Macleantown		
Sunwich Port	Sunwich Port		
Compensation	Compensation		
Wuppertal	Wuppertal		
Natures Valley	Natures Valley		
Esperanza	Esperanza		
De Hoek	De Hoek		
Nondweni	Nondweni		
Felixton	Felixton		
Carlisonia	Carlisonia		
Ritchie	Ritchie		
Baardskeerdersbos	Baardskeerdersbos		
Wooldridge	Wooldridge		
Waterkloof	Waterkloof		

In the determination of threshold populations for variate services a regression calculated to fit a distribution of the exponential growth type ($y = ab^x$) is used. Where y = the population, and x = the number of service units occurring, and a and b are parameters estimated from the data.

The formula: $y = a(b^x)$ reduces to the form

$\log y = \log a + x \log b.$

The least squares technique has been used to ensure that the sum of the squares of the differences between logarithmic values of the population and the regression line is as small as possible. This has meant that the dependence of the logarithmic values is minimised but does not affect the utility of the method, for the final result takes the anti-logarithmic form.

The regression drawn for each service enables the threshold population to be determined as well as the rate at which the number of service units increases with population size. The relevant values are illustrated in Table 41 in which the mean population for all cities having only one service unit of a particular type has also been calculated.

In general threshold populations determined by the regression method appear to provide realistic estimates. Some anomalies do, however, exist and include in particular a discrepancy in threshold between White secondary schools and primary schools. At least one of the values is obviously incorrect. Other threshold values which may be regarded with suspicion include those for bank agencies, bank branches, hospitals and accounting firms.

Comparing mean values with threshold levels shows that thresholds are generally lower than the means. This may be expected if threshold populations are realistic measures of the approximate number of people required to support a service unit. In some cases, however, (attorney/lawyer, hardware store, tea room, speciality shop, butcher, doctor, and garage), threshold values are somewhat higher than mean populations. In these cases both threshold population and mean values should be regarded with some suspicion.

Index Urban Hierarchy.

An Index Urban Hierarchy may be determined by using a set of 12 index central functions which in Smailes' words 'appear themselves to be especially significant as measures of different degrees of urban importance and because at the same time they are readily and widely applicable'. (Smailes, 1944). The index functions selected are representative of those which occur in more complex higher order centres and those which occur more ubiquitously.

The data were collected for the 601 cities previously used in the determination of an urban hierarchy using more rigorous methods.

Differences in the level or quality of the selected functions have been recognised by assigning a weighted score to each function. The scores correspond to those listed in Table 38. The centrality index of a city is determined by the summation of weighted scores assigned to the functions it possesses.

A graphical relationship of centrality index and total population enables groups of cities to be identified by distinctive breaks in the curve of centrality index scores. Breaks in score may be subjected to statistical tests to determine their significance.

The procedure identified an eight tier hierarchy and the cities are ranked by hierarchical order in Table 68 where a comparison between the hierarchy determined by the Berry and Garrison (1958) method and the Index Method may be made. Statistically a high level of correlation by hierarchical order may be demonstrated. Furthermore a Spearmans Rank Correlation Coefficient between ranked centrality index scores on the two hierarchies carried out for cities in Natal for example has a value of 0.83 significant at the .01 level. It is apparent that the Index hierarchy achieves acceptable results and it may be used where rapid updating of the hierarchy is required.

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