
Kang Cheong. Chan

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A FACTORIAL ECOLOGY OF
SINGAPORE, 1970

by
Kang Cheong Chan

Submitted to the Department of Geography of
The University of Windsor in partial
fulfillment of the requirements for
the degree of Master of Arts

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A FACTORIAL ECOLOGY OF
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ABSTRACT

Factorial ecology approach has been applied for studying the urban social and spatial structure of a large Asian city, Singapore. Thirty-five variables reflecting the demographic, ethnic, family, housing, and occupational characteristics of Singapore's population of 1970, were selected. In order to identify the basic dimensions of the social structure, principal component analysis is employed for factoring the data used. The technique employed extracted six factors from the data matrix, which together explained about 84% of the total variance. These derived factors are: Family status, Occupational status, Poor Housing, Socioeconomic Status, Ethnic Pluralism, and Malay Occupational Status. These factors indicated the basic characteristics of Singapore's urban society. Obviously, the basic structure is significantly different from that of Western cities. However, there exist some minor similarities, for instance, the factor structure and spatial pattern of the social status, family status, and ethnic status in Singapore are nearly the same as those of Western cities. Thus, Shevky's typology has been partly confirmed in the case of Singapore. Furthermore, the results of this study show that factorial ecology approach is useful in studying the urban social and spatial structure of non-Western cities.
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CHAPTER ONE
INTRODUCTION

1.1 Nature of The Study.

The urban society of most twentieth century cities is quite heterogeneous with respect to the socioeconomic, demographic, and ethnic characteristics. In addition, the spatial distribution pattern regarding the above characteristics within an urban society is not homogeneous. This spatial differentiation of urban population is mainly due to social, economic, and cultural factors. For example, it has been shown that individuals prefer to reside in neighbourhoods containing households of similar characteristics. This residential bias contributes to the spatial segregation of the urban society. As a result, people living in one part of the city may be entirely different from those living in other parts of the city. As cities become larger, the pattern of residential segregation becomes more distinctive. Consequently, within a large urban society there may exist many socially, economically, and culturally different urban communities.

The process of the evolution of these urban communities and their spatial distribution patterns, and the responsible factors involved has interested many social scientists for decades. For further understanding of these urban communities...
and in order to provide more information for urban development and social reformation, social scientists looked at the urban society in various ways.

In the early 19th century, in North America, human ecologists (such as Park and Burgess) applied biological ecology concepts in their studies of human urban communities. Burgess suggested a concentric model for describing the urban growth in a wave-shaped pattern. Later, in the late 1930s, Hoyt applied land value concepts in his study of urban development in American cities, and derived a sectoral model. Basically, these researchers were interested in studying the spatial pattern of urban growth. Shifting away from the spatial aspect, urban sociologists (such as Shevky and his associates) in the nineteen fifties concerned themselves with the social structure of the city, and suggested social area analysis for studying urban social structure. Recently, by coordinating and modifying the results and methods of those previous studies, urban geographers obtained a new approach, that is, factorial ecology. By the aid of modern statistical and computational techniques, factorial ecologists have broadened the scope of those classical studies. They, therefore, are able to look more closely at the social and spatial structure of modern urban society.

The factorial ecological approach has been widely and successfully used in the studies of western cities (such as
Zurdie, 1969; Rees, 1970; Haynes, 1971; Herbert, 1971; Davies and Barrow, 1973; and Parkes, 1973). The vast majority of these studies found that this approach was useful in studying the urban social and spatial structure. By means of this approach, the underlying social characteristics of these cities have been clearly shown so that further understanding of urban society was achieved.

Being a useful approach, factorial ecology, however, has seldom been used in studying the urban social geography of Asian cities. This study, then, is aimed at applying such an approach to study the intra-urban social geography of Singapore, one of the larger cities in Asia.

1.2 Area of The Study

Singapore, the area chosen for this study, is the smallest nation, but the largest city in Southeast Asia. Its outstanding social and economic development and its complex urban society have been studied by many local and foreign scholars.

The existing studies concerning Singapore, however, are mainly done on a macro scale base and are involved only in describing the individual population characteristics of the urban society. Mostly, these studies deal with the ethnic and demographic characteristics (Hodder, 1953; Neville, 1965, 1969; You, 1967), socioeconomic and housing status (Yeh, 1962; Yeh and Lee, 1968; Weldon and Tan, 1969; Hassan,
1970), and the recent urban and housing development (Choe, 1969; Teh, 1969; Yeung, 1970; Yeh, 1972; Yeh and Kwok, 1972; Yeh and Pan, 1973). These studies have shown the general characteristics of the population, and also the trend of the change in these characteristics. In addition, these studies have shown the influences of Singapore's historical and social background on the present socioeconomic characteristics. However, they have not investigated further the social structure by coordinating those individual characteristics into a systematical study. Thus, the results of these studies are piecemeal and uncoordinated.

Apart from the above-mentioned studies, there have some studies concerning the whole urban society of Singapore as a whole. These studies (such as McGee, 1967; Bu-chanan, 1972; Yeung, 1973) related each of the population characteristics to the whole social and economic structure of Singapore. Thus, they have shown the interrelations of those characteristics and have elaborated the results of the interactions of those characteristics. However, these studies failed to identify the basic urban social structure of Singapore, and also failed to investigate the areal differentiation of the social structure.

As a whole, previous studies have shown only the general population characteristics of Singapore, the internal social structure of the city has not been adequately investigated.
1.3 Purpose and Objectives of The Study

As those previous studies concerning Singapore were limited in scope, the purpose of this study is to analyse and to describe the urban social and spatial structure of Singapore more completely by employing the latest data, on a small unit base, and by applying an advanced approach.

The four objectives of this study are:

1) to find out the underlying dimensions of the internal social structure of Singapore;

2) to compare these underlying dimensions of Singapore with those of Western cities, and to see in what way and to what extent the urban structure of Singapore differs from Western cities;

3) to investigate the areal differentiation of the urban structure of Singapore; and

4) to compare the results of this study with those obtained from less detailed research endeavours in order to ascertain the comparability of findings obtained at different levels of intensity of research.
CHAPTER TWO
REVIEW OF LITERATURE

In this chapter, we are going to look at the basic thoughts, contributions, and works of the previously mentioned streams of urban study. Chronologically, the classical studies will first be dealt with, then the current factorial ecological studies will be examined. A review of former works on Singapore will be done in the later section of this chapter.

2.1 Classical Studies on Urban Structure

Some of the pioneering works on urban spatial structure were done by classical urban ecologists such as Park, McKenzie, and Burgess (1925). These urban ecologists were interested in studying the evolution of urban community structure. The ideas and concepts which they used in discussing the evolution of urban structure were borrowed directly from biological ecology; these were: "dominance", "succession", and "invasion" (Robson, 1969; Timms, 1971; Carter, 1973). The process of these ecological phenomena was applied to the process of human communities. For example, the residential areas were invaded by commercial and business undertakings, and higher status residential areas were invaded by lower income groups (Robson, 1969:11). Based on these biological concepts, and based on his study of Chicago, Burgess derived
a concentric model which showed the urban structure of Chicago in five concentric zones. This concentric model implies that each inner zone of the urban structure expands outwards by invading the adjacent outer zones. The model thus implies that the social rank of the population increased with distance from the center of the city. In other words, the residential pattern of the city was that poor housing (associated with high land value) was located in the city center, whereas the good housing was located at the periphery of the city.

In the late 1930s, a modified model was developed based on the rental value of land by Hoyt (1939). Deriving his model from a study of the housing characteristics of 142 U.S. cities, Hoyt found that the highest rental residential area was located in one or more sectors on the side of the cities, and the average rental value increased with increasing distance from the center of the city. Therefore, the general pattern of residential distribution can be explained by a sector model. However, within each of the sectors, the high value housing was not growing outwards homogeneously, but mingled with lower value housing.

Both Burgess and Hoyt attempted to explain the complex spatial urban structure through univariant procedures. Later studies which employed these models found inconsistencies in results obtained since the observed high value housing was
not necessarily distributed in a sectoral pattern or located at the outer zones of the city. The failure of these early models to have universal consistency and to explain the urban structure adequately resulted in the development of new procedures and new theories.

2.2 Social Area Analysis

Social area analysis was first introduced by Shevky and Williams (1949), and then modified by Shevky and Bell (1955). It was developed for studying the social structure of a city. The essence of this approach lies in the basic assumption that "the city is a product of the complex whole of modern society; thus, the social forms of urban life are to be understood within the context of the changing character of the larger containing society" (Shevky and Bell, in Theodorson, 1961:227).

In their studies, they distinguished three broad sets of interrelated trends of change in the society. These changes are: 1) the distribution of skill; 2) the organization of productive activity; and 3) the composition of the population (Shevky and Bell, 1961:235). They then postulated that the social differentiation is becoming more marked over time with increasing scale. Each trend contributed to the process of social differentiation: 1) the changing distribution of skills leads to more definitive ordering of groups in society according to the socioeconomic status of their
occupation; 2) the changes in organization of productive activity are associated with changes in style of living in which increasing scale is characterized by a decline of family life; 3) the changes in the composition of population lead to a grouping of like types, usually as ethnic minorities. These are the conceptual frameworks of Shevky's typology.

In short, social area analysis approach suggests that the complexity of social structure of modern cities can be explained by using three factors, namely, social rank (socioeconomic status), urbanization (family status), and segregation (ethnic status). These three factors were derived from six variables which they used in their study of social area analysis. These were: occupation, education, fertility, women in the labour force, single family dwelling units, and ethnic minority. They further postulated that social rank is linked with occupation and education, urbanization is linked with fertility, and segregation is linked with ethnic minorities. With available census data, the indices of these three factors were computed. Then each census tract was assigned indices of the three factors. The social areas can then be classified by grouping those census tracts with similar scores. By means of this classificatory scheme, they were able to show the social areas of the city.

Social area analysis has been commonly used in social
science studies. The earlier studies mainly followed the format set up by Shevky. Bell (1953) applied it to study the social areas of San Francisco in which he found confirmation of Shevky's typology. In his study, "Economic, Family and Ethnic Status: An Empirical Test", Bell (1955) first set up hypotheses to test the factors of Shevky's typology by employing factor analysis. He found that the three factors of Shevky's typology were necessary to account for the social differentiation of the urban society. Bell (1958, 1959) further applied the social area analysis approach as a framework for studying urban social sub-areas.

Following Bell (1955), Van Arsdol, Camrilleri, and Schmid (1959) applied Shevky's typology in their study of social differentiation of ten American cities by using factor analysis technique. They found that Shevky's typology was confirmed in eight of the ten cities. But, they found that in two of high Negro concentration cities, Kansas and Atlanta, the fertility ratio was related strongly to social rank, but not with urbanization or family status.

The majority of the later studies of social area analysis (such as Herbert, 1967; Jones, 1968) modified the original format. Anderson and Bean (1961) expanded the variable set to include other relevant variables such as income and status of occupancy. In this study, they found four factors, namely, urbanization, family status, social rank, and segre-
gation. Their findings were somewhat different from Shevky's typology. In Shevky's typology, urbanization and family status were the same thing. Anderson and Bean, however, obtained these two factors separately. The importance of the factors obtained were varied. Obviously, Anderson and Bean found that urbanization and family status were the most important two factors, but not social status as in Shevky's typology. These findings indicated that while more relevant variables were used, more underlying dimensions may be extracted.

In classical urban studies, Burgess suggested a concentric pattern of urban growth, and Hoyt, a sectoral pattern of urban residential distribution while urban sociologists, Shevky and his associates, suggested three basic factors of urban social differentiation. Integrating these results, it is possible to obtain a spatial pattern of urban structure. On this assumption, Anderson and Egeland (1961) tested the two classical urban models by using the structural dimensions suggested by social area analysis approach. They first employed the social area analysis approach to identify the underlying social structure, and then to express them in a spatial pattern. By these procedures, they found that the dimension of urbanization or family status varied primarily concentrically, while prestige or social status varied primarily sectorally. This was the first study concerned with urban social spatial structure. The format
of this study has therefore been employed by many of the current factorial ecological studies.

While the approach of social area analysis was prevalently used, there have been some strong critics on this approach made by Hawley and Duncan (Duncan, 1955; Hawley and Duncan, 1957), and some other researchers. In their article, Social Area Analysis: A Critical Appraisal, Hawley and Duncan (1957) questioned the value of such an approach. They pointed directly towards the theoretical framework of the approach. They strongly charged that Shevky and his associates confused the social area and geographical units. In addition, they questioned the sufficiency of census tract data used for identifying the basic factors of social differentiation and stratification. They claimed that the homogeneity of census tract data was not true. In short, their "negative appraisal" on social area analysis has pointed to the theoretical basis of the approach, as they pointed out that "it seems to us evident that 'social area analysis' boasts no theory that cogently relates hypotheses about areal structure to propositions about social differentiation" (Hawley and Duncan, 1957:334). Tiebout (1958) argued that Hawley and Duncan misunderstood the real underlying meaning and the homogeneity of social areas.

Following Hawley and Duncan, Van Arsdol et al (1961, 1962) called for a new approach to replace the social area
analysis approach, since they thought that it was not a theoretically sound approach for studying the social structure of a city, although they themselves have successfully used it to study the social structure of ten American cities (1958). On the positive side, however, Bell and Geer made the strong claim that "social area analysis constitutes a unifying, generally powerful, efficient, and sociologically-meaningfully approach to the study of urban phenomena" (Bell and Geer, 1962:9). Schnore (1962) simply pointed out that the negative evaluation of the social area analysis made by Van Arsdol et al was simply a "conflict" of social scientists which could not be considered as a document sentencing social area analysis to its death.

In contrast to the great amount of criticism in the nineteen fifties of social area analysis, this approach has gained some favourable comments from recent social area analysts and factorial ecologists. For example, Anderson and Bean stated, "the indices effectively summarize the bulk of the common information contained in the characteristics reported for census tracts by the census" (Anderson and Bean, 1961:394). Curtis et al (1957) found a similar usefulness in this approach. Berry (1965), Timms (1965) and Herbert (1967) suggested that social area analysis was a useful framework for the comparative study of urban social structure. Herbert highly recommended the mapping techniques of social
area analysis, on which the comparative studies could be
based. As he commented, "The social area map is meaningfully
and accurately differentiates the urban structure of New-
castle, thus fulfilling one claim what may be made of the
approach in that it summarizes several essential aspects of
the social geography of an urban area... social area map and
social space diagram are also held as valuable frames of re-
ference in the context of which sample studies of selected
parts of the urban area may be made" (Herbert, 1967:55).

More recently, Michelson (1970) made such a comment on the
social area analysis, "(it) has made possible a greater un-
derstanding of what social variables tend to cluster in
space. It also makes known certain gross characteristics of
area so as to choose among them for further study".

As it has been noted in many empirical studies (such as
Robson, 1969, and Timms, 1971), neither classical urban
growth models nor the social area analysis approach has been
adequate in describing or explaining the urban residential
structure. The residential differentiation of modern urban
society is a multi-dimensional phenomenon which cannot be
explained by any single factor or any small set of variables
of the population characteristics. Thus, the models generated
by Burgess and Hoyt and even Shevky's typology are not up-
dated approaches for studying the urban residential differen-
tiation of modern cities. The realization of this fact has
brought about a more sophisticated approach to replace those outdated approaches, and that is factorial ecology.

2.3 Factorial Ecology Approach

The framework of factorial ecology approach, in fact, is constructed on the basis of social area analysis. Thus, Berry and Rees (1969) considered it as an outgrowth of social area analysis. Another element of this framework is the spatial models of urban growth. Within this framework, factor analysis has been most commonly accepted as a technique to handle a large number of observations with multivariate variables.

The factorial ecological approach has been used mainly in two aspects of urban studies. One is the inter-city classificatory scheme; the other is the study of intra-urban structure. The main difference of these two aspects lies in their concern with a different unit of analysis. The inter-city classificatory scheme deals with a regional or a national base, while intra-urban study deals with a city base.

2.3.1 Inter-city Classificatory Scheme

There were quite a few studies done on the inter-city classificatory scheme. These include Moser and Scott's study of British Towns (1961), Ahmad's study of Indian Cities (1965), Hodge's Canadian Urban Structure (1968), Berry's American Urban System (1972), Ray and Murdie's study of
Canadian and American Urban Dimensions (1972), etc. These works were concerned with classifying cities of similar characteristics in a group based on their basic properties which were mainly revealed in census data.

2.3.2 Intra-Urban Factorial Ecology

The factorial ecology approach has more successfully been used in intra-urban studies for the reason that "there is a set of well-defined hypotheses concerning variations in the socioeconomic structure of individual cities and an outline of the conditions necessary to produce a particular factor structure" (Ray and Murdie, 1972:182). In other words, intra-urban factorial ecologists set up the hypotheses in the light of those in social area analysis. Furthermore, they were able to draw the idea from classical urban models and express the results in spatial forms by employing mapping techniques.

Basically, urban factorial ecologists were interested in two aspects. First, identifying the underlying structural patterns from a large urban data set. From the obtained patterns they interpreted the basic structural dimensions of the city. Mostly, these studies obtained three commonly existing dimensions, namely, socioeconomic status, family status, and ethnic status. Together with these three common dimensions, they obtained a set of additional but important factors. Among these obtained factors, often the socioeconomic
and family status were the two invariable dimensions. However, ethnic status occurred often in American cities, but not in some of the European countries. With respect to the structure of the factors, it varied from one study to another. Usually, socioeconomic status was correlated highly with variables as to occupation, education, and income level; family status was associated with the demographic structure of the population, fertility, household characteristics, and females in the labour force, while ethnic status was related to ethnic minorities.

Secondly, the factorial ecologists were interested in investigating the areal differentiation of the obtained factors. Mapping techniques were employed for expressing the results in spatial forms. Thereby, the spatial structure of the city was shown. From that, an attempt was made to scan the areal differentiation of the urban structure. Following the results obtained by Anderson and Egeland (1961), many of the later factorial ecological studies expected to obtain a concentric pattern of family status, a sectoral pattern of the distribution of socioeconomic status, and a multi-nuclear pattern of ethnic minorities. However, these spatial patterns were not invariable. While many of the studies found these patterns, others found deviations. For example, Murdie (1969) and Rees (1970) found that the socioeconomic status dimension was distributed primarily in sectoral patterns both in Toronto and Chicago; family status
was distributed concentrically in both of the cities. While ethnic status was found in sectoral and zonal pattern in Toronto, it was in a cluster pattern in Chicago.

2.3.3 Types of Intra-Urban Factorial Ecology

Although to identify the underlying dimensions of the urban structure and to investigate the areal differentiation of the urban structure were the two most important interests of intra-urban factorial ecologists, these were not the only aims of their studies. Based on the apparent differences, the factorial ecological studies could further be classified into several types as following:

First, there are studies of the underlying dimensions of urban structure. Studies of this aspect were concerned mainly with identifying the underlying dimensions of the urban structure and to investigate the areal differentiation. This is the most commonly used format of factorial ecology. These works include Herbert's study of Newcastle-under-Lyne (1967), Jones' study of Melbourne (1969), Sweetser's study of Helsinki (1965), Nicholson and Yeate's study of Winnipeg (1969), Badcock's study of Metropolitan Sydney (1973), Parkes' study of Newcastle (1973), and Davies' study of Leicester (1973).

Secondly, there is a time-base comparative factorial ecology. The studies of this type were mainly aimed at
finding out the changing pattern of the internal structure of the city over a certain time period. They hypothesized that the effect of time on the spatial patterning of each social area dimension provides some insight into characteristics of social area change. By such a study, "more light will be thrown upon the processes underlying an observed social area change" (Brown and Horton, 1970:286). Studies of this aspect include Sweetser's study of Metropolitan Boston, 1951-1961 (1962), Murdie's study of Metropolitan Toronto, 1951-1961 (1969), Brown and Horton's study of Chicago, 1950-1960, (1970), and Johnston's study of Melbourne, 1960-1966 (1973).

The third type of intra-urban factoral ecology is the comparative study of the communities within a large metropolitan area. This application has not been commonly used. Rees first applied it in a study of Chicago's factoral ecology. In this study, Rees compared the internal structure of City of Chicago, its suburbs, and the total metropolis. Here, he found that there were five common factors useful in describing the internal structure of these three areal units, namely, socioeconomic status, stage in life cycle, race and resources, size and density, and Jewish and Russian. But, the relative importance of these factors varied from one area to another. The internal structure of the metropolis as a whole was more close to that of the suburbs, while the internal structure of city area was very different from that of the suburbs. In city area, whites and blacks were extrac-
ted in the same factor, but were separately extracted in the suburbs. In this study, Rees found that the social space of Chicago (plotting race and resources against socioeconomic status) distinguished a clear picture of black and white communities.

Another type of intra-urban factorial ecology is the comparative study of internal structure of several cities of the same time period. The studies of this kind are aimed at comparing the internal structure of several cities by using the same year's data and to find out their differences in internal structure. By means of this set-up, factorial ecologists were able to show in what way and to what extent the structure of a city differs from that of others, as well as the factors that caused the differences. To date, not much work has been done on this aspect, with the exception of Sweetser's study of Boston and Helsinki (1965), Timms' study of four large New Zealand cities (1970), and Davies and Barrow's study of three Canadian prairie cities (1973).

The factorial ecology approach, finally, has also been used in the study of the cross-cultural base. The purpose of this study was aimed at investigating the deviations of the urban structure of cities of different cultural backgrounds. The attempt to test the validity of factorial ecological approach in studying non-western cities was also made in this type of study. Using the factorial-ecological approach to
study non-western cities, factorial ecologists obtained different results. Abu-Lughod (1969) applied such an approach to study the urban social structure of Cairo, Egypt. Three factors were derived from a relatively small data matrix (216 x 13). These were, social status, male dominance, and social disorganization. No family status was obtained. This finding simply indicated the deviations between Western and non-western cities. Berry and Rees (1969) found further variations in Calcutta. Ten factors were extracted from the data matrix as to Calcutta's population characteristics, which described the complex social structure of the city. The most important four factors were: a land use and familism gradient, Muslim concentrations, axiality in literacy, and substantial residential areas¹. While family status was found related to land use patterns, social status was linked with ethnic status. The findings were not only different from Western cities, but also from Cairo. This illustrated that the cultural factor may be more important than other factors in explaining the urban structure of non-western cities.

2.4 Criticism on the Factorial Ecology Approach

¹ These factors have been further explained as family status, ethnic status, social status and social status respectively, by Rees (1972).
The factorial ecology approach, as has been pointed out, was developed from the social area analysis and was advanced by the aid of modern statistical computational techniques. Obviously, modern factorial ecology approach took root in mathematical grounds and was enriched by many other socio-scientific researches. However, the mathematical foundation of this approach was also the root of many associated problems in factorial ecological studies.

Most of the thorny problems were not only associated with the mathematical or methodological aspects, but also with theoretical aspects. Beginning with the data to be used for analysis, variables were usually subjectively selected on the basis of certain previous results. It is uncertain whether the selected variables will produce meaningful results for further interpretation. In addition, areal unit data have been debated on the problem of data weighting (see the next chapter for further discussion). Another problem related to the data was the data transformation. To fit the factor analytic model, data were required to be transformed into a suitable form. This is a troublesome procedure (see chapter three for further discussion on this problem).

With respect to the factor analytic model, more uncertainties were raised: first, the uncertainty on the selection of a suitable model; secondly, uncertainty about choosing of a right rotational solution; thirdly, the uncertainty on the
number of factors that should be extracted. Although many previous works and textbooks on these problems exist and provide a number of solutions which researchers could consult, they, in fact, do not solve any of these problems. Instead, they raise further questions.

Once a suitable analytic model was selected, it might produce different results from other studies using the same technique. This raised the instability of the factors obtained (Romse, 1973). Most probably, this problem was caused by the scale of the study area. In addition, the size of variable-set used was also an important factor. To a great extent, the instability of the factors was caused by the basic differences existing between the cases under studying.

The above-mentioned problems, however, did not necessarily invalidate the use of the factorial ecological approach for studying internal urban structure. It has in fact been successfully used in many of the studies, such as those reviewed in the foregoing sections. Murdie found that this approach was able to show the social space of Metropolitan Toronto. Rees found that it was useful for studying communities within a large metropolitan area. Timms (1971) found that factorial ecology was a powerful approach among many existing approaches for studying the residential differentiation of modern urban society. Senior (1973) considered factorial ecologies to be sophisticated descriptive models
of urban residential structure.

On the principle that factorial ecology is a useful approach for studying urban residential structure, it is employed in this particular study. By means of this approach, it is hoped that the basic urban structure of Singapore can be delineated.

2.5 Previous Studies on the Socioeconomic Characteristics of Singapore's Population

Singapore, as the largest and most modernized city of Southeast Asia, has been studied by both the local and foreign researchers in political, social, economic, and geographic aspects. However, limited by the availability of detailed data of small areal units, and the lack of modern computation techniques, the studies of Singapore's urban social geography were restricted in analysing and describing the general socioeconomic characteristics of the population. As a result, the intra-urban areal differentiation of the social structure has not been adequately investigated. Although the majority of the existing literature on Singapore was done on a macro scale base, and failed to look at the internal urban social structure, it provides some basic but important information on the overall socioeconomic characteristics of the city.

In his study, The Southeast Asian City, McGee (1967) investigated the social, economic, and demographic charac-
teristics of the larger Southeast Asian cities such as Singapore, Kuala Lumpur, Bangkok, and Manila. He found that the urban structure of these cities was greatly affected by their historical and cultural background. The existing urban, social, as well as spatial structures were affected by both the Western and local racial culture. He said that the overall urban structure of these cities was too complicated to be described adequately by Burgess' concentric model, although such a model is claimed to be useful in predicting the urban growth of cities in developing countries (Timms, 1971:222). McGee, therefore, modified Burgess' model to accommodate the localities. Nevertheless, his model is not differed significantly from Burgess'. The land use pattern of these cities was mainly concentric in pattern. Furthermore, he found that the residential structure of these cities was a mixture of the poorest and wealthiest elements of the city in both the core and outer zones. Assuming that McGee's findings are valid in the case of Singapore, it is expected that the findings of this study will be consistent with McGee's macro scale study.

With respect to the ethnic structure of Singapore, one might expect a distinctive racial segregation pattern to exist for these reasons: 1) Singapore is a multi-racial society, and 2) there was a strong effort made by the British Colonial Governor to isolate the main ethnic groups of the
city. However, recent studies showed that racial segregation did not exist. Hodder (1953) found no clear racial segregation pattern, but a tendency towards occupational specialization by races. Neville (1965) confirmed Hodder's findings, but pointed out that some racial residential concentrations existed in line with original racial segregation patterns. The latest census report in fact revealed the same phenomenon. Sze (1972) found that the occupational structure of the three main ethnic groups was proportionally imbalanced. As a whole, these studies suggested that ethnicity is still an important dimension of the urban social structure. Thus, one of the aims of the present study is to find out how important is the ethnicity in accounting for the variation in Singapore's urban structure.

The recent change in the demographic characteristics in Singapore has been observed by You (1966), Neville (1969), and the Census Report of 1970. The most remarkable changes were a decline in the fertility rate which indicated the achievement of recent modernization and family planning, and the integration of immigrant characteristics in the population which was shown by the relatively balanced sex ratio among the three main ethnic groups. The effect of these changes was a change in family structure and lifestyle. For instance, the small family structure today in Singapore is far more important than it was before. In addition, females of all races in the labour force increased tremendously. How
these changes will influence the social structure of Singapore is a problem this study will examine.

Associated with the changes in demographic characteristics was the change in households characteristics. Yeh (1967) found that during the years 1957 - 1966, the proportion of single family households increased substantially while single person households decreased significantly¹. Meanwhile, the average household size increased. As a whole, single family household was the dominant type. These changes indicated further the changes in life style of the population. In Western cities, the single family dwelling is usually related to young family status. It is, thus, expected to obtained such a dimension in Singapore.

Regarding the socioeconomic status of Singapore's population, studies on this aspect usually employed housing types as the indicators of their social status. Yeh and his associates (Yeh and Lee, 1968) have shown the basic relationships between the housing types and the social status. They suggested, on the basis of the 1966 Household Survey data, that there were four distinctive housing types, which housed population of different social status. These were: first, bungalows, semi-detached houses, and private flats (apart-

¹ The decline in single person households during this period was mainly due to the counter-movement of immigrants. See Yeh (1967), 104.
the majority of these houses were newly built which housed some 11% of the population who were predominantly middle and upper class people; secondly, shop-houses and row houses which housed 27% of the population in 1966 whose social status ranged widely from very poor to fairly well-to-do; thirdly, the public housing flats (HDB and SIT)\(^1\) which housed some 25% of the total population who were mainly upper low and low middle class people; and finally, the poor housing which in 1966 housed about 31% of the total population who were mainly lower social class people and were living in attap, zinc roofed, and wooden houses.

The relationship between housing types and social status has been further illustrated by Weldon and Tan (1969). In their social area analysis of Singapore's "urban area\(^2\), they employed five variables in order to look at the socio-economic characteristics of the population. These variables were income, education, occupation, car ownership, and housing types. They found that occupation and income were strongly related to housing types. Based on this, they obtained three social areas: Rank A represented an upper class social status which was associated with private housing es-

\(^1\)Before 1960, the public housing development was conducted by Singapore Improvement Trust. It has been replaced by the Housing and Development Board in 1960.

\(^2\)Including the governmental administrative units, city central area and urban area. Another GAA is rural area.
tates; Rank B represented a middle class social status which was related to public housing flats; and Rank C, a low social status which was linked with temporary structures (or poor housing), including attap, zinc roofed, and wooden houses -- squatter dwellings.

Excluding housing types and taking only education and occupation into consideration, Hassan (1970) found that the educational level was a determinant of occupation status. Accordingly, he grouped the population into three classes, namely, white collar workers who were well-educated, blue collar workers with less education, and farm workers mainly without basic education. However, his findings did not reveal any insight into the real social differentiation among the population.

In his investigation of the social, economic characteristics of Singapore's population, Bu-chanan (1972) suggested a more detailed social classification. Based on the estimated income level, occupation, and educational level, his classifications were the upper class, the middle class, the intermediate middle class, the lower middle class, the upper working class, and the low working class. While he thought that upper and some middle class population were related to good housing, the others were not necessarily associated with particular housing types. In fact, he pointed out that the majority of the housing types were blankets
which covered people of different social status.

Apparently, some of the researchers favoured housing as an indicator of the social status while others were to the contrary. In spite of their classificatory criteria being slightly different, they both suggested the existence of a distinctive social differentiation among the population. By employing a factorial ecology set-up, this author hoped that the social differentiation of Singapore could be shown and its areal differentiation could be investigated.

The increasing importance of public housing in Singapore has interested many authors. Choe (1969), Teh (1969), Yeh (1972), Yeh and Kwok (1972), Yeh and Pang (1973), and Yeung (1970, 1973) have shown the importance of housing development in the changing pattern of land use in Singapore and its influence on the population.

The role played by the housing development in the change in physical landscape of the city is obvious; lands that previously occupied by slums, squatters, and agriculture have now been converted into "concrete jungles" -- high-rise housing flats. Meanwhile, the relocation of population from slums, squatters, and agricultural lands to the housing flats caused a drastic change in their living style, and social structure. Based on these results, Yeung (1973) considered the public-housing development as an agent to the change of land use in Singapore on one hand, and that of the popula-
tion's way of living on the other. By integrating land use with housing estates, Yeung derived an idealized land use model which described the land use in Singapore in a sectoral pattern. However, his study did not look at the actual role played by the housing development in the change of urban structure by using the latest data. With the availability of the latest census data and by employing an advanced technique, this exercise is, thus, aimed at demonstrating Yeung's insufficiency.

The above cited non-systematic studies on the urban social characteristics of Singapore suggested that the internal urban social structure was a complex one. However, they failed to show clearly what were the main dimensions and failed to look at the areal differentiation of the structure. These inadequacies, however, can be demonstrated through the integration of these piecemeal and uncoordinated results in a systematic approach. By means of a factorial ecology approach, it is hoped that the urban structure of Singapore can be completely delineated and better understood.

2.6 Formation of Hypotheses

The review of literature given above revealed three important factors: first, for the majority of Western cities, socioeconomic status, family status, and ethnic status were important dimensions of the urban structure; secondly, in non-Western cities, cultural factors may be more important
than others in explaining the urban social structure of these
cities; and finally, the previous studies on Singapore il-
illustrated a basically different urban structure with others,
both Western and non-Western cities.

In Singapore, if the findings of former studies on
Singapore are valid, housing types which include good hou-
sing, poor housing, shop-houses, and public housing flats
may be the most important dimensions of the urban structure.
These housing types may mirror different family status as
well as different social status. Thus, the complexity of the
urban social structure of Singapore can be delineated along
these four basic housing types. However, as it has been
noted, ethnicity is an important dimension of the urban so-
ciety, and it exists independently. As a result, to adeque-
tly depict the urban social structure of Singapore, ethnicity
should be included. In short, the structure of the whole
urban society of Singapore can be delineated by an ethnic
factor together with the four mentioned basic housing types.
Accordingly, the hypotheses set up for testing in this study
are the following:

1) It is hypothesized that no more than five factors,
including an ethnic status and four housing types,
will be needed to explain the urban social struc-
ture of Singapore.

2) It is hypothesized that ethnic status will be
extracted as the most important dimension of the
urban society of Singapore.
3) It is hypothesized that the four basic housing types will be extracted individually as important factors in the urban structure of Singapore other than the ethnic factor in the following order: poor housing, public housing, shop housing, and good housing.

4) It is hypothesized that the distribution pattern of these factors will occur in the following forms:

a) Poor housing located at the outer zone of the metropolis in a concentric pattern;

b) Public housing distributed sectorally;

c) Shop-houses distributed concentrically;

d) Private housing distributed sectorally; and

e) Ethnic minorities distributed sectorally and also in a cluster pattern.
CHAPTER THREE
METHODOLOGY

Following the traditional methodology of factorial ecological studies, factor analysis is adopted as a basic technique for analysing the data used in this study. This chapter, therefore, is aimed at discussing some of the relevant problems of the data and the analytic approach. The data source will first be discussed, and then the selection of a factoring technique.

3.1 Data

The data used for this study were prepared from the recently published 1970 Census of Population of Singapore. Since census divisions are at present the smallest areal units on which adequate data exists, they are utilized as the basic units of analysis in this report. In the 1970 census, there were 58 census divisions set up (see Appendix A for census division network, and B for the name of these divisions). All of these census divisions will be used in the present study with an exclusion of those small islands belonging to Singapore. Since the population of these islands is too small to affect the total population, the exclusion of them will certainly not affect or distort the results of this research.
From the census, a set of 35 relevant variables were chosen. These variables reflected the demographic characteristics, ethnic structure, occupational status, family structure, household characteristics, housing types, and population density of Singapore (see Appendix C). Data relating to income level was not available. Also, no detailed data on the educational level was given on a census division base. The lack of these two variables, which are usually the indicators of socioeconomic status, is the weakness of the data matrix used in this study. Nevertheless, in the case of Singapore, it can be offset by using more detailed data on occupational groups and housing types. Since the income and educational level has been proved related strongly to occupational status (Weldon and Tan, 1969).

The utilization of census tract data in factorial ecology raised an argument whether the used areal unit data should be weighted by certain parameters. It has been argued that in regression analysis the areal unit data should be weighted by suitable parameters because "different numbers of areal units of different size used in the study will produce different correlation parameters among the variables" (Robinson, 1956). The results otherwise will be distorted. This problem has been discussed by Thomas and Anderson (1965), Morris (1966), and Curry (1966). They have suggested different ways for weighting the areal unit data, but no conclusion has been
generally accepted. However, this problem has not been oftenly discussed by factorial ecologists with a few exceptions. For instance, Murdie (1969), and Davies and Barrow (1973) have observed such a problem. But, they obtained meaningful results by using non-weighted data.

Since no suitable weighting system can be followed, no weightings will be imposed on the data used in this study. Although large variations of the population size among the census divisions exist, for moderating the acute variations among these census divisions, the data are presented in percentage with the exception of fertility ratio, sex ratio, and density variables which are expressed in ratio form.

To meet the theoretical assumptions of linearity and the normal distribution of the data in the factorial analytic model, and "in order to realistically relate the empirical findings to the initial research question", the data used in factor analysis should be transformed to match the technique (Rummel, 1970). Through such a distributional transformation, "the chance, unique or unrepresentative variance in a data matrix that may distort the interpretation of the results may be minimized" (Rummel, 1970). However, some of the factorial ecologists (such as Clark, 1973; and Davies and Barrow, 1973) argued for the necessity of data transformation. To the extent that normalized data will fit the
assumptions of the technique and produce more powerful results than non-normalized data (as mentioned in Clark's study, 1973), the data used in the present research are normalized (the procedures of normalization follow Rummel's suggestions, 1970). The normalized data will be factored by selected factoring techniques.

3.2 Choice of Factoring Techniques

Factor analysis was first commonly used for psychological studies and later was widely accepted by many other social science studies. In terms of its uses, factor analysis has been used as a tool to reduce a large number of variables for studying; to separate pattern of interrelationships of the variables; to group interdependent variables into descriptive categories; to test the hypothesis about the existence of dimensions of a cluster or group of highly interrelated characteristics; and to explore the unknowns in the complex interrelations of phenomena (Rummel, 1970; Gorsuch, 1974). Obviously, it is a technique of multiple uses. In factorial ecological studies on urban internal structure, most of these uses co-exist compatibly.

In the present study, the factor analysis approach is employed for reducing a large data set into a few number of factors for these purposes: 1) to identify and to delineate the underlying characteristics of urban structure, and 2) to produce a set of factor scores which can be used to depict
the spatial structure of the underlying urban structure.

Among the factor analytic models, principal component analysis and common factor analysis are the two commonly used techniques in social science studies. These models have inherently different purposes. While principal component analysis is used for identifying the basic dimensions of variable clusters, common factor analysis is used for testing theories. Usually, in the studies of urban social structure, principal component analysis is employed for identifying the underlying urban structure. Common factor analysis has seldom been used in these studies.

While principal component analysis has been commonly used in factorial ecological studies with remarkably meaningful results (such as Murdie, 1969; Rees, 1970; Herbert, 1971; Timms, 1971; Parkes, 1973; and Davies and Barrow, 1973), its basic assumption that "the data are the universe of content" has been criticized by Conway and Haynes (1973) as an unrealistic one in most geographical studies. They recommended common factor analysis for the geographical studies which are dealing primarily with census data. However, to select a common factor analysis to any great extent means an involvement in mathematical estimation, and a confrontation with many uncertainties. For example, the estimation of communalities takes time and energy. Also the selection of any existing method for estimating the communalities is faced with uncer-
tainty. Thus, in order to avoid these problems, most of the factorial ecologist's selected principal component analysis.

As a matter of fact, as has been pointed out, the results of principal component analysis and those of common factor analysis are quite similar to each other (Rummel, 1970; Haynes, 1971). Principal component analysis, therefore, will produce meaningful results, although less rigorous. It, thus, is employed for factoring the data used in this study.

3.3 Number of Factors

Theoretically, principal component analysis will produce as many factors as variables used. Since the factors are extracted in the order of their importance in terms of the variances explained, we are able to choose factors with according meaningfulness. However, the number of factors which will be needed for explaining the variation of the data matrix is a problem to be settled. To deal with this problem, the Bartlett test of significance of principal components has been commonly used. It is a method which tests the significance of the residuals in the data correlation matrix after a given number of factors has been extracted. This test can be calculated solely from the characteristics roots of the correlation matrix with unities as the diagonal elements (Gorsuch, 1974:137). This test is employed in this study to test the significance of principal components.
To test the significance of the principal components in this research, a WATFIV computer has been written for computing the Bartlett's chi-squares (see Appendix D). Table 1 shows part of the results. Owing to too large a degree of freedom in this test, chi-square critical value could not be obtained from the chi-square table. A transformation of the chi-square into t-ratio is conducted when the degree of freedom is larger than 30. Guilford (1956) provided the equation for this transformation. The results of this test show that the data used are extremely good so that as many factors as desired could be extracted (see Appendix E).

Table 1

<table>
<thead>
<tr>
<th># of Factors extracted</th>
<th>DF</th>
<th>Chi-square</th>
<th>t-ratio</th>
<th>t-critical Value(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>594</td>
<td>2920.34</td>
<td>41.97</td>
<td>2.586</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>495</td>
<td>1825.04</td>
<td>23.97</td>
<td>2.588</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>377</td>
<td>1161.58</td>
<td>20.76</td>
<td>2.593</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>209</td>
<td>563.28</td>
<td>13.14</td>
<td>2.601</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>104</td>
<td>281.78</td>
<td>9.35</td>
<td>2.626</td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>14</td>
<td>43.60</td>
<td>(4.660)</td>
<td></td>
</tr>
</tbody>
</table>

1Significant level = 0.01
2Chi-square critical value
The results of Bartlett's test are obviously inconclusive. The test does not solve the problem of how many factors will be needed to explain the variance of the data adequately. However, it does indicate that any one of the factors extracted is meaningful. This facilitates us to employ other methods as a supplementary criterion for extracting factors. In this study, an eigenvalue of one criterion is adopted for retaining the factors extracted. This means that factors with eigenvalue one or over will be retained for further interpretation; otherwise, they will be truncated. By means of this simple, neat, and commonly used criterion, six factors are obtained from the principal component analysis. In Bartlett's test, these six factors are significant at the level of 0.01.

3.4 Rotation Solution

Having decided the number of factors to be retained for further interpretation, the next step is to decide whether or not to rotate the original factors. The preliminary factoring technique adopted produced six basic dimensions of the cluster of variables used. But, the structure of these factors are too complicated for interpretation. In order to obtain more meaningful results, it is decided to rotate the factor axis to a certain degree.

The decision to rotate the factors, however, raises another problem, that is, which of the rotation solutions will
be the most suitable one for producing meaningful results? This problem has been discussed quite often in factorial ecological studies and other social science researches. Among the two rotation solutions, orthogonal rotation is most commonly used. But, it has been argued that using oblique rotation in producing correlated factors is more realistic than employing an orthogonal solution in producing independent factors (such as Cattell, 1965; Rummel, 1970; Johnston 1971; Conway and Haynes, 1973; Haynes, 1971; Davies and Barrow, 1973; and Gorsuch, 1974). However, Huges and Carey (1972) found that the choice of a rotation technique has but little effect upon the factorial social structure. In the conclusion of their study, they said: "if the identification of the social dimensions underlying the data is the interest of the researcher, the simplicity, conceptual clarity, and mathematical elegance of the orthogonal rotation solution is probably to be preferred" (Huge and Carey, 1972:161). In the light of this finding, it is decided to employ orthogonal rotation solution. Thus, it produced statistically independent factors for further interpretation. In addition, for obtaining a simple factor structure, varimax rotation is adopted since it is the most successful criterion for orthogonal rotation.

3.5 Conclusion

In short, principal component analysis is employed as
a preliminary factoring technique in extracting the data matrix which contained variables reflecting the socioeconomic characteristics of Singapore's population. The orthogonal rotation solution is selected in order to produce statistically independent factors, and varimax criterion is chosen to produce simple factor structure. The computational procedures are done by PAL program of the Statistical Packages for The Social Sciences. Thereby, six statistically independent, structurally simplified factors are obtained which explained 84% of the total variance of the data matrix. The produced statistical outputs included factor loadings, percentage of variance explained by each of the factors extracted, eigenvalues, communalities, and factor scores which will be used for further interpretation in the next chapter.
CHAPTER FOUR
ANALYSIS OF RESULTS

4.1 Introduction

The employed principal component analysis approach extracted six factors from the data matrix used. Since they explained a high proportion of the total variance of the data, the data matrix thus has been adequately explored. In addition, the factors together explained sufficiently the variance of each variable used. This is indicated by the final value of communalities (see table 2 for factor structure and communality). Generally, these factors are bipolar in nature which is indicated by variables loaded heavily on both the positive and negative ends of the factor. The bipolarity illustrated the dichotomous nature of the underlying characteristics of the urban structure in Singapore.

The analysis given in this chapter will be based on the results obtained. A short discussion on the selection of significant factor loadings for further interpretation will be given prior to the elaboration and discussion of the factorial ecology of Singapore. The analysis will then shift to examine the areal differentiation of the urban social structure. A comparison of the urban structure of Singapore with that of Chicago, Toronto, and Calcutta will be given in a later section of this chapter.
Table 2: Factor Structure of Principal Components with Varimax Rotation

<table>
<thead>
<tr>
<th>Variable</th>
<th>Communality</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
<th>Factor 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>YOUNG</td>
<td>0.847</td>
<td>-0.40</td>
<td>-0.07</td>
<td>0.35</td>
<td>-0.28</td>
<td>-0.03</td>
<td>0.02</td>
</tr>
<tr>
<td>OLDAGED</td>
<td>0.903</td>
<td>0.86</td>
<td>0.66</td>
<td>-0.23</td>
<td>-0.02</td>
<td>0.31</td>
<td>0.07</td>
</tr>
<tr>
<td>MALAY</td>
<td>0.681</td>
<td>-0.25</td>
<td>-0.01</td>
<td>0.27</td>
<td>-0.11</td>
<td>-0.60</td>
<td>0.41</td>
</tr>
<tr>
<td>CHINESE</td>
<td>0.856</td>
<td>0.15</td>
<td>-0.07</td>
<td>-0.22</td>
<td>-0.02</td>
<td>0.77</td>
<td>0.43</td>
</tr>
<tr>
<td>INDIAN</td>
<td>0.755</td>
<td>0.10</td>
<td>0.21</td>
<td>-0.02</td>
<td>0.12</td>
<td>-0.63</td>
<td>0.02</td>
</tr>
<tr>
<td>RESIDENT</td>
<td>0.780</td>
<td>0.34</td>
<td>-0.05</td>
<td>-0.03</td>
<td>-0.01</td>
<td>-0.81</td>
<td>0.12</td>
</tr>
<tr>
<td>FEMALE</td>
<td>0.893</td>
<td>0.25</td>
<td>-0.10</td>
<td>-0.43</td>
<td>0.71</td>
<td>0.33</td>
<td>-0.11</td>
</tr>
<tr>
<td>MPTEC</td>
<td>0.933</td>
<td>-0.21</td>
<td>0.42</td>
<td>0.07</td>
<td>0.81</td>
<td>0.02</td>
<td>0.23</td>
</tr>
<tr>
<td>FPTEC</td>
<td>0.867</td>
<td>-0.16</td>
<td>0.73</td>
<td>0.17</td>
<td>0.51</td>
<td>-0.11</td>
<td>0.04</td>
</tr>
<tr>
<td>MADJAGER</td>
<td>0.924</td>
<td>-0.04</td>
<td>0.39</td>
<td>0.09</td>
<td>0.86</td>
<td>0.12</td>
<td>0.15</td>
</tr>
<tr>
<td>PEDJAGER</td>
<td>0.720</td>
<td>0.04</td>
<td>0.32</td>
<td>0.15</td>
<td>0.76</td>
<td>-0.10</td>
<td>0.06</td>
</tr>
<tr>
<td>MACLER</td>
<td>0.890</td>
<td>-0.36</td>
<td>0.84</td>
<td>-0.16</td>
<td>0.12</td>
<td>-0.08</td>
<td>-0.10</td>
</tr>
<tr>
<td>PECLER</td>
<td>0.899</td>
<td>-0.03</td>
<td>0.91</td>
<td>0.07</td>
<td>0.22</td>
<td>0.22</td>
<td>-0.13</td>
</tr>
<tr>
<td>MASALE</td>
<td>0.846</td>
<td>0.72</td>
<td>0.27</td>
<td>0.14</td>
<td>-0.26</td>
<td>0.40</td>
<td>-0.07</td>
</tr>
<tr>
<td>PESALE</td>
<td>0.897</td>
<td>0.49</td>
<td>0.07</td>
<td>-0.43</td>
<td>-0.61</td>
<td>0.29</td>
<td>0.02</td>
</tr>
<tr>
<td>MASERE</td>
<td>0.671</td>
<td>0.07</td>
<td>-0.11</td>
<td>0.09</td>
<td>-0.07</td>
<td>-0.40</td>
<td>0.70</td>
</tr>
<tr>
<td>PESERE</td>
<td>0.760</td>
<td>0.02</td>
<td>0.11</td>
<td>0.03</td>
<td>0.34</td>
<td>-0.12</td>
<td>0.78</td>
</tr>
<tr>
<td>MANKUR</td>
<td>0.860</td>
<td>-0.34</td>
<td>-0.71</td>
<td>0.10</td>
<td>-0.33</td>
<td>0.14</td>
<td>-0.31</td>
</tr>
<tr>
<td>PELKUR</td>
<td>0.859</td>
<td>-0.08</td>
<td>-0.54</td>
<td>-0.19</td>
<td>-0.41</td>
<td>0.16</td>
<td>-0.57</td>
</tr>
<tr>
<td>YOUTHKUR</td>
<td>0.730</td>
<td>0.27</td>
<td>-0.65</td>
<td>-0.11</td>
<td>-0.17</td>
<td>0.15</td>
<td>-0.41</td>
</tr>
<tr>
<td>BUNTER</td>
<td>0.694</td>
<td>0.28</td>
<td>0.42</td>
<td>0.22</td>
<td>0.59</td>
<td>-0.14</td>
<td>0.15</td>
</tr>
<tr>
<td>SHOF</td>
<td>0.813</td>
<td>0.90</td>
<td>0.05</td>
<td>-0.02</td>
<td>-0.04</td>
<td>-0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>HDB</td>
<td>0.919</td>
<td>0.60</td>
<td>0.02</td>
<td>-0.65</td>
<td>-0.11</td>
<td>0.25</td>
<td>-0.24</td>
</tr>
<tr>
<td>ATAZIN</td>
<td>0.905</td>
<td>-0.21</td>
<td>-0.21</td>
<td>0.88</td>
<td>-0.03</td>
<td>-0.13</td>
<td>0.16</td>
</tr>
<tr>
<td>PPH4AU</td>
<td>0.962</td>
<td>-0.27</td>
<td>0.22</td>
<td>-0.50</td>
<td>0.03</td>
<td>-0.21</td>
<td>0.04</td>
</tr>
<tr>
<td>PPH11O</td>
<td>0.936</td>
<td>0.27</td>
<td>0.11</td>
<td>0.92</td>
<td>0.06</td>
<td>-0.09</td>
<td>0.03</td>
</tr>
<tr>
<td>HWPOJMO</td>
<td>0.878</td>
<td>-0.27</td>
<td>0.35</td>
<td>0.49</td>
<td>0.32</td>
<td>0.52</td>
<td>-0.27</td>
</tr>
<tr>
<td>ONEFAM</td>
<td>0.893</td>
<td>-0.91</td>
<td>0.14</td>
<td>0.09</td>
<td>0.05</td>
<td>0.16</td>
<td>0.03</td>
</tr>
<tr>
<td>MUTFAM</td>
<td>0.939</td>
<td>-0.41</td>
<td>0.36</td>
<td>0.76</td>
<td>0.09</td>
<td>0.25</td>
<td>-0.01</td>
</tr>
<tr>
<td>SINFAM</td>
<td>0.919</td>
<td>0.83</td>
<td>-0.24</td>
<td>0.32</td>
<td>-0.09</td>
<td>-0.25</td>
<td>0.04</td>
</tr>
<tr>
<td>PRIMARY</td>
<td>0.882</td>
<td>-0.33</td>
<td>-0.24</td>
<td>0.81</td>
<td>-0.20</td>
<td>-0.10</td>
<td>0.11</td>
</tr>
<tr>
<td>OLEWORK</td>
<td>0.794</td>
<td>0.78</td>
<td>-0.29</td>
<td>-0.25</td>
<td>0.10</td>
<td>-0.10</td>
<td>0.12</td>
</tr>
<tr>
<td>FERTILE</td>
<td>0.845</td>
<td>-0.54</td>
<td>0.53</td>
<td>0.40</td>
<td>-0.22</td>
<td>-0.25</td>
<td>0.19</td>
</tr>
<tr>
<td>SEX</td>
<td>0.714</td>
<td>-0.57</td>
<td>-0.31</td>
<td>-0.05</td>
<td>0.35</td>
<td>-0.36</td>
<td>0.15</td>
</tr>
<tr>
<td>DENSITY</td>
<td>0.702</td>
<td>0.12</td>
<td>0.00</td>
<td>-0.71</td>
<td>0.33</td>
<td>0.25</td>
<td>0.00</td>
</tr>
</tbody>
</table>

% of Variance explained: 29.8 20.5 15.4 9.5 5.9 3.8
4.2 Selection of Significant Factor Loadings

The obtained factors in factorial ecology are interpreted on the basis of those variables with significant loadings in the factor matrix. As a rule of thumb, loadings of 0.3 or 0.4 was commonly used in the above cited factorial ecological studies as a cut-off value for selecting significant factor loadings. However, Gorsuch (1974) pointed out that the cut-off value should be chosen on the basis of the sample size of the study; when sample size is small, for instance smaller than 100, factor loadings lower than 0.4 should not be interpreted. Therefore, when selecting a cut-off value, one should be aware of the effects of high or low factor loadings; when too low a value is used, too many variable complexities will be produced thus complicating the interpretation; on the other hand, when too high a value is used, those variables with moderate loadings but with meaning for factors will be omitted. If 0.3 is selected as a cut-off value, more than 20 variable complexities are produced in this study. When 0.5 is used, it produced only three variable complexities but, in turn, omitted some important variables.

To prevent the occurrence of too many variable complexities as well as to retain those meaningful but moderately loaded variables, two criteria are adopted in the present study: first, using 0.5 as a preliminary cut-off point for the purpose of producing a simplest factor structure, and then
to use 0.4 as a secondary cut-off point to retain those variables loaded slightly lower than 0.5 on the factors which will help keeping the important meanings in the factor structure. Thereby, no more than ten variable complexities are produced yet some meaningful variables remain. These simplified factors will be used in the interpretation of the urban structure.

4.3: The Underlying Dimensions of the Urban Structure of Singapore

By means of the two cut-off points, the factor structure has been further simplified so that the precise underlying meanings are shown. A close examination of the factor loadings of the obtained factors reveals that two factors are strongly related to housing types; two are correlated with occupational status, and the others are associated with ethnicity. Based on their factor loadings, these six factors are family status, occupational status, poor housing, socioeconomic status, ethnic pluralism, and Malay occupational status. Each of them will be elaborated individually in the following sections.

Factor 1: Family Status

As the most important factor of the urban structure of Singapore, factor 1, which explained 30% of the total variance, is composed of about one-third of the variables used. These include variables relating to housing types, demographic characteristics, and household characteristics (see table 3). Thus,
it is named as family status. The overall loadings of this factor indicated two contrasting family statuses in the population. On the positive end is the old family status which is indicated by the elderly population, older working persons, single person households, and the male population in a sales occupation. On the opposite side are the young family households and the younger population. These two different family statuses are related strongly to different housing types. While the old family is related to shop housing, young family status is related to public housing (HDB).

Table 3
Factor Structure of Family Status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of population living in shop-house</td>
<td>0.90</td>
</tr>
<tr>
<td>% of old-aged population</td>
<td>0.86</td>
</tr>
<tr>
<td>% of single person households</td>
<td>0.83</td>
</tr>
<tr>
<td>% of old-aged working population</td>
<td>0.79</td>
</tr>
<tr>
<td>% of small size households</td>
<td>0.73</td>
</tr>
<tr>
<td>% of male labour force in sales occupations</td>
<td>0.72</td>
</tr>
<tr>
<td>*% of female labour force in sales occupations</td>
<td>0.49</td>
</tr>
<tr>
<td>*% of multi-family households</td>
<td>-0.41</td>
</tr>
<tr>
<td>Fertility ratio</td>
<td>-0.54</td>
</tr>
<tr>
<td>Sex ratio</td>
<td>-0.57</td>
</tr>
<tr>
<td>% of population living in HDB flats</td>
<td>-0.60</td>
</tr>
<tr>
<td>% of young population</td>
<td>-0.80</td>
</tr>
<tr>
<td>% of one family households</td>
<td>-0.91</td>
</tr>
</tbody>
</table>

* Secondary variable
Spatially, factor 1 scored highly positive on those census divisions located in the central city area. These include Bras Basah, Kampong Glam, Stamford, Rochore, Havélock, Hong Lim, Anson, Telok Ayer, and Kampong Kapor (see fig. 1). These are the most important commercial areas of the city since her early history. Before the mid nineteen sixties, many of these areas were occupied by slum dwellers. The housings were generally poor and overcrowded. As Yeh and Lee (1968) pointed out, in 1966 about one-third of the households in these areas were living in housing units having five or more households. However, the overcrowded living conditions have not been mirrored by this factor. Most probably such overcrowded housing has declined considerably during the past few years due to the clearance of slum areas and the relocation of slum dwellers conducted under the urban redevelopment program. To date, apparently, the housing in commercial areas is characterized by a great old-age population and some single families who are running their own businesses.

This factor also scored highly negatively in those census divisions where public housing estates are found. These areas include Alexandra, Queenstown, Bukit Ho Swee, Bukit Merah, Aljunied, Toa Payoh, Macpherson, Mountbatten, and Whampoa (see fig. 1). These are intensive public housing areas which housed a considerable proportion of the previous slum dwellers, the population moving from agricultural lands, and squatter
dwellers. Also, these housing estates housed many people who lived in the central city area who moved from these areas simply to seek a better living environment outside the crowded commercial areas. Limited by their economic capability, they could obtain a better living area by renting a housing unit in those estates. Overall, these areas are characterized by a large number of single family households with a relatively high fertility ratio and a slightly balanced sex ratio. Associated with these family characteristics is the large young population.

Factor 2: Occupational Status

The second important dimension of the urban structure picked up by the technique used relates to the occupational status of Singapore's working population. This factor, which accounted for 20% of the variance, identified two different working groups in the population. On the positive side is the white collar work force which is reflected by many male and female workers engaged in clerical and related occupations, and a relatively great female labour force employed in professional, technical and related occupations (see Table 4). On the negative end is the blue collar work group which is represented by many male and female labourers and the young population in the labour force.
Table 4
Factor Structure of Occupational Status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of female labour force in clerical occupations</td>
<td>0.91</td>
</tr>
<tr>
<td>% of male labour force in clerical occupations</td>
<td>0.84</td>
</tr>
<tr>
<td>% of female labour force in professional, technical and related occupations</td>
<td>0.73</td>
</tr>
<tr>
<td>*% of male labour force in professional, technical and related occupations</td>
<td>0.42</td>
</tr>
<tr>
<td>*% of population living in good housing</td>
<td>0.42</td>
</tr>
<tr>
<td>Fertility ratio</td>
<td>-0.53</td>
</tr>
<tr>
<td>% of female labourers</td>
<td>-0.54</td>
</tr>
<tr>
<td>% of young working population</td>
<td>-0.65</td>
</tr>
<tr>
<td>% of male labourers</td>
<td>-0.71</td>
</tr>
</tbody>
</table>

*Secondary variable

Regarding the social status of these two working groups, according to Hassan (1970), the white collar workers' rank is higher than the one of the blue collar workers. However, the overall factor structure shows us that since a vast majority of them are engaged in clerical occupations, they are most probably lower middle income people. In addition, the slight correlation of this group with good housing indicated that not many of them are high income people. Thus, in most of the cases, the white collar workers reflected by this factor belong to the middle and lower middle class. In contrast to the white collar workers, the blue collar workers are obviously low social status people, although no significant relationship between them and housing types is mirrored by this factor. This,
in fact, makes known that the blue collar workers are not specifically linked with certain types of housing.

In Singapore, the white collar workers are concentrated conspicuously in several census divisions such as, Queens-town, Sepoy Lines, Siglap, Joo Chiat, Kampong Kembangan, Upper Serangoon, Serangoon Gardens, Moulmein, Farrar Park. The distribution of these white collar workers formed two weak sectoral patterns (see fig. 2). One of them extended from Farrar Park towards the northeast including Moulmein, Serangoon Gardens, and Punnggol. The other located at the southeastern part of the island included Joo Chiat, Siglap, Kampong Kembangan, and Kampong Chai Chee. The blue collar workers are mainly distributed in the western part of the island such as Jurong, a newly developed industrial estate of Singapore where a great number of factory workers are concentrated. The other main blue collar workers are distributed consistent with industrial estates such as Bukit Timah, Bukit Panjang, Ulu Pandan, and Bukit Merah. These are the small industrial areas of Singapore.

Factor 3: Poor Housing

The third important factor, which explained about 15% of the variance, picked up the most common type of housing in Singapore's population, its poor housing. Loaded heavily on the positive side of this factor were large households,
population living in poor housing (such as attap and zinc roofed structures), and a labour force engaged in primary economic activities (see table 5). On the negative side is the entirely different living type, the HDB flats associated with small households.

Table 5
Factor Structure of Poor Housing

<table>
<thead>
<tr>
<th>Variable</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of households with persons 11 and over</td>
<td>0.92</td>
</tr>
<tr>
<td>% of population living in poor housing</td>
<td>0.88</td>
</tr>
<tr>
<td>% of labour force engaged in primary economic activities</td>
<td>0.91</td>
</tr>
<tr>
<td>% of multi-family households</td>
<td>0.76</td>
</tr>
<tr>
<td>% of households with 3 or more working persons</td>
<td>0.49</td>
</tr>
<tr>
<td>*Fertility ratio</td>
<td>0.40</td>
</tr>
<tr>
<td>% of female in labour forces</td>
<td>-0.43</td>
</tr>
<tr>
<td>* % of female in sales occupation</td>
<td>-0.43</td>
</tr>
<tr>
<td>% of household with persons 4 and under</td>
<td>-0.50</td>
</tr>
<tr>
<td>% of population living in HDB flats</td>
<td>-0.65</td>
</tr>
<tr>
<td>Density</td>
<td>-0.71</td>
</tr>
</tbody>
</table>

*Secondary variable

Apparently, the variables on the positive side of this factor illustrated a "rural" living pattern which indicated that many people were living in attap and zinc roofed houses and were engaged in primary economic activities. However, in interpreting this factor, especially in the case of Singapore, we should bear in mind that a "rural" area does not distinctively exist on the island city even though
a considerable proportion of the working people are engaged in primary economic activity. This, however, is only one of many characteristics of the population. If one takes other marker variables of this factor into consideration, it is obvious that to name this factor as "poor housing" will be more appropriate than to label it as "rural area".

The extraction of public housing in this factor on the negative end showed the differences between the improved living environment and the unplanned living environment. Together with factor 1, the principal component analysis employed picked these three important but entirely different patterns of living in Singapore. In addition, these factors mirrored the relationship between housing types and family characteristics in the population. While the family status of public housing estates was affected by government policy, that of shop housing and poor housing was conspicuously not affected by government policy. As a whole, HDB estates were related to young family status; shop-house were linked with old family status, and poor housing associated most probably with mixed family status.

While the factor scores of this factor were plotted on the census map, it was found that not all of the census divisions under the "rural area" of governmental administrative areas of Singapore scored high on this factor (the other two GAA are urban and central city area). But, most of the areas
with high scores coincided with the main agricultural areas on the island; these included Chua Chu Kang, Nee Soon, Punggol, Tampines, Changi (see fig. 3). Nevertheless, not all of the population living in these areas was primary economic activity labourers. Conspicuously, poor housing characterized much more these areas than primary activity did. Table 6 showed where the percentage of population living in poor housing is high; this does not necessarily mean that the percentage of primary labour force is high too. In other words, primary, especially agricultural activity characterized only a small proportion of this population. As a matter of fact, whether or not the areas were characterized by primary economic activity, a vast majority of the population of these

Table 6

<table>
<thead>
<tr>
<th>Census Division</th>
<th>% of Poor-housing Population(1)</th>
<th>% of Primary Labour Force(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bukit Panjang</td>
<td>74.8</td>
<td>10.6</td>
</tr>
<tr>
<td>Bukit Timah</td>
<td>79.9</td>
<td>10.2</td>
</tr>
<tr>
<td>Changi</td>
<td>82.8</td>
<td>13.0</td>
</tr>
<tr>
<td>Chua Chu-Kang</td>
<td>88.8</td>
<td>38.5</td>
</tr>
<tr>
<td>Jalan Kayu</td>
<td>83.7</td>
<td>15.5</td>
</tr>
<tr>
<td>Kampong Chai Chee</td>
<td>63.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Nee Soon</td>
<td>82.4</td>
<td>17.1</td>
</tr>
<tr>
<td>*Serangoon Gardens</td>
<td>54.7</td>
<td>4.9</td>
</tr>
<tr>
<td>Tampines</td>
<td>94.9</td>
<td>6.4</td>
</tr>
<tr>
<td>*Thomson</td>
<td>66.4</td>
<td>6.4</td>
</tr>
<tr>
<td>*Paya Lebar</td>
<td>80.5</td>
<td>2.2</td>
</tr>
<tr>
<td>Punggol</td>
<td>81.2</td>
<td>13.1</td>
</tr>
</tbody>
</table>

* Census divisions listed under "urban area" of GAA.

areas was living mainly in "deteriorated or dilapidated" and "temporary" structures.

As has been reflected by this factor, people accommodated in these houses were living under conditions of overcrowding. Many of the housing units housed two or more families and usually contained 11 or more persons. Although the average density of these areas was not as high as that of public housing estates, furthermore, many of these houses have no piped water, no private bath or toilet facilities, and no electricity supply. Compared with their counterparts, HDB flats, these areas were, no doubt, the less developed parts of the city.

Factor 4: Socioeconomic Status

Explaining about 8% of the total variance of the data set, factor 4 was loaded very heavily by the variables related to high level occupations such as the male and female labour force engaged in administrative, managerial, professional, technical, and related occupations (see table 7). It, thus, reflected the high social status of the population.

With the acquisition of high level occupations, this population was mainly high income groups who thus could afford living in good housing (such as bungalows, semi-detached houses, and private flats). They probably are well-educated workers who are employed in commercial, industrial, adminis-
trative, and professional organizations. Thus, they formed the top layer of the social pyramid of the urban society. Certainly, it is a relatively small social group but also contains the influential elements of society (Buchanan, 1972).

Table 7
Factor Structure of Socioeconomic Status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of male labour force in administrative, managerial, and related occupations</td>
<td>0.86</td>
</tr>
<tr>
<td>% of male labour force in professional, technical, and related occupations</td>
<td>0.81</td>
</tr>
<tr>
<td>% of female labour force in administrative, technical, and related occupations</td>
<td>0.76</td>
</tr>
<tr>
<td>% of female population with age 10 and over in labour force</td>
<td>0.71</td>
</tr>
<tr>
<td>% of population living in good housing</td>
<td>0.59</td>
</tr>
<tr>
<td>% of female labour force in professional, technical, and related occupations</td>
<td>0.51</td>
</tr>
<tr>
<td>% of female labour force in sales occupations</td>
<td>-0.61</td>
</tr>
</tbody>
</table>

High factor scores were noted for a few census divisions such as River Valley and Cairnhill which are the high class residential areas of well-to-do population for the last few decades. From these two census divisions to the north along Bukit Timah Road, new high class residential areas were developed including Ulu Pandan and Tanglin (see fig. 4). Other areas included Serangoon Gardens, Thomson in the central part of the island, and Katong and Siglap at the eastern part. These were mostly recently developed middle and high class
residential areas. Spatially, these areas were mainly distributed outside the city central area.

Factor 5: Ethnic Pluralism

Unlike the majority of western studies, this study picked up an ethnic status as only a minor dimension of the urban structure. Also, it explained only about 6% of the total variance of the data. However, it reflected the multi-racial characteristics of Singapore's social structure. On the positive end, this factor recorded the Chinese population which was associated slightly with a sales occupation (see table 8). On the opposite end were the ethnic minorities who were related to service occupations. These minorities are Malay and Indians who are strongly associated with immigrant status which was indicated by a considerable amount of them only hold residential status.

Table 8
Factor Structure of Ethnic Pluralism

<table>
<thead>
<tr>
<th>Variable</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Chinese population</td>
<td>0.77</td>
</tr>
<tr>
<td>% of households with 3 or more working persons</td>
<td>0.52</td>
</tr>
<tr>
<td>% of male labour force in sales occupation</td>
<td>0.40</td>
</tr>
<tr>
<td>% of male in service occupations</td>
<td>-0.40</td>
</tr>
<tr>
<td>% of Malay population</td>
<td>-0.60</td>
</tr>
<tr>
<td>% of population with residential status</td>
<td>-0.81</td>
</tr>
<tr>
<td>% of Indian population</td>
<td>-0.83</td>
</tr>
</tbody>
</table>

*Secondary variable
Economically, these three main ethnic groups possess different occupations as it has been shown by Sze (1972) and others. However, this factor showed only a slight relationship between the ethnic groups and occupational status. Also, this factor indicated the existence of a considerable number of immigrants who are mainly Indians or Malays.

The spatial distribution pattern of these three main ethnic groups was shown in Figure 5. As the majority in the nation, the Chinese population was more evenly distributed over the whole island. However, certain parts of the city were predominantly occupied by the Chinese people such as Bukit Ho Swee, Alexandra, Aljunied, Mountbatten, Hong Lim, Kampong Glam (see Table 9).

**Table 9**

<table>
<thead>
<tr>
<th>Census Division</th>
<th>Chinese</th>
<th>Indian</th>
<th>Malay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bukit Ho Swee</td>
<td>97.2</td>
<td>2.1</td>
<td>0.6</td>
</tr>
<tr>
<td>Havelock</td>
<td>96.8</td>
<td>2.3</td>
<td>0.9</td>
</tr>
<tr>
<td>Hong Lim</td>
<td>97.9</td>
<td>1.9</td>
<td>0.2</td>
</tr>
<tr>
<td>Kreta Ayer</td>
<td>97.7</td>
<td>1.6</td>
<td>0.7</td>
</tr>
<tr>
<td>Mountbatten</td>
<td>94.3</td>
<td>1.5</td>
<td>3.7</td>
</tr>
<tr>
<td>Rochore</td>
<td>91.5</td>
<td>6.2</td>
<td>1.7</td>
</tr>
<tr>
<td>Serangoon Gardens</td>
<td>90.7</td>
<td>6.2</td>
<td>0.8</td>
</tr>
<tr>
<td>Thomson</td>
<td>91.7</td>
<td>3.5</td>
<td>2.5</td>
</tr>
<tr>
<td>Tiong Bahru</td>
<td>93.5</td>
<td>3.9</td>
<td>2.4</td>
</tr>
</tbody>
</table>


Figure 5 indicates also the concentrations of the ethnic
minorities on the island. These include Anson, Telok Blangah, Pasir Panjang, Sepoy Lines, Farrer Park, Kampong Kapor, Geylang Serai, Kampong Ubi, and Kampong Kembangan (see table 10). These areas contained a relatively important proportion of Malay and Indian population in the census division population. Some of these census divisions contained a more balanced ethnic structure. However, on the whole, the Indian population contributed a less important portion to the census division population than the Malay and the Chinese. Anson, Farrer Park, Kampong Kapor, and Sembawang were the areas where the Indian population was concentrated. In some of the census divisions, the Malay population was more important than the other two ethnic groups. Particularly in Geylang Serai, Kampong Ubi, and Kampong Kembangan, these three joined census divisions are the famous "Malay World" of Singapore.

Table 10

<table>
<thead>
<tr>
<th>Census Division</th>
<th>Chinese</th>
<th>Indian</th>
<th>Malay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anson</td>
<td>69.9</td>
<td>20.7</td>
<td>8.4</td>
</tr>
<tr>
<td>Changi</td>
<td>57.7</td>
<td>35.3</td>
<td>7.0</td>
</tr>
<tr>
<td>Farrer Park</td>
<td>65.8</td>
<td>21.3</td>
<td>11.6</td>
</tr>
<tr>
<td>Geylang Serai</td>
<td>37.2</td>
<td>5.5</td>
<td>55.6</td>
</tr>
<tr>
<td>Kampong Kapor</td>
<td>68.3</td>
<td>21.7</td>
<td>9.8</td>
</tr>
<tr>
<td>Kampong Kembangan</td>
<td>36.4</td>
<td>8.2</td>
<td>52.9</td>
</tr>
<tr>
<td>Kampong Ubi</td>
<td>43.0</td>
<td>5.6</td>
<td>50.4</td>
</tr>
<tr>
<td>Pasir Panjang</td>
<td>48.8</td>
<td>16.5</td>
<td>37.4</td>
</tr>
<tr>
<td>Sembawang</td>
<td>46.1</td>
<td>28.6</td>
<td>23.9</td>
</tr>
<tr>
<td>Sepoy Lines</td>
<td>61.9</td>
<td>15.1</td>
<td>23.9</td>
</tr>
<tr>
<td>Tanglin</td>
<td>51.5</td>
<td>5.7</td>
<td>35.3</td>
</tr>
<tr>
<td>Telok Blangah</td>
<td>39.8</td>
<td>16.5</td>
<td>42.3</td>
</tr>
<tr>
<td>Ulu Pandan</td>
<td>55.1</td>
<td>5.8</td>
<td>30.1</td>
</tr>
</tbody>
</table>

Table 9 and 10 indicated the existence of an obvious ethnic residential segregation. Moreover, these ethnic concentrations are consistent with the ethnic segregation pattern designed by the British Colonial Governor of the 1890s (Hodder, 1953). However, the boundaries between them are less definitive. As pointed out by Bu-čhanan (1972), there still were Chinese districts, Indian districts, and Malay districts adjoining one another and merging but retaining their distinctive character.

Factor 6: Malay Occupational Status

As a minor factor which explained only 4% of the total variance of the data matrix, factor 6 picked up primarily a service occupational status which was indicated by the heavy loadings in the male and female labour force employed in service occupations (see table 11). Associated with service occupation is the Malay population. This factor, thus, revealed a Malay service occupational status. It reflected that there was a large male and female Malay working population engaged in service occupations, especially in the police and armed services. On the other hand, very few Malay female were engaged in labourer occupations.

Figure 6 shows the distribution pattern of Malay population who are engaged in service occupations. In addition to figure 5, this figure showed some more Malay residential concentrations such as Ulu Pandan, Tanglin, and Changi. The first
two areas coincided with the high class residential areas. Probably, some of the higher social class Malay people were living in these areas. Apart from these two areas, the Malay population seldom occurred in high or middle residential areas.

Table II
Factor Structure of Malay Occupational Status

<table>
<thead>
<tr>
<th>Variable</th>
<th>Loading</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of female in service occupations</td>
<td>0.79</td>
</tr>
<tr>
<td>% of male in service occupations</td>
<td>0.70</td>
</tr>
<tr>
<td>% of Malay population</td>
<td>0.40</td>
</tr>
<tr>
<td>% of young working population</td>
<td>-0.41</td>
</tr>
<tr>
<td>% of Chinese population</td>
<td>-0.43</td>
</tr>
<tr>
<td>% of female labourers</td>
<td>-0.57</td>
</tr>
</tbody>
</table>

*Secondary variable

If one co-ordinates figures 5 and 6, the concentrated residential pattern of the minorities shows more clearly. Obviously, Geylang Serai, Kampong Ubi, Kampong Kembangan, Pasir Panjang, Telok Blangah, Changi, Ulu Pandan, and Tanglin are Malay's main residential areas. On the other hand, the Indian population resided mainly in only a few census divisions; these included Anson, Kampong Kapor, Farrer Park, and Sembawang.

4.4 Spatial Differentiation of Urban Structure

The interpretation of the results of this study given in the previous sections reveals that the basic urban social structure of Singapore can be sufficiently delineated by using
six dimensions. These are Family Status, Occupational Status, Poor Housing, Socioeconomic Status, Ethnic Pluralism, and Malay Occupational Status. A rough spatial distribution pattern of these dimensions has been depicted, but the spatial social differentiation of the urban structure as a whole has not been thoroughly investigated. An attempt to analyse the areal differentiation of the urban structure is made in this section.

Figure 1 has shown the distribution pattern of two different family statuses of the population. Old family status is distinctively characterized by the traditional commercial areas while young family status is characterized by the public housing estates. Other areas apart from these two are mostly characterized by mixed family status. Conclusively, the family status varied from old to young proportionally with an increase in distance from the city central area but not in a perfectly concentric pattern. The oldest family status, located in the core of the commercial area, was surrounded by a relatively old family status found in relatively new residential and commercial mixed areas. The young family status did not form a ring surrounding the old family status but formed a sectoral pattern on the west of the city area and clusters on the eastern part of the city's outer zone.

These two different family statuses were linked with different housing types. However, the social status of the population was generally similar with each other. Figure 7, plotting factor 1 against factor 4, showed the social space of
these two groups of population. Clearly, neither the shop-house areas (or the old family) nor the public housing estates (or young family status) has fallen into the highest or the lowest social statuses. They mainly belonged to lower middle or low social classes. In this diagram, B1, C1, and D1 represent the social status of the shop-house population which varied middle, lower middle, to low class respectively. On the HDB side, B4 and C4 represent the social status of public housing population. This finding concurred with Yeh and Lee's finding (1968). However, the well-to-do population has disappeared from the city's central area. Two possibilities can explain this finding; first, the small group of rich businessmen has moved to high or middle class private housing estates or high class public housing estates; and secondly, the number of remaining well-to-do businessmen are too small to be noticeable among the mass of poor inhabitants and shop-house dwellers. Limited by the availability of relevant data and information, this study could not make further investigation whether these rich businessmen still live in the central city areas in their own shop-houses. To find the truth, further studies are necessary.

Depicting the spatial distribution pattern of Singapore's white and blue collar workers, figure 2 reveals a very complicated picture. Generally, white collar workers are not definitively related to any type of housing pattern. However, they
are mainly distributed in the outer zone of the city, especially in some middle class residential areas. The blue collar workers reside mainly in the western part of the island far from the city's central area but with a strong relationship to industrial areas. Mostly, these two groups of population were related only moderately to shop-house and public housing estates.

With respect to the ethnic occupational specialization, figure shows that no clear racial occupation boundaries can be drawn. Generally, the three main ethnic groups are engaged in all kinds of available occupations. However, figure 3 exposes three outstanding racial occupation sub-groups. One is the Chinese blue collar workers; another is the Indian blue collar worker; and the last is the minority white collar worker. Other than these three groups, the population is characterized by a racial, occupational mixture.

A large part of Singapore is characterized by poor housing. As it has been shown in figure 3, the poor housing areas form a thick zone surrounding the most developed part of the island. Physically, with respect to the houses' construction, these poor-housing areas are different from the public housing estates and shop-housing areas. However, their social statuses are not drastically different from the majority of shop-house dwellers or public housing estates inhabitants. Figure 9, plotting factor 3 against factor 4, shows that poor housing together
FIG. 8 ETHNIC OCCUPATIONAL STATUS

FACTOR 2
WHITE COLLAR

MINORITIES
WHITE COLLAR

MINORITIES
BLUE COLLAR

INDIAN WORKING GROUP
MAINLY BLUE-COLLAR

*WHITE COLLAR GROUP
MAINLY CHINESE

CHINESE
BLUE COLLAR

CHINÉSE
BLUE COLLAR

MINORITIES
BLUE COLLAR

BLUE COLLAR

K.C. CHAN 27-11-74
with a great majority of HDB and shop-house areas have fallen into the low middle and the low social statuses.

In contrast to poor housing, middle or high class residential areas are distributed throughout some parts of the island. Figure 4 clearly shows that a large fan-shaped high class residential area is wedged between the most intensively developed public housing estates, Toa Payoh on the east, and Queenstown and Delta on the west, on the northwestern part of the city central area. This area includes River Valley, Cairnhill, Ulu Pandan, and Tanglin. Joined with this area on the northwestern corner are another newly built middle and high class residential areas, Serangoon Gardens and Thomson. There is another middle and high class residential area developed along the sea front east of the city area towards the mid-east of the island; this area includes Katong, Joo Chiat, and Siglap. Physically and socially, these areas are different from the poor housing, shop-house, and HDB estates. Living in these new bungalows, semi-detached houses, terrace houses, row houses, and private flats are high income or middle high income groups. Their social status is the highest among the population.

Showing the social status of the poor-housing population, figure 9 also shows the social status of the high income or well-housed population. All of the census divisions that scored heavily in socioeconomic status have fallen into the high social class with exception of Serangoon and Thomson. These two
census divisions are characterized not only by much poorly-
housed population, but also by a well-housed population. In
fact, these two types of population live side by side. Thus,
their actual social status is moderate somewhat as to the va-
riation between their status. Further areal differentiation
of the social statuses of these two areas was limited by the
availability of extra detailed data.

The spatial distribution pattern of the three main eth-
nic groups is shown in figure 5. The overall pattern is that,
while the Chinese population is more evenly distributed over
the whole island, ethnic minorities are concentrated in some
parts of the island. For example, Pasir Panjang, Telok Blan-
gah, Changi, Kampong Kembangan, Kampong Ubi, Geylang Serai,
Ulu Pandan, and Tanglin are the main residential areas of the
Malay population. Clearly, the Malay population resides mainly
at the outer zone of the city. Very few of them live in the
City's central areas. Occupationally, they are seldom engaged
in business.

Slightly different from the Malay population, the Indian
population is concentrated in fewer census divisions and lives
mainly on the fringe of the city's central area. Anson, Parter
Park, Kampong Kapor, Sepoy Lines are their main residential
areas. To a considerable extent, Indians engage in various
kinds of occupations, from small businesses to high class ci-
vil servants. But the majority of them are poor small busi-
ness owners, or, blue collar or low income white collar work-
ers.

Considering the racial distribution pattern of the urban society as a whole, it was found that the racial residential concentrations clearly exist and are consistent with the ethnic segregation patterns designed by the British Governor in the 1990s. The expansion of population in the later years, however, has changed the areal distribution pattern of the ethnic groups on the island. The traditional living patterns have not changed much.

The social differentiation, however, could not be found along the racial boundaries. The most notable phenomenon of ethnic-social status, as depicted by figure 10, is the existence of a large group of middle and low social class population across the ethnic boundaries. At the top of the social pyramid is a high social class consisting of three main ethnic groups. Nevertheless, there exist some ethnically dominated social sub-groups. Group B and C, in the diagram, represent the Chinese lower middle and low social classes respectively, while group D indicates the minorities (Indians and Malays) middle classes, group E and F represent the lowest and lower social statuses of the ethnic minorities respectively.

Summing up the spatial distribution pattern of each dimension, it was found that a vast majority of the census divisions are characterized by several distinctive characteris-
FIG. 10  ETHNIC SOCIAL SPACE

HIGH STATUS
NON-ETHNIC DOMINATED

MIDDLE CLASS
INDIAN

LOW MIDDLE CLASS
MINORITIES

LOW STATUS
MINORITIES

LOW STATUS
CHINESE

LOW MIDDLE
CHINESE

LOW STATUS
CHINESE
tics. This simply indicates that the urban social structure in Singapore is a complex one. Thus, any highly generalized spatial models (such as Burgess' concentric model, Hoyt's sectoral model, McGee's modified concentric model, or Yeung's modified sectoral model) could not sufficiently delineate the spatial social structure of Singapore.

However, based on the prominent characteristics, especially housing types, social status, and ethnic structure, the spatial structure can be adequately delineated by figure 11. This figure shows the most outstanding social areas in Singapore, including poor housing area, high social status area, shop-house area, and the concentrated minority areas. Each of these areas was associated with other characteristics (as shown in the figure). Basically, the sectoral and cluster patterns describe most of the spatial pattern of the housing and ethnic distribution. Poor housing, obviously, is the only conspicuous zone that is in a concentric pattern. On the whole, it was clear that the structure in the urban area is very much more complicated than the sub-urban area.

4.5 A Brief Comparison of Urban Structure -- Singapore with Western Cities and Calcutta

The interpretation given in the previous sections reveals that the basic urban structure of Singapore was different from that of Western cities. In this section, an attempt is made to find out in what way and to what extent Singapore is different from others.
FIG. 11
SOCIAL STRUCTURE OF SINGAPORE, 1970

- HDB Public Housing
- MS Malay in Services Occupation
- MH Middle- and High
- L Low Status
- H High Status
- PH Poor Housing
- WC White Collar
- CH Chinese
- IN Indian
- MAL Malay

MINORITIES
LOW STATUS
POOR COLLAR
BLUE COLLAR
HIGH STATUS
HIGH STATUS
MINORITIES
HDB M & H STATUS
HDB MAL
MIXED
HDB

MILES
0 2 4

KCCHAN 27-11-74
Primarily, Shevky's typology has been confirmed in the case of Singapore. Social status, family status, ethnic status have been extracted as the basic urban dimensions of Singapore. However, the relative importance of these dimensions are different from those of most Western cities. These three factors are invariably important in the vast majority of Western cities; however, in Singapore, only family status has been extracted as the one important factor of the three. Social status and ethnic status are not as important as poor housing and occupational status. This variation, thus, unearthed the basic differences between Singapore and Western cities regarding their essential urban structure.

In Chicago, Rees (1970) obtained ten factors that described the basic urban structure of the metropolitan area; and Murdie (1969) derived six factors for delineating the internal social structure of Toronto. Among the factors obtained in these two studies, social status, family status, and ethnic status were the most important three urban dimensions. Rees obtained a high social status in Chicago whereas Murdie derived a low social status in Toronto. In Singapore, however, the social status is split into two factors, occupational status and socioeconomic status, which differentiated the high, middle, and low social ranks of the population.

Structurally, social status and family status derived in these three cities were nearly the same. As it was in Chicago and Toronto, family status in Singapore is strongly related
to household characteristics and demographic characteristics. Similarly, social status in Singapore is highly associated with occupational status and housing types which to some extent reflected the income level of Singapore's population.

Regarding the ethnic structure of these cities, it was split into at least two factors. In Chicago, Rees extracted no less than three ethnic factors; in Toronto, Murdie obtained two ethnic factors, and in Singapore, two ethnic factors were produced. In the case of Chicago and Toronto, ethnic factors were related to social and family status. However, it is slightly related to occupational status in Singapore. Furthermore, the ethnic segregation in Singapore is not as serious as it is in Chicago, and a clear ethnic community boundary could not be found in Singapore.

Since the complexity of urban structure varied from one city to another, the necessary number of factors extracted for describing the urban structure varied. Rees produced 10 factors, but they together explained only 77% of the urban structure of Chicago. Murdie was able to explain 75% of the urban structure of Toronto by six factors. In this study, the extracted six factors together explained about 84% of the urban structure of Singapore (see table 12).

In the case of Singapore, as a matter of fact, the three leading factors together explained two-thirds of the urban structure. But in Chicago and Toronto, the four leading factors
explained only 55% and 60% of the urban structure respectively. A conclusion can, thus, be drawn from this difference: that the urban structure of Singapore is very much simpler than that of Chicago and Toronto. Therefore, less factors were needed to delineate the internal urban structure of Singapore than Chicago and Toronto.

Table 12
A Comparison of Factor Results

<table>
<thead>
<tr>
<th>Factor</th>
<th>Singapore</th>
<th>Toronto</th>
<th>Chicago</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>29.8</td>
<td>21.1</td>
<td>17.8</td>
</tr>
<tr>
<td>2</td>
<td>20.5</td>
<td>15.6</td>
<td>14.2</td>
</tr>
<tr>
<td>3</td>
<td>15.4</td>
<td>12.2</td>
<td>13.1</td>
</tr>
<tr>
<td>4</td>
<td>9.5</td>
<td>11.5</td>
<td>10.9</td>
</tr>
<tr>
<td>5</td>
<td>5.9</td>
<td>7.7</td>
<td>7.5</td>
</tr>
<tr>
<td>6</td>
<td>3.8</td>
<td>6.9</td>
<td>3.9</td>
</tr>
<tr>
<td>Total</td>
<td>83.9</td>
<td>75.0</td>
<td>77.3*</td>
</tr>
</tbody>
</table>

* 10 factors

The comparison of urban structure of Singapore to that of Calcutta is restricted by two problems. First, the variables used in these two studies are quite different. Secondly, the percentage of variance explained by each of the factors has not been given in the study of Calcutta. Thus, the comparison is restricted. However, it was found there exist some variations as well as similarities between the two cities. The most notable similarity is the dimensions of the urban structure. Factor 1 of both studies which indicates the family
status of the cities is nearly the same and is related strongly to housing types. Secondly, the commercial and residential mixed land use pattern is coexistent in both cities. The main deviation is that the social status was separately extracted in Singapore while it was related to ethnic minorities in Calcutta. In Singapore, ethnic groups are slightly associated with occupational status.

Spatially, there are some similarities between Singapore and Calcutta (see figure 11 of this study, and figure 29 of Berry and Rees' study). The core area of these two cities is characterized by shop houses; the commercial and residential mixed areas are found immediately outside the core, and the low class residential areas are located at the periphery of the city. The high class residential areas are found between the city central area and the low residential area. These similarities indicate the residual characteristics of a previous colonial city much like Singapore and Calcutta. However, the urban structure of Singapore has been recently changed. The urban redevelopment and housing development programs have modified Singapore's urban physical landscape. The decline in the commercial and residential mixed area together with the clearance of slums in the city area has changed the land use patterns. Public housing estates have replaced the slums and squatter areas. This has not been the case in Calcutta (as shown by Berry and Rees, 1969).
4.6 Conclusion and Discussion

The foregoing analysis of the findings of this research reveals that the urban social structure of Singapore can be delineated by mainly using housing types (associated with family status) and occupational status. Supplemented by a social status and ethnic status, the whole urban structure can be shown more completely. Since the derived factors explained a high proportion of the variance, these dimensions do describe the urban structure adequately.

Basically, hypothesis 1 of this study can be accepted. Since the three leading factors have already explained two thirds of the total variance of the urban structure, the rest serve as important supplementary ones. This indicates that the urban structure of Singapore is very much simpler than that of Western cities such as Chicago and Toronto.

The second hypothesis of this study, which is set based on the assumption that ethnic status will be the most important factor of the urban social structure of Singapore, has been rejected. Since the derived ethnic factors are not the most important ones, two of the ethnic factors together explain only 10% of the variance. Nevertheless, the extraction of these two factors indicated that ethnic elements are important to the urban society. While factor 5 shows the racial pluralism, factor 6 further shows their differentiations in occupational status. Spatially, these two factors also
differentiate the main ethnic residential concentration patterns.

The principal component analysis employed picked out four basic types of housing in three factors. These are: factor 1, shop housing and public housing; factor 2, poor housing; and factor 3, good housing. The extraction of these factors was not consistent with the importance of these housing types in terms of number of the population housed. Hypothesis three, thus, can be partly accepted. In addition, these housing types do not independently exist with the exception of poor housing. While shop housing and public housing are related to family status, good housing is associated with high social status. It is obvious that only good housing among the four basic housing types indicated the social status of the population. From this evidence, the relationships between housing types and social status as claimed in some of the previous studies are in fact exaggerated. Thus, the adoption of housing types as the sole indicator of the social status of the population is dangerous and delusive.

Regarding the spatial pattern of the social structure of the Metropolitan Singapore, figure 1 to 6 show the spatial distribution of each of the social dimensions. The generalized structure is shown in figure 11. Basically, shop-housing (old family status) is distributed in an incomplete concentric pattern, and is surrounded by public housing, and high and middle
class residential areas; public housing (or young family status) is distributed in sectoral and cluster pattern; poor housing forms a concentric zone surrounding the most developed part of the metropolis — the urban area; high and middle class residential areas are distributed sectorally while ethnic minorities are distributed in both sectoral and cluster patterns.

Obviously, McGee's concentric model of the land use pattern of Southeast Asian cities has been very little confirmed in this study. Yeung's sectoral model has been partly confirmed. However, Yeung's model is too simple to show the complex social structure of Singapore since it merely took land use patterns into consideration. Thus, for delineating the urban social structure of Singapore, a more complete model is needed. By coordinating the basic elements of urban social structure, this study derived a generalized urban social structure model of Singapore which shows that a sectoral and cluster pattern best describes most of the spatial arrangement of the basic urban dimensions.

In conclusion, the principal component analysis employed in this study has enabled the breaking down the multiplicity of the mixed socioeconomic characteristics into a few basic cluster patterns. Thereby, the investigation of the urban structure was possible. In the analysis, it was found that the basic urban structure is different from that of Western
cities despite there being some minor similarities. In addition, the spatial structure of Singapore is too complicated to be adequately described by using both McGee and Yeung's model. This study, thus, deduced a new model for describing the urban social structure of Singapore. Of course, this model is open for further study.
CHAPTER FIVE
SUMMARY AND CONCLUSION

5.1 Summary

Classical studies on urban spatial structure (such as Burgess, 1925; Hoyt, 1939) and urban social area analysis (by Shevky and his associates, 1955) have been replaced by current urban factorial ecological studies since the 1960s. The classical studies took into account too few of the population characteristics of the complex urban society. The factorial ecological approach deals with a large number of socioeconomic characteristics simultaneously by the aid of modern computational techniques. Thus, it is able to look at the internal urban structure more closely than classical studies.

Aimed at studying the urban social structure of Singapore, this study employed a factorial ecological approach as the basic methodological framework. The main objectives were to identify the underlying characteristics of the urban society and to investigate the areal differentiation of the urban structure. To approach these objectives, principal component analysis was employed as the basic analytic technique for obtaining basic urban dimensions. Three basic steps were undertaken:
First, thirty-five variables of demographic, ethnic, occupational, housing, and family characteristics of the urban population were selected.

Secondly, the data of these variables were prepared from the Report of Census of Population of Singapore, 1970. To fit the analytic model, the data were normalized.

Thirdly, for factoring the data, the PAI program was employed from the Statistical Package for the Social Sciences. Orthogonal rotation with varimax criterion was selected, thus producing a set of statistically independent factors with simple structure.

5.2 The Results

The selected program produced six significant factors for further interpretation. Explaining about 94% of the total variance of the data set used, these factors adequately delineated the underlying characteristics of the urban society of Singapore. These factors were interpreted according to a heavily loaded variable with loading 0.4 and over.

The first factor alone explained 30% of the variance of the urban structure, which reflecting the different family statuses of the population. Meanwhile, the factor also picked up two entirely different housing types. The relationship between family status and housing types was clearly shown in this factor, that old family status is related to shop-housing and that young family status is associated with public hous-
ing. While the former one occurred in the central city area, the latter, in the public housing estates.

The two important occupational groups of the society were mirrored by factor 2 explaining about 20% of the variance. These two contrast working classes were the white collar workers and the blue collar workers who represented the middle and low social statuses respectively.

Having picked out two types of housing in factor 1, the principal component technique picked up another distinctive housing type -- poor housing -- in factor 3. Explaining about 15% of the variance, this factor reflected the poor, overcrowded living conditions of the people inhabiting those less planned developed areas. In addition, this factor indicated that living in these attap and zinc roofed houses was that low social class population.

The smallest social group among the population, the high social class, was picked out by factor 4 in this study. This factor showed a wholly different social group in the population compared to the already mentioned social groups. Possessing high income level occupations and living in good houses, they were the well-to-do people of the city.

In addition to housing types and occupational status, the technique employed picked up two less important factors reflecting the ethnic characteristics of the urban society.
The multi-racial property was reflected by factor 5 which recorded the majority (the Chinese) on the positive end and the ethnic minorities (the Malay and the Indian) on the opposite end. Spatially, this factor differentiated the ethnic residential concentration pattern but did not mean the existence of any racial segregation. Both of them have an equal right to share all social amenities with each other. Still, it was found that several census divisions with low or lower social status coincided with the minorities' residential concentrations. Together with factor 6, which slightly showed the ethnic occupational difference, this factor implicitly distinguished the identity of the racial segregation as residential or occupational, although not social.

Summing up the spatial pattern of the social dimensions, figure 11 noted six main social areas of Singapore. The spatial pattern shown in this figure obviously was somewhat different from "cGee's and Yeung's model where sectoral and cluster patterns have described most of the dimensions.

5.3 Problems Encountered and Recommendations for Further Studies

The principal component analysis here employed enabled the investigation of the individual dimensions of the urban structure. However, the results of this study admit to some limitations.

One of these limitations is linked with the data used.
The utilized data were prepared on the basis of the census divisions which were the smallest units upon which detailed data could be obtained. By using these data, the basic, obvious, and important areal differentiations of the urban structure were shown. However, some of the census divisions contained population of different social statuses. Thus, the actual social status of these census divisions was moderated. For example, those peripheral census divisions of the metropolis usually contain high and low class residential sub-areas. Within these areas, the high and low class population are not mingled with each other but live in separate parts. They, thus, form different social sub-areas. However, such a small areal unit datum which might show the actual differentiation was not available. Similarly, the public housing estates which housed population of different social classes concealed certain important social differentiations among the population. Owing to this limitation, the areal differentiation of the social structure of Singapore revealed in this study to some extent was restricted.

Another limitation of this study was that it dealt only with the socioeconomic characteristics of the year 1970. It, thus, merely showed the static social and spatial structure of Singapore. The changing pattern of the underlying social structure and the spatial pattern, however, could not be shown in this study.
Owing to the above mentioned limitations, the value of the findings in this study is restricted. However, it provides further information upon which new studies on the urban social geography of Singapore can be designed. As a matter of fact, to understand thoroughly the social geography of Singapore, more studies that employ more detailed data are needed. This study raised certain important problems to be further researched. First, the socioeconomic characteristics of the population living in peripheral census divisions and housing estates should be further studied in order to find out their actual social structure. Secondly, the ethnic social differentiation should be further investigated to see the actual ethnic social status. Thirdly, a study of the migration pattern of the urban population would help to further understand the residential segregation pattern of the population. These researches would no doubt provide more actual information on the social areal differentiation of Singapore. In order to find out the changing pattern of the urban social structure, a time-base factorial ecology by employing the 1957 and 1970 census data is needed. The results of these studies, certainly, will provide valuable information for urban and social development.

5.4 Conclusion

As it has been successfully used in studies of the urban structure of Western cities, factorial ecology approach has been found useful in studying the urban structure of an Eastern city.
Singapore. By employing this approach, this study was able to identify the underlying social structure patterns of Singapore. Furthermore, it has also enabled the investigation of the areal differentiation of the urban social structure. Thereby, the comparison of Singapore's urban structure with that of other cities was possible.

Generally, the urban social structure of Singapore has been sufficiently studied by this factorial ecological set-up. The basic dimensions of the urban social structure are Family status, Occupational Status, Poor Housing, Socioeconomic Status, Ethnic Pluralism, and Malay Occupational Status. These findings have led to the conclusion that the basic urban structure of Singapore is different from that of others but with some similarities. In terms of the spatial pattern of these dimensions, family status is almost the same as Western cities, here distributed in an incomplete concentric pattern; socioeconomic status is sectorally distributed, the same as Western cities; and ethnic minorities were found to be distributed both in a sectoral and cluster pattern similar to Western cities.

In conclusion, this study has shown more clearly the underlying socioeconomic characteristics of Singapore than any previous studies. However, this was only the first attempt in applying the factorial ecological approach to study the urban structure of Singapore. Certainly, this study has its limitations. The findings of this study need further testing. For a
more thorough understanding of the urban social geography of Singapore, more research in addition to this is in fact needed. Hopefully, this study will stimulate further research on the urban social geography of Singapore and will provide at least some basic references on this aspect.
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**Data Source**

Singapore, Volume I & II*, Department of Statistics, 
Appendix B

Census Divisions of Singapore, 1970

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Appendix C
Variables List

Demographic Characteristics

YOUNG -- % of population with age 5 to 14.
OLDAGED -- % of population with age 60 and over.
FERTILE -- Fertility ratio (number of population with age 4 and under / female with age 15 - 49).
SEX -- Sex ratio (male per thousand females).

Ethnic Structure

MALAY -- % of Malay population.
CHINESE -- % of Chinese population.
INDIAN -- % of Indian population.
RESIDEN -- % of population holding only residential status.

Family Characteristics

YOUTHWOK -- % of population with age 10-19 in labor force.
OLDWORK -- % of population with age 60 and over in labour force.
FEMLABOR -- % of female population with age 10 and over in labour force.

Household Characteristics

PPHI4AU -- % of households with 4 persons or less.
PPH110 -- % of households with persons 11 and over.
ONEFAM -- % of households with one family.
MUTFAM -- % of households with two or more families.
SINFAM -- % of single person households.
HPMO3 --- % of households with 3 or more working persons.

Housing Types

BUNTER -- % of population living in good housings: such as bungalows, semi-detached houses, terrace houses, and private flats.
Appendix C (Cont'd)

SHOP --- % of population living in shop houses or floors of shop houses.

HDB --- % of population living in public housing estates, include STF and HDB flats.

ATAZIN --- % of population living in poor housing, include attap and zinc roofed houses, and wooden houses.

Occupational Status

MPTEC --- % of male labour force in preprofessional, technical and related occupations.

FPTEC --- % of female labour force in professional, technical and related occupations.

MADMAGER --- % of male labour force in administrative, managerial and related occupations.

FEMAGER --- % of female labour force in administrative, managerial and related occupations.

MACLER --- % of male labour force in clerical and related occupations.

FECLER --- % of female labour force in clerical and related occupations.

MASALE --- % of male labour force in sales and related occupations.

FESALE --- % of female labour force in sales and related occupations.

MASERE --- % of male labour force in service occupations.

FESERE --- % of female labour force in service occupations.

MANWORK --- % of male labour force are production and related workers; transportation equipment operators, and labourers.

FENWORK --- % of female labour force are production and related workers; transportation equipment operators and labourers.

PRIMARY --- % of labour force are agricultural and animal husbandry workers and fishermen.

Size

DENSITY --- Number of population per acre.
Appendix D

A WATPIV Program for Bartlett's Test of
Significance of Principal Components

DIMENSION R(50), SUM(50), RF(50), A(50)
DIMENSION CHISQ(50), C(50), DF(50), T(50)

READ, N
READ 10, (C(I), I=1,N)
10 FORMAT(F10.0)

M=5
K=N-5
DO 100 I=1,N
IF(I.EQ.1) GO TO 11
R(I)=R(I-1)*C(I)
GO TO 100
11 R(I)=C(I)

100 CONTINUE

RVV=R(35)
DO 200 I=1,N
IF(I.EQ.1) GO TO 21
SUM(I)=SUM(I-1)+C(I)
GO TO 200
21 SUM(I)=C(I)

200 CONTINUE

DO 150 I=1,N
150 PRINT 160, I, R(I), I, SUM(I), I, C(I)

DO 300 I=1,K
RF(I)=RVV/R(I)*((N-SUM(I))/(N-I))**(N-I))
300 PRINT 31, I, RF(I)

DO 400 I=1,K
CHISQ(I)= -(N-I-1)*((2*N+5)/6)-((2*I)/3)*A(I)
400 CONTINUE

DF(I)=((N-I-1)*(N-I+2)/2)

DO 600 I=1,K
T(I)=(2*CHISQ(I)**0.5-((2*DF(I)**0.5)
600 CONTINUE

DO 500 I=1,K
500 PRINT 550, I, DF(I), CHISQ(I), T(I)
550 FORMAT(3X, I2, F10.0, F15.5, F15.5)
STOP
END
# Appendix E

The Results of The Bartlett's Test of Significance of Principal Components

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VITA

Kang Cheong Chan was born in Singapore, 1947. Completed his high school education at the Chinese High School, Singapore, in 1966, he carried on his university education at Nanyang University, Singapore, in 1967. He obtained his B.A. and B.A. Honours degrees major in Geography at the University in 1970 and 1971 respectively. In September of 1972, he came to Canada for doing his M.A. program at the Department of Geography, University of Windsor, Windsor, Ontario, Canada.

In 1973, he married Chew Ee Kwa, who was his classmate for three years at Nanyang University, and who obtained her M.A. at the Department of Geography, University of Windsor, in October, 1974.