DISCRIMINANT ANALYSIS OF LOW-COST HOUSING ALTERNATIVES:
A STUDY OF NON-PRICE FACTORS INFLUENCING HOUSING CHOICE DECISIONS

DISSERTATION
Presented in Partial Fulfillment of the Requirements for the Degree Doctor of Philosophy in the Graduate School of The Ohio State University

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* * * * *

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CHAPTER I
INTRODUCTION

Since 1949 it has been a stated goal of the United States Government to insure that every American lives in a decent home. In accordance with this goal the Congress of the United States has passed many pieces of legislation providing funds, programs, and policies to help reach this objective.

Recently the Congress again manifested its concern for the problems of the housing industry by passing the Housing Act of 1968. One section of this law recognized an impending weakness in the housing supply and set a goal calling for the construction of 26.2 million new dwelling units by 1978. This law reiterated a high priority for the channeling of resources into housing construction and financing.

The high priorities implied in housing legislation manifest a concern for the process by which needed resources are channeled into housing. The allocation process takes place in both the public and private sectors of the economy. The governmental efforts are explicit attempts to affect the process. The bulk of the needed resources are provided by the private sector, however. What is important is that the efforts of both sectors be directed as much as
possible toward a common goal and that both sectors attempt to use
economic analysis to arrive at their decisions. Further discussion
of the social implication of economic analysis appears in a later
section of this chapter.

The Problem

Economic analysis of the type assumed here has as its criter­
ion or goal the maximization of consumer utility for each resource
dollar spent. In order to maximize this utility it is necessary that
there be accurate information available to the decision-maker concern­
ing the nature of the demand for the resources and the impact of each
dollar spent.¹ In terms of the housing market it is necessary to
know how much demand there is for each type of dwelling unit and how
different types of dwellings may be used to satisfy the overall de­
mmand.

Thus, in order to allocate resources in the housing sector a
model is needed to describe the behavior of the system and its sub­
sectors. It is the contention of this dissertation that there is no
such model available at this time. Further, there are two areas of
weakness with current models to which this research is addressed.
These are:

1. The lack of knowledge about the mobile home subsector
   of the housing market, and

¹Charles Hitch and Roland McKeen, The Economics of Defense in
2. The inadequacy of the treatment of non-economic variables in conventional economic models of the housing market.

The Mobile Home

One of the fastest growing industries in the United States in the past decade has been the mobile home industry, growing at a rate of eleven percent per year over the period. Mobile home shipments of over 400,000 units accounted for around twenty percent of the total new housing starts in 1969. Yet even in view of statistics such as these, very little rigorous research has ever been done concerning the place of the mobile home in the housing supply. In fact, standard national housing start statistics do not even consider new mobile homes as housing starts.

The most widely available major study of the mobile home is the

Housing Survey: Part Two, prepared in 1968 by the Department of Housing and Urban Development (HUD). This study consisted of data gathered in 1966 from mobile home owners and attempted to define dwelling and owner characteristics. A limited number of attitude

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3Based on non-farm, non-mobile home starts of approximately one million units in 1969. Source: U.S. Department of Housing and Urban Development.

questions were also included. The study included no statistical tests of the data gathered, however. Further, no attempt was made to correlate these data formally with available data describing other segments of the housing market. Finally, no attempt was made to isolate the elements affecting the demand for these units.

There have been major studies concerned with approaches to the demand for housing done by Muth, Reid, and Coons and Glaze which might have been relevant to the problem of concern for this research. However, their analyses did not consider the mobile home. Rossi and Beyer have also studied housing choice along similar lines. Their studies were done in 1955 and, similarly, did not include mobile homes.

In conclusion, knowledge about the mobile home segment of the housing market is limited. There are demographic data available describing some dwelling and owner characteristics, but little information concerned with the question of why a person would live in a mobile home rather than some other form of housing.

---


6Margaret Reid, Housing and Income (Chicago: University of Chicago Press, 1962).

7Alvin Coons and Bert Glaze, Housing Market Analysis and the Growth of Home Ownership (Columbus, Ohio: The Ohio State University Bureau of Business Research, 1963).


The Economic Models

Inherent in the question of why a person would choose a mobile home rather than some alternative form of housing is a need to isolate a group of the variables which affects such a decision. These variables imply a concept of consumer behavior. Micro-economic theory has provided housing market analysts with a starting point—a model which states that the aggregate demand for a good is a function of the price of the good, the prices of competing goods, income (in some form), and consumer tastes and preferences. This economic model, which proports to explain demand, generally holds consumer tastes and preferences constant, income constant, and computes the quantity demanded as a function of price. This is, however, an aggregate model.11

There is a more sophisticated model of consumer choice which begins by deriving housing demand for individual households. The individual demand for each household is summed over all households in some housing submarket and an aggregate function is derived for that submarket. Using such a model, changes in price in one submarket can be followed to changes in demand in any other submarket according to the cross-elasticity of demand with respect to price between the two submarkets.12 This model has many outstanding features, but there

10See the section on the Model Concept later in this chapter.

11For an example of the simple traditional model, see Coons and Glaze, Housing Market Analysis, Chapters 1 through 4.

12A discussion of this type of model may be found in William G. Griesby, Housing Markets and Public Policy (Philadelphia: University of Pennsylvania Press, 1953). This model is also discussed in Chapter II of this dissertation.
is limited information concerning the critical choice variables that determine in which submarket a household will demand a unit. To an undetermined extent this may be a matter of tastes and preferences. In addition, cross-elasticity between submarkets is unknown.

There is a body of literature growing in the discipline of marketing concerned with the behavioral aspects of consumption and aimed at the weakness in economic models regarding the effect of non-price variables on demand. This literature is concerned with the marketing and consumption of items substantially less durable than housing, however, and its application to housing demand is unclear.

The Model Concept

In the modeling of complex systems such as the housing market, a well-defined approach is needed. Modeling is the process of abstracting systems from the real world. The first step of modeling describes the real world "... not as a thing, but as a list of variables." The importance of this list is described by Professor Daniel Howland.

These variables constitute the behavioral dimensions of the system, and the values they assume change as a function of system resources and the operational environment. Selecting the variables is the first, most difficult and important problem faced by the researcher.14


Only after this list of variables—those which are central to
describing the system's behavior—is isolated can the task of describ-
ing their functional relationships begin. When a functional relation
is discovered, test predictions of system behavior can be made and
conclusions drawn. Finally, when the model has been validated by
showing its ability to predict system behavior accurately, conclusions
can be drawn about future system behavior in the real world. To
facilitate understanding of the approach to the modeling process
employed in this research, a diagram of the process has been included
in Figure 1.

Purpose of This Research

The purpose of this research is to develop a portion of the
qualitative housing market model. In a system as complex as the
housing market it is not possible for a research effort such as this
to produce a model of the total market and its subsectors. Thus,
this research proposes no complete function which can be applied to
the prediction of housing market demand. However, a list of variables
is described which can be used as the starting point for the develop-
ment of such a function (or set of functions).

There are two ancillary products which result from the major
research effort. The first is a deeper understanding of the nature of
one specific low-cost housing alternative, the mobile home. The

15The qualitative model is the list of variables described in
the previous section. See also Figure 1.
Figure 1 -- The Model Concept

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16Howland, "Program in Interdisciplinary Research", p. 249.
second is a judgment about the usefulness of applying discriminant
analysis to the type of research conducted.

The major usefulness of the present research, however, is its
application to further study of the housing market and the develop-
ment of a model describing the behavior of this market.

Approach of the Research

The general approach taken in this research was to consider
that households residing in low-cost dwellings in the new private
housing stock fall into one of three general populations. These
populations contain the dwellers in new single-family residences
costing no more than $17,500 for three-bedroom units or $19,000 for
four-bedroom units, new apartments renting for no more than $160 for
two-bedroom units, and new mobile homes. The housing choice decision
process of households in these populations was treated as a multivar-
iate classification problem. Analysis of this type of problem yields
a set of functions which can be used to classify the dwellers into one
of the populations on the basis of individual characteristics. The
result is a set of variables having the maximum discriminatory power
in the classification decision, as well as the functions needed to
perform this operation.

The technique employed developed a list of variables, both
dependent and independent, which might have some functional relation-
ship to housing market behavior. Then a preliminary list of variables
was developed and the individual independent variables were tested by
one-way analysis of variance to see whether they had any measurable relationship to the dependent variable. The assumption was that those variables which had significant power to classify the various households into the proper dwellings were those which in some way affected the choice among alternatives and, therefore, comprised the desired list of variables constituting the qualitative model.

The actual validation of the discriminant power of the test variables was accomplished by the use of discriminant functions. Multiple Discriminant Analysis (MDA) was the technique used to develop these functions. The data for this study were gathered through personal interviews of households in the Franklin County, Ohio, housing market.

**The Social Impact of the Problem**

It is important to discuss one additional point before proceeding further. When dealing with a societal problem such as housing it is impossible to separate social factors from economic factors. The need to allocate resources efficiently is a social problem. However, the basic method of allocation in our society is based on economics.

In accordance with the free enterprise philosophy it is hoped that the development of a model of the total housing market and its subsectors would enable major private sector decision-makers such as builders to predict demand more accurately. Additionally, the model could serve government program decision-makers to counteract any
failures of the private sector. In other words, the private and
public sectors must both be involved, with the former serving the
bulk of the demand and the latter serving to adjust the system. Both
sectors must complement each other, however, for such a process to
work.

Outline of the Presentation

The chapter following discusses the more important recent
economic models of the housing sector as they relate to the problem
approached in this research. The attempt was to isolate the weak­
nesses in these models and develop from them the plan of attack.

The third chapter is a brief description of the role played by
the mobile home in the overall model of the housing market, as well
as a discussion of some of the published research pertaining to this
role. The chapter includes a summary of the results of the HUD study
as they apply to this research.

Following the chapter on mobile homes are two chapters which
present the analysis and methodology of this research. Chapter IV
is concerned with the research design and the variables under scrut­
iny. Chapter V discusses the statistical techniques employed.

The last two chapters present the results of the study and
the conclusions, respectively.
CHAPTER II
ECONOMIC MODELS

Land, the fixed commodity, and housing, the object of one of man's primitive needs, have been the object of theorizing and research far back into the history of the economic discipline. In recent times, especially since the passage of the 1949 Housing Act, there has been a substantial amount of research done concerning the problem of housing the population. This chapter explores some of the more significant items of housing market research relating to the topic of this present study, establishing several weak points in previous research.

One of the most important of these inadequacies--and this is a major point in this thesis--is that previous studies have not looked at demand in subsectors. That is to say they have either been too broad to help solve the problem of providing housing or too narrow to relate to the problem properly. This is not to say that the prior work discussed below does not represent a series of significant contributions. That is not so. However, as yet there seems to be no common thread to tie the body of knowledge together. It is the process of relating all of this past work to the housing problem that is begun in this thesis.
The Problem Context

The basic resource allocation problem, also called the economizing problem, is that all resources are scarce and the demand for them is insatiable. Additionally, there are alternative uses for resources which require that choices be made concerning the application of these scarce resources. Thus, man has always been forced to satisfy himself through a series of trade-offs between the resources available in alternative combinations to serve his desires.

One of the alternative uses to which resources must be applied is housing. Resources in the form of money and materials can be applied to housing instead of roads, factories, or some other competing uses. An additional and interrelated set of trade-offs occurs once a dollar has been allocated to housing. The question is which types of housing should be constructed in what quantities? The two sets of trade-offs, housing versus competing needs and housing A versus housing B, are inseparable. If x number of units are needed to meet some specific demand, then the type of housing constructed influences the resources allocated to housing in general, as different types of units consume different amounts of resources.

Eventually, in order to fashion a comprehensive market model, three areas of inquiry need to be completed and combined.\(^1\)

1. The factors which affect the supply of dwelling units need to be determined.

\(^1\)The term comprehensive market model will be taken to mean a model which encompasses not only the market as a whole, but also a model which describes the behavior of the various market subsectors.
2. The factors affecting demand need to be determined, and
3. The result of the interaction of supply and demand needs to be thoroughly understood.

Actually, the understanding of the third area depends on the other two.

Factors Affecting Demand

One useful approach to the traditional pattern of demand factors is outlined in Coons and Glaze.2 The short-run parameters of this traditional model are:

1. The pattern of consumer preferences,
2. The level of liquid assets, and
3. The level of income.

The short-run variables influencing demand are:

1. The price of the product,
2. The level of rents,
3. The price of competing budget items, and

Finally, the long-run factors affecting demand are:

1. Net new family formation,
2. Growth in real income,
3. Changing family preference patterns, and
4. Asset holdings.

These variables all combine to produce long-run and short-run

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2 Coons and Glaze, Housing Market Analysis, Chapter 2.
demand schedules which may be used to describe the economic demand for housing. It should be noted, however, that these are aggregate demand schedules which may become increasingly less accurate in their predictions as the size of the market considered decreases.

There are other factors which have also been found to influence demand. Location, for instance, has been considered an important variable influencing the value of and the demand for urban real property. The journey-to-work and the distances from various parcels to schools, churches, shopping, and other facilities have been held to have influence on values and rents. Additionally, Reid shows the relationship between consumption and certain demographic characteristics such as family composition, size, age of the household head, educational attainment of the household head, and others. The factors considered, however, may be reduced to those which influence family income, which in turn influences housing demand.

All these factors—including income, location, and demographic characteristics—are, however, related to demand in terms of consumption measured by service cost. It is questionable whether cost is the best way to measure demand. Muth, for instance, makes the assumption that all units with the same cost are essentially interchangeable. In other words, they are perfect substitutes. This assumption is


\[ \text{Reid, Housing and Income, Chapter 14.} \]

\[ \text{Muth, "Non-Farm Housing", pp. 32 - 33.} \]
relaxed here, however, because it can be observed that there are real world examples of dwellings which have the same cost (statistically), but are not substitutes for the randomly chosen family. In cases such as these the choice decision between dwellings seemingly must be explained by non-price considerations. Because it was felt that the prediction of demand for non-price differentiated units must be an important part of any comprehensive model of the housing market, this research attempted to isolate the non-price factors which might influence housing choice.

When considering the problem of housing demand prediction in this light, some method of measurement must be used which does not require the use of price as the dependent variable. Extending the theory which measures demand in terms of periodic cost, Muth shows that all units in the standing stock can be expressed in terms of the average unit at the average cost. Thus, only the number of units demanded is needed to express demand quantity. For this research, cost was held statistically constant to neutralize its functional effect and the number of units of each type of dwelling was taken as the expression of demand. Under this scheme, a search was conducted for those factors which could differentiate the different types of units. Cost constancy was achieved by considering only those units whose total housing service costs (measured by summing monthly rent, utilities, and the cost of the journey-to-work) were not statistically

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Muth, "Non-Farm Housing", p. 32.
To conclude, the traditional view of the demand for housing yields an aggregate curve, which differentiates units on the basis of price. Thus, research to date in this area has often been concerned with explanations of the structural patterns of price and rent levels in the total market. This view, however, has been impractical for use by decision-makers trying to measure demand in the various subsectors of the market. Therefore, the approach of this dissertation was to find a list of variables which seems to explain housing choice when price is constant in order to contribute to the eventual construction of a model that is useful in predicting not only aggregate demand, but subsector demand as well.

Factors Affecting Supply

Coons and Glaze also provide a traditional list of the factors affecting the supply of housing. They consider the five short-run variables:

1. Monthly mortgage costs,
2. Insurance costs,
3. Real estate taxes,
4. Maintenance costs, and
5. Housing prices.

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For an explanation of the terms "held statistically constant" and "not statistically dissimilar" see Edward C. Bryant, Statistical Analysis (New York: McGraw-Hill, 1966), Chapter 5.

Coons and Glaze, Housing Market Analysis, p. 41.
There are seven long-run variables which are:

1. Downpayment,
2. The rate of new construction,
3. Construction cost levels,
4. Current mortgage terms,
5. The mortgage rate of interest,
6. The supply of mortgage funds, and
7. The cost of local government.

These variables make up the composite cost of home ownership and the supply price at which such housing will be offered. This extremely straight-forward approach yields a market equilibrium of the standard form equating supply and demand in both the short-run and the long-run.

Demand-Supply Interaction

This section will focus its attention on a relatively new approach to demand-supply interaction formulated by Grigsby. This approach is a theoretical extension of the more traditional economic approach emphasizing the structural and mechanical aspects of market behavior.

In order to present the submarket view of market interaction, as this might be called, an hypothetical market situation will be examined. Assume that the growth rate of new family formations in Columbus, Ohio, will be three percent higher in 1971 than in 1970.

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9 Grigsby, Housing Markets.
It follows that housing demand will probably increase by some amount. It also follows that if this fact becomes evident, builders may become cognizant of it and supply housing. The following questions arise:

1. By how much will demand increase?
2. By how much will supply increase?
3. What will be the effect on the prices of residential real properties?
4. What will be the composition of any change in supply (and thus the resulting stock of dwelling units)?

These questions, however, are only part of the problem. Because the products involved (even real estate is a product\textsuperscript{10}) are not homogeneous, it becomes nearly impossible to answer the four questions above. It is clear, for instance, that a three percent increase in net new family formations could take place in many ways. The demand deriving from such a change could be translated to many alternative combinations of dwelling unit types. Again, one cannot necessarily look at the market and say that if two thousand more new units are demanded and two thousand more are supplied the market will be in equilibrium. A two thousand unit demand for apartments is not necessarily met by a two thousand unit supply of mobile homes, especially in the short-run.

Grigsby has developed the submarket view of the housing sector to use when aggregate considerations are impractical.\textsuperscript{11} To begin the


\textsuperscript{11}Grigsby, \textit{Housing Markets}.
analysis, housing units are considered in categories which relate those units that are effectively equivalent in the amount of utility they provide. Since value is derived from a combination of locational and physical characteristics, properties are divided first on the basis of location and then into physical types for submarket analysis.

An example submarket on these terms might be the block of residential properties from Karl Road to Cleveland Avenue between Morse Road and Granville Road in Columbus, Ohio. This may be called the Northland Area. This area is characterized by units with a fundamentally constant locational linkage to churches, schools, shopping, and jobs, as well as containing homes in the same size, style, and price category.\(^{12}\) With a market of such homogeneity the impact of changes in supply and demand should be fairly predictable.

However, conventional housing has a special feature which is important to this analysis. It must be consumed where it is produced. Its consumers must move to it, in and out of various submarkets.\(^{13}\) As the value or price of property changes, so may the type of user. This immobility feature may have an impact on changes in supply and demand quantities and their effects on price. It should be noted that at the present time this feature is even true, to some extent, of the less traditional forms of housing, such as the mobile home. For even though the "home" is shipped to the consumer, the location where

\(^{12}\) A linkage is some measure of the cross-elasticity of demand between submarkets as the value of some variable changes. See Grigsby, *Housing Markets*, n. 34 ff.

\(^{13}\) Grigsby, *Housing Markets*, n. 33.
consumption finally takes place is fixed and must be moved to and bid for the same as conventional housing.

The general definition of a housing submarket to be used in this analysis is the "physical area within which all dwelling units are linked by a chain of substitution..."\(^{14}\) Further, the test is whether "substitutability is sufficiently great to produce valuable and observable cross-relationships with respect to occupancy, sales, prices, and rents..."\(^{15}\) In other words, do the units serve as perfect substitutes to demanders of shelter space?

On a map a regional market divided into submarkets appears as a matrix or checkerboard of these submarkets, each connected by various links of substitution. In order to understand the interactive effects of this model, one must first see what factors affect substitutability for the potential user. Although some of these factors are not known, some are evident and can be shown by example.

Using the Northland Area previously defined and the western suburb of Upper Arlington, Ohio, as examples, imagine a family in submarket C half-way between the other two and examine the linkages.

Say houses in A, Northland, cost $20,000 on the average and families living there earn approximately $8,000 per year. Houses in B, Upper Arlington, cost $40,000 and families living there earn $18,000 per year. Finally, assume families in C earn $6,000 per year and own homes costing $15,000. Now, assume a family in C desired to

\(^{14}\)Grigsby, Housing Markets, p. 33.

\(^{15}\)Grigsby, Housing Markets, p. 34.
move and is trying to choose between A and B as a place to buy a new home. This family has received a raise in income from $6,000 to $10,000 per year. Consider that the head of the household of this family also works in C. Because of its central location, the family will be equally linked to its old neighborhood in terms of journey-to-work. However, because of its new level of income, the family is more likely to move to A than to B. Linkages may also be compared for such things as tenure, value, type of structure, and similar characteristics.

The algebraic sum of all the links from A to C is computed and compared to the sum of the links from B to C to see which submarket will most likely be chosen by the family in C. In other words, the submarket whose characteristics most resemble those sought by the family in C will be the one to which this family is most closely linked. In general, the shorter the linkages, the closer the relationship between two submarkets.

The use of the linked submarket analysis might be as follows. Assume the values of dwellings in submarket A fall because of deterioration or some other change. As this occurs, some occupants are likely to move out, leaving vacant units offered for sale. This increase in supply in A will probably cause prices to fall. Thus, the linkages between A and other submarkets, such as C in this case, will now be shorter. As this occurs there will be residents in these submarkets moving to A and vacating units in C, causing prices to fall there also. However, unless everyone moving into A moves from C, very
likely the price change in C will be less than the one which originally occurred in A (assuming an upward sloping supply curve).

The markets that will be least affected by a change in prices in another submarket will be those with the longest links to it. Consider now a drop in prices in B from $40,000 to $30,000. It is very unlikely that even this great drop will cause any great demand for the properties in Upper Arlington by dwellers in the central city. If units in submarket C were to fall by the same percentage from $15,000 to $11,000, this might affect many more moves from the central city because of the substantially shorter linkages involved.

The important point in the foregoing type of analysis is that the products, urban housing units, are not homogeneous. Many factors affect the substitutability of one for another or even the motivation to switch units at all. However, using this type of analysis, it is much easier to see the various local market segments, their linkages, and how they are affected variously by changes in supply, demand, value, and economic conditions. Thus, the submarket approach seems more likely to be useful for making some types of policy decisions to solve urban housing problems than an approach which views an aggregate market.

Another point worthy of note is that as yet very little has been done to develop a working design for this submarket analysis. The basic problem is the determination of the linkages. How are they measured? What ones are relevant? These are questions which need to be answered. It is hoped that some of the variables explored in the
present research can be studied and exploited to discover more about the processes of linked submarkets and the substitutability of the units within them because it would seem that linkages are nothing more than variables which affect the choice decision.

A model which included a type of submarket analysis was developed and tested in the San Francisco Bay area. The Bay Area Simulation Model (BASS) was a long-range regional forecasting model which was intended to show the impact of major resource input decisions for a general area. The model's greatest success was in pointing up the weak base of useful information which exists as input for such a model's development and exercising. Further, though the model described a large submarket, it only described aggregate features of this submarket and did not predict housing requirements in various subsectors of the submarket. This further serves to emphasize the need for a strong basic understanding of housing market and other local economic forces, as well as the need to develop good submodels which can be pieced together to provide a useful decision tool for resource allocation. 16

Summary

This chapter has explored briefly the major areas which must be

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16Center for Real Estate and Urban Economics, Institute of Urban and Regional Development, University of California, Berkeley, Jobs, People, and Land (Berkeley: University of California Printing Department, 1988).
studied and understood before an adequate model of the housing market can be completed. The concern was with the factors which affect the demand for housing units which are substitutes in price, as well as with the concept of linked submarket analysis. In order for decision-makers to make accurate demand predictions, there must be a practical model to apply to housing subsectors. The concept of submarket interaction seems to fit this need well. In addition, there must be an understanding of the specific effects of changes in demand-supply factors on specific types of housing, measured in unit terms.
The mobile home is a relatively new form of housing, having come into prominence only since World War II. In fact, mobile homes have really only been an important force in the housing market for the last ten years. As was stated earlier mobile homes accounted for about twenty percent of the total housing starts in 1969, and were almost the only units produced priced at $10,000 or less. \(^1\)

In spite of the rapid growth and the high percentage of housing starts accounted for by the mobile home, there is a relative dearth of mobile home parks at this time. In a June, 1969, interview Richard C. Mitchell\(^2\), the New Business Development Director of the Mobile Homes Manufacturers Association, stated that he felt the reasons for this were:

1. There is a widespread image problem surrounding the mobile home,
2. It is difficult to obtain zoning for such developments, and

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\(^1\) Based on calculations from information given in the U.S. Department of Housing and Urban Development, Housing Survey, pp. 68 - 78.

\(^2\) This interview was conducted at length by this author.
3. It is difficult to obtain adequate financing for park development.

All of these reasons are interrelated and stem from the image of the trailer park of the late 1940's and early 1950's. The last two items may be categorized as market restrictions in the sense that if these problems could be overcome, there is a strong intuitive indication that there would be increased demand for mobile home housing. Though the image problem is also a market restriction in the same sense, it is not clear what influence that image has in the decision process involved in choosing or rejecting a mobile home.

The chief advantage of the mobile home, ostensibly, is its cost. According to the HUD study of 1968 the average price per unit is about $5600. On the other hand, the average price of new one-to-four family units studied in the same survey was $19,300. With these figures in mind it might be questioned why many more people do not live in mobile homes and why more resources are not channeled into the mobile home industry. There may be many reasons for this apparent discrepancy. Some of them are inherent in the above problems, but others may be found elsewhere.

In this chapter research pertaining to mobile home housing will be examined to see how further study into its problems may be used to shed light on the general concerns of this dissertation.

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Definitions

The following is the industry's accepted definition of a mobile home. The purpose of its inclusion is to show precisely what kind of dwelling is included in the category of the mobile home. This definition is quoted from an industry-published work by Frederick Bair.4

Mobile Home—"A detached single family dwelling unit with the following characteristics: a) designed for long term occupancy, and containing sleeping accommodations, a flush toilet, a tub or shower bath, and kitchen facilities, with plumbing and electrical connections provided for attachment to outside systems; b) designed to be transported on its own wheels, or on flatbed or other trailers or detachable wheels; c) arriving at the site where it is to be occupied as a dwelling complete, including major appliances and furniture, and ready for occupancy except for minor and incidental unpacking and assembly operations, location on foundation supports, connection to utilities and the like."

This definition does not include such units as the so-called travel trailer or motor home. It does include the large double-unit homes, assembled on site from two standard twelve-foot wide mobile home sections.

The Mobile Home in the Housing Market

There is almost no doubt in the mind of any urban economist today that the only real solution to the impending shelter shortage in the United States will be some kind of mass produced housing. This has been pointed up vividly by a sudden addition of programs such as

"Frederick H. Bair, Local Regulation of Mobile Homes, Travel Trailer Parks, and Related Facilities (Chicago: Mobile Homes Research Foundation, 1965).
Operation Breakthrough and the one providing for F.H.A. backing of mobile home park mortgage funds. Additionally, there have been a number of recent articles concerned with the subject of mass produced housing.\(^5\) Though most of the recent literature has not dealt with a need to build more mobile homes, there is an indirect need for more of this type of housing, which will be explained below.

As the need for more and more new housing is increasing at present, especially for low-income families, the ability to meet this demand is actually decreasing. A recent issue of the Morgan Guaranty Survey points out that construction costs in 1969 were at 150% of their 1957 to 1959 levels.\(^6\) Much of this rise is due to the rising cost of labor.\(^7\) The reason that the rise in labor costs hurts so much is that the average cost of a single-family dwelling is mostly labor. Additionally, ninety percent of the labor cost is skilled labor.\(^8\) With these rising costs housing is becoming simply too expensive.

The solution to this problem lies in cutting down the absolute percentage of labor in the dwelling, as well as the percentage of


\(^6\)Morgan Guaranty Survey, p. 7.

\(^7\)Morgan Guaranty Survey, p. 8.

skilled labor. This can be done by mass production. Europeans in many countries have found what fantastic savings can be augmented through mass production in home building. In the United States, too, it has been shown that "prefabs" are much cheaper than housing created entirely on the site. Unfortunately, even the prefabs in the United States still have as much as sixty percent of their costs incurred on the site.

There is one type of housing which is almost entirely mass produced, however. The mobile home, with the exception of the so-called "double-wide" unit, is constructed, complete with furniture, in the factory and delivered to the site ready for occupancy. Though, as the results of this present research showed, the mobile home is hardly a universally acceptable form of housing, it does seem it could be exploited more fully as a short-term solution to the shelter shortage.

The mobile home is one of a growing family of what might be called "modular dwellings". Included in this group, along with mobile homes, are such dwellings as Habitat built for the Montreal World's Fair. Dwelling systems, such as Habitat, seem to be the wave of the future. However, the construction methods and technologies needed for large-scale production in the United States are years away. There is

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10 Ratcliff, Real Estate Analysis, p. 297.
no academic research on these types of dwellings at present. Further, little data is available to work from. However, as more and more projects, such as the one at Reston, Virginia, are completed, it will be possible to more fully assess the potential of fixed modular housing in the United States.

In the meantime, the only large scale production of modular housing is taking place in the mobile home industry. The greatest advantage to this type of housing is its already-developed technology. If a 300,000 unit increase in the production of currently produced types of units was desired over the next two years, it could be had by simply adding capacity. It is doubtful that this could be done with other types of modular units.

One additional strength of the mobile home industry lies in its ability to convert to other types of modular units. McQuade points to apartment buildings built by inserting mobile home modules, minus the wheels, into large frames of steel beams, or simply attached in a pile on each other.¹¹

The question, then, is why has there not been a wider expansion of the industry? Are there problems too serious to overcome which prevent the use of mobile homes as a stop-gap measure to provide low-income housing units? Three general problems were mentioned earlier in this chapter. Several more will be discussed below.

Besides the problems of image, Alfred Rinz points out in a 1966

¹¹McQuade, "Assembly Line Answer", n. 101.
article that taxation is a problem. 12 Because mobile homes are still considered personal property in most localities, they cannot be taxed to provide school revenues. Because there is no tax revenue from mobile homes, many local governments, through the zoning codes, restrict park development so their school systems will not become overcrowded with non-paying customers. Berney and Larson also bring up the tax problem in their study of mobile home owners in Arizona. 13 They point out that there is seemingly no reason why mobile home owners could not be taxed as any other home owner. However, there is the mechanical problem of keeping track of the units. Further, the owner can move his trailer regularly to escape taxes, but only if the cost of moving is less than the tax. 14

It has been pointed out by many that mobile homes are substandard dwellings. However, a study by Hadden and French measured the mobile home by all Census Bureau standards for dwellings and found this was generally not so. 15

Although many of the problems restricting the expansion of


mobile home ownership in the housing supply seem to be reasonably
minor, there is one serious problem at this time. The building and
zoning codes which require most mobile homes to be located in isolated
locations further raise the costs of ownership through higher trans­
portation costs.

Thus, the role of the mobile home in the housing market is
great in potential, but uncertain as a practical matter. However,
because of its potential importance and the lack of information
available concerning its role in the market, it was included as a
key area of this research.

The HUD Study

In 1966 the U.S. Department of Housing and Urban Development
sent questionnaires to mobile home owners who resided in new mobile
homes. 16 In a study published in 1968 the results of the HUD survey
were reported along with those for similar questions asked of the
dwellers in more conventional housing units. 17 This was the most
comprehensive study to date and it will probably maintain that status
until the full results of the 1970 Census are known.

The 1968 survey is not an analytical study, as much as it is a

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16U.S. Department of Housing and Urban Development, Housing
Survey, p. 16.

17HUD, Housing Survey, p. 66.
tabulation of characteristics. It is neither practical nor necessary to report all of its findings here, as there is a great deal of information, the relevancy of much of which is questionable. However, the more important conclusions follow below.

1. The mode mobile home family size is three—a husband, a wife, and a child. Mobile home households are generally smaller and younger than those in conventional housing. There are proportionally fewer retirement age households living in mobile homes than in conventional housing. This latter proportion is increasing for mobile homes.

2. Mobile home household members are generally less educated than those in the general population. The mode household head has not completed high school and is probably a skilled or semi-skilled blue collar worker with a $6700 family income. The median household income for mobile homes is $6300, compared to $7440 for the general population.

3. The mode mobile home has two bedrooms and a telephone. The median size in 1966 was 600 square feet, compared to 1161 square feet for FHA (203) homes and 1465 square feet for all homes sold.

4. The typical mobile home is located outside of a Standard Metropolitan Statistical area. Mobile homes are most
important as elements of the housing supplies in small communities and do not serve households in the central city areas. Neither do they serve as an important factor in non-white housing. Mobile homes do serve a very special segment of housing demand, as they supply 94% of the new units priced under $10,000.

5. The typical monthly cost for the home, site, and utilities is $135 per month. The median value of the mobile home and site in 1966 was $8834, compared to $16,798 for FHA (203) homes and $21,400 for all new homes. Financing for mobile homes is generally for a seven year period and downpayments are usually less than $1000. One-fourth of the households pay $1000 to $2000 down, however.

6. It is estimated that in 1966 2.75% of our population lived in mobile homes, forming 1.8 million households or 3.1% of the total United States households.

These are a very general summary of the survey results. There were no statistical tests conducted on the results, so only rough generalizations are available, using averages and percentage breakdowns. However, the survey does at least serve as a base point for future work.
CHAPTER IV
RESEARCH APPROACH: THE NATURE OF THE DATA

The objective of this dissertation was to identify a set of variables which could be used to discriminate among the dwellers in various types of dwellings and assign the subjects to their proper dwelling unit category.

The statistical technique of discriminant analysis is used to determine which of a group of independent variables should be used to classify individual households properly into the dwellings they now occupy. The assumption underlying this approach is that the variables differentiating households in different types of housing are the variables upon which the choice discrimination of the households hinges. It was found, for instance, that downpayment is a variable which should be used to discriminate between households in different classes of dwellings. This would imply it is a variable which would be important to a model predicting the type of dwelling that a household will choose.

Hypothesis

The hypothesis of this study is that there is a discernable relationship between the type of dwelling a household will choose and
a set of observable characteristics indigenous to either the household or the dwelling.

In mathematical terms this may be stated as follows:

\[ y_1 = f(x_{1j}) , \]

where \( y_1 \) designates the type of dwelling in which a family resides and \( x = (x_j) \) is a set of variables describing characteristics of the household or the dwelling.

Further, it is presumed that this function is linear and additive, as:

\[ y_1 = a_1x_1 + a_2x_2 + \ldots + a_qx_q. \]

For this experiment the set \( Y \) contains the following \( y_1 \):

- \( y_1 \) = mobile homes,
- \( y_2 \) = apartments, and
- \( y_3 \) = single-family residences.

The linearity assumption is standard to housing models and its applicability is shown by Reid.\(^1\) Additionally, this assumption is requisite for discriminant analysis. More will be said about these dependent \((Y)\) and independent \((X)\) variables in a later section of this chapter.

By showing that the hypothesized general relationship exists, a set of variables is generated which is the qualitative model sought by this dissertation. In order to support the hypothesis, statistical analyses are performed on a large set of independent variables logically or empirically related to the dependent variables.

\(^1\)Reid, *Housing and Income*, pp. 33 - 40.
Dependent Variables

In Chapter II of this thesis it is shown that many of the detailed studies of the housing market such as those by Reid and Huth use the amount of housing service consumed, $h$, as the dependent variable of the housing function. Measured in terms of the dollar outlay for housing consumption, $h$ is then related to a set of independent variables presumed to have an effect on its magnitude. While this is perhaps a reasonable approach in terms of the accepted economic model of demand and many variables can be shown to relate to $h$, it is also possible that $h$ is an independent variable that can be shown to affect demand if another proxy for demand is used.

It is the contention of this thesis that information is lost when $h$ is taken to be the dependent variable to stand for demand. When a household contemplates a move to a new home, many variables may affect the decision to choose whatever unit is finally chosen. One of these variables, whether by practice or in standard economic theory, is the price outlay required to purchase the services of the dwelling. However, when cost or outlay is used as the measure of demand or choice, its measured effect on the choice process is not discerned. Additionally, it is impossible to show which of several types of dwellings offered at a given cost level will be chosen. If it is merely desired to know the distribution of housing prices, $h$ may be

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2Reid, Housing and Income.

3Huth, Cities and Housing and "Non-Farm Housing".
used as the dependent variable. However, when the need is for a model to describe the behavior in a particular rent class, then h is not a satisfactory dependent variable.

Because, by observation, it can be seen that there are groups of dwelling units at particular rent levels which, seemingly, compete for use by demanders of shelter space, the question arises: Are they really competitive? If it can be shown, by considering the type of dwelling unit as the dependent variable, that it is possible to differentiate households when costs are equal, then it must be said that there is non-price competition among the various types of dwelling units.

Dwellings in different categories at the same cost level do not necessarily have the same utility level. If all dwellings in the same rent class had the same total utility, then any dweller in any one of them should be indifferent between all types of dwellings in the rent class. However, the fact that dwellers could be differentiated by non-price factors must refute this constant-utility thesis.

The use of the dwelling-type category as the dependent variable has certain limitations. The major potential difficulty that may be encountered is the presence of bias which may result from the fact that many of the independent variables in the hypothesized function may be interrelated.

The interrelationship between housing consumption and income,
pointed out by Reid, may cause problems when both are treated as independent variables. There are also relationships between education and income and others described in the section to follow. However, unlike other linear models, discriminant functions exploit these interrelationships. With a regression model there is a need to predict a value of the dependent variable with some measurable accuracy. However, the discriminant function is only classifying observations and the predictions are much more gross. Additionally, the technique uses all the information yielded from the relationships to make the classification.

Thus, the dependent variable to be used is \( Y \), the category of new dwellings that the test households may choose. The forms which this variable may choose are listed and described below.

\[ y_1 = \text{Dwellers of new mobile homes purchased after January 1, 1967}. \]

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4Reid, Housing and Income, Chapter 14.


6The sample of one hundred mobile home owners, which comprised the data for this category, was chosen from the eight largest mobile home parks in Franklin County, Ohio. The parks were spread geographically in all parts of the city of Columbus, Ohio, and its suburbs. The units chosen were picked at random by the interviewer who could complete interviews only with owners who met the qualifications of purchase above. By quota, no one park was allowed to have more than its relative share of the sample (based on share of the population). This procedure had to be used because no list of addresses or other information was available prior to the completion of the interview.
\[ y_2 = \text{Dwellers of apartments completed after January 1, 1967.} \]

\[ y_3 = \text{Dwellers of F.H.A.-insured single-family residences on which loans were closed after January 1, 1968.} \]

The Independent Variables Used In Discriminant Analysis

In the current literature and studies of the housing market, many variables have been suggested, studied, and otherwise alluded to as influential in the overall operation of the market. Below is the list of variables being employed for this study and a brief explanation of the source or rationale for each.

The sample of apartment dwellers was also one hundred units and was chosen in the same way the sample for \( y_1 \) was chosen and for the same reasons. There were only six complexes of apartments which met the criterion of completion after January 1, 1967, and also had two bedroom units renting for less than $160 per month. The latter criterion was used because it was felt that this rent range would equalize the cost between the mobile homes sampled and the homes sampled.

The sample of one hundred home owners was chosen at random from a list containing the addresses of all of the F.H.A.-insured mortgages closed in the city of Columbus, Ohio, since January 1, 1968. Because low-income units were the real focus of this study, only the minimum cost—$17,500 three-bedroom and $19,000 four-bedroom—units were used.

New units were used in all three cases above, because it was desired that external economic variables be held as constant as possible to minimize their effects on the outcome of the experiment. Franklin County, Ohio, was used for this study because a lack of time and money made a wider study impractical at this time. However, this area is deemed to be a very representative one and it is a favorite test market. The data for all three samples of one hundred households were gathered in face-to-face interviews using the questionnaire found in Appendix A.
$x_1$ -- Sex of the Household Head.

This variable has an indirect potential bearing on the demand for housing and housing choice. It was demonstrated by Reid that there is a relationship between non-normal households (those with a female head are one such type) and the income elasticity of demand for housing. It was felt that the sex variable served as a proxy for other non-measured variables.

$x_2$ -- Age of the Household Head.

This variable is included in census information and is in nearly all of the important housing studies to date as a variable influencing consumption because of its relationship to earning power. Earning power first rises and then falls with age, and in turn, affects the amount of income available for use in housing consumption. Reid, who uses the permanent income hypothesis in her theories of housing demand, notes a changing ratio of housing consumption to income as age increases. There may also be other relationships which could justify the inclusion of this variable, but this seems to be the most important.

$x_3$ -- Level of Educational Attainment of the Household Head.

Here again, the educational attainment is closely related to income level and housing consumption. Reid reports that this is a

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9 Reid, *Housing and Income*, p. 68.

10 Reid, *Housing and Income*, p. 61.
fairly stable indicator of economic status.\(^{11}\)

\(x_4\) through \(x_{10}\) — Occupation of the Household Head.

This variable also is an indicator of economic status, but not as stable in all cases as educational level.\(^{12}\) The specific variables listed below are zero-one categories or "dummy" variables used to portray the appropriate occupation.

- \(x_4\) — White collar professional
- \(x_5\) — White collar nonprofessional
- \(x_6\) — Blue collar supervisory
- \(x_7\) — Blue collar nonsupervisory
- \(x_8\) — Military personnel
- \(x_9\) — Retired persons
- \(x_{10}\) — Unemployed persons or students

\(x_{11}\) — Employment Status of Spouse of Household Head.

This variable is also a zero-one or "dummy" variable which has obvious implications in terms of family unit economic status.

\(x_{12}\) — Family Size.

This variable is not as much related to income as some of the others previously described. However, Reid did find that income

\(^{11}\) Reid, *Housing and Income*, p. 203.

\(^{12}\) Reid, *Housing and Income*, p. 203.
tended to rise as family size increased, to a point, and then it fell. However, family size did not have much relation to housing consumption. There is a more important reason for this variable and that is an expected relation to dwelling type. It was felt that probably the larger families will reside mainly in single-family residences.

\( x_{13} \) -- Total Family Income in 1969.

This variable is the total gross income for the family unit in 1969. It should be noted that this gross income figure is not the only way of expressing family unit income. However, it is the most consistent way in terms of the consumption variable being utilized. This will be explained more fully later. Many of the "standard" variables that have been previously included in major housing studies have been included because of their apparent link to income, and, therefore, to housing consumption, based on the income-housing consumption relationship known as Schwabe's Law.

The important relationship in this thesis, however, is between income and housing consumption, as expressed by the type of dwelling unit. This relationship is determined by more than income, because it is tied more to the cultural and psychological factors. For instance, the present reputation and image of the "trailer park"

\[13\text{Reid, Housing and Income, p. 71.}
\[14\text{Reid, Housing and Income, Chapter 1.}
may discourage even someone who cannot afford any other type of new housing. However, the fact that income and housing consumption are related does imply an indirect ability to classify dwellers on the basis of income.

$x_{14}$ -- Number of Utilities Included in Rent or Mortgage Payment.

This variable, not ordinarily included in housing studies, was included even though the cost of utilities is also included (see variables $x_{19}$ and $x_{46}$). An attempt was made to hold cost, including utility cost constant, and, therefore, to remove it from any final function. However, it was felt some proxy should be included for the amenity of paid utilities. This variable should have an inverse relationship to housing choice.

$x_{15}$ -- Appliances Included in Rent or Mortgage Payment.

If a number of appliances are included in a dwelling, this, in effect, reduces the financial outlay of a resident as he may pay over a longer period of time for their use. Thus, this variable is being included to see whether it can be used to help discriminate between the groups of dwellers.

$x_{16}$ -- Number of Rooms in Present Dwelling.

This variable and the next one, $x_{17}$, were included to test possible differentiation of dwelling types on the basis of size. It
was also intended to help set a comparative base for the cost figures for interpretive purposes, i. e. to see whether cost differences and size differences were both present and in the same direction.

\( x_{17} \) -- Number of Bedrooms in Present Dwelling.

See \( x_{16} \) above. This variable uses census-type wording for comparative consistency.

\( x_{18} \) -- Miles to Center City.

There are two measures of location that were used in this study. This one relates each dwelling to a common base point, the center city shopping area. This allows the analysis to differentiate the dwellings on locational differences if significant bunching occurs in different locational latitudes based on the center point, the mythical hub of the downtown area.\(^{15}\) For instance, if mobile homes, apartments, and conventional homes tend to be mixed together in heterogeneous groups, there should be no significant differences in distance to the center city. However, if the mobile homes are bunched by themselves outside city limits, whereas apartments tend to be bunched close to the center city, as might be expected, then location is probably a strong discriminator. Another location measure is journey-to-work time and is discussed under variables \( x_{19} \) and \( x_{47} \) below.

\(^{15}\)Huth, Cities and Housing, pp. 3 - 4.
\( x_{19} \) -- Total Monthly Housing Service Cost.

Housing cost is defined here as the sum of \( x_{45} \), the monthly mortgage or rental payment, including taxes, insurance, and the supplied utilities; \( x_{46} \), the cost of any remaining utilities; and \( x_{47} \), the cost of the journey-to-work for the household head. The conceptual rationale for considering the cost in this way is based on the conclusions by Coons and Glaze, which show housing as a consumer good, rather than an investment.\(^1\) Thus, the cost of home ownership is treated in terms of the financial outlays required to obtain the use of the good in much the way Maisel\(^2\) does. Downpayment is included as a separate variable because it does not recur on a regular basis (see \( x_{20} \)).

The components of the cost variable were chosen because it was felt they represented the major direct financial outlays incurred as a result of the use of a particular dwelling. The cost variable included all major aspects of the dwelling unit, including a measure of the cost of location. More will be said about the specific rationale and calculation of the variable components at the end of this section (see \( x_{45}, x_{46}, \) and \( x_{47} \)).

The purpose of the cost variable was simply to see whether there really was enough difference in the costs of the various types of housing to classify the residents on this basis. It was hoped,

\(^1\)Coons and Glaze, *Housing Market Analysis*, Chapter 1.

however, that the categories would be chosen correctly and there would be no cost differences. Thus, classification would have to take place on the basis of non-price variables.

$x_{20}$ -- Downpayment.

The downpayment is the non-recurring financial outlay made to obtain rights to the services of certain dwellings. This variable was included as a possible additional influence in the classification of dwellers. It was expected that differentiation would be possible on the basis of this variable, as there is no downpayment for an apartment, a generally small one for a mobile home, and usually a larger one for the single-family residence. The significance of this is unclear, however, as the monthly cost relationships are not intuitively obvious for these three groups. It may be that these two types of cost will offset each other, or they may complement each other, allowing an even clearer differentiation of the dwellers using both variables simultaneously.

$x_{21}$ through $x_{26}$ -- Current Dwelling Unit Problems.

The next six variables are major categories of deficiencies which the individuals interviewed stated they felt were inherent in their present dwelling unit. The purpose of including these variables

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1 It may be argued that the deposit an apartment dweller pays is a form of downpayment. Since it is unclear that he considers it this way and since it rarely exceeds $75 for the type of apartment being studied, it is considered to be effectively zero in terms of a downpayment.
was twofold. First, it was expected that there would be certain problems which attach inherently to different categories of dwellings in sufficient numbers to allow discrimination to take place. Among these might be the unpleasant appearance of the trailer park or the built-in size problem of the mobile home. These were tested. Second, it was hoped that information from these answers might prove useful in the behavioral interpretation of the discriminant analysis. The variables are zero-one type categories and a respondent may have made more than one problem response.

\begin{align*}
x_{21} & \quad \text{Locational problems.} \\
x_{22} & \quad \text{Structural problems. These problems are deemed to be complaints inherent in the type of structure, rather than the specific unit.} \\
x_{23} & \quad \text{Maintenance. These problems are more concerned with some specific unit; also included are service problems.} \\
x_{24} & \quad \text{Size problems.} \\
x_{25} & \quad \text{Cost problems.} \\
x_{26} & \quad \text{Other problems.} \\
x_{27} & \quad \text{through } x_{33} \quad \text{Previous Dwelling Unit Type.}
\end{align*}

The next seven variables are categories of dwelling units previously occupied by the interviewed subjects. These variables should be helpful in determining whether there are any patterns of
loyalty or migration which are consistent and different among the residents of the different types of dwellings.

\[ x_{27} \text{ -- Mobile home} \]
\[ x_{28} \text{ -- Furnished apartment} \]
\[ x_{29} \text{ -- Unfurnished apartment} \]
\[ x_{30} \text{ -- Owned single-family residence} \]
\[ x_{31} \text{ -- Rented furnished single-family residence} \]
\[ x_{32} \text{ -- Rented unfurnished single-family residence} \]
\[ x_{33} \text{ -- Other} \]

\[ x_{34} \text{ -- Years in Previous Dwelling.} \]

It was expected that this variable would be a potential differentiator for a number of reasons. It does have an intuitive relationship to age and occupation variables. For instance, very few young couples or military personnel have lived many years in their previous dwelling. On the other hand, many older, retired couples may have lived a long time in their previous dwelling. Thus, there may be a significant pattern that can be derived with this variable.

\[ x_{35} \text{ -- Number of Rooms in Previous Dwelling.} \]

This variable and the one to follow, \( x_{36} \), were included for a combination of reasons involving a rationale similar to that for the current dwelling rooms and bedrooms variables and also similar to that used for \( x_{34} \). This is an extension of the investigation of the potential discriminatory power of the pattern of housing tenure.
x_{36} -- Number of Bedrooms in Previous Dwelling.

Same reasons as for x_{35}.

x_{37} -- Previous Rent or Mortgage Payment.

This variable was used as a proxy for total cost in the previous dwelling for comparative purposes. No other costs were included for a number of reasons. The most important of these is that most people do not remember enough about their previous unit to provide reliable information. This latter fact was exemplified by the large number of people who could not even remember the address of their previous unit.

x_{38} -- New Family Formation.

This zero-one variable was included to see if there was a significant relationship between new family formation and the type of dwelling unit that these families picked as a residence.

x_{39} through x_{44} -- Reasons for Last Move.

These six categories are consistent with the current-dwelling-unit-problems variables. The attempt here was to see whether dwellers could be differentiated because of the problems they had with their last dwelling. The potentially strongest variables are cost, size, and structure, although all six had a good chance of being related to dwelling change.
$x_{39}$ -- Locational problems

$x_{40}$ -- Structural problems

$x_{41}$ -- Maintenance problems

$x_{42}$ -- Size problems

$x_{43}$ -- Cost problems

$x_{44}$ -- Other problems

$x_{45}$ -- Current Monthly Rent or Mortgage Payment.

The subject was asked to include taxes and insurance, and, if living in a mobile home, site cost. This was part of $x_{19}$.

$x_{46}$ -- Cost of Utilities Not Included in Rent or Mortgage Payment

The subject was asked his average monthly cost for any utilities he did not have included directly in $x_{45}$. This was also part of variable $x_{19}$.

$x_{47}$ -- Transportation Cost

This cost was computed on the basis of a combination of costs. If the subject used public transportation, the charge was added to a cost factor for the time he spent in traveling. If the subject used his car, an operating cost of 11¢ per mile was charged for the miles traveled, and this was added to the travel time cost factor. The rationale for the travel time cost factor was taken from Muth's notion

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that location is a partial function of relevant travel cost.\textsuperscript{20} Travel
cost for a home dweller is a function largely of the time it takes for
the breadwinner to get to work. Under economic theory the alternative
use of time for work is leisure, which is valued at the wage rate.\textsuperscript{21}
The time it takes to get to and from work is a subtraction from
leisure and is valued at the same rate. Thus, the journey time will
be multiplied by the wage rate and added to operating transportation
cost.

It should be noted that the travel information obtained from
the raw data was in terms of time, not miles. In order to obtain a
mileage figure needed to calculate operating cost, a conversion was
made by multiplying the time spent in travel by thirty, the approxi-
mate miles per hour at which it is felt traffic moves during the
normal commuting times in the test city. There is no specific refer-
ence for this figure, as consultation with one of the traffic engin-
eers at The Ohio State University led to the conclusion that no such
reference exists. However, this engineer also felt from his experi-
ence and observation that thirty miles per hour was a good, average
speed for the entire metropolitan area. This variable is part of
$x_{19}$.

\textsuperscript{20}Muth, Cities and Housing, pp. 21 - 22, 34 - 36.

\textsuperscript{21}Armen Alchian and William Allen, University Economics
(Belmont, California: Wadsworth Publishing Company, 1967), pp. 360 -
362.
Other Independent Variables

The above variables include all those which were in the discriminant analysis. There were several others, however, that were used for interpretive purposes after the results of the discriminant analysis were complete. These follow below.

\( x_{48} \) through \( x_{51} \) -- Next Dwelling Choice.

The subjects were asked to respond which general type of dwelling they felt they would most likely occupy after their present one.

- \( x_{48} \) -- Mobile home
- \( x_{49} \) -- Apartment
- \( x_{50} \) -- Single-family residence
- \( x_{51} \) -- Other

\( x_{52} \) -- Months in Present Dwelling.

The subjects were asked how long they had lived in their present dwellings. This variable was included to ascertain that each of the three groups of dwellers had lived in their present dwelling long enough to identify its inherent deficiencies or advantages.

\( x_{53} \) -- Mobile Home Type of Next home.

Mobile home owners who responded they would probably move into a mobile home on their next move were then asked whether they would
move their mobile home to a new site on their next move or whether they would buy a new mobile home and put it on a new site. This variable was included to provide interpretative information for the actual case of moving mobile homes.

$x_{54}$ -- Presence in a Mobile Home Park.

Non-dwellers of mobile homes were asked whether they had ever been inside a mobile home in an established mobile home park. This was included to gain insight into the informational basis of decisions to reject mobile homes. How many people who say they would never live in a mobile home have ever really seen one in its mobile home park environment?

$x_{55}$ through $x_{87}$ -- Considerations, Rejections for Last Move.

Finally, each type of dweller was asked about his decision to move to his present dwelling. He was asked whether or not he considered each of the two types of dwellings, other than the type he chose. If the subject stated he considered a certain type of dwelling, he was then asked why he ultimately rejected it. If he responded he did not consider a particular type of unit, he was asked why he did not. The answers to these questions of rejection of each type of dwelling unit were used in Chi-square analysis to be explained in the next chapter.

The responses are categorized by one or more of the following zero-one classifications:
\( x_{56} \) -- Dwelling size too small,
\( x_{57} \) -- Dwelling size too large,
\( x_{58} \) -- Location,
\( x_{59} \) -- Dwelling proximity to other dwellings,
\( x_{60} \) -- Cost,
\( x_{61} \) -- Lack of equity,
\( x_{62} \) -- Inherent structural restrictions,
\( x_{63} \) -- Inherent quality,
\( x_{64} \) -- Lack of maintenance services,
\( x_{65} \) -- Other.

The above ten variables refer to non-mobile home dwellers who rejected a mobile home unit for their present dwelling. Similar variables for non-apartment dwellers were \( x_{67} \) through \( x_{76} \). Variables for non-single-family dwellers were \( x_{78} \) through \( x_{87} \).

Variables \( x_{55} \) for non-mobile home dwellers, \( x_{66} \) for non-apartment dwellers, and \( x_{77} \) for non-single-family dwellers were also zero-one variables, indicating whether a non-dweller considered or immediately rejected that type of unit for his present dwelling.
The primary method of analysis being used in this research is discriminant analysis. Not a new technique, it is only recently becoming popular in multivariate statistical applications in the social sciences. The technique is derived classically in T. W. Anderson¹ and Hope². An example of the multiple discriminant analysis form can be seen in an application to finance in Altman³ and Meyers and Forrey⁴.

Discriminant analysis is a statistical technique used to classify individual observations into one of several a priori groupings depending upon the subjects' observed values on a set of independent characteristics. It is used to classify observations in problems where the dependent variable is in qualitative form. For


example, in this study the dependent variables $y_1$, $y_2$, and $y_3$ are categories of dwellings, purely descriptive in nature. Each household observation in the various populations has a set of identifiable characteristics (income, family size, etc.). These are the values of the various elements of $(X)$. Discriminant analysis functions are derived which correctly classify households into the appropriate groups, using the observed values of $(X)$.

Discriminant analysis requires two distinct steps to complete. In the first step a list of $q$ independent variables is examined to determine if, for any of the variables, there is a significant difference in the observed values among the test groups. The variables are tested using one-way analysis of variance for this step. The discriminant functions themselves are developed in step two, using the variables for which significant differences were found in step one. These two steps and a subsidiary technique used to analyze some of the data are explained in detail below.

**Analysis of Variance**

Discriminant analysis is a classification technique which differentiates between different categories or groups, in this case types of dwellings. In elementary statistics one of the basic operations is the hypothesis test by which inferences are made as to whether or not an observed sample was drawn from some designated population. In discriminant analysis the basic operation, in effect,
is to determine whether or not a particular observation comes from some specified population. In actuality, the operation is reversed, in that the function may be used to infer into which of several populations the observed value falls, whereas in standard statistical inference only one population at a time may be tested. 5

Discriminant analysis does not choose its own variables. It must instead be fed variables for which there is a difference in observed values between the categories. This part of the analysis is accomplished by using analysis of variance.

In standard statistical analysis a t-test is used to test for a significant difference between the means of the observed values of a variable in each of two groups. If more groups are involved, this becomes impossibly complicated, so the F-test is used.

This study tested one independent variable at a time to determine whether values of that variable were significantly different among dwellers in the three categories. The following is an example of this kind of analysis.

Fifty households are drawn at random from each of the three populations \( y_1 \), \( y_2 \), and \( y_3 \) and measured for the amount of their total family income for 1969. For each group, \( y_1 \), a mean income \( x_i \) can be computed. Income is \( x_{13} \) in this study, so if the subjects in \( y_1 \) are numbered 1 through 50, those in \( y_2 \) are 51 through 100, and those in

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5 For a further explanation of the basic statistical relationships upon which discriminant analysis depends, see Bryant, Statistical Analysis.
$y_3$ are 101 through 150, then the income measurement for the first subject in $y_1$ is denoted $x_{1,13}$. The next is $x_{2,13}$ and so forth through $x_{50,13}$.

The sample of income variables from $y_1$ has a mean $\bar{x}_1$ and two sums of squares can be computed. The first is equal to the sum of the squared variations of the $x_{i,13}$'s from $\bar{x}_1$ and the second is equal to the sum of the squared differences between the $x_{i,13}$'s and the grand mean $\bar{x}_T$ of all 150 subjects. The grand mean is equal to

$$\frac{1}{150} \sum_{i=1}^{150} x_{i,13}$$

There are, additionally, the same relationships for each of the other two groups, $y_2$ and $y_3$. Finally, there is a sum of squares equal to the sum of the squared variations of $\bar{x}_1$, $\bar{x}_2$, and $\bar{x}_3$ from $\bar{x}_T$, the grand mean.

It should be noted that

$$\sum (\bar{x}_i - \bar{x}_T)^2 = \sum (x_{i,13} - \bar{x}_i)^2 + \sum (x_{i,13} - \bar{x}_T)^2$$

The first term above is the total sum of squares; the second is the within group sum of squares; and the last term is the between group sum of squares. If each of these is divided by the appropriate degrees of freedom, it yields

$$MS_T = MS_W + MS_B$$

Thus, the within group mean square or variance is a measure of
the variability of the observations as they relate to themselves in a particular group. The between groups mean square relates the variability of the data in each group to that of the other groups. By comparing the variance between the groups to the variance within the groups, an $F$-ratio is derived which may be compared to a table value to see the likelihood of a chance occurrence of the computed value given no difference between the groups. If the computed ratio is the higher value, the no difference hypothesis is rejected. This computed $F$-ratio appears below.

$$F_{v_B, v_W} = \frac{MS_B}{MS_W}.$$  

This type of analysis of variance was conducted for each of the first forty-seven independent variables. At the conclusion, the variables were ranked in order of their $F$-ratios from the highest to the lowest, so that the ones with the most significant differences between groups were ranked at the top. This ranking appears in Appendix B, Tables 1 and 2.

Once the ranking was completed the significant variables (at the .005 significance level) were scrutinized and those with reasonable potential predictive power were used in the discriminant analysis.

It should be noted at this point that there are two potential weaknesses in this approach. By treating the independent variables one at a time, there is a possibility that information is lost.
Although two or three variables considered separately may be rejected, taken together they might all have been accepted. However, it is nearly impossible to avoid this problem because there is such a large set of variables involved. Additionally, the extent of any such problem can be checked by the success of the discriminant analysis. A high error (indicated by a large number of misclassified households) may indicate that the set of variables being used is not the best one. However, if there is a low error, this may indicate that little information is being lost by the variables utilized.

The second problem may exist when analysis of variance is used on binary (zero-one or "dummy") variables. In order to use the F-ratio for analysis of independent samples, certain requirements must be met by the data. Chiefly, interval data must be used. Where these requirements are not met, as with the zero-one variables employed for some of the independent variables in this study, a non-parametric test such as the Chi-square for k independent samples must be employed.

The drawback of the Chi-square is that it gives no ranking showing how significantly different the several groups might be for a particular variable. F-ratios can be ranked, Chi-squares cannot. Therefore, what was done in this research was to conduct both tests for the zero-one variables. When the results were consistent, the F-ratio was used to get a rough ranking and the Chi-square to insure that no wrong results were being used. Once any of the variables are inserted into the discriminant analysis, there is no longer any need to worry about
the question "how significant". The ranking is needed just to avoid inserting a number of poor discriminators, thereby weakening the success of the outcome.

**Discriminant Functions**

Once the variables had been ranked and the significant "core" of variables selected, a series of discriminant analyses were conducted using these variables for two groups at a time for all three possible combinations of the groups: mobile homes versus apartments, apartments versus single-family residences, and single-family residences versus mobile homes. Using the functions developed in this analysis, individual household observations were then classified one at a time to test the ability of the functions to assign these families to their proper dwelling unit categories.

What discriminant analysis does for two groups, in effect, is maximize the difference between the means of the two groups. For standard statistical analysis, where only one variable is studied at a time, the distribution of variables is the univariate normal distribution. However, this study is concerned with households distributed on the basis of a value for each of forty-seven variables. Subjects such as these which are normally distributed form a multivariate normal distribution. The attributes of these two kinds of normal distributions are the same, except for this one difference: the number of variables.
Anderson describes what is happening here for the two-group case by pointing out that if a certain sample of subjects with numerous characteristics is chosen they will cluster in an ellipse. If another group is chosen, different from the first, it will form a similar cluster. Imagine these two clusters (using only two variables to describe each object in the distribution) on a plane such as that found in Figure 2. If all of the elements in the two clusters are projected to the base line, two normal distributions will form. By varying the linear functions which describe the two samples, their relative positions can be changed. There is one point at which they will be a maximum distance apart. The discriminant function is that function which places the two distributions in this position. This is a rather simplistic view and the analysis becomes complicated when forty-seven variables are used. However, the basic idea remains the same.

The relationship between the analysis above and the F-ratio calculation should now be intuitively obvious. The variables which are the best discriminators are those with the greatest differences in values between the groups. The analysis of variance eliminates the sampling error from consideration and what remains is an analysis based solely on group differences. By looking at Figure 2 it can be seen that if the two variables chosen to describe the elements of the two samples had values with a very small difference between the two groups, then no function could be found that would move the groups

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6Anderson, Multivariate Analysis, pp. 135 - 149.
**FIGURE 2**
Discrimination of Non-Intersecting Distributions

**FIGURE 3**
Discrimination of Intersecting Distributions
very far apart. Perhaps they would even overlap, making the choice of
deciding into which population to put some of the objects completely
arbitrary.

Algorithm for Discriminant Analysis

The discriminant function program being utilized here is a two
group program. As was stated in the beginning of this chapter, the
function being assumed in this study is of the general form

\[ y_i = f(x_{ij}) \]

In linear form this is

\[ y_i = \sum_{i=1}^{N} \sum_{j=1}^{P} a_{ij} x_{ij} + b, \]

where \( i = 1 \ldots N \) denotes the observation, \( j = 1 \ldots P \) denotes the variable under consideration, and \( b \) is a constant term. More will be said about this later.

Considering the new housing choice function in this way, with
the dependent variable as a dwelling class, the discriminant analysis
becomes essentially like a standard linear program. Rather than go
into a complete explanation of this technique, the reader is referred
to a standard linear programming text such as Smythe and Johnson. 7

The operation of the program being utilized refers back to Figure 2
in this chapter.

7 William R. Smythe and Lynwood A. Johnson, Introduction to
The program calculates a set of linear functions, each one of which is a linear combination of the variables obtained in the variance analysis and each one of which effectively serves to place the ellipses referred to in Figure 2 somewhere in space. These linear combinations are each equal to some $d$, or discriminant value. The program calculates linear combinations of the $x_{ij}$'s until it finds the maximum $d$. This defines the discriminant function. As it happens, this procedure is equivalent to maximizing the $t$-value (or $t^2$), which can be shown to be equal to the $F$-ratio.

Now a word must be said about the process of classification itself. Referring to Figure 2 again, the two-group, two-variable case, it was stated that if the two groups are far enough apart so there is no overlap, the function allows clear classification. If the two groups overlap, however, then some way must be found to decide in which group certain household observations are said to fall. If, as in Figure 3, for instance, it is decided that it is more expensive to mistake objects from group one for those in group two, then a line may be drawn so that all objects falling on the left side of the line are classified in group one and the rest in group two. This line is set by controlling the constant linear term $b$. However, it may be that this line is too arbitrarily set. It is not clear that a proper rationale exists for the use of such a criterion.

Instead of using such a line based on cost or some other criterion, the cut-off for classification in this study was made where the least number of total elements were misclassified. This is more
in keeping with the objective of this study, which is to find the qualitative model and test it. The best function set is the one which does the most efficient job of classification, that is, which makes the least mistakes.

In order to choose the best function, a type of sensitivity analysis was used. In this technique the computer tries different combinations or subsets of the significant variables to point out the one subset that makes the least mistakes. The objective is to find a function, composed of only significant variables, which makes no classification errors. If there was more than one function, the one with the least number of variables was chosen.

Additionally, it should be reiterated that the program for discriminant analysis utilized was for the two group case and there were three groups in this research. The reason for this was that the three group programs available were generally unreliable, and with the criterion being used here, it is easier to run three separate analyses: \( y_1 \) and \( y_2 \), \( y_2 \) and \( y_3 \), and \( y_1 \) and \( y_3 \). This still allows proper classification and under the desired standard.

Because the discriminant functions themselves are linear, they suffer from the weaknesses of the linearity assumptions. However, because the model being sought here was merely the qualitative and not the functional model, it was felt that if the discriminant functions could do their job under a linearity assumption, enough good information would be provided to proceed safely. In terms of housing model
relationships studies by Reid⁸ and others seem to bear out the fact that the linear assumption is reasonable.

Finally, a problem may occur using the regular linear assumption because many of the variables are interrelated. However, in discriminant analysis, this interrelationship may be utilized to advantage.⁹ Additionally, if it should happen that some unexplainable variables find their way into the discriminant function as proxies, their reasonableness will be checked by the Chi-square analysis to be described later in this chapter.

Validation of the Discriminant Functions

The calculation of the discriminant function just described was completed using samples of fifty subjects from each housing category. Classifications were then checked by individually categorizing each subject using the derived functions and observing the number of misclassifications. The standard alpha and beta error terms can be calculated to measure the amount of error. It should be obvious that if the variables are chosen wisely, the functions should do a very good job of classification on the variables used to construct the equations. This could hardly be considered a final test of the function, however.

⁸Reid, Housing and Income.

Therefore, the remaining forty or so subjects from each housing category sample (there were originally one hundred sampled, fifty were used in discriminant analysis, and some data were not useable because of refusals to answer questions) were run through the previously calculated function to determine how well it could classify new random data. If the variables were correctly chosen, the results of this analysis would prove more fully how reliable the functions were.

Chi-Square Analysis

The first forty-seven variables studied in the discriminant analysis were what might be termed implicit variables. They did not necessarily represent the reasons why a household would choose the dwelling it does, but perhaps implied those reasons. The remainder of the data were concerned with the stated reasons why the household chooses its current dwelling unit. These latter variables were analyzed by Chi-Square analysis and the results compared to the results of the discriminant analysis to see whether the explicit reasons given by the households for their last housing choice decision matched the proxies for these reasons derived in the discriminant analysis.

There were two types of questions for which answers were sought in this section. The first was whether or not dwellers in each of two types of dwellings rejected the third type of dwelling for the same reasons. For example, did the mobile home owners and apartment dwellers each reject single-family residences for the same reasons?
The second question was whether or not each type of dweller rejected the two other types of dwellings for the same reasons. For example, did each apartment dweller reject mobile homes and single-family residences for the same reasons?

The responses to the questions asking for the reasons a subject rejected or did not consider a particular dwelling were first placed in one of ten categories (see Chapter IV--variables $x_{56}$ through $x_{65}$). The responses were compiled and the frequency for each response for each group of dwellers, $y_i$, was determined.

These data were binary data and as such they could not be subjected safely to the use of analysis of variance to achieve the desired objective of this portion of the analysis. The appropriate test for difference between such groups is the Chi-square test for independent samples.¹⁰

There were six such difference tests and they are listed below.

1. Was there a significant difference between the reasons for the rejection of single-family residences by present apartment and mobile home dwellers?

2. Was there a significant difference between the reasons for the rejection of apartments by present single-family residence and mobile home dwellers?

3. Was there a significant difference between the reasons for the rejection of mobile homes by present apartment dwellers?

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and single-family residence dwellers?

4. Did mobile home dwellers reject apartments and single-family residences for the same reasons?

5. Did apartment dwellers reject mobile homes and single-family residences for the same reasons?

6. Did single-family residence dwellers reject mobile homes and apartments for the same reasons?

The mathematical techniques for the Chi-square analysis are based on familiar statistical relationships. If there were no difference between the two groups being measured regarding a set of characteristics, then the frequency of occurrence of these characteristics would be theoretically the same for the two groups. The Chi-square analysis merely compares the actual frequency of occurrence of the various characteristics with the theoretical frequency to see if the amount of variation present can be reasonably expected in a random chance occurrence under the no-difference assumption.

The formula for this analysis is

$$\chi^2 = \sum_{i=1}^{r} \sum_{j=1}^{k} \frac{(O_{ij} - E_{ij})^2}{E_{ij}},$$

where $O_{ij}$ is the observed number of cases in the $i$th row of the $j$th column and $E_{ij}$ is the number of cases expected under the null hypothesis to be categorized in the $i$th row of the $j$th column. The double sum causes one to sum over all rows and columns. The degrees of freedom for this test is $(r-1)(k-1)$, where $r$ is the number of rows.
and \( k \) is the number of columns in the Chi-square contingency table created from the response frequencies.\(^\text{11}\)

The results of the use of this technique will show where group differences occur and additional work may be done to show which reasons cause the observed differences to occur. These may then be compared to the discriminant function to see if any explanatory interpretation may be attached to the set of variables shown to discriminate dwelling type.

For example, since it was shown by the discriminant functions that downpayment, transportation cost, and current rent were discriminators, then it might be expected that there would be strong evidence in the Chi-square analysis to show that cost is a basis for differentiating dwelling types:

CHAPTER VI
RESULTS

The results of this study are presented in three parts. Part one is an examination of the results of the analysis of variance. Each variable is discussed in the order of its significance (F-level). Part two is a discussion of the discriminant functions derived using the significant variables. Part three is a discussion of the Chi-square analysis performed on the independent variables $x_{55}$ through $x_{87}$.

Analysis of Variance

The independent variables analyzed by analysis of variance were variables $x_1$ through $x_{47}$ inclusive. A complete listing of these variables, their dwelling unit mean values, F-ratios, and Chi-square ratios, where appropriate, are included in Tables 1 and 2 in Appendix B. It should be remembered that all the variance analysis reported in this section was conducted on a random subsample of fifty subjects for each group $y_1$, $y_2$, and $y_3$. The F-ratio required for significance at the .01 alpha level is 4.76 and at the .005 alpha level is 5.50. The significant Chi-square values are 9.21 at the .01 alpha level and 10.60 at the .005 alpha level.
significant variables

$x_{15}$ -- Number of Appliances in Present Dwelling.

With an F-ratio computed at 377.8 this variable proved to be very highly significant as a discriminator between groups. It would seem this result was due to the fact that there was little internal variation within each group. This might indicate that the suppliers of the different types of dwellings are very consistent in their practices of appliance installation in the dwellings in each group. This implies strong competition among builders on this item, with no one builder able to gain a differential advantage by installing more appliances than the others, within groups.

$x_{14}$ -- Number of Utilities Included in Monthly Payment.

With an F-value of $264.9$, $x_{14}$ was also very highly significant. This variable, like $x_{15}$ above, probably served to measure the consistency of industry practice more than anything else. The apartment group had the highest number of supplied utilities, while the single-family residence group had the least number of supplied utilities.

$x_{16}$ -- Number of Rooms in Present Dwelling.

An F-ratio of 63.2 was calculated for this variable. The average number of rooms, which served as a size proxy for this study, was about the same for both mobile homes and apartments, with 4.3 and
4.2 rooms respectively. For the single-family residence group this number jumped to 5.9. Thus, the homes provided much more space on this basis.

$x_{45}$ -- Monthly Rent or Mortgage Payment at Present Dwelling.

This variable, a major element of the total housing service cost, carried an $F$-ratio of 54.9. Thus, there was a significantly different base monthly cost among the three dwelling types. However, it should be noted that the monthly charge for single-family residences was slightly lower than that for the apartments, making the house a better buy on the basis of cost per unit of space. The mobile home, as expected, was far less expensive than either of the other two in absolute dollar terms. This variable, however, was not used in the discrimination, as total housing service cost, $x_{19}$, was felt to be the better measure of cost. It should be noted, however, that the psychic value of the out-of-pocket payment may be worthy of exploration for predictive value.

$x_{17}$ -- Number of Bedrooms in Present Dwelling.

The number of bedrooms also is some indication of dwelling size. Thus, with an $F$-ratio of 51.9 the significance of this variable was not unexpected. It showed the same relationship between groups as $x_{16}$ above.
\( x_{45} \) and \( x_{46} \) -- Housing Service Cost, Except Transportation.

By combining monthly payment, \( x_{45} \), and the cost of utilities, \( x_{46} \), and treating them as one variable, an F-ratio of 40.9 was calculated. When the cost of utilities not included in the monthly payment was added to the monthly payment, the differences among the groups was lessened. This was due to the relatively high cost of utilities for the mobile homes, which brought the mobile home group's total cost much closer to the other two. This variable was not included in the derivation of the discriminant functions for reasons stated under \( x_{45} \) above.

\( x_{46} \) -- Cost of Utilities Not Included in Monthly Payment.

The calculated F-ratio for this variable was only 34.9, compared to 54.8 for \( x_{45} \). This variable was also not included in the derivation of the discriminant functions. It should be noted that the results of the analysis of this variable were consistent with those of the complementary variable \( x_{14} \), the number of utilities included in monthly payment, though far less significant.

\( x_{40} \) -- Reasons for Last Move: Structure.

This was the most significant of the "dummy" variables, carrying an F-ratio of 31.3 and a Chi-square value of 44.8. These results stemmed from the fact that 56% of those living in single-family residences felt there were problems inherent in the type of dwelling in which they last resided which caused them to move to their present
quarters. This would be compared to 8% of the mobile home dwellers registering similar complaints and 6% of the apartment dwellers.

Of the subjects in $y_3$, the single-family residence group, who responded affirmatively to such problems 71% came from rented dwellings. The significance of this fact is not completely clear. However, it appears that people currently living in mobile homes or rented dwellings are not particularly mindful of structural problems. If they are, the concern is not strong enough to cause a move. However, at some point when the family begins to be concerned about the deficiencies in its dwelling type, it seems to want to move to single-family residences ownership tenure, where ostensibly something can be done about the problems. The potential usefulness of this variable is discussed more fully in the next chapter.

$x_{20} \quad$ Downpayment.

It was expected that this variable, which had an F-ratio of 26.8, would be significant. With no downpayment for apartments, it was reasonable to assume a large variation between that group and the other two. However, what was not expected was the fact that the mobile home group had the highest average downpayment. This perhaps accounts for the very low monthly payment found in the mobile home group. The fact that there is high significance attached to the downpayment supports the popular economic thesis that cash position is an important factor affecting the demand for housing (see Chapter IV,
variable $x_{20}$). The size of the downpayment and the factors affecting consumer feelings toward it may have a great potential in terms of predictive value in a market model.

$x_{12}$ -- Family size.

The family size variable produced an F-ratio of 23.8 which was fairly high. It is reasonable to assume this variable was in some way related to the two size variables, $x_{16}$ and $x_{17}$ above. The family size variable was included in this study in large part because of its probable relation to family income. However, the results tend to show that the variable of size is much more important than that of income, with three variables relating to size ranking in the top ten tested.

$x_{14}$ and $x_{5}$ -- Occupation: White Collar.

For this variable, both of the white collar categories, professional and nonprofessional respectively, were combined and the resulting sum yielded an F-value of 12.5. Strangely, $x_{5}$ alone had an F-value of only 7.9 and $x_{4}$ alone had an F-value of only 1.9. For this reason the combination form was chosen as the one to use for the discriminant analysis. The breakdown of the categories showed that 42% of the household heads in single-family residences were white collar workers, compared with 56% in apartments and 12% in mobile homes. These results are very much in line with the findings of the HUD study.

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1Coons and Glaze, Housing Market Analysis, pp. 24 - 25.
and may serve as predictors to some degree on a gross basis.²

$x_6$ and $x_7$ -- Occupation: Blue Collar.

Here again two occupation variables were combined, this time for blue collar supervisory and nonsupervisory household heads. The F-value for this combination was 11.6. This combination variable showed that 60% of the household heads in mobile homes were blue collar workers, compared with 20% for apartments and 52% for single-family residence household heads. These findings were also as expected. The HUD study showed 53% of the mobile home dwellers were blue collar workers, compared with 60% for this research.³ The remaining workers who were not blue collar or white collar workers fell into the other three categories of military personnel, retired persons, or unemployed persons or students (see Chapter IV, variables $x_4$ through $x_{10}$).

$x_3$ -- Education Level of the Household Head.

This variable, which was one of the income related demographic variables, had an F-value of 10.9, which was higher than the F-value for the income variable, but not exceedingly high considering the other variables discussed previously. The exact interpretation of the outcome of the variance analysis for this variable and the other

²HUD, Housing Survey.

³HUD, Housing Survey, p. 89.
income-related variables is unclear.

\( x_{18} \) -- Miles to Center City.

This is the first of the two location-oriented variables. The F-value of 9.3 was significant, but, interestingly, the results were not as expected. The most closely located dwellings in relation to the center of the city were the mobile homes, while the farthest were the single-family residences. The outcome of this variable could be the fault of sampling bias, but more than likely it is the result of the fact that there are several large, old mobile home areas located reasonably close to the center of the city which are populated with new mobile homes. Additionally, though new mobile home parks are, as expected, some distance from the center of town, so are all the new housing developments. Land is at a premium and it is difficult for any new low-cost unit to be located near the heart of a large city.

\( x_{27} \) -- Previous Dwelling: Mobile Home.

This variable, with an F-ratio of 8.8 was significant because 76% of the subjects interviewed who moved from a mobile home moved to a mobile home. Once a person lives in a mobile home, the odds seem to be very high he would move to another one.

\( x_5 \) -- White Collar Nonprofessional, \( x_7 \) -- Blue Collar Nonsupervisory.

These two occupation variables, already discussed, were both
significant, but neither was used to derive any discriminant equations in lieu of the presence of more powerful substitutes in the form of the combination variables, white collar workers and blue collar workers.

\(x_{13}\) -- Total Household Income for 1969.

The income variable had an F-value of 7.3 which was significant but not at an extremely high level. There was a great difference between the income level for home owners and the households in the other two categories. However, there was a large amount of internal variation in the incomes within each dwelling category, which lowered the F-value, a result whose significance is unclear.

\(x_9\) -- Occupation: Retired.

This occupation variable was significant with an F-value of 7.1. As might be expected most of the retired households (82%) lived in mobile homes. There were no retired households in the new single-family residences, which is logical since it was not expected that a retired household would take on the burden of a new mortgage at that age.

\(x_{29}\) and \(x_{32}\) -- Previous Dwelling: Rented Unfurnished.

Here again a summed variable proved to have a higher F-value than either of its parts. The results of this combination were in line with other findings concerning previous dwellings. Only 24% of
current mobile home dwellers moved from an unfurnished dwelling. This is logical since furniture comes with a mobile home. It is also reasonable in terms of the previous evidence that most mobile home dwellers moved from other mobile homes. On the other hand, 58% of the dwellers in single-family residences came from unfurnished rental housing, further substantiating the earlier point, that at some point the average family is likely to become a home owner, when it becomes disturbed enough with rental housing.

$x_{38}$ -- New Family Formation.

This variable was intended to measure the number of new family formations which caused moves. It was found that 16% of the households sampled for this part of the research were new families. Of these 58% moved into apartments, and all the rest, but one, moved into mobile homes. This would support a family cycle hypothesis based on the probable income level of a new family.

$x_{44}$ -- Reason for Last Move: Other.

This variable was tested and found significant. However, because the results were based only on a few subjects, all of whom gave inexpressive reasons for their move, the variable was discarded.

$x_{28}$ -- Previous Dwelling: Furnished Apartment.

As might be expected most of the dwellers moved to mobile
homes (66%), with the rest moving to other apartments. This is logical in light of the fact that without furniture one might be expected to move to a furnished dwelling or, at least, to a smaller unfurnished one.

$x_2$ -- Age of the Household Head.

This was the lowest variable in F-value that was still significant at the .005 level of error. The results were not quite as might have been expected, as the average age of the household head was highest for the mobile home group and lowest for the single-family residence group. Probably the influx of retired households into mobile homes has accounted for this result.

Non-Significant Variables

The remainder of the variables to be discussed were not sufficiently significant for inclusion in the derivation of the discriminant functions. Not all the non-significant variables are discussed, as the results of their analyses added nothing valuable to the output of this research. For explanations of the various variables in groupings below, see Chapter IV.

$x_{41}$ -- Reasons for Last Move: Maintenance.

This variable did not provide a great deal of information, except for the fact that only mobile home dwellers gave this as a reason for moving. This may have implied that there is some feature
inherent in the mobile home or its environment which was felt to cause unnecessarily high maintenance.

\( x_{43} \) -- Reasons for Last Move: Cost.

The subjects responding to this variable felt that their previous dwelling cost too much for one reason or another. Of those responding this way 70% were mobile home dwellers. This is logical since the mobile home was shown to have the lowest cost.

\( x_{19} \) -- Total Housing Service Cost.

This variable was the sum of the monthly payment, utilities cost, and transportation cost for the journey-to-work. The differences in total costs were large in absolute amount (see Appendix B, Table 3). However, the internal variation in each group was extremely high, thus disqualifying the variable for use in the discriminant functions. Additionally, one of the important components of this variable, transportation cost, had an F-ratio of only .4. Further, as is pointed out later in this chapter, the addition of this variable was unnecessary for errorless discrimination. In other words, it added no new information to the functions. For these reasons it was judged that this variable was, for practical purposes, held constant. Further discussion of this variable follows in the conclusions.
None of these previous dwelling types was significant, which indicates that dwellers in these various dwelling types moved to uniformly different dwellings in their last move. Thus, it is difficult to predict, at least for these dwelling types, which type will be the choice for the next move.

Here again these various occupational types were distributed more or less uniformly throughout the various current dwelling unit categories.

All of the current dwelling unit problem categories showed no significant differences. This means that none of the current dwelling types seemed to have any unique problems associated with it, at least for their current occupants.

Demographic Information Concerning Previous Dwelling.

Such variables as previous rent, previous dwelling size, and some of the previous dwelling types (see above) failed as predictors of current dwelling types. This fact was somewhat disturbing and its ramifications are discussed in the conclusions.
Discriminant Functions

The discriminant functions derived to classify the households in this study were calculated using the Bio-Medical program BMD04M, developed at U.C.L.A. The calculations were run at the IBM 360 facility at The Ohio State University. The program is a two-group program, so it was run three times for each unique pair of groups. The variables used were those derived in the first section of this chapter, significant at the .005 level of alpha, except for the variables $x_5$, $x_7$, and $x_{44}$ which were not included because they conveyed either meaningless or redundant information. Additionally, variables $x_{45}$ and $x_{46}$ were not run simultaneously with the combination variable created by summing these two in order to avoid redundancy. Finally, it was decided that since variables $x_{45}$, $x_{46}$, and $x_{45+46}$ were not the best cost variables because they did not represent the total service cost (see variable $x_{19}$ in Chapter IV) and since the best cost variable, $x_{19}$, was not significant at the .005 level of alpha, no cost variable was finally used.

The program employed automatically calculates a function using all the variables provided as input, even if some are not meant to be analyzed together. To obtain the proper functions, selections can be made choosing the desired variables. The procedure was to start with a small selection and add variables in order of significance to achieve the smallest equation which made no mistakes in classification. (For a list of the variables contained in the final discrimin-
ant equations, see the list on pages 90 and 91.

The first selection used seven variables: \( x_{15}, x_{14}, x_{16}, x_{12}, x_{17}, x_{20}, \) and \( x_{40}. \) This selection produced the following set of functions.

\[
\begin{align*}
y_1 &= -0.006x_{12} - 0.035x_{14} - 0.095x_{15} + 0.002x_{16} + 0.029x_{17} + 0.000x_{20} + 0.004x_{40} \\
y_2 &= -0.002x_{12} + 0.466x_{14} + 0.024x_{15} - 0.025x_{16} + 0.007x_{17} + 0.000x_{20} + 0.032x_{40} \\
y_3 &= -0.004x_{12} - 0.008x_{14} + 0.02x_{15} + 0.018x_{16} + 0.024x_{17} + 0.000x_{20} + 0.041x_{40}
\end{align*}
\]

This selection made a combined total of three classification errors.

The second selection added the two occupation combination variables, \( x_{4+5} \) and \( x_{6+7}, \) to the variables used in selection one, and the following functions were derived.

\[
\begin{align*}
y_1 &= -0.02232x_{4+5} + 0.0336x_{6+7} - 0.00673x_{12} - 0.03833x_{14} - 0.10410x_{15} + 0.00177x_{16} + 0.02453x_{17} + 0.00002x_{20} - 0.00757x_{40} \\
y_2 &= -0.06171x_{4+5} - 0.00397x_{6+7} - 0.00382x_{12} - 0.50151x_{14} + 0.02341x_{15} - 0.02394x_{16} + 0.00841x_{17} + 0.00001x_{20} - 0.03756x_{40} \\
y_3 &= -0.02938x_{4+5} + 0.05731x_{6+7} - 0.00463x_{12} - 0.09900x_{14} - 0.09333x_{15} + 0.01910x_{16} + 0.01733x_{17} + 0.00003x_{20} + 0.04377x_{40}
\end{align*}
\]

\(^4\)The coefficients of the \( x_i \) variables were actually computed to five decimal places. However, since this selection made misclassifications and was not used as the final selection, the coefficients were rounded to three decimal places for their inclusion here.
By using these equations, inserting the entire group of test subjects, no classification errors were made. The assigned group $Y_1$ contained the fifty highest $y$-values—from .50722 to .38966—and all of the subjects so classified were actually from the mobile home group $Y_1$. The assigned group $Y_2$ contained the fifty lowest $y$-values—from -.20955 to -.47771—and contained all the subjects actually living in apartments. Finally, the assigned group $Y_3$ with $y$-values from .36488 to -.05573 contained the actual subjects dwelling in single-family residences.

Because the purpose of this procedure was to find the smallest selection which made no mistakes, the above results are not very impressive. It was, however, surprising that so few variables were needed to make a successful trial.

One additional selection was tried, not necessarily on the basis of significance. The selection contained all of the significant family characteristics variables and one non-significant variable: family size, age of the household head, income, education level of the household head, spouse working, and the white and blue collar occupation variables. The attempt was to see if occupancy could be predicted on the basis of family characteristics alone. The equations are not included, as the attempt failed utterly, classifying 45 of the 150 subjects erroneously.

In order to test the real applicability of the errorless functions, the hold-out samples of remaining subjects, hitherto untested and unanalyzed, were used as inputs to the functions. This hold-out
sample set consisted of 42 mobile home dwellers, 39 apartment dwellers, and 40 single-family residence dwellers. The y-values were calculated for all 121 subjects and the 42 highest y-values were assigned to group \( y_1 \), the 39 lowest were assigned to group \( y_2 \), and the other 40 values were assigned to group \( y_3 \). When the actual dwelling group identity of the subjects was disclosed, after assignment, it was found that all subjects had been properly classified. Thus, the derived functions made no mistakes on the hold-out sample.

The validity of the functions for these data was upheld. This does not mean that the functions are generally applicable to any data in any city at any time. However, it does show that it is possible to develop functions from a small sample which can validly classify other random subjects, without having to adjust the functions.

To summarize briefly, after the original variables were sorted according to rank of the F-value, a set of discriminant functions was derived and tested. The final functions chosen and validated included the variables listed below:\(^5\)

\[ x_{45} \quad \text{Occupation: white collar} \]
\[ x_{67} \quad \text{Occupation: blue collar} \]
\[ x_{12} \quad \text{Family size} \]
\[ x_{14} \quad \text{Number of utilities included in monthly payment} \]
\[ x_{15} \quad \text{Number of appliances in present dwelling} \]
\[ x_{16} \quad \text{Number of rooms in present dwelling} \]
\[ x_{17} \quad \text{Number of bedrooms in present dwelling} \]

\(^5\)The F-ratios for the final variables may be found in Table 1; the means, where applicable, may be found in Table 3.
Chi-Square Analysis

There was, in addition to the set of variables whose test results have just been described, an additional set of variables which were studied using Chi-square analysis. These variables, \( x_{55} \) through \( x_{87} \), are described in Chapter IV. Six sets of tests were conducted on these data. They are listed below with their significant results. For a tabular description of the results below, see Table 4 and Table 5 in Appendix B.

Rejection of the Mobile Home.

This test was conducted to see if there were significant differences in the reasons why current apartment dwellers and current single-family residence dwellers rejected the mobile home as a choice for their last move. Only one of the reasons showed a Chi-square ratio significant at the .05 level of alpha or lower. Home owners felt overwhelmingly that mobile homes were too small. This is quite in line with the size findings of the previous variance analysis.

Though there were no other significant reasons, one variable which very nearly was significant at the .05 level involved location. Again more single-family home owners felt that they disliked mobile homes because of their locations. This is in line with the image and
location problems brought up so often. However, it would appear these problems are not as severe as they once were, at least in the test area.

Rejection of the Apartment.

This test was to see if there were significant differences between dwellers in single-family residences and mobile homes in the reasons for rejecting apartments. There were two significant variables for this test. Again, single-family households were significantly more critical of the size problem. Many more single-family residence households rejected apartments for this reason than did mobile home households. This completely corroborates the size data of the variance analysis.

The second significant variable in this test was the cost variable. Significantly more mobile home dwellers had rejected apartments for cost reasons. The meaning of this is unclear. It might be the natural reaction of the type of household which thinks it is paying a very low cost for its shelter as implied in the variance analysis. However, it would seem that there should have been a strong feeling from single-family residence owners about the quantity per dollar cost of the apartments, which was higher than that for the single-family residences.

Rejection of Single-Family Residences.

The only significant result in this test showed that mobile
home owners rejected single-family residences because of their lack of
equity more frequently than apartment dwellers. This is a strange
result, which rather defies explanation. The only reaction that seems
at all plausible is that the mobile home dweller feels his property
is more tangible than a conventional home would be since it is paid
for sooner and can be moved. It is also possible that these mobile
home dwellers considered only the rental of a single-family residence
and, therefore, saw no equity.

There was a variable which was nearly significant. A great
number of mobile home owners rejected the conventional dwelling
because of high upkeep. This is logical if one views the mobile home
owner as sort of a "mini" home owner, with ownership of a dwelling
that is less expensive and easier to maintain.

Rejection of Dwellings by Mobile Home Owners.

This test was intended to show whether or not a mobile home
household rejected the other two types of dwellings for the same
reasons. Most of the results in this test were as expected. The
mobile home owners rejected apartments significantly more often than
conventional homes because of the close proximity of the units and
the lack of equity. They rejected single-family homes more often on
the basis of cost and upkeep. There was one unexpected result here.
Mobile home dwellers did not seem to feel that homes were significant-
ly larger than apartments, even though the variance analysis showed
that the homes were 50% larger.
Rejection of Dwellings by Apartment Dwellers.

In this test apartment dwellers failed to consider the mobile home as an alternative shelter choice significantly more often than the single-family dwelling. In corroboration with this, a significant number stated they never even thought of a mobile home as an alternative. The reasons for this need to be explored more closely and are important to the whole future of this type of housing.

In addition to these results, mobile homes were rejected significantly more often than single-family residences for reasons of small size and structural inadequacies. On the other hand, single-family dwellings were rejected more often than mobile homes because of high cost and high upkeep. These results again corroborate previously analyzed results which showed that single-family dwellings were larger and cost more than mobile homes on the average.

Rejection of Dwellings by Single-Family Residence Dwellers.

In this final test three significant differences were observed. Mobile homes were rejected significantly more often because of their small size and because of their location. Finally, apartments were rejected significantly more often than mobile homes because they yield no equity.
The objective of this research was to analyze a list of variables which might be related to the housing choice decision and to identify from this list those variables which could properly classify test households into three dwelling types: new mobile homes, new apartments, and new single-family residences. Further, there were two ancillary objectives which were: 1) to gain insight into the mobile home submarket, and 2) to attempt to determine the potential success of discriminant analysis in applications to further research of this type.

**Major Objective: Conclusions**

The variance analysis performed on the data divided the original variable list into two parts—those variables which were significant discriminators and those variables which were not. In addition, the discriminant analysis further divided the list of significant variables to yield a smaller list of the most highly

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1For a list of the significant variables, in order of the significance of their F-ratios, see Table 1 in Appendix B. A list of the non-significant variables is found in Table 2 in Appendix B.
significant variables which could be used to discriminate between test households. These variables were:

\[x_{45}\] -- Occupation: white collar
\[x_{67}\] -- Occupation: blue collar
\[x_{12}\] -- Family size
\[x_{14}\] -- Number of utilities
\[x_{15}\] -- Number of appliances
\[x_{16}\] -- Number of rooms
\[x_{17}\] -- Number of bedrooms
\[x_{20}\] -- Downpayment
\[x_{40}\] -- Reason for last move: structure.

The final list, which was the smallest and most highly significant, contained nine variables. Three of these variables described present characteristics of the test families, five described present characteristics of the dwellings, and one represented a reason for some of the test households' most recent move.

It was also shown that a list of variables containing only present family characteristics could not be used to classify the households properly. Finally, it was shown that the list of prior dwelling characteristics contained very few significant variables and such a list could not be successful at discrimination either.

One possible application of the findings of this research was the extension of the results to the prediction of the demand for various dwelling types. In order for a predictive model to be based
directly on these results, however, a particular outcome would have been desirable. If a set of family characteristics could have been used successfully to predict current dwelling unit types, the implication would have been that by measuring the family characteristics in a particular market a judgment could have been made about the demand for dwellings at the time of the measurement. Further, if an accurate prediction could be made concerning the future characteristics of families under this scheme, specific future dwelling needs could be predicted. Such a direct result, however, is not possible according to the findings reported here.

Although it was not possible to discriminate between dwelling types on the basis of family characteristics, it was possible to conclude that there is a group of variables which can be used to classify households into the proper dwelling unit categories. One such list was found, identified, and reiterated above.

Further, there was one group of variables which would not classify households into their dwelling units. This, too, must be considered significant, as it is not readily apparent why the family variables did not have discriminatory capability.

**Application of the Major Findings**

Another practical application of the results of this research is its potential usefulness in the further development of the submarket analysis technique. It was stated earlier that the major problem
preventing the successful exploitation of the submarket model for predicting demand is the inability to determine appropriate linkages. The definition of a submarket is that it contains dwellings which are substitutes. One submarket is distinguished from other submarkets, presumably, by differences in the values of certain characteristics. It would seem that the search for such differences could be carried out effectively through discriminant analysis using the submarkets as dependent variables and the characteristics as independent variables. For example, assume there are two housing submarkets, A and B, and a family trying to choose a dwelling in one of them. Assume further that the dwellings in both A and B all cost the same, are the same size, and the same color. Thus, the family is indifferent between them. If, however, all of the dwellings in A are ten miles from the nearest school, whereas those in B are one mile from schools, then distance to school might be a linkage (or variable) upon which the choice decision might hinge. Discriminant analysis could be used to determine such variables, thereby helping to delineate submarkets. Further, it would seem that additional study of the variables in the final discriminant functions of this research would provide a starting point for such exploration.

The Methodology: Conclusions

One of the ancillary purposes of this research was to gain insight into the potential usefulness of discriminant analysis for research in the housing market area. Mechanically, the technique
was successful and there was no indication that it could not be made to work in any future application where the objects of the study could be classified. For instance, a future study of the factors affecting housing service cost might be attempted by using some measure of this cost as a category and testing which variables have the ability to classify the dwellings properly into the proper cost categories. Many different variables could be held constant one at a time by using them as the category (dependent) variables and testing for the factors which differentiate the classes. This offers potential for the study of various hypothesized linkages in the submarket scheme.

There are problems associated with the discriminant technique, which have been discussed earlier. However, its inherent flexibility makes it ideal for research in which it is desireable to determine which of a group of independent variables affect some other controlled variable. The method of search is systematic and annealing. It should be noted, however, that when a specific functional relationship between variables is the object of research this method is not applicable. It merely finds the variables that are related. The exact relationship must be found by using differential equations, regression analysis, or some similar technique.

The Mobile Home: Conclusions

The second ancillary objective of this study was to gain insight into the nature of the mobile home submarket. This was accomplished to perhaps a lesser degree than was originally desired.
There were, however, some interesting findings.

First, as in the HUD study\textsuperscript{2}, it was found that mobile home families were the smallest, though not the youngest, for the units tested. Additionally, the mobile home household heads were the least educated of those for the three groups and sixty percent were blue collar workers, while only twelve percent were white collar workers. Again, in line with the HUD study, the lowest incomes of the three groups were found in the mobile home group. Though mobile homes had the lowest total dollar cost per month of the three groups, when the costs were compared on a room by room basis the mobile home cost was $55 per month per room, whereas the single-family residence was only $45 per month per room. Unlike the findings of the HUD study, this research showed that 82\% of the retired households interviewed lived in mobile homes.

A second set of major findings about the mobile home dwellers was concerned with the choice decision itself. It was found that seventy-six percent of the people moving from mobile homes moved to other mobile homes. The reasons for this were not completely clear. Further, this group comprised only twenty-six percent of those tested who moved into mobile homes. This seems to imply that while mobile home dwellers do come from all other types of dwellings, once they move into a mobile home, they tend to stay with that type of dwelling.

\textsuperscript{2}A summary of the findings of the HUD study, relevant to this research, are found in Chapter III, pp. 34 - 35.
One of the prime reasons given for the move to a mobile home was cost. Over seventy percent of those tested in the mobile home group listed this as a reason for their move to a mobile home. Additionally, mobile home dwellers rejected single-family residences more often than apartments for this reason. Unkeep was also given as a reason for the rejection of single-family homes by the mobile home dwellers significantly more often than for apartments.

On the other hand, mobile home owners rejected apartments significantly more often because of a lack of equity and the close proximity of the units.

Finally, mobile homes were rejected significantly more often than the other types of dwellings by both home owners and apartment dwellers because they were too small. Single-family owners also rejected mobile homes because of bad locations, and apartment dwellers also rejected mobile homes because of structural inadequacies.

To summarize, the mobile home subjects tested implied that the mobile home combined the equity and low-density features of conventional homes with the low-cost and low-unkeep of apartments. However, the small size of the mobile home, its structure, and its location seem to drive a great number of potential dwellers to other alternatives. Therefore, the conclusion that might be reached from all of these results is that mobile homes still reach only a specialized segment of the population.

It had been thought that perhaps some of the decisions to reject mobile homes as dwellings would be made on the basis of myth
rather than a knowledge of the facts. However, the results showed that seventy percent of the families who decided not to live in mobile homes had been in mobile homes in developed mobile home parks.

It should be emphasized that though generalized conclusions are drawn concerning these results, this was a case study of a single housing market. Much further research would be required to allow broader generalizations on any of the conclusions of this research as they might apply to housing markets in general.

**Findings About Mobile Homes: Applications**

Perhaps the most important conclusion that can be reached about the overall impressions concerning the mobile home is that it is not a universal cure-all, even in the short-run, for low-cost housing problems. There are so many weaknesses with this alternative, especially concerning the cost-quality trade-off, that some changes will have to be made if this mode of housing is to be made more desirable. It would seem that some of the problems implied in the results above could be explored by market research to see what features might reasonably be added to make the mobile home a better product. At the same time, it must be kept in mind that if cost is raised too much by the addition of features, many potential demanders might be lost. Thus, some study of the demand elasticity for mobile homes might be an important part of future research.
APPENDIX A

QUESTIONNAIRE

1. Are you the head of the household or spouse?
   ______ Yes
   ______ No (Terminate interview)

2. How long have you lived in your present dwelling?
   ______ Months
   ______ Years (If more than 3 years, terminate interview)

3. (Check the type of dwelling unit below and skip to the question directed)
   ______ Mobile home -- Go to Question 4
   ______ Apartment -- Go to Question 5
   ______ Home -- Go to Question 6

4. Do you own this mobile home or do you rent? (Go to Question 7)
   ______ Own
   ______ Rent

5. Do you rent this apartment furnished or unfurnished? (Go to Question 7)
   ______ Furnished
   ______ Unfurnished

6. Do you own your home or do you rent furnished or unfurnished?
   ______ Own
   ______ Rent furnished
   ______ Rent unfurnished

7. What utilities are included in your monthly rent or mortgage payment?
   ______ Gas
   ______ Electricity
   ______ Water (may include sewerage)
   ______ None
   ______ All (Go to Question 9)

8. What is the approximate average monthly cost of the utilities not included in your monthly payment, excluding telephone?
   $________

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9. What major appliances are furnished in your residence and are included in your monthly payment?

___ Range
___ Refrigerator
___ Dishwasher
___ Waste disposer
___ Washer (may include dryer)

10. How many rooms are in your residence, excluding bathrooms and unfinished basement rooms?

___ 3
___ 4
___ 5
___ 6
___ 7 or more

11. How many of these rooms were originally intended to be bedrooms?

___ 1
___ 2
___ 3
___ 4 or more

12. In which range does your total monthly mortgage or rental payment fall? Include taxes and fire insurance, if separate. Mobile home residents include site cost.

___ Under $100
___ $100 - $109
___ $110 - $119
___ $120 - $129
___ $130 - $139
___ $140 - $149
___ $150 - $159
___ $160 and over

13. (Home and mobile home owners only)
In which range does your approximate total downpayment fall?

___ None
___ $1 - $499
___ $500 - $999
___ $1,000 - $1,999
___ $2,000 - $2,999
___ $3,000 - $3,999
___ $4,000 - $4,999
___ $5,000 and over

14. Do you have any major unsatisfactory features or service problems with your present home?

___ Yes
___ No (Go to Question 17)
15. Please describe these major problems very briefly.

16. Would any of these major problems cause you to move sooner than you originally intended to move?
   _____ Yes
   _____ No

17. How long do you intend to remain in your present residence?
   _____ Months
   _____ Years
   _____ Uncertain

18. What type of dwelling do you think you will most likely move to when you do move again?
   _____ Mobile home (Check Question 19)
   _____ Apartment (Go to Question 20)
   _____ Single-family home (Go to Question 20)
   _____ Other: __________________ (Go to Question 20)

19. (Mobile home owners who will be moving to a mobile home) Will your move to a mobile home involve buying a new mobile home or will you just move your present one to a new site?
   _____ Buy a new mobile home
   _____ Move present mobile home to a new site

20. Were you either a dependent living with your family or were you in a school residence facility before you moved to this residence?
   _____ Yes
   _____ No

21. What type of dwelling did you live in just before you moved here?
   _____ Mobile home
   _____ Furnished apartment
   _____ Unfurnished apartment
   _____ Owned a home
   _____ Rented a furnished home
   _____ Rented an unfurnished home
   _____ Other: __________________

22. What was the address of your previous residence?

23. How long did you live in your previous residence?
   _____ Months
   _____ Years
24. Is someone living in your previous residence since you moved out?
   ____ Yes (Go to Question 25)
   ____ No (Go to Question 26)
   ____ Uncertain (Go to Question 26)

25. Who is presently living there?
   ____ Parents
   ____ Other relatives
   ____ Roommate
   ____ Other: __________________________

26. How many rooms were in your previous residence, excluding bathrooms and unfinished basement rooms?
   ____ 3
   ____ 4
   ____ 5
   ____ 6
   ____ 7 or more

27. How many rooms were intended to be used as bedrooms?
   ____ 1
   ____ 2
   ____ 3
   ____ 4 or more

28. In which range did your approximate total monthly mortgage or rental payment for your previous residence fall? Include taxes and fire insurance, if separate. Mobile home residents include site cost.
   ____ Under $100
   ____ $100 - $109
   ____ $110 - $119
   ____ $120 - $129
   ____ $130 - $139
   ____ $140 - $149
   ____ $150 - $159
   ____ $160 and over

29. Very briefly, what were the major reasons for your move?

30. (Single-family home dwellers go to Question 32)
    When you made the decision to move to your present dwelling did you consider living in a conventional single-family home?
    ____ Yes (Interviewer read Part A below)
    ____ No (Interviewer read Part B below)
31. Part A: Briefly, why did you decide not to move into this type of dwelling?
   Part B: Briefly, why didn't you consider living in this type of dwelling?

32. (Apartment dwellers go to Question 34)
   When you made the decision to move to your present residence did you consider living in an apartment?
   Yes (Interviewer read Part A below)
   No (Interviewer read Part B below)

33. Part A: Briefly, why did you decide not to move into this type of dwelling?
   Part B: Briefly, why didn't you consider living in this type of dwelling?

34. (Mobile home residents go to Question 37)
   When you made your decision to move to your present residence did you consider living in a mobile home?
   Yes (Interviewer read Part A below)
   No (Interviewer read Part B below)

35. Part A: Briefly, why did you decide not to move into this type of dwelling?
   Part B: Briefly, why didn't you consider living in this type of dwelling?

36. Have you ever been inside a mobile home in a mobile home park?
   Yes
   No

37. (Interviewer check the sex of the respondent)
   Male
   Female

38. What is the age of the head of the household?
   Years

39. What is the occupation of the head of the household? Be specific.
40. What is the highest level of education completed by the head of the household?
   _____ Less than a high school diploma
   _____ High school diploma
   _____ Some college work
   _____ College graduate
   _____ Post-graduate work

41. What is the approximate total travel time per day for the head of the household to commute to and from work?
   _____ Minutes
   _____ Not applicable--travels for a living

42. Does the head of the household use public transportation to commute to and from work?
   _____ Yes
   _____ No (Go to Question 44)

43. What is the approximate cost per week of the public transportation?
   $_____

44. Does the spouse of the head of the household also work?
   _____ Yes
   _____ No

45. How many people are living in this household?
   _____

46. How many are children?
   _____

47. In which range did your approximate total annual family income for 1969 fall?
   _____ None
   _____ $1 - $2,000
   _____ $2,000 - $3,999
   _____ $4,000 - $4,999
   _____ $5,000 - $5,999
   _____ $6,000 - $6,999
   _____ $7,000 - $7,999
   _____ $8,000 - $9,999
   _____ $10,000 - $14,999
   _____ $15,000 - $19,999
   _____ $20,000 and over
APPENDIX B

TABLE 1

F and Chi-Square Values for Variables Significant at .005 Level

<table>
<thead>
<tr>
<th>Variable Number</th>
<th>Name of Variable</th>
<th>F</th>
<th>Chi-square Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td># of Appliances in Present Dwelling</td>
<td>377.845</td>
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</tr>
<tr>
<td>14</td>
<td># of Utilities in Present Dwelling</td>
<td>284.911</td>
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<tr>
<td>16</td>
<td># of Rooms in Present Dwelling</td>
<td>63.222</td>
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<tr>
<td>45</td>
<td>Monthly Payment at Present Dwelling</td>
<td>54.687</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td># of Bedrooms in Present Dwelling</td>
<td>51.896</td>
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<tr>
<td>45,46a</td>
<td>Housing Service Cost, ex. Trans.</td>
<td>40.903</td>
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</tr>
<tr>
<td>46</td>
<td>Cost of Utilities at Present Dwelling</td>
<td>34.935</td>
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<tr>
<td>40</td>
<td>Reasons for Last Move--Structure</td>
<td>31.295</td>
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<td>20</td>
<td>Downpayment</td>
<td>26.814</td>
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<td>12</td>
<td>Family Size</td>
<td>23.750</td>
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<td>4, 5a</td>
<td>Occupation--White Collar</td>
<td>12.472</td>
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<tr>
<td>6, 7a</td>
<td>Occupation--Blue Collar</td>
<td>11.602</td>
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<tr>
<td>3</td>
<td>Education of Household Head</td>
<td>10.922</td>
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<td>18</td>
<td>Miles to Center City</td>
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<td>27</td>
<td>Previous Dwelling--Mobile Home</td>
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<td>5</td>
<td>Occupation--White Collar Nonprof.</td>
<td>7.890</td>
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<td>7</td>
<td>Occupation--Blue Collar Nonsuperv.</td>
<td>7.499</td>
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<td>13</td>
<td>Total Household Income for 1969</td>
<td>7.262</td>
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<tr>
<td>9</td>
<td>Occupation--Retired</td>
<td>7.060</td>
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<tr>
<td>29,32a</td>
<td>Previous Dwelling--Rented Unfurn.</td>
<td>6.901</td>
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<td>38</td>
<td>New Family Formation</td>
<td>6.856</td>
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<tr>
<td>44</td>
<td>Reasons for Last Move--Other</td>
<td>5.898</td>
<td></td>
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<tr>
<td>28</td>
<td>Previous Dwelling--Rent Furn. Apt.</td>
<td>5.880</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Age of Household Head</td>
<td>5.612</td>
<td></td>
</tr>
</tbody>
</table>

\( ^a \)A combination of two or more individual variables by addition of variable values for each member of sample or by addition of positive responses for zero-one variables.

\( ^b \)Chi-square values computed for zero-one variables only.
### Table 2
F and Chi-Square Values for Variables Not Significant at .005 Level

<table>
<thead>
<tr>
<th>Variable Number</th>
<th>Name of Variable</th>
<th>F Value</th>
<th>Chi-Square Value^b</th>
</tr>
</thead>
<tbody>
<tr>
<td>41</td>
<td>Reasons for Last Move--Maintenance</td>
<td>5.444</td>
<td>10.345</td>
</tr>
<tr>
<td>43</td>
<td>Reasons for Last Move--Cost</td>
<td>5.379</td>
<td>10.215</td>
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<tr>
<td>19</td>
<td>Total Housing Service Cost</td>
<td>5.132</td>
<td></td>
</tr>
<tr>
<td>28,31^a</td>
<td>Previous Dwelling--Rented Furn.</td>
<td>4.780</td>
<td>9.160</td>
</tr>
<tr>
<td>29</td>
<td>Previous Dwelling--Rented Unfurn. Ant.</td>
<td>4.658</td>
<td>8.939</td>
</tr>
<tr>
<td>10</td>
<td>Occupation--Student or Unemployed</td>
<td>4.533</td>
<td>8.996</td>
</tr>
<tr>
<td>39</td>
<td>Reasons for Last Move--Location</td>
<td>4.014</td>
<td>7.767</td>
</tr>
<tr>
<td>34</td>
<td>Years at Previous Dwelling</td>
<td>2.731</td>
<td></td>
</tr>
<tr>
<td>33</td>
<td>Previous Dwelling--Other</td>
<td>2.544</td>
<td>5.018</td>
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<tr>
<td>32</td>
<td>Previous Dwelling--Rented Unfurn. S-F</td>
<td>2.252</td>
<td>4.459</td>
</tr>
<tr>
<td>1</td>
<td>Sex of Household Head</td>
<td>2.014</td>
<td>4.026</td>
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<tr>
<td>4</td>
<td>Occupation--White Collar Professional</td>
<td>1.913</td>
<td>3.304</td>
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<tr>
<td>6</td>
<td>Occupation--Blue Collar Supervisory</td>
<td>1.873</td>
<td>3.228</td>
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<td>Previous Dwelling--Cowned Single-Fam.</td>
<td>1.752</td>
<td>3.493</td>
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<tr>
<td>36</td>
<td># of Bedrooms in Previous Dwelling</td>
<td>1.712</td>
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<tr>
<td>31,32^a</td>
<td>Previous Dwelling--Rented Single-Fam.</td>
<td>1.437</td>
<td>2.876</td>
</tr>
<tr>
<td>37</td>
<td>Monthly Payment at Previous Dwelling</td>
<td>1.184</td>
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</tr>
<tr>
<td>26</td>
<td>Current Problems--Other</td>
<td>1.021</td>
<td>2.055</td>
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<tr>
<td>8</td>
<td>Occupation--Military</td>
<td>1.014</td>
<td>2.041</td>
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<tr>
<td>23</td>
<td>Current Problems--Maintenance</td>
<td>1.014</td>
<td>2.041</td>
</tr>
<tr>
<td>25</td>
<td>Current Problems--Cost</td>
<td>1.000</td>
<td>2.013</td>
</tr>
<tr>
<td>35</td>
<td># of Rooms in Previous Dwelling</td>
<td>0.678</td>
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<tr>
<td>30,31,32^a</td>
<td>Previous Dwelling--Single-Family</td>
<td>0.567</td>
<td>1.016</td>
</tr>
<tr>
<td>47</td>
<td>Total Transportation Cost</td>
<td>0.36</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>Spouse Working</td>
<td>0.293</td>
<td>0.595</td>
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<td>28,29^a</td>
<td>Previous Dwelling--Apartment</td>
<td>0.256</td>
<td>0.521</td>
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<tr>
<td>31</td>
<td>Previous Dwelling--Rented Furn. S-F</td>
<td>0.253</td>
<td>0.514</td>
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<tr>
<td>22</td>
<td>Current Problems--Structure</td>
<td>0.209</td>
<td>0.305</td>
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<td>42</td>
<td>Reasons for Last Move--Size</td>
<td>0.030</td>
<td>0.062</td>
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<tr>
<td>24</td>
<td>Current Problems--Size</td>
<td>-----^c</td>
<td>-----^c</td>
</tr>
<tr>
<td>21</td>
<td>Current Problems--Location</td>
<td>-----^c</td>
<td>-----^c</td>
</tr>
</tbody>
</table>

^a A combination of two or more individual variables by addition of variable values for each member of sample or by addition of positive responses for zero-one variables.

^b Chi-square values computed for zero-one variables only.

^c No F nor Chi-square values can be computed, since there were no positive responses in the samples.
<table>
<thead>
<tr>
<th>Variable Number</th>
<th>Name of Variable</th>
<th>Mobile Home Mean</th>
<th>Apartment Mean</th>
<th>Single-Family Mean</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>Age of Household Head</td>
<td>42.12</td>
<td>34.72</td>
<td>32.60</td>
</tr>
<tr>
<td>3</td>
<td>Education of Household Head</td>
<td>12.20</td>
<td>13.76</td>
<td>12.24</td>
</tr>
<tr>
<td>12</td>
<td>Family Size</td>
<td>2.50</td>
<td>2.58</td>
<td>4.04</td>
</tr>
<tr>
<td>13</td>
<td>Total Household 1969 Income</td>
<td>$8220.00</td>
<td>$8820.25</td>
<td>$11560.00</td>
</tr>
<tr>
<td>14</td>
<td># of Utilities--Present Dw.</td>
<td>1.00</td>
<td>1.20</td>
<td>1.04</td>
</tr>
<tr>
<td>15</td>
<td># of Appliances--Present Dw.</td>
<td>2.06</td>
<td>3.38</td>
<td>1.62</td>
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<tr>
<td>16</td>
<td># of Rooms--Present Dwelling</td>
<td>4.32</td>
<td>4.22</td>
<td>5.88</td>
</tr>
<tr>
<td>17</td>
<td># of Bedrooms--Present Dw.</td>
<td>2.16</td>
<td>1.92</td>
<td>3.02</td>
</tr>
<tr>
<td>18</td>
<td>Miles to Center City</td>
<td>6.10</td>
<td>7.14</td>
<td>7.50</td>
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<tr>
<td>19</td>
<td>Total Housing Service Cost</td>
<td>$217.02</td>
<td>$243.02</td>
<td>$271.36</td>
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<tr>
<td>20</td>
<td>Downpayment</td>
<td>$1815.00</td>
<td>$0.00</td>
<td>$1410.00</td>
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<tr>
<td>34</td>
<td>Years at Previous Dwelling</td>
<td>5.30</td>
<td>5.28</td>
<td>2.98</td>
</tr>
<tr>
<td>35</td>
<td># of Rooms--Previous Dw.</td>
<td>4.58</td>
<td>4.80</td>
<td>4.88</td>
</tr>
<tr>
<td>36</td>
<td># of Bedrooms--Previous Dw.</td>
<td>2.18</td>
<td>2.42</td>
<td>2.04</td>
</tr>
<tr>
<td>37</td>
<td>Monthly Payment--Previous Dw.</td>
<td>$92.70</td>
<td>$93.80</td>
<td>$104.20</td>
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<td>Monthly Payment--Present Dw.</td>
<td>$99.22</td>
<td>$142.20</td>
<td>$140.20</td>
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<td>Utilities Cost--Present Dw.</td>
<td>$28.60</td>
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<tr>
<td>45,46b</td>
<td>Housing Serv. Cost ex. Trans.</td>
<td>$127.88</td>
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<td>47</td>
<td>Total Transportation Cost</td>
<td>$89.42</td>
<td>$82.72</td>
<td>$96.02</td>
</tr>
</tbody>
</table>

*a No meaningful arithmetic means can be calculated for the zero-one variables, so they are not included in this table.

*b A combination of two or more individual variables by addition of variable values for each member of the sample.
TABLE 4

Dwelling Rejection Analysis by Chi-Squares*

<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Apartment and Single-Family Rejections of Mobile Homes</th>
<th>Mobile Home &amp; Single-Family Rejections of Apartments</th>
<th>Mobile Home &amp; Apartment Rejections of Single-Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>Too Small</td>
<td>9.180</td>
<td>9.756</td>
<td>1.010</td>
</tr>
<tr>
<td>Too Large</td>
<td>1.010</td>
<td>----b</td>
<td>1.383</td>
</tr>
<tr>
<td>Location</td>
<td>2.990</td>
<td>.710</td>
<td>2.174</td>
</tr>
<tr>
<td>Proximity</td>
<td>7.10</td>
<td>0.000</td>
<td>----b</td>
</tr>
<tr>
<td>Cost</td>
<td>.709</td>
<td>5.741</td>
<td>.342</td>
</tr>
<tr>
<td>No Equity</td>
<td>2.020</td>
<td>.046</td>
<td>4.167</td>
</tr>
<tr>
<td>Structure</td>
<td>2.154</td>
<td>.694</td>
<td>.071</td>
</tr>
<tr>
<td>Quality</td>
<td>0.000</td>
<td>2.020</td>
<td>----b</td>
</tr>
<tr>
<td>Upkeep</td>
<td>1.010</td>
<td>1.010</td>
<td>3.731</td>
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<tr>
<td>Other</td>
<td>.796</td>
<td>1.043</td>
<td>1.895</td>
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</tbody>
</table>

*Critical Chi-square values at alpha levels:
  - \( \alpha = .050 \) , Chi-square = 3.841
  - \( \alpha = .010 \) , Chi-square = 6.635
  - \( \alpha = .005 \) , Chi-square = 7.880

b No Chi-square value can be computed, since there were no positive responses in the samples.
<table>
<thead>
<tr>
<th>Variable Name</th>
<th>Mobile Home Rejections of Apartments &amp; Single-Family</th>
<th>Apartment Rejections of Mobile Homes &amp; Single-Family</th>
<th>Single-Family Rejections of Mobile Homes &amp; Apartments</th>
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</thead>
<tbody>
<tr>
<td>Too Small</td>
<td>3.093</td>
<td>13.255</td>
<td>7.955</td>
</tr>
<tr>
<td>Too Large</td>
<td>2.020</td>
<td>2.837</td>
<td>---b</td>
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<tr>
<td>Location</td>
<td>.711</td>
<td>.444</td>
<td>6.050</td>
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<tr>
<td>Proximity</td>
<td>11.111</td>
<td>2.020</td>
<td>2.990</td>
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<td>Cost</td>
<td>6.112</td>
<td>15.486</td>
<td>.444</td>
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<td>No Equity</td>
<td>7.862</td>
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<tr>
<td>Structure</td>
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<tr>
<td>Quality</td>
<td>2.020</td>
<td>3.093</td>
<td>3.093</td>
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<tr>
<td>Upkeep</td>
<td>14.583</td>
<td>4.891</td>
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<tr>
<td>Other</td>
<td>.154</td>
<td>5.984</td>
<td>2.837</td>
</tr>
</tbody>
</table>

\[a\text{Critical Chi-square values at alpha levels:}\]
\[\text{alpha} = .050 \quad \text{Chi-square} = 3.841\]
\[\text{alpha} = .010 \quad \text{Chi-square} = 6.635\]
\[\text{alpha} = .005 \quad \text{Chi-square} = 7.880\]

\[b\text{No Chi-square value can be computed, since there were no positive responses in the samples.}\]
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