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Impacts of the Subdivision Control Act of 1967 on land fragmentation in Michigan's townships

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IMPACTS OF THE SUBDIVISION CONTROL ACT OF 1967 ON LAND FRAGMENTATION IN MICHIGAN'S TOWNSHIPS

By

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ABSTRACT

IMPACTS OF THE SUBDIVISION CONTROL ACT OF 1967 ON LAND FRAGMENTATION IN MICHIGAN'S TOWNSHIPS

By

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Michigan has experienced an increase in the amount of land that is in unplatted lots less than 20 acres. A common perception is that the Subdivision Control Act of 1967 (SCA) has contributed in the growth in the number of 10 acre lots. By defining "subdivision" as the creation of more than 4 lots, 10 acres or less, within a ten year period, the SCA created an incentive to create unplatted 10 plus acre lots. Michigan law requires platting when a subdivision is created. Landowners desiring to create more than 4 lots and avoid platting would be required to create lots greater than 10 acres. This research examined the land fragmentation process in Michigan and the impact of the SCA on land fragmentation.

The level and pattern of land fragmentation was determined by counting the number of lots, 1-19 acres in size in 72 sample townships, using plat maps for the years 1960, 1970, 1980, and 1990. Townships were grouped into three population density

groups, low, medium, and high. Three hypotheses were tested to determine the rate and pattern of land fragmentation in Michigan.

The results of these tests indicate: (1) that the number of unplatted lots 1-19 acres in size have increased over time; (2) the percentage increase in number of unplatted lots 1-19 acres in size are not equal across township groups; (3) the mean percentage of new unplatted lots 10-11 acres in size are not equal over time or township groups.

A fourth hypothesis, stated that land division patterns are impacted by ecological, economic, social, and institutional factors but that the SCA has had no affect on the number of 10-11 acre lots. An econometric model was used to estimate four equations testing this hypothesis. In three of the four equations, the null hypothesis that the SCA had no affect was rejected. These results indicate that the SCA caused the creation of an additional 15 to 51 lots between 10-11 acres in size per township during the time period from 1960 to 1990.

Given the results of this research, policy makers may want to examine the SCA to determine whether formation of a large number of 10-11 acre lots is consistent with the objectives stated in the Act.

Dedicated to my wife, Sandy, and children, Caleb and Stephanie

whose encouragement, sacrifice, and love made this possible.

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INTRODUCTION AND PROBLEM DEFINITION

1.1 INTRODUCTION

The State of Michigan consists of 36.1 million acres of forest land, agricultural land, wetlands, and urbanized areas. Of this total, approximately 30 million acres in 1987 were considered rural land held by others than the federal government (*U.S. Bureau of the Census*, 1992).

Healy and Short specify three long term trends that are observable in rural land use. Rising prices, different demands by new owners and the changing size of parcels were identified as important trends that have existed since World War II but have accelerated greatly since the late 1960's (Healy and Short, 1981). Many factors are considered important in influencing these trends but a central issue appears to be the property rights governing land ownership.

The term "property rights" is defined in this study as a person's rights with respect to a resource. Furthermore, "in our society the existence of property rights presupposes the presence of: (1) an owner together with other persons who can be excluded from the exercise of ownership rights; (2) property objects that can be held as private or public possessions; and (3) a sovereign power that will sanction, and if necessary protect, the property rights vested in individuals or groups" (Barlowe, 1978, pp. 395-6).

Property rights associated with land ownership are continually evolving and must be considered dynamic. Land ownership typically has been defined as a bundle of rights. The individual who holds title or ownership to a parcel of land can sell, lease, mortgage, subdivide, devise and grant easements to that property. Other separable rights include air, water, mineral, and development rights.

The public's rights include the power to tax, control use (police power), escheat, and take for public use. Both private and public property rights have "rules" that characterize and define these rights. For example, the public has the right to confiscate land for public use but compensation must be given for such takings.

The rules regarding land ownership have received increased attention during the past 25 years. Since 1970, the population of rural areas in Michigan has grown more rapidly than that of urban areas. This migration creates increasing pressure on traditional land uses, such as agriculture and forest management, as the demand for land for low density residential use has increased. As an indication of this demand, the total amount of farm land in Michigan has declined 30% from 1960 to 1990 (*Michigan Agricultural Statistics Service*, 1961, 1991) while the percent of Michigan's population classified as rural has increased from 27% to 30% (*U.S. Bureau of the Census*, 1963, 1993). This growth in population has been uneven, with some areas experiencing net losses whereas others have experienced growth.

1.2 PROBLEM STATEMENT

Subdividing, or the division of land into multiple lots, is the result of the real estate market functioning within the existing set of property rights. Originally surveyed as large parcels suitable for agriculture or forestry, rural land is being divided into smaller lots, most commonly used for residences. Land use planners often define fragmentation as the division of large parcels into smaller unplatted parcels. Platted parcels are generally referred to as a subdivision or plat.

The effects of land fragmentation have not gone unnoticed. These and related issues have been at the forefront of land use literature since the 1970's. Although academic interest from the 1970's regarding the significant loss of agricultural land has diminished, public attention is refocusing on this issue, along with special attention to the preservation of prime agricultural land (Misseldine, 1992). Other concerns related specifically to land divisions in rural areas are loss of open space, loss of rural character, increased cost of public services and facilities, and an increase in the number of conflicts between agricultural and nonagricultural residents (Wyckoff, 1986).

As evidence of the growing concern over land use and land fragmentation, a 1992 report ranked the "absence of land use planning that considers resources and the integrity of ecosystems" among the most pressing environmental issues facing the State of Michigan (*Michigan Relative Risk Analysis Project*, 1992). Several of the problems mentioned in this report include: farmland loss, wildlife habitat modification, loss of open space, timber management, and urban sprawl/urban flight. While the report attributed these problems to inadequate local regulations and a lack of appropriate land use planning, some planning experts have attributed these issues in part to the state statute defining the rules regarding land division. According to an article in Planning & Zoning News, the applicable State of Michigan statute, the Subdivision Control Act of 1967 (SCA), has allowed an unknown number of parcels to be created without platting and has created an incentive to develop 10 + acre lots. Landowners desiring to avoid the cost of subdividing would create 10 + acre lots after the fourth split in 10 years. The SCA is described in detail in Chapter 2.

Relatively lax platting requirements, combined with these incentives, have created opportunity for large amounts of land to be fragmented. The division of land into lots larger than 10 acres converts more acres than if the same number of lots had been created of smaller size, thus causing a greater amount of land to be fragmented (Wyckoff, 1986).

Although there is some suspicion that the SCA has contributed to the fragmentation of land, the validity of this belief has not been tested. The significance of this allegation is amplified because of the nature of land fragmentation. Land developed principally for use as a residence is typically not also used for commercial forestry or agricultural production. In addition, residential use, for all practical purposes, is an irreversible choice for the life of the residence.

Perhaps more importantly, an indiscriminate pattern of large lot land divisions in an area historically suited for agricultural and/or forest use reduces the viability of the entire area for resource production. This is because a few 10 + divisions: 1) take the land out of production; 2) introduce incompatible land uses into an area; 3) create an uneconomic land resource management unit; and 4) tend to result in higher tax assessments on the larger parcels used for resource production (Dunford, 1979).

In Michigan, the data needed to determine the scope of land fragmentation are not easily available. Records of land division, transactions, and ownership are maintained by local jurisdictions. Any attempt to aggregate and analyze the data for any significant number of jurisdictions is extremely difficult.

Additional questions related to where fragmentation is occurring and at what rates are not easily answered because of the lack of congruity in the data. These questions must be answered in order to examine the impact of the Subdivision Control Act of 1967 on land fragmentation patterns.

1.3 PURPOSE OF THE STUDY

The objective of this study is to analyze the impact of the Subdivision Control Act of 1967 on land fragmentation in Michigan. Public Program Evaluation (PPE) methodology is used as a framework to conduct this study. The purpose of PPE is "to measure the effects of a program against the goal it set out to accomplish as a means of contributing to subsequent decision making about the program and improving future programming" (Hatry, et al, 1981).

In the first step of this methodology, the program's or in this case, the SCA's history, goals, and potential unanticipated consequences are described. By contrasting the SCA with the Plat Act of 1929 (Plat Act), which the SCA replaced, important elements in the SCA affecting land fragmentation are identified.

The unique characteristics of the real estate market is described next. Differences between the real estate market and the perfectly competitive ideal are considered. Additionally, factors influencing the division of land in Michigan are identified. Data for these variables are given on a state-wide basis to provide a background for this study.

Using this information, four hypotheses regarding fragmentation are formed. To test these hypotheses the level of fragmentation is established. The amount of fragmentation is measured by determining the total acreage of land in lots less than 20 acres. Because of the difficulty in acquiring the data, the analysis is limited to a sample of 90 townships in Michigan.

An econometric model of the land division process in Michigan is developed. Specific variables are identified that represent the influential factors identified in this study. This model is then used to examine the contribution of the Subdivision Control Act of 1967 to land fragmentation in Michigan.

1.4 RESEARCH OBJECTIVES

The objectives of this study are:

(1) To describe the Subdivision Control Act of 1967, identify the statute's objectives and potential unanticipated consequences;

(2) To illustrate the land market, the land division process, and the factors affecting this process;

(3) To form testable hypotheses regarding land divisions;

(4) To develop an econometric model of the land division process in Michigan;

(5) To use the econometric model developed to estimate the impact of the Subdivision Control Act of 1967 on land fragmentation patterns in Michigan.

1.5 FORMAT OF THE STUDY

Chapter 2 examines the Subdivision Control Act of 1967. By contrasting the SCA with the Plat Act, a shift in property rights regarding land division is highlighted. In Chapter 3, the land market and factors affecting the land division process in Michigan are described. Testable hypotheses and the methodology for testing these hypotheses are developed in Chapter 4. The levels of fragmentation discovered and the results of the analysis are presented in Chapter 5. Chapter 6 concludes the study, giving attention to future areas of research.

Chapter 2

THE SUBDIVISION CONTROL ACT OF 1967

2.1 INTRODUCTION

Subdivision regulation is an exercise of the police power directed to the division of land, in order to insure proper access, size and shape, safe water supply and waste disposal, and a buildable area under other related state or local laws. In so doing, subdivision regulation seeks to ensure a proper survey and recording of legal lots thereby protecting future buyers and public taxable interests. In all of these ways, subdivision regulation promotes the general health, safety and welfare of the community. Subdivision regulation differs from zoning in that zoning regulates the use of land, often maintaining the status quo until development occurs, while subdivision control regulates the way in which the land is divided and prepared for building development or other uses (Wyckoff, 1986).

Development of land resources is often beneficial to communities. The division of land can promote economic growth and provide needed housing, commercial or industrial lands for the community. However, the fragmentation of land may promote urban sprawl and its associated costs (*Environmental Protection Agency*, 1974). In addition, the fragmentation of renewable land resources means that such land is converted from another use such as agriculture or forestry. Loss of these renewable resources needs to be considered when determining the benefits gained by development.

2.2 SUBDIVISION CONTROL REGULATIONS

Material for the next sections, which focus on the SCA, is taken generously from a law review article written by Professor Roger A. Cunningham (Cunningham, 1968) and conversations with Richard Lomax, Manager of the Subdivision Control Unit of the Michigan Department of Commerce (Lomax, Personal Communication, Nov. 1993).

Legislation to assure uniform methods of recording subdivision plats was adopted in the Michigan territory in 1821. Since this original legislation, several acts were added in piecemeal fashion until 1929, when the Plat Act was enacted to unify and reorganize all laws relating to plats. In 1931, Michigan enacted the Municipal Planning Act, which was patterned after the U.S. Standard City Planning Enabling Act. The Municipal Planning Act gave municipalities the right to regulate subdivisions after forming planning commissions. However, some question remained as to whether the definitions of municipalities empowered to adopt such regulations included counties and townships.

In 1945, subdivision control powers were eliminated from county planning commissions by the enactment of the County Planning Commission Act. This Act provided that the powers exercised by all county planning commissions should "be those specified for . . . county commissions in the terms of the Act," and since the County Planning Commission Act conferred no power on county planning commissions to regulate subdivision, subdivision control powers were therefore eliminated (Cunningham, 1967). Questions about the authority of townships were resolved in 1952 when an amendment was enacted to redefine the term "municipality" to include townships, charter townships, cities, villages, and other incorporated political subdivisions. To clarify the role of townships, the legislature adopted the Township Planning Act in 1959. This Act authorized townships to "make and adopt a basic plan as a guide for the development of unincorporated portions of the township" and to perform certain advisory functions concerning land subdivision regulations.

In 1967, the Michigan legislature passed the Subdivision Control Act (SCA), which repealed and replaced the Plat Act of 1929 (Plat Act). The SCA, like the Plat Act it replaced, did not make any references to the Municipal Planning Act or the Township Planning Act.

In summary, Michigan has three separate subdivision control statutes, none of which makes reference to the others. The Municipal Planning Act and the Township Planning Act are primarily enabling Acts while the SCA is largely mandatory (Cunningham, 1967). Cities, villages and townships in Michigan have the legal authority to govern all land divisions under these statutes. However, according to a survey completed in 1978 only 233 townships and 196 cities and villages had any type of subdivision regulation (*Michigan Planning & Zoning Survey*, Office of Intergovernmental Relations, State Department of Management & Budget, 1979 quoted in *Planning & Zoning News*, January 1986, p. 14).

2.3 LAND DIVISION: A NEW SITUATION

Introduction

The Subdivision Control Act of 1967 (SCA) replaced the Plat Act to provide the minimal mandatory requirements of subdividing. The passing of the SCA by the state legislature inaugurated a new era for dividing land in Michigan. From a historical perspective, one can see that the new law in unison with other changes around that time, created a fundamentally different set of property rights for landowners regarding land division.

Subdivision Control Act versus the Plat Act

The SCA and the Plat Act, were similar in that both ordinances regulated the land division process in Michigan. In the next section, these laws are contrasted to highlight differences regarding subdivision definitions and other aspects of platting.

The division of land into smaller lots is commonly called the subdivision process. For purposes of this study, "subdividing" or "subdivision" is defined as the process of land division meeting certain criteria as described in the state statute or local subdivision control ordinance. When a land division qualifies as a subdivision, the legal requirements are quite different from a division of land that is not a subdivision.

Several sections taken from the SCA and the Plat Act are cited below to display how they differ in defining subdivision. Articles written about the SCA have consistently emphasized that this definition is important (Cunningham, 1967; Wyckoff, 1986).

Michigan Compiled Laws Annotated (MCLA) Section 560.103 of the SCA, titled "Subdivision of land; surveys and plats, when required" addresses the question of when platting is required. Part (1) of Section 560.103 states:

> "Any division of land which results in a subdivision as defined in section 102 shall be surveyed and a plat thereof submitted, approved and recorded as required by the provisions of this Act."

Therefore, to know when platting is required, the definition of subdivision as stated in Section 102 must be known. Subdivision from Section 560.102 is defined as follows:

> "Subdivide" or "subdivision" means the partitioning or dividing of a parcel or tract of land by the proprietor thereof or by his heirs, executors, administrators, legal representatives, successors, or assigns for the purpose of sale, or lease of more than one year, or of building development, where the act of division creates 5 or more parcels of land each of which is 10 acres or less in area; or 5 or more parcels of land each of which is 10 acres or less in area are created by successive divisions within a period of 10 years."

This language of the 1967 Subdivision Control Act should be contrasted with that of the 1929 Plat Act. Section 3 of the Plat Act states:

> "Any proprietor who shall hereafter subdivide any lands shall make and record a plat thereof in accordance with the provisions of this Act and said plat shall be made, approved, filed, recorded, altered and vacated in the manner hereinafter provided."

Therefore, to know when platting is required under the Plat Act, the definition of "subdivision" as stated in Section 2 must be known. Section 2 of the Plat Act defines subdivide:

> "The word "subdivide," when used in this Act, shall mean the partitioning or dividing of a lot, tract or parcel of land into 5 or more lots tracts or parcels of land: provided, however, that this limitation shall not apply to the partitioning or

dividing of agricultural lands into tracts or parcels of land 10 acres or more in area for continuing agricultural use."

In summary, once landowners have divided their land in such a manner as defined as a subdivision, the platting process mandated by the statute must be followed. Landowners wanting to avoid this process must divide their land in a way that avoids the definition of subdivision.

In comparing the two Acts, both define subdividing as the dividing of a lot into five or more lots. In the Plat Act, lots of 10 acres or more in size are not to be included if they are for continuing agricultural use. The definition of subdivision in the SCA excludes parcels created greater than 10 acres. The result would be that 10 acre parcels created would not be considered as a lot under the Plat Act but are under the SCA. The difference between "greater than 10 acres" or "10 acres or greater" is minor. The major issue is the specific size of the lot required to be excluded. For example, lots that are 10.1 acres would not be considered as a lot when counting for platting requirements under the SCA.

Another difference between the definitions of subdivision was the addition of the 10 year period clause in the SCA's definition. This 10 year period applies to the new lots created and the original piece of land. Under the SCA, 10 years after a lot is created, a landowner can split the lot into a maximum of 4 lots under 10 acres without platting. In effect, the counting of the number of lots created 10 acres or less is reset on each parcel created 10 years after the split. The number of lots on the original or parent parcel is counted as a running total. Ten years after a split of a lot under 10 acres, that split is not counted as a division according to the SCA. Therefore, another lot under 10 acres could be created and platting would not be required.

No time period was given in the Plat Act. A fifth creation of a lot smaller than 10 acres of the original parent parcel would require platting. The 10 year time period in the SCA lawfully allows land to be split into more parcels without platting than under the Plat Act.

The SCA also had additional language describing the landowner(s). "Proprietor" in the Plat Act was expanded to "proprietor thereof or by his heirs, executors, administrators, legal representatives, successors." This additional description is necessary because the vague wording of "proprietor" in the Plat Act

"The opportunity for avoidance of the Plat Act requirements is obvious when one considers the possibility that the original proprietor may convey each of his first four lots to relatives, or to corporations controlled by him especially formed for the purpose" (Cunningham, 1967, p. 54).

A 1966 study concluded that the imprecise definition of subdivision in Section 2 of the Plat Act make it "virtually unenforceable and that consequently there have been thousands of subdivision of land without recording of plats, with resulting serious problems to the community, road commissions and fire departments because of roads too narrow or too poorly designed to permit entry of snow plows and fire vehicles and inadequate storm water and sanitary drainage" (*Bureau of Local Government Services*, 1967?). Research on legal records did not find any convictions regarding violations of the Plat Act (Cunningham, 1967).

The SCA was different from the Plat Act in several areas that ultimately established a new situation for land divisions in Michigan. In some cases these differences raised the cost of platting and in other instances may have prevented platting.

In the SCA, the county road commission was given greater authority over final plat approval. Section 183 in the SCA states:

> ". . . for all highways streets and alleys in its jurisdiction or to come under its jurisdiction and also for all private roads in unincorporated areas to require . . ." and a list of specifications for roads followed.

This is important because the county road commissions in the state were updating their road specifications at approximately the same time as the SCA was enacted. This may have significantly increased the cost of platting depending on the new specifications. With the increased cost, landowners may choose to avoid platting and these higher costs, and create lots in a manner that do not qualify as a subdivision. Before the SCA was enacted, landowners would go through the platting process. With the new rules they would no longer plat, but rather create 10 + acre lots after the creation of four lots in at 10 year period.

Another difference was the SCA included definitions of "land suitability." In the Plat Act the interpretation of land suitability was at the discretion of the individual municipality. Section 105 of the SCA states:

> "By conditioning approval of both preliminary and final plats upon compliance with rules of the water resources commission of the state department of conservation adopted for the determination and establishment of floodplain areas of rivers, streams, creeks or lakes, . . . as published in the state administrative code" and "with rules of the department of public health as published in the state administrative code relating to suitability of soils for subdivisions not served by public water and public sewers."

This defining of land suitability by the SCA gave precise guidelines for acceptable land for subdivisions. This standard definition could decrease the amount of land available to be subdivided. Thus, owners of land, unsuitable for subdivisions, would divide their land in a manner that does not qualify as a subdivision.

The enactment of the SCA provided a new start for local municipalities regarding subdivision control. By exempting all land divisions up to January 1, 1968, enforcement could begin with a clean slate.

Moreover, the Survey Recording Act of 1970 required that all new lots created be surveyed. By surveying all new lots, records would become more accurate and small lots disguised as large lots would be eliminated.

Also, in this period of time land use regulation at the township level experienced great growth. Some estimates have the percent of townships with land use regulations increasing from 9% in 1965 to 63% ten years later (Lomax, Personal Communication, Nov. 1993). This large expansion in number of townships with land use regulations is evidence of increased public concerns regarding private use of land.

2.4 UNINTENDED CONSEQUENCES OF SUBDIVISION CONTROL ACT

The objectives of the SCA were described as follows:

> "AN ACT to regulate the subdivision of land to promote the public health, safety and general welfare, to further the orderly layout and use of land; to require that the land be suitable for building sites and public improvements and that there be adequate drainage thereof; to provide for proper ingress and egress to lots; to promote proper surveying and monumenting of land subdivided and conveyed by accurate legal descriptions; to provide for the approvals to be obtained by subdividers prior to the recording and filing of plats; to establish the procedure for vacating, correcting and revising plats; to control residential building development within floodplain areas; to provide for reserving easements for utilities in vacated streets and alleys; to provide for the filing of amended plats; to provide for the making of assessors plats; to provide penalties for the violation of the provision of this Act and to repeal certain Acts and parts of Acts."

The objectives of this Act can be divided into two parts. First, the reason for having a subdivision control act was "To promote the public health, safety and general welfare, to further the orderly layout and use of land." And, the second part of the objective states in general terms the means on how the SCA will facilitate the reasons given above. The bulk of the 193 sections of the Act are the specific provisions designed to meet these objectives.

The common perception is that in many areas the cost of complying with the SCA is great enough to cause a number of landowners to avoid platting by creating lots of 10 + acres after the fourth split under 10 acres in a 10 year period. In the language of Public Program Evaluation, this would be the unanticipated consequence of the Subdivision Control Act.

As stated earlier, a landowner has the right to divide and sell property, conditional to the rules applicable to these rights. Many reasons exist why individuals might choose to sell, but it is assumed that, when selling all or a portion of land, landowners would desire to maximize their returns on the sale. The returns would be positively impacted by the number of lots sold and by the price of the lots while the costs associated with land division would negatively affect total returns. Another assumption is that the lots are primarily sold for use as residential building sites. Usually local regulations specify minimum lot size and minimum road frontage required. For landowners to maximize their number of lots, they would divide their land at the minimum road frontage and size until all the land was divided. With the definition of subdivision as specified in the SCA, landowners would incur the costs of platting once more than four lots 10 acres or under were created in a 10 year period. If lots could be sold at a high enough price to justify incurring the costs of platting, 10 + acre lots possibly would not be created. However, in many areas the demand and price of the lots is not of a magnitude and landowners would not incur the costs to plat and would only create lots greater than 10 acres after the fourth split under 10 acres.

To maximize the number of lots with the required road frontage, the lots could be long narrow lots with the minimum amount of road frontage required. The result can be seen on plat maps as long narrow lots, sometimes called "bowling alley lots."

The Michigan Department of Natural Resources, Office of Land Use, published a working report in 1974, seven years after the enactment of the SCA. A major conclusion in this draft was that a large number of 10 + acre lots had been created in order to circumvent the Act. This report noted that this creation of large lots had led to "increased service costs to local units, accelerated and often poor development of northern resources, and loss of agricultural and forestry land in manageable size tracts (40 acres or more)." Included in this draft were recommendations to enlarge the scope of the definition of subdivision from 10 to 40 acres *(Michigan Department of Natural Resources*, 1974?).

2.5 ATTEMPTED AMENDMENTS TO THE SUBDIVISION CONTROL ACT

Since the SCA became law in 1968, several attempts have been made to revise this Act. In a few cases, the proposed bills were extensive, covering many areas of the Act. In the following paragraphs, portions of these amendments that would have had an impact on land fragmentation are highlighted.

House Bill No. 4151 was introduced in February 1977. The first amendment of this bill would have changed the section on definitions. The most notable change was the definition of "subdivide" or "subdivision." The 10 acre minimum was changed to a 2 acre minimum and the 10 year period clause was dropped. An indication of the significance of this definition change can be gained from an analysis of the bill by Department of Treasury.

This report contrasted the positive and negative aspects of the bill and also included some suggested amendments. One positive aspect of the bill identified was that by establishing a minimum width of 165 feet for lots, this would require that many 10 + acre parcels of width of 360 feet could only be divided into two lots without platting.

A negative aspect of this bill identified that failing to require the 10-year limit would lead to successive divisions that could not be controlled. This uncontrollable division could result in lengthy descriptions and cumbersome tax rolls. To correct this the Department of Treasury recommended that all divisions less than 10 acres require that a certified survey be presented to the Office of Register of Deeds (*Michigan Department of Treasury*, 1977). This would correct the lengthy descriptions and cumbersome tax rolls but would still fail to control the number of successive divisions.

In 1985, another attempt was made by the legislature to revise the SCA. House Bill 5152, or the "Land Division Control Act," was a major proposed revision covering 105 of the 118 sections. The revisions pertinent to this study are discussed below.

As in the prior revision attempt, this bill would have changed the definition of subdivision. Wyckoff (1986) felt that while the new definition of subdivision would remove the incentives to create 10 + acre lots, the nature of land divisions would not be significantly altered. The shape of lots might be changed by the addition of maximum length to width ratio included in the provision but probably the general pattern of development would not have varied much, although a local review process would have been required. A 40 acre parcel could be spilt into either 4 or 9 lots depending on whether the community had zoning and/or subdivision regulations. The fact that property owners desire to maximize their returns when dividing land could have had a substantial impact on this process.

This proposal created much discussion about the purposes of the SCA. Some insight can be gained from an article in *Planning & Zoning News* of January 1986. Several individuals involved with this amendment were interviewed in this article. A number of questions focused on the incentives to create the 10 + acre lots. While some individuals thought this issue should be resolved by changing of the SCA, others said this was a subdivision control law rather than a land preservation law and that land fragmentation issues should be addressed by a separate land preservation law (Wyckoff, 1986).

House Bill 5152, discussed and reviewed for several years, did not pass. Richard Lomax, Manager of the Subdivision Control Unit of the Michigan Department of Commerce, suggested that the impetus behind the bill was the building industry. By changing the SCA, the cost of doing business would decrease thus stimulating the industry. However, after economic growth accelerated and the construction business recovered, pressures for changing the SCA diminished (Lomax, personal communication, Nov. 1993).

2.6 SUMMARY

The Subdivision Control Act of 1967 replaced the Plat Act of 1929 as the minimum state mandate for regulating the division of land in Michigan. When contrasted to the Plat Act, the SCA's definition of subdivision had changed. The common perception is that the SCA is responsible for defining subdivision in part as more than four lots that are 10 acres and under which hypothetically sets up the incentive to create 10 + acre lots. This research has shown that the change in definition regarding the cutoff point at 10 acres was minor. Subdivision as defined in the Plat Act was vague and, as a result, was not being enforced. The SCA created a more precise definition and also included a 10 year redivision provision. Several additions in the SCA raised the cost of platting. These changes in the SCA initiated a greater level of enforcement. More stringent enforcement and greater platting costs could impact the pattern of land divisions. In particular, the number of 10 + acre lots could increase as a result of landowners avoiding qualifying as a subdivision.

Several attempts to revise the Act have been unsuccessful. One of the major points of contention is the definition of subdivision. Incentive to avoid the classification of a subdivision and thus avert the platting process exist because of the current definition of subdivision in the SCA. In doing so, many of the lots being created are larger than 10 acres and are causing more land to be fragmented than if the lots were smaller. The exact amount of land included in these 10 + acre lots is unknown because available land use records are difficult to aggregate for these types of questions. However, perusing plat maps at different points in time provide some indication of the number of 10 + acre lots. The SCA is only one of many possible factors that could affect the pattern of lot divisions and land fragmentation. In the next chapter, factors affecting supply and demand for lots are investigated.

Chapter 3

A MODEL OF THE FRAGMENTATION PROCESS

3.1 INTRODUCTION

Land economists generally describe the land market as having four dimensions: quantity, price, spatial location, and time. At any point in time the quantity, price, and location will both independently and interdependently be affected by certain factors. Barlowe groups these factors into three categories: ecological, economical and social-institutional (Barlowe, 1978). With the emphasis of this study on the Subdivision Control Act of 1967, the social-institutional group will be separated into two sections.

These factors (ecological, economical, social, and institutional) can influence both the supply and demand for lots in rural areas. In this chapter, these factors are examined as to their impacts on land fragmentation. Chapter 2 stated that some believe that the SCA has caused an increase in land fragmentation. The SCA and other factors will be discussed in this chapter and their appropriateness in the model to be considered.

Characteristics of the land market will be addressed before these factors are examined. Some knowledge of the land market provides a background for the model.

3.2 THE LAND MARKET

Healy describes four principal ways in which land is transferred from one owner to another: (1) non-market transfers such as a gift or inheritance; (2) sale by private agreement; (3) sale through a real estate broker; and (4) sale at an auction by verbal or sealed bid. The volume of each type of transfer is difficult to determine, but a 1978 survey found that 62% of the land had been acquired by purchase from a non-relative (*USDA Landownership Survey*, 1978). Therefore, a large percentage of transfers are executed through the market.

Questions about the financing of land purchases were also asked on the 1978 survey. Only 17% of the acreage transferred from 1975 to 1977 was an all cash transaction. The balance of the land was purchased with borrowed capital.

3.3 IMPERFECT MARKETS

The land market differs from the perfectly competitive ideal for a number of reasons. First, land is a fixed location. The immobility of land could restrict the number of potential buyers causing the price to be less than in a perfectly competitive market. Potential buyers outside the geographical area would not bid on the land. Also because land is in a fixed place the location of the property could have a profound effect on its value.

Second, land is not homogeneous. Location, land uses permitted, soil type, and quality of structures are variables that affect the value of land. Potentially great differences between individual lots explain why information is important for the real estate market. In those cases where the buyer or seller does not have adequate information, real estate agencies can provide that service for a fee.

Another reason that land differs from other goods in a perfectly competitive ideal is that land is usually sold in relatively expensive units. This high cost of land could also limit the number of potential buyers. The availability of financing would also effect the number of potential buyers.

Land is subject to certain transfer costs that may not pertain to other commodities. A longer time frame for settlement, fees for title searches, legal fees and brokerage costs all combine to create relatively large transaction costs. These costs could reduce the number of land transfers.

These differences from a perfectly competitive ideal make the land market complicated to study. Given the dissimilarities between lots it is difficult to measure price behavior by inspecting sales records alone. Also sales and ownership records are kept at the local level. Thus, information is difficult to aggregate since the data may be maintained differently at each locale (Healy and Short, 1981).

In this study, the factors affecting the land market were grouped into four categories. In the next several sections these factors are discussed as to how they affect land fragmentation.

3.4 ECOLOGICAL DETERMINANTS

The physical factors of land can effect both the supply and demand of land for housing. Some natural amenities are appealing for residential use, whereas others are limiting either because of physical constraints or laws regarding the use of those amenities. For instance, in Chapter 2, definitions of land suitability in the SCA were discussed.

Soil Types

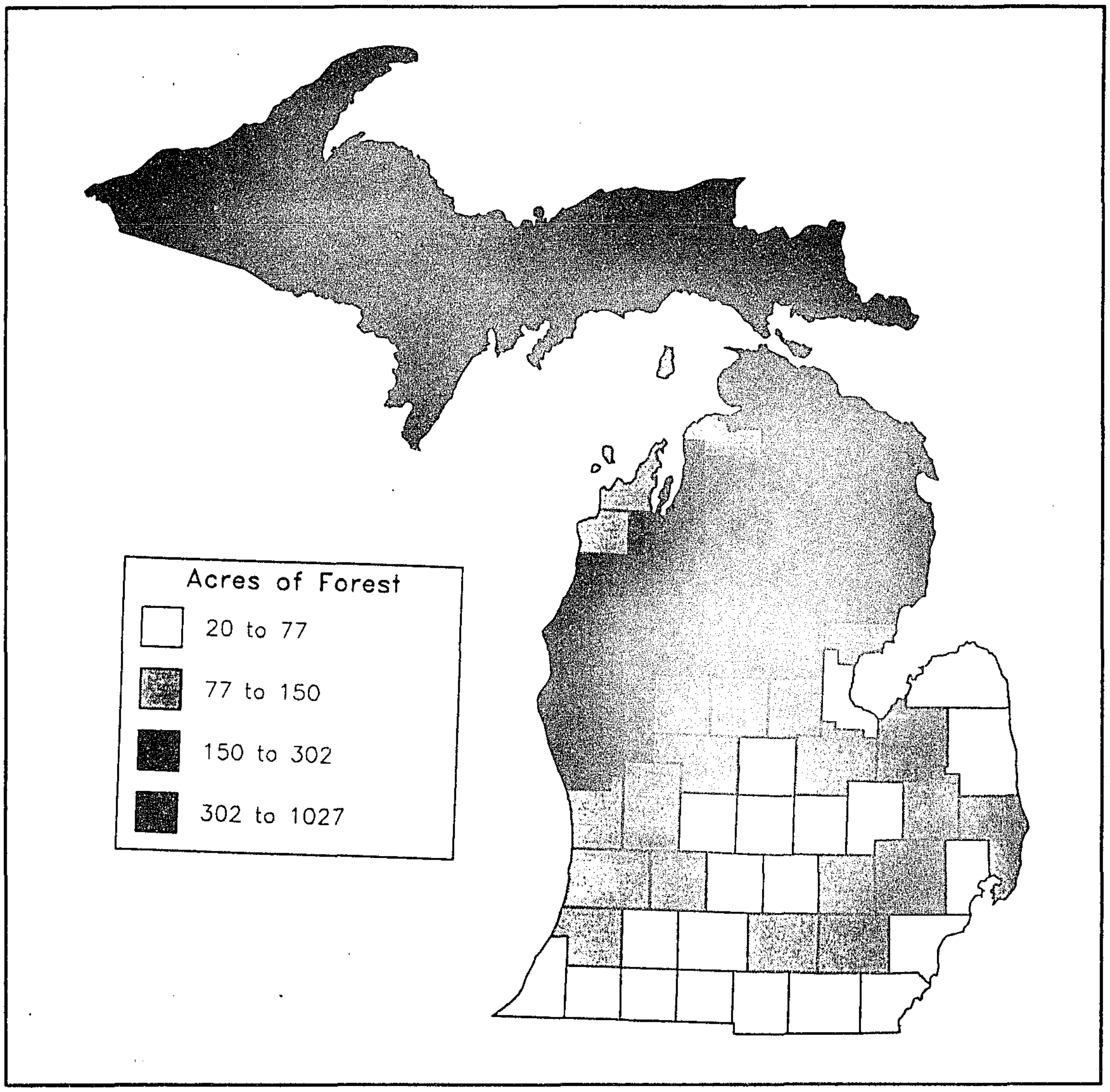
Soil types can limit the supply of land for lots. In rural areas, septic systems are the predominant means for waste disposal. Not all soils are conducive to a septic system, and therefore, standards specify which types of soils can support septic fields. Land with inadequate soils for septic fields are not suitable for residence lots without the additional cost of an engineered field. Land suitable for agriculture is often acceptable for septic fields. Consequently, farm land is often in demand for use as residential lots.

Additional knowledge about ecosystems can have an impact on land use. In the past, wetlands might have been filled or drained for other uses but are now being protected from development by various statutes. Thus, wetlands are eliminated as potential building sites, which reduces the potential amount of land available to be developed.

Forests

Approximately 51 percent of Michigan's land area is covered with forests. Of the total 18.4 million acres, 95 percent of this total is commercial forest (Source: USDA, Resources Bulletins NC-60,62,64,66, 1982). The percent of land in forest is shown on a county basis in Figure 3.1.

Figure 3.1 Acres of Forest by Counties in Michigan



Source: USDA, Resources Bulletins NC-60,62,64,66

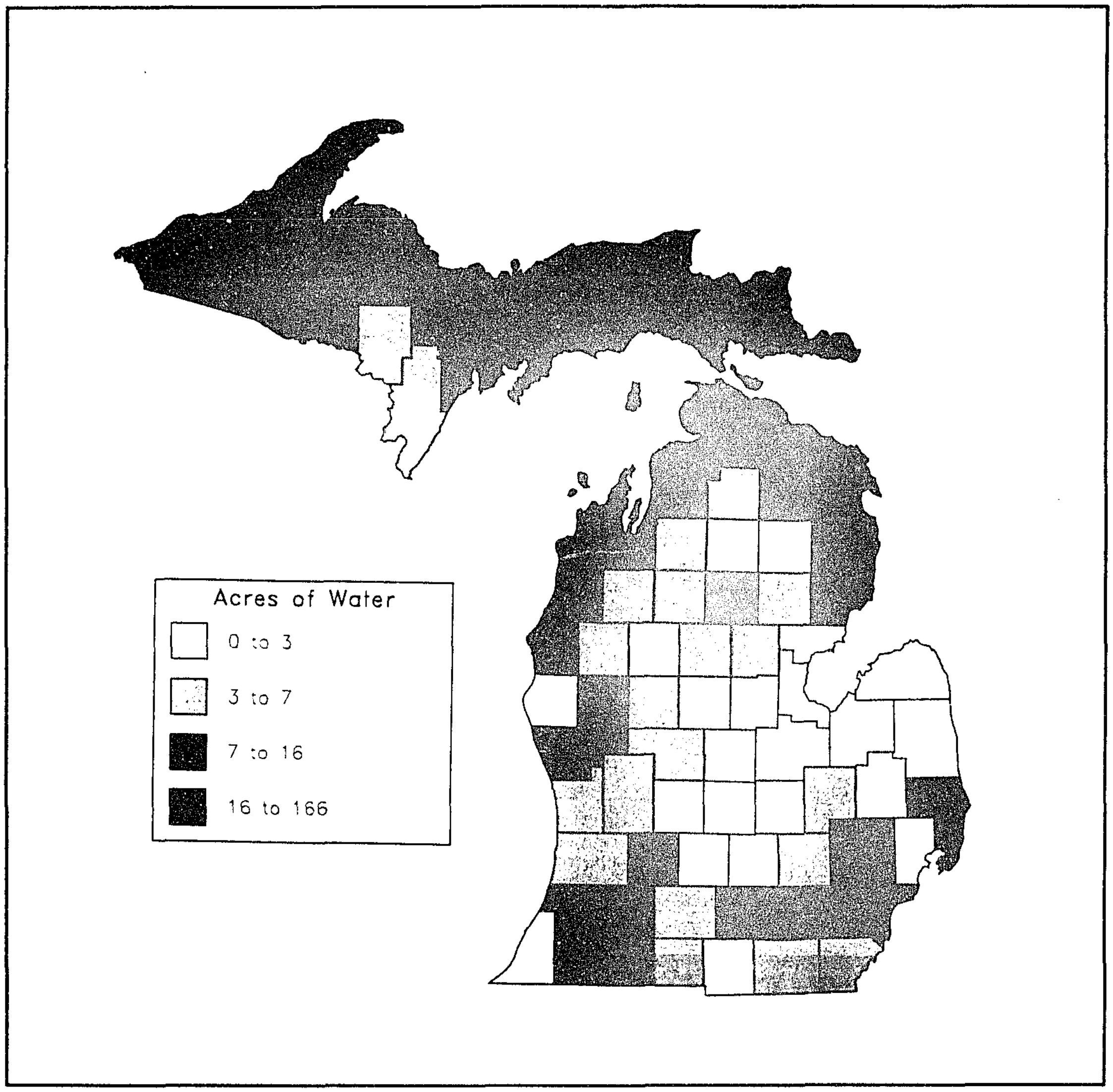
The physical characteristics of forest land can play an important role in the desirability of a specific location for residence use. Generally the cost of the developing of forest land is higher because clearing of trees increases the cost of the lots. However, the mature trees of a forest may be more appealing than land without such amenities.

Also, a significant portion of Michigan's wetlands are forested. These lands are generally unsuited for building construction.

Lakes

Access to lakes and rivers might also affect the demand for land for lots. Michigan has 11,037 inland lakes and 36,350 miles of rivers. Figure 3.2 displays the number of acres of water per county. The close proximity to water conceivably makes some areas more desirable than others.

Figure 3.2 Acres of Water by Counties in Michigan



Source: USDA, Resources Bulletins NC-60,62,64,66

3.5 ECONOMIC DETERMINANTS

Income

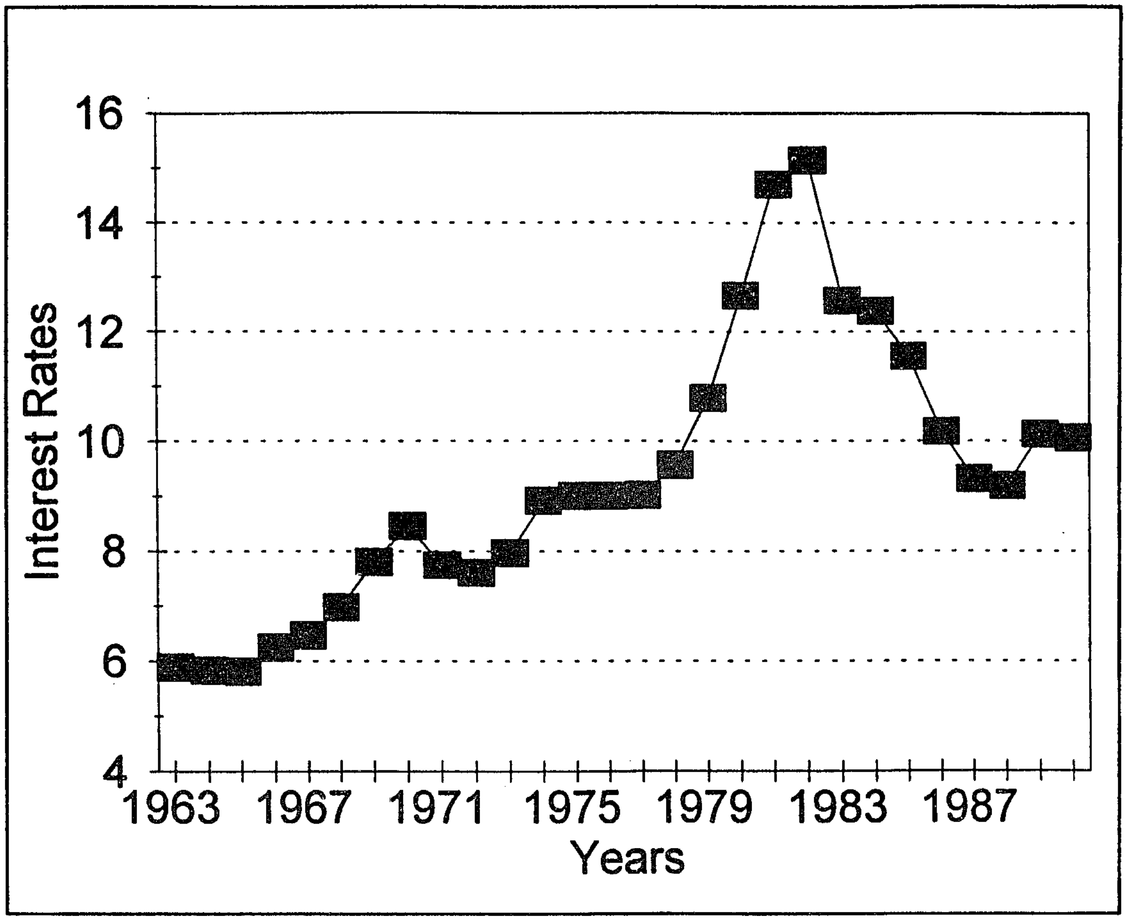
The demand for lots is affected by the economic ability of the prospective buyers. Over the last 30 years the average per capita income in real terms in Michigan has increased from $7,902 to $14,061 (*U.S. Bureau of the Census*, 1993). This increase in per capita income could be a contributing factor of having larger residential lots.

Results from the USDA 1978 Land Ownership Survey indicate that a large percentage of the lots are purchased with borrowed capital. Proof of employment and sufficient income is often required to qualify for financing. The increasing per capita income could be an argument for a greater demand for lots.

Interest Costs

The cost of borrowed capital, or interest cost, could affect the demand for lots. In years of high interest rates, demand would be impacted negatively and in years with low rates, positively affected. Nominal mortgage rates from 1963 to 1990 are shown in Figure 3.3.

Figure 3.3 - Nominal Mortgage Rates, 1963-1990



Source: U.S. Department of Commerce, *Business Statistics, 1963-91*

Mortgage rates rose dramatically in the late 1970's early 1980's and then dropped nearly as dramatically in the late 1980's. While the relatively high interest rates might negatively affect demand, supply of land for lots might increase because of the high cost of holding land. These two separate effects make the impacts of changing interest rates difficult to determine.

Agricultural Income

Another factor affecting the supply of land for lots would be income from the agricultural use of land. Present and future income from owning the land would be contrasted with profits from selling immediately. Ability to capture greater economic rents by dividing their land may induce property owners to divide land.

Though highly variable, total net farm income in Michigan has been generally decreasing in real terms the last 30 years. This may encourage farmers to divide their land and sell lots for residential use. This selling of lots could have negative spill-over effects on agriculture. New construction in the area could raise the state equalized values on all property, thus raising property taxes. Increasing property taxes are blamed as part of the decreasing farm income (Dunford, 1979).

The possibility of future land division can influence agriculture. Both the uses and prices of land could be affected. Land with development potential would be in high demand by speculators which would raise prices. Farm land that is being held awaiting development could be left to lay idle.

Costs of Travel

This section identifies various factors related to costs of travel. The topic "costs of travel" is interpreted broadly to include time, money and convenience of travel.

Demand for land for residence use would be inversely related to distance from an urban area, taking into account items related to travel time. Such items as distance from a major city, accessibility to a freeway and type of roads could substantially change travel time. Travel time to work, shopping, and other activities would be weighed by potential buyers when choosing where to live. Those areas further away and not having access to a freeway would be less desirable than those closer to a freeway (Ronald Briggs, 1983).

The cost of gasoline is also an important factor related to costs of travel. With little public transportation in rural areas, the main form of transportation is the automobile and the cost of gasoline is a major component in the cost of driving.

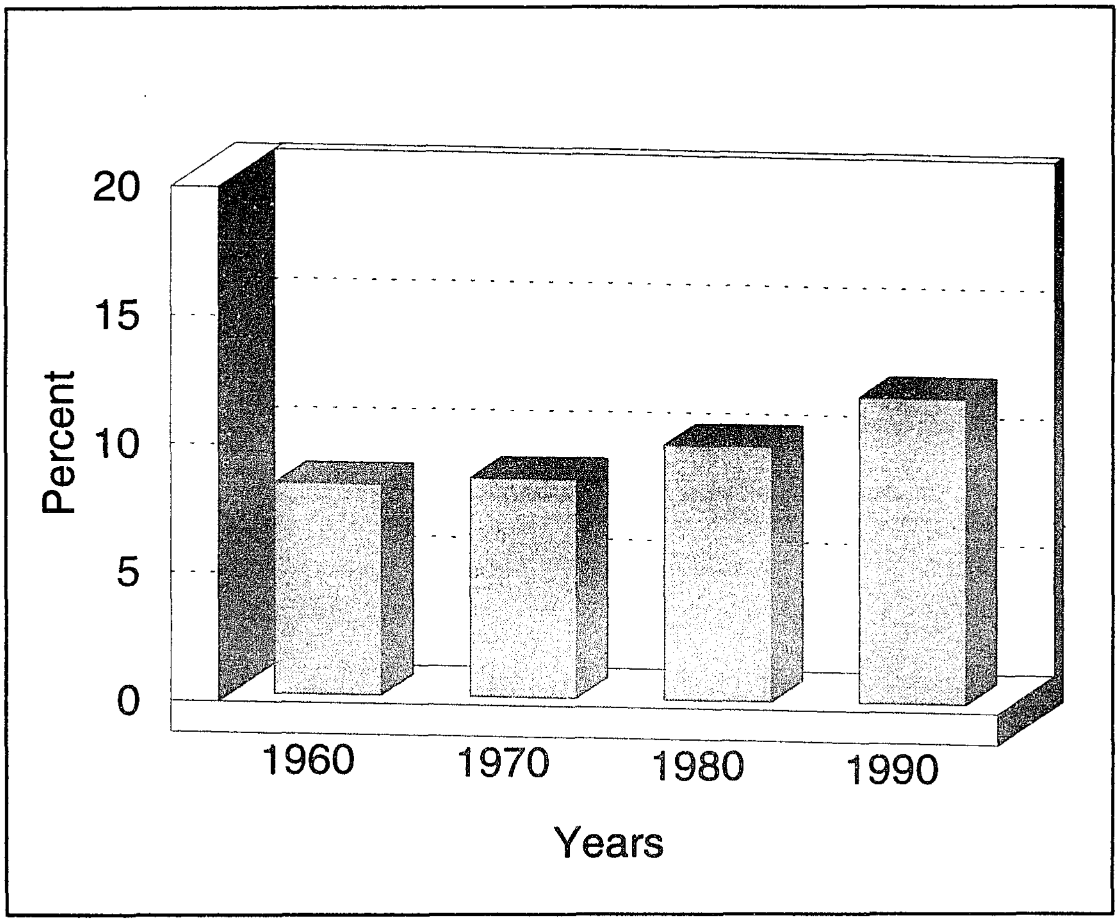
3.6 SOCIAL DETERMINANTS

Non-economic factors can also effect the supply and demand for lots. A survey of farmland owners in Vermont who sold land listed the top three reasons in this order: health, age and "received a good offer for the land." Divorce and death are other common reasons for selling of land (Bancroft et al, 1977).

As the survey indicated, an aging landowner population could increase the supply of land. Desires to capitalize on their investment in land would prompt landowners to sell some or all of their land.

Another impact of the aging population would be the increase in the number of retirees. Figure 3.4 displays the percent of the population over 65 years of age. As the number of retirees increases, residences in rural areas might become more appealing because of lower housing costs, slower life style and not having to commute to work. In addition, an aging population may mean that a greater percent of the population are prospective home buyers.

Figure 3.4 - Percentage of Michigan's Population Over 65

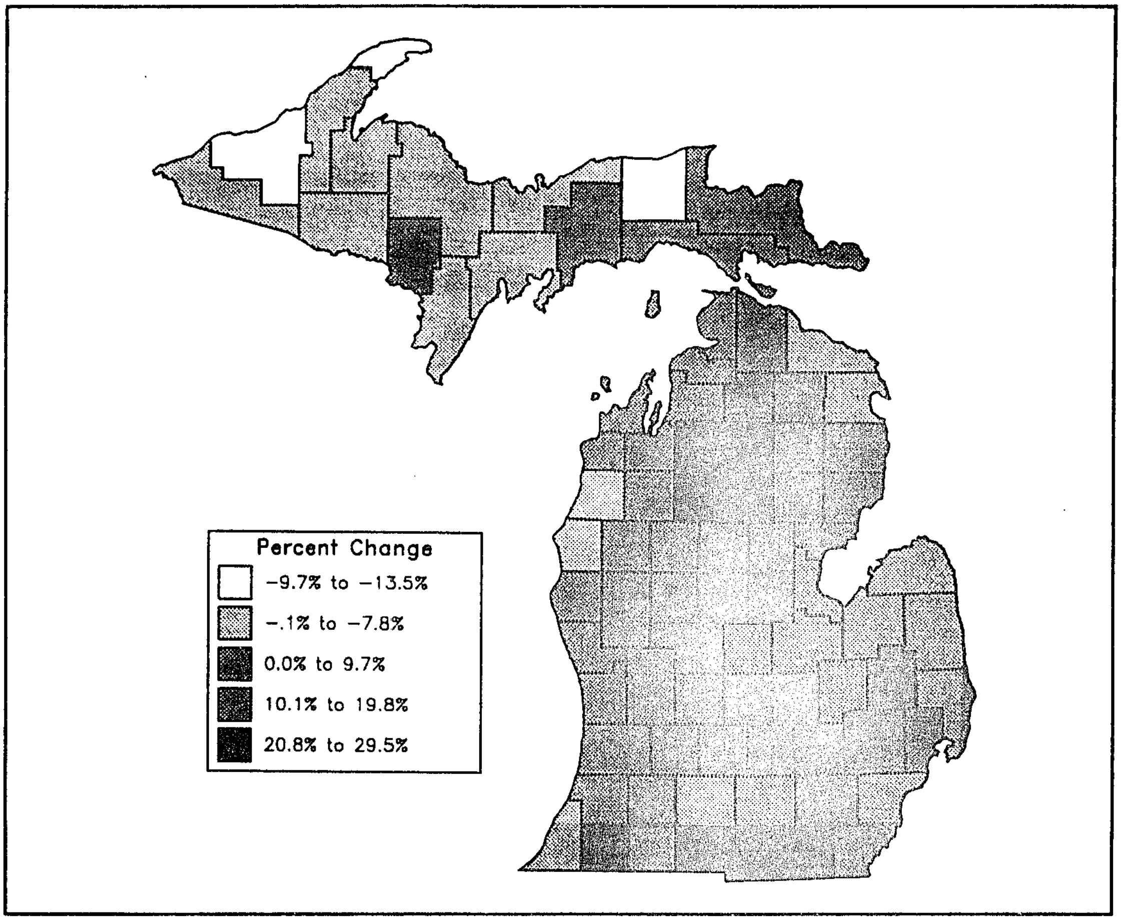


Source: *U.S. Bureau of the Census*, 1961, 1991

If the demand for lots is affected by the number of prospective buyers, changes in population and age of the population could have an impact on demand. Areas of substantial population growth would have relatively greater demands for lots. Some have attributed the increase in rural populations to the expanded employment opportunities. New technology and economic development strategies have enticed employers in new areas, thus creating jobs.

Michigan's average annual rate of population growth since 1960 has been approximately 3% (*U.S. Bureau of the Census*, 1990), but this low growth can be misleading. Some areas have experienced tremendous growth in contrast to other areas that experienced net loss in population. Figure 3.5 displays population growth per county from 1980 to 1990. The areas with the largest percentage increases in population are not the major urban areas.

Figure 3.5 Change in Population By County, 1980-90



Source: *U.S. Bureau of the Census*, 1961, 1991

Another phenomena of Michigan's population is the decrease in the average size of households. From 1960 to 1990 the average size of household has dropped from 3.42 to 2.66 (*U.S. Bureau of the Census*, 1961, 1991). Noting that households are the principal buyers of houses, this decrease in average size of households could reflect a greater demand for lots because of a greater number of households, populations being equal.

3.7 INSTITUTIONAL DETERMINANTS

Institutional determinants can be defined as any application of the powers of government, (i.e., police, taxation, spending, proprietary, and eminent domain powers to direct land use). These are designed to enhance the welfare of the public in those instances where market forces are insufficient to bring about acceptable land use patterns. Some form of institutional restrictions over land use have been employed in many municipalities for nearly a century. However, in many rural areas of Michigan, the land use restrictions are spotty and weak (*Michigan Planning & Zoning Survey*, Office of Intergovernmental Relations, State Department of Management & Budget, 1979 quoted in *Planning & Zoning News*, January 1986 p. 14).

Local zoning powers can affect the resultant lot size of land divisions. Requirements of minimum road frontage, a lot's length to width ratios, and minimum lot size, could be included in a local zoning ordinance. These requirements would affect the maximum number of lots available for creation from a given parcel.

Land divisions in Michigan are regulated by the Subdivision Control Act of 1967 (SCA). Under this Act, a landowner would incur the costs of platting after five lots of 10 acres or less are created in a 10 year period. It is hypothesized that with these rules in place many landowners would not incur the costs associated with platting and would create lots greater than 10 acres after the fourth division. This behavior, multiplied many times, could have a significant impact on the sizes and patterns of lots in Michigan. An example of how a 40 acre parcel could be divided and not platted is given in Figure 3.6.

Figure 3.6 · Possible Land Divisions Not Qualifying as "Subdivision"

Source: Author

3.8 CONCLUSION

This chapter described the land market and its unique characteristics. A number of factors affecting the land market were presented and discussed. These factors and their impact on the demand and/or supply of lots were presented. In the next chapter, variables representing these factors will be identified. These variables will then be used to create an econometric model to examine the impact of SCA on land fragmentation in Michigan.

Chapter 4

HYPOTHESES AND ECONOMETRIC MODEL

4.1 INTRODUCTION

Chapter 3 identified factors affecting the land division process in Michigan. These factors were arranged into ecological, economical, social, and institutional categories. Supported by this background analysis, several hypotheses and appropriate general statistical models to test these hypotheses are formulated in this chapter.

This study examines four major hypotheses. These hypotheses build on one another, culminating with the fourth hypothesis. The first two hypotheses focus on the subject of land fragmentation. The third hypothesis concentrates on patterns of land division over time and the fourth examines the impact of the Subdivision Control Act of 1967 on land division patterns.

In Michigan, all land area is either in a city or a township. The 83 counties are divided into 1,241 townships and 273 cities. The township is chosen as the unit of study in this analysis for the following reasons: (1) most of the land area in Michigan is in townships; (2) a majority of unplatted land divisions are in townships; (3) data on unplatted land division are in plat maps on a township basis; (4) concerns about land fragmentation focus on land in townships; (5) townships, as compared to cities, are less likely to have local subdivision control laws; (6) townships are the smallest units for many data sources; and (7) the use of townships allows for definitive locational and descriptive factors.

The summary in Chapter 3 stated that the factors affecting the process of land fragmentation was suspected as being inconsistent throughout Michigan. An attempt was made to create homogeneous groups by utilizing population density. Townships were sorted by use of population density and then arranged into three groups. Chapter 5 further describes the method used. These groups are used in the following hypotheses.

4.2 LAND FRAGMENTATION HYPOTHESIS

The first question to be answered is whether land fragmentation is occurring. After its resolution, the next question must explore whether the rate of land fragmentation is consistent over time. For this study, the levels of land fragmentation is measured by the number of lots less than 20 acres. The first hypothesis is in two parts. Part A of the Land Fragmentation Hypothesis states:

"The mean number of unplatted lots under 20 acres in size is equal over time."

and if A is rejected then Part B states:

"The mean rate of change in number of unplatted lots under 20 acres in size is equal over time."

This hypothesis implies that the mean number of lot divisions is not statistically different over time. The rejection of this hypothesis leads to questions of where land fragmentation is occurring. Questions in regard to spatial considerations are addressed by the next hypothesis.

4.3 LAND FRAGMENTATION CONSISTENCY HYPOTHESIS

If land fragmentation is occurring, the next question would ask where fragmentation is taking place. The Land Fragmentation Consistency Hypothesis is:

> *"For any decade, the mean change in the number of unplatted lots less than 20 acres in size is equal across township groups."*

In order to test this hypothesis the townships must be grouped in some manner. The method of township grouping is addressed in a later section titled "Selection of Sample". In discussing land fragmentation it was hypothesized that certain patterns were the result of the Subdivision Control Act. Lot division pattern questions are addressed in the third hypothesis.

4.4 CONSISTENCY OF LAND DIVISION PATTERNS HYPOTHESIS

In Chapter 2, differences between the SCA and the Plat Act were examined and, as a result, several conclusions were reached. First, upon enactment of the SCA there was a fundamental change in the rules regarding land divisions. Second, wording in the SCA in combination with economic impetus created incentives to encourage landowners to create 10 + acre lots. Because the SCA was implemented January 1, 1968, land division patterns after this time were contrasted to land division patterns before 1968 to demonstrate whether any changes in land division patterns existed. The Consistency of Land Division Patterns Hypothesis is in two parts. Part A of the hypothesis states:

> *"The mean percentage of all new unplatted lots that are 10-11 acres in size is equal over time."*

and, if Part A is rejected, Part B would be:

"The mean percentage of all new unplatted lots that are 10-11 acres is equal across township groups."

By testing the first three hypotheses, the foundation is built for the hypothesis on factors affecting land division patterns.

4.5 LAND DIVISION PATTERNS HYPOTHESIS

In Chapter 3, factors were identified as potentially affecting land division patterns. The SCA was highlighted as a possible contributor to the number of lots 10 + acres. The Land Division Patterns Hypothesis states:

"Land division patterns are impacted by ecological, economical, social, and institutional factors. However, the Subdivision Control Act of 1967 has had no effect on the number of 10 + acre lots."

This hypothesis is the nucleus of this study. The first three hypotheses are used as building blocks for the fourth hypothesis. By using time trend analysis to test these hypotheses, land fragmentation trends and patterns can be identified. However, factors affecting land fragmentation can not be established. Multiple regression analysis will be used to test the fourth hypothesis, which will account for the factors identified as affecting land division patterns.

4.6 MULTIPLE REGRESSION ANALYSIS

The Land Division Pattern Hypothesis focused on the impact of one of multiple factors affecting the pattern of land division patterns. The least squares multiple regression analysis will be used to account for these other factors.

The General Model

The General Statistical Model is a functional relationship between the number of 10 + acre lots and the factors identified in Chapter 3. This model can be specified in the general form:

$$Q_{it} = f\,(E_{jit}, S_{kit}, Ec_{lit}, I_{mit}, e_{it})$$

where:

Q_{it} = The number of lots 10 + acres in township i in year t;

E_{jit} = A set of n ecological factors (j = 1 ...n) affecting the number of lots in township i in year t;

S_{kit} = A set of p social factors (k = 1 ...p) affecting the number of lots in township i in year t;

Ec_{lit} = A set of q economic factors (l = 1 ...q) affecting the number of lots in township i in year t;

I_{mit} = A set of r institutional factors (m = 1 ...r) affecting the number of lots in township i in year t;

e_{it} = An error term.

Variable Specification

The factors affecting land division, examined in Chapter 3, will be used to specify the variables included in the model. A description of the data used to construct each variable is given. With the SCA enacted January 1, 1968, the period of study is 1960 to 1990 with four distinct time periods. The years 1960, 1970, 1980, and 1990 are used because of the availability of data from the U.S. Bureau of the Census.

For a few variables, the value at that one point in time (i.e., 1960), would not adequately demonstrate the effects of the factor over time. For those variables, the values over the four years previous and that year are averaged to create a proxy for that factor. For example, the interest rate of home mortgages in 1960 would be an average of the home mortgages from 1956 to 1960.

Number of Lots

The dependent variable in this model is a description of the pattern of development believed to be caused by the SCA. The fourth hypothesis implied that the SCA has affected the number of lots 10 + acres. Data for this variable is obtained by counting lots using plat maps (*Rockford Map Publishers, Inc*, Rockford, Illinois). These plat maps are updated approximately every three years. For each time period desired, the plat map that most closely met the date needed was used. For example, plats for 1970 would come from a 1971 plat map rather than a 1968 plat map.

In this model, the number of lots 10-11 acres is used as a representative of this pattern of 10 + acres. Fractions on most plat maps are commonly reported as whole numbers. Therefore, to capture the number of lots 10.1 to 11.0 acres, 10 acre lots must be counted. Lots that are truly 10 acres would not be the pattern of development sought, however, this number is assumed to be small.

Distinguishing Between Groups

The townships were divided into three groups to account for differing impacts from the factors affecting land division. To reflect this in the model, two dummy variables were created to distinguish among the different groups. These dummy variables were of value "1" when it was the group identified and "0" otherwise. For example, variable D1 for a township equaled "1" when it was a low density townships, and equaled "0" when the township was a high density township.

Ecological Determinants

All variables in this section were township specific but not time specific. To construct variables specifying the ecological determinants, data from the Michigan Resource Information System (MIRIS) published by the Land and Water Management Division, Department of Natural Resources was used. These data were compiled from 1978 aerial photography, therefore information on a township would be how it appeared in 1978. Ideally, information on land types in 1960 would be used. However, since 1960 data is not available and the 1978 data provides the detail needed, this is the best choice.

The ecological factors stated as affecting the demand for lots because of recreational amenities were the presence of lakes, rivers and forest in a particular area. From MIRIS, the acreage of all types of forest and all water for each township was obtained. Summing these values and dividing by the number of total acres in the township created a variable that represented the percent of the township that was considered recreational.

The supply of lots was affected by the acreage of agricultural land and soil types. The number of acres of agricultural land from MIRIS was divided by the number of total acres in the township to create a variable representing the percent of the township in agriculture. The acreage of land with suitable soil types for residence use was not available, therefore, a variable for soil type was not included.

Economic Determinants

Several factors were identified as economic determinants. Economic ability of prospective buyers was measured by two different items, (1) per capita income and (2) employment figures. Data from the U.S. Bureau of the Census for years 1960, 1970, 1980, and 1990 were used. Some data was not available on a township basis for 1960 but were available on a county basis. As a proxy for township data in 1960, the ratio of the township to county in 1970 was multiplied by the county data in 1960 to extrapolate a township figure for 1960. To calculate per capita income, the total income per township was divided by the total population in that township. This variable was deflated using a consumer price index published in *Statistical Abstract of the United States,* 1992.

Total income data for the year 1960 was not available on a township basis, however, it was on a county basis. For a proxy, the ratio of township to county for the year 1970 was used to extrapolate a figure for per capita income by township in the year 1960.

An employment rate was created by dividing the number of employed persons by the number of people in the work force in each township. The number of employed persons was not available for 1960 on a township basis. Therefore, the township to county ratio for 1970 was multiplied by the county data for 1960 to determine a proxy. Again, the data needed for these calculations came from the *U.S. Census Bureau.*

The cost of financing was identified as a factor that could affect land division. This is specified in the model by using home mortgage interest rates for new homes, Federal Housing Authority (FHA) insured (*Statistical Abstract of the United State*, 1970, 1984, 1992). Ideally the average rate in Michigan would be used, but attempts to find specific data for Michigan were unsuccessful. Chris Peters, an economist employed by the U.S. Federal Reserve in Chicago, suggested that there would be no significant difference between the Michigan average and the U.S. average (Peters, personal communication, November 1993).

Average interest rates on home mortgages in 1960 would not identify changes in the years leading up to 1960. Therefore, interest rates for that year and the previous four years were averaged for a proxy of effects of interest rate over time. This method was also used for 1970, 1980, and 1990.

Costs of travel were also identified in Chapter 3 as an economic factor affecting the demand for lots. Distance to a freeway interchange and from a major city were two factors considered as indicators of the cost of travel. To obtain distances to a freeway interchange, road maps from the Michigan Department of Transportation (MDOT) for 1960, 1970, 1980, and 1990 were used in combination with a detailed township map. Using the detailed township map, the distances to freeway interchanges were established for townships in 1960. The MDOT maps exhibited additions of freeways over time. Once changes in freeways were identified, new distances were calculated for those townships affected. The center of the township was used for measuring all distances.

Distances to a major city were measured slightly differently. A major city was defined as having a population of 50,000 or more in 1990. Once the major cites were identified, a mapping software program, Atlas Pro, was used to measure the distance from the center of the township to the center of the nearest major city.

Another factor identified as a cost of travel was the price of gasoline. Ideally, the average price of gasoline for Michigan would be used. However, the closest descriptive historical price was the average price of gasoline for Detroit, Michigan (*American Petroleum Institute*, 1993). To capture changes in prices over time the price of gas used in the model was an average for the five years ending in the specified year (the gasoline price used for 1960 for example, was the average price for 1956 through

1960). This variable was deflated using a consumer price index which excluded energy (*Statistical Abstract of the United States*, 1992).

The amount of paved roads in a township was also considered as a factor affecting the demand for lots. Such data were not available at a township level and this variable was not included in the model.

One of the factors identified as possibly increasing the supply of lots was that periods of economic hardships would force farmers to sell their land as lots. As a proxy, average net farm income per farm for farms in Michigan was utilized. To determine this figure, total net farm income (*U.S. Department of Agriculture*, 1986) was divided by the number of farms in Michigan (*Michigan Agricultural Statistics Service*, 1992). For each year, the average income of the five years ending on that specified year was used.

Social Determinants

In Chapter 3, total population, number of households and the age of the population were identified as factors affecting the land market. Township data for total population and total number of households were used to measure this impact. Median age of the population was used as a measure of the changes or differences in ages of the population. The U.S. Bureau of the Census published this data on a township basis except for median age in 1960. The ratio of median age in the township to median age in the county in 1970, in conjunction with the median age in the county in 1960 was used to estimate a median age in the township in 1960.

Institutional Determinants

It was noted earlier that several institutional variables would affect the rate and pattern of land divisions. Township zoning ordinances would have an impact on land divisions. However, townships have different types of ordinances and these ordinances change at different times, therefore, it would be infeasible to represent these in the equation.

An institutional determinant represented in the model is the Subdivision Control Act. This Act is treated as a shock variable and is specified in the model as a dummy variable. Because the real estate market has a significant time lag, it was concluded that the SCA should be included as a dummy variable with "0" for 1960 and 1970, and "1" for 1980 and 1990.

4.7 SUMMARY

Four hypotheses were developed in this chapter. Questions regarding levels and patterns of land fragmentation were presented in such a manner to allow for testing. The first three hypotheses will be tested using trend analysis. The fourth hypothesis, which is the central question of this study, requires multiple regression analysis. An econometric model was developed using the factors identified in Chapter 3. The manner in which the factors identified in Chapter 3 are incorporated in the model and the sources of the data are included in this chapter. The empirical results from testing the hypotheses are reported in Chapter 5.

Chapter 5

EMPIRICAL RESULTS

5.1 INTRODUCTION

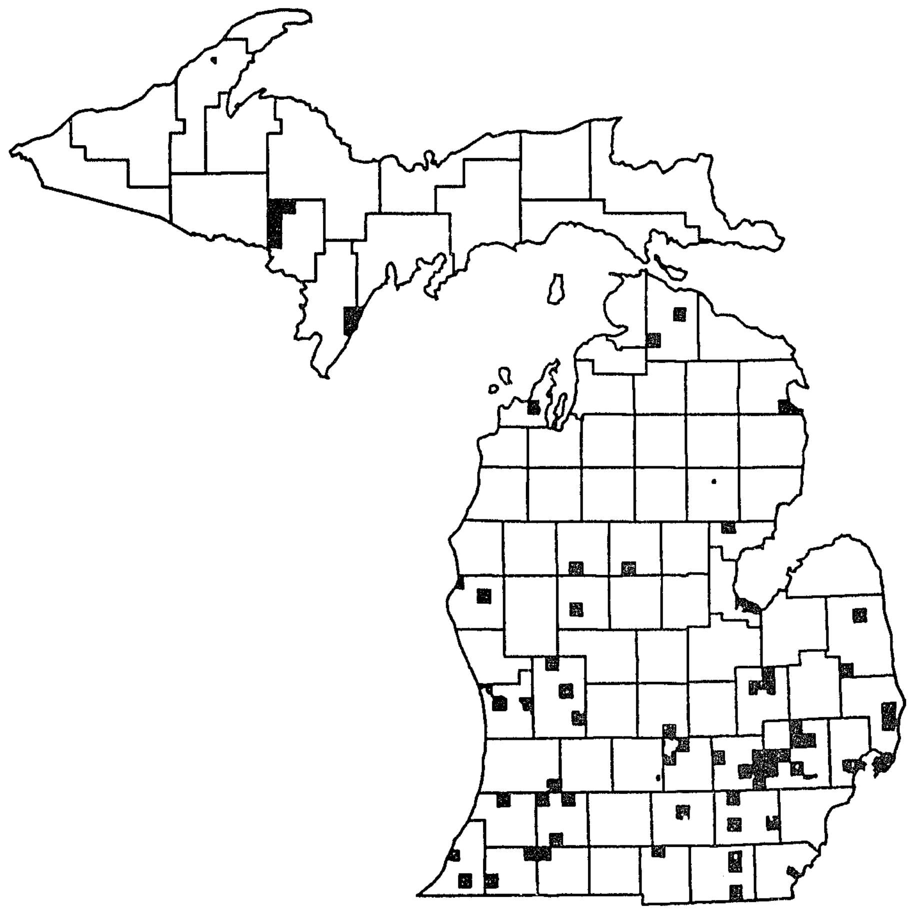
This chapter presents the empirical results of this research. The first section focuses on the manner in which land fragmentation is measured. The amount and distribution of land fragmentation and changes of lot patterns over time are then presented. These data are used to test the first three hypotheses proposed in Chapter 4. Estimates of the multiple regression model, that was constructed to test the fourth hypothesis, are presented in the next section. The final section summarizes the findings of the study.

5.2 SELECTION OF SAMPLE

The State of Michigan consists of 1,241 townships. Due to the difficulty in acquiring local land use information, a random sample of 90 townships was used in this study. Because of possible inconsistent effects of the factors affecting the land fragmentation process, population density was used to stratify the sample townships into homogeneous segments.

A measure of population density was created for each township by dividing the 1990 population by the number of square miles in the township. After ranking all townships according to this factor, the patterns in the data suggested natural discontinuities at the cutoff points of 100 and 600 persons per square mile, creating three distinct strata. The low density stratum included 940 townships, the medium density stratum included 246 townships, and the high density stratum included 54 townships. A random number generator was used to select a random sample of thirty townships in each stratum. Townships that were selected more than once were replaced with different townships so that 30 unique townships were selected per stratum. Figure 5.1 depicts the townships selected. The townships included in the sample are listed in Appendix A.

Figure 5.1 Seventy Two Townships Selected in Study Sample



Eighteen townships were eventually deleted from the sample because of missing plat maps or because of radical changes in the size of the township during the study period. Table 5.1 shows the number of townships in each group in the study.

Table 5.1 Number of Townships Selected and Used in Each Population Category

Title	Selected	Used
Low Density (0-100 persons per square mile)	30	22
Medium Density (101-600 persons per square mile)	30	28
High Density (Over 600 persons per square mile)	30	22

5.3 DETERMINING LAND FRAGMENTATION

The level of land fragmentation in each township was determined by counting the number of unplatted lots of less than 20 acres for the years 1960, 1970, 1980, and 1990. The limit of 20 acres was chosen because a lot greater than 20 acres could be further divided into lots of 10 + acres and still be greater than the 10 acre maximum established by the Subdivision Control Act (SCA). Also, lots greater than 20 acres are generally considered large enough to still be used for agricultural purposes. All data are collected using plat maps published by Rockford Publishing Inc.

Number of Lots

A summary of the number of total lots counted in the sample townships is given in Table 5.2. The complete listing is included in Appendix B. In presenting the results, the number of lots were divided into five groups: 1-9 acres, 10-11 acres, 12-19 acres, 1-19 acres, and 10-19 acres. These distinctions are made because of the definition of subdivision in the SCA. With incentives in the SCA to create 10 + acre lots, the 10-11 acres group was generated to demonstrate any changes in this size category. The 1-9 acres and the 12-19 acres groups included the number of lots on either side of the 10-11 acres group. The 1-19 acres group provides a summary of all lots counted. The 10-11 acres group is combined with the 12-19 acres group to create the 11-19 acres group, which represents the number of large lots identified in the plat count. These large lots are important because of their potential contribution to land fragmentation.

Table 5.2 Number of Lots Under 20 Acres for 72 Sample Townships, 1960-1990

	1960	1970	1980	1990	% Change 1960-90
1-9 Acres	4,625	7,294	12,933	16,271	251.8%
10-11 Acres	1,538	2,563	5,321	7,197	367.9%
12-19 Acres	1,340	1,955	3,040	3,753	180.1%
10-19 Acres	2,878	4,518	8,361	10,950	280.5%
1-19 Acres	7,503	11,812	21,294	27,221	262.8%

For the 72 townships used in this study, the number of total lots under 20 acres increased from 7,503 in 1960 to 27,221 in 1990. Thus, in a span of 30 years 19,718 new parcels were created, a 262.8% increase in the number of lots of this size. This increase was not consistent throughout the period studied. The number of lots created from 1970 to 1980 more than doubled the number of lots created from 1960 to 1970. The number of lots created in 1980 to 1990 was notably less then in 1970 to 1980.

Comparing lots of 1-9 acres, 10-11 acres and 12-19 acres demonstrates that the increase was not equal across lot groups. The number of lots 1-9 acres increased by 251.8%, 10-11 acres lots increased by 367.9%, while the 12-19 acres lots increased by 180.1%. This evidence suggest that the number of 10 + acre lots increased relatively faster than other sized lots. This increase in the number of large lots is a concern because of their potential contribution to land fragmentation.

Number of acres

Another method of examining the data is to calculate the number of acres in the lots under 20 acres. The total acreage in each size category was computed by multiplying the number of lots by their respective size and summing across all lots. The total number of acres each year are shown in Table 5.3.

Table 5.3 Number of Acres in Lots Under 20 Acres for 72 Sample Townships, 1960-1990

	1960	1970	1980	1990	% Change 1960-90
1-9 Acres	20,758	30,598	52,450	64,404	210.3%
10-11 Acres	15,563	25,882	53,675	72,581	366.4%
12-19 Acres	20,373	29,806	45,837	56,499	177.3%
10-19 Acres	35,936	55,688	99,512	129,080	259.2%
1-19 Acres	56,694	86,286	151,962	193,484	241.3%

The total acreage in lots under 20 acres increased from 56,694 acres in 1960 to 193,484 acres in 1990, a 241.3% increase. For all groups, the percent change from 1960 to 1990 decreased slightly when measured as acreage rather than number of lots. Once again, the largest total increase was in the 10-11 acres group, which increased by 366.4%

Using the total acreage in lots under 20 acres, the percent of land in a township in unplatted lots can be calculated. These results are presented in Table 5.4.

Table 5.4 Percentage of Township Land Area in Unplatted Lots Under 20 Acres

	Percent
Maximum	41.1%
Minimum	1.2%
Mean	11.7%
Median	10.7%

The percentage of township land in unplatted lots under 20 acres ranged from 1.2% to 41.1%, with the mean equaling 11.7% and the median 10.7%. One cannot assume that those townships with relatively low percentage of lots under 20 acres do not have much land division activity. Land division activity could have been platted and therefore, would not be included in this figure. In addition, total acreage in a township includes villages and the land divisions inside village limits were not included in this study.

5.3 ASSUMPTIONS UNDERLYING STATISTICAL TESTS

The choice of valid statistical models requires assumptions regarding the sample data. The data from counting the number of lots were assumed to be normally distributed and the mean was assumed to be the appropriate statistic of central tendency. Two different procedures were used in testing the hypotheses, depending on whether the means were independent or dependent. When the means were dependent, or coming from the same source, the data were compared using the difference in their numerical value, (a paired difference test). The two dependent means were compared using the observed mean of the resulting paired differences.

When the means are independent, pair-wise tests of equality among means are based on the differences between the means. If the differences between the means are statistically significant using t-test analysis, then the null hypothesis is rejected (Snedecor and Cochran, 1980).

Land Fragmentation Hypothesis

The Land Fragmentation Hypothesis was stated in Chapter 4 as:

(A) *"The mean number of unplatted lots under 20 acres in size is equal over time."*

and

(B) *"The mean rate of change in the number of unplatted lots under 20 acres in size is equal over time."*

Because the means were dependent, the paired differences procedure was used to test Part A of this hypothesis. The null hypothesis for Part A was that the mean difference in the number of lots between each decade was equal to zero. This hypothesis was rejected at the .01 significance level for each of the decade comparisons and for the 1960 to 1990 comparison. This implies that there were statistically significant changes in the number of lots during this period. The results indicate that, on average, there were 60 more 1-19 acres lots in 1970 than in 1960. There were 132 more lots, on average, in each township in 1980 than in 1970 and 81 more lots in 1990 than in 1980. There were on average, 273 more lots in each township in 1990 than in 1960.

For Part B of this hypothesis, the mean change in the number of lots from 1960 to 1970 was compared to the change in the number of lots between 1970 to 1980 and 1980 to 1990. Similarly, the mean change from 1970 to 1980 was compared to 1980 to 1990. The null hypothesis was rejected because the mean change in the number of lots for all comparisons were significantly different at the .01 level. The results indicate that, on average, there were 72 more 1-19 acres lots created in the time period 1970 to 1980 than in 1960 to 1970. There were 49 more lots, on average, created in each township during 1980 to 1990 than in 1970 to 1980 and 23 more lots created during 1980 to 1990 than in 1960 to 1970. Table 5.5 presents the results from the tests.

Table 5.5 Descriptive Statistics and Results of Statistical Tests for Land Fragmentation Hypothesis

Paired Differences	Mean Difference	Std. Dev. *	Calculated t-value **	df	2-tail Prob.
Comparison of number of total lots in the years:					
1960 and 1970 ***	59.8	52.1	9.75	71	0.000
1970 and 1980	131.7	115.5	9.68	71	0.000
1980 and 1990	80.9	59.5	11.55	71	0.000
1960 and 1990	272.5	195.2	11.81	71	0.000
Comparison of the increase in number of total lots between the years:					
1960-70 and 1970-80	71.8	85.2	7.15	71	0.000
1970-80 and 1980-90	49.4	97.3	4.31	71	0.000
1960-70 and 1980-90	22.5	62.2	3.06	71	0.003

* Std. Dev. of the Mean Difference
** The t-value was calculated as t= (mean difference)/((Std Dev)/(sq. root of N))
*** For example. to test this hypothesis, the number of lots in each township was counted in 1960 and in 1970. The number of lots in 1960 was subtracted from the number of lots in 1970 to calculate the paired difference from 1960 to 1970. These differences for each township were used to calculate the mean and standard

Land Fragmentation Consistency Hypothesis

The study townships were sorted by population density and using cutoff points of 100 and 600 persons per square mile, created three distinct strata, classified as: low, medium, and high density. The number of lots per density group are given in Table 5.6.

Table 5.6 Number of Lots under 20 Acres for 72 Sample Townships, 1960 to 1990, by Population Density Group

Total Number of Lots	1960	1970	1980	1990	% Change 1960-90
Low Density Group (less than 100 persons per square mile)					
1-9 Acres	396	901	1,894	2,804	608.1%
10-11 Acres	133	257	679	1,029	673.7%
12-19 Acres	177	246	413	628	254.8%
10-19 Acres	310	503	1,092	1,657	434.5%
1-19 Acres	706	1,404	2,986	4,461	531.9%
Medium Density Group (100 < persons per square mile < 600)					
1-9 Acres	2,381	3,816	7,208	8,807	269.9%
10-11 Acres	767	1,393	3,200	4,356	467.9%
12-19 Acres	604	961	1,567	1,917	217.4%
10-19 Acres	1,371	2,354	4,767	6,273	357.5%
1-19 Acres	3,752	6,170	11,975	15,080	301.9%
High Density Group (Greater than 600 persons per square mile)					
1-9 Acres	1,848	2,577	3,831	4,660	152.2%
10-11 Acres	638	913	1,442	1,812	184.0%
12-19 Acres	559	748	1,060	1,208	116.1%
10-19 Acres	1,197	1,661	2,502	3,020	152.3%
1-19 Acres	3,045	4,238	6,333	7,680	152.2%

Comparing across densities, the lowest percentage increase in the number of total lots was in the high density townships (152.2%). This result might be expected because landowners in high population density areas, would most likely develop subdivisions to maximize lots per acre because of heightened development pressure created by limited land and greater population.

The highest percentage increase was in the low density townships (531.9%). Though this was the largest percentage increase, the medium density group had the largest increase in total number of lots under 20 acres (11,328). There is typically a substantial demand for lots in townships in the medium density group. However, the demand is not so great to encourage landowners to develop the more costly subdivisions. The Land Fragmentation Consistency Hypothesis was used to test whether these differences are significant. The results and discussion from testing this hypothesis are given in the next section.

Land Fragmentation Consistency Hypothesis

The Land Fragmentation Consistency Hypothesis was stated in Chapter 4 as:

> *"For any decade, the mean change in the number of unplatted lots less than 20 acres in size is equal across township groups."*

This hypothesis was tested by comparing the mean change in the number of lots of each density group. The data and results of this test are presented in Table 5.7.

Table 5.7 Descriptive Statistics and Results of Statistical Tests for Land Fragmentation Consistency Hypothesis

	Mean	Std. Dev. *	Calculated t-value **	df	2-tail Prob.
Average increase in the number of total lots					
1960-70					
Low Density	30.1	22.5			
Medium Density	84.1	62.4			
High Density	58.6	44.2			
Test of Low and Medium Density			-3.86	48	0.000
Test of Medium and High Density			1.62	48	0.111
Test of Low and High Density			-2.70	42	0.010
1970-80					
Low Density	68.7	32.8			
Medium Density	209.9	136.1			
High Density	95.1	80.6			
Test of Low and Medium Density			-4.75	48	0.000
Test of Medium and High Density			3.50	48	0.001
Test of Low and High Density			-1.42	42	0.162
1980-90					
Low Density	62.5	35.1			
Medium Density	118.0	56.5			
High Density	56.8	56.1			
Test of Low and Medium Density			-4.03	48	0.000
Test of Medium and High Density			3.82	48	0.000
Test of Low and High Density			0.41	42	0.687

* Std. Dev. of the Mean Difference

** The t-value was calculated as t= (mean difference)/((Std Dev)/(sq. root of N))

The null hypothesis that the rate of change of land fragmentation was equal across all density groups was rejected for all years and all density groups except for 1980 and 1990, when the mean number of lots created were not statistically different between the high and low density townships at the .05 significance level. This rejection of the null hypothesis implies that differences in the rate of land fragmentation exist among townships of different population densities. In the two cases when the null hypothesis was not rejected, one would expect the number of new unplatted lots to be similar for a variety of reasons. In low density townships, one would expect a low number of unplatted lots because the average demand for new lots would be low. In high density townships there would be a greater demand for lots, therefore, landowners would develop subdivisions to maximize lots per acre.

Having tested the level and rates of land fragmentation, the remainder of this research will focus on land fragmentation patterns. In the next section, the number of 10-11 acres lots are examined.

Consistency of Land Division Patterns

The number of 10-11 acre lots is examined in detail because of the incentive in the SCA to create 10 + acre lots. The data are presented as the percent of lots created in each period in order to observe patterns of land fragmentation. The data are also sorted by density group to present any differences between density groups. These results are given in Table 5.8.

Table 5.8 Distribution of Created Lots Under 20 Acres by Population Density Group, 1970 to 1990

	1-9 acre	10-11 acre	12-19 acre
All Townships			
1960-70	61.9%	23.8%	14.3%
1970-80	59.5%	29.1%	11.4%
1980-90	56.3%	31.7%	12.0%
Low Density Group			
1960-70	72.3%	17.8%	9.9%
1970-80	62.8%	26.7%	10.6%
1980-90	61.7%	23.7%	14.6%
Medium Density Group			
1960-70	59.3%	25.9%	14.8%
1970-80	58.4%	31.1%	10.4%
1980-90	51.5%	37.2%	11.3%
High Density Group			
1960-70	61.1%	23.1%	15.8%
1970-80	59.9%	25.3%	14.9%
1980-90	61.5%	27.5%	11.0%

For all 72 sample townships, 24 percent of the lots created between 1960 to 1970 were 10-11 acres in size. During 1970 to 1980, 29 percent of the lots created were 10-11 acres in size and during 1980 to 1990, 32 percent of the lots created were 10-11 acres in size. This increase in the percentage of 10-11 acre lots was not a downsizing from

12-19 acre lots because as a percentage the number of lots 1-9 acres decrease from 61.9% to 56.3%. The pattern of having a greater percentage of lots at 10-11 acres was consistent for 1970 to 1980 and 1980 to 1990.

The medium density group had the largest percentage of lots, 10-11 acres, of the three groups in all three time periods with the maximum in 1990 at 37%. For both the medium and high density groups, there was a trend of a continual increase in the percentage of lots being created being 10-11 acre lots. However, for the low density group the percentage in the final period decreased as the percentage of 12-19 acre lots increased.

The next section addresses the hypothesis on the pattern of land fragmentation. The hypothesis and test results are presented.

Consistency of Land Division Patterns Hypothesis

The Consistency of Land Division Patterns Hypothesis focused on the pattern of new lots being created. It was hypothesized that the SCA introduced an incentive to create 10 + acre lots. This hypothesis investigates this pattern in two parts:

> (A) *"The mean percentage of all new unplatted lots that are 10-11 acres in size is equal over time."*

and

> (B) *"The mean percentage of all new unplatted lots that are 10-11 acres in size is equal across township groups."*

Several tests were conducted to test this hypothesis. For Part A of the hypothesis, the mean percentage of new lots in each township that were 10-11 acres in size, are tested across the different time periods. Because the means were dependent, the paired difference procedure described earlier was used. For Part B of the hypothesis, each density group is compared to the other groups in each time period. The results of these tests are reported in Table 5.9.

Table 5.9 Descriptive Statistics and Results of Statistical Tests for Consistency of Land Division Patterns Hypothesis

	Mean	Std. Dev. *	Calculated t-value **	df	2-tail Prob.
Paired Differences Comparison of percent of 10-11 acre lots in years:					
1960-70 and 1970-80***	8.5	14.3	5.02	70	0.000
1970-80 and 1980-90	1.5	16	0.78	70	0.435
1960-70 and 1980-90	8.5	20.2	3.58	71	0.001
Average increase in percent of 10-11 acre lots					
1960-70					
Low Density	5.5	5.4			
Medium Density	21.0	24.7			
High Density	14.4	22.9			
Test of Low and Medium Density			2.90	48	0.006
Test of Medium and High Density			0.98	46	6.700
Test of Low and High Density			1.79	42	0.081
1970-80					
Low Density	18.9	12.4			
Medium Density	65.5	55.1			
High Density	23.1	20.3			
Test of Low and Medium Density			3.89	48	0.000
Test of Medium and High Density			3.43	48	0.001
Test of Low and High Density			0.83	42	0.409
1980-90					
Low Density	15.6	12.4			
Medium Density	42.6	27.5			
High Density	15.4	18.5			
Test of Low and Medium Density			4.26	48	0.000
Test of Medium and High Density			3.98	48	0.000
Test of Low and High Density			0.05	42	0.962

* Std. Dev. of the Mean Difference

** The t-value was calculated as t= (mean difference)/((Std Dev)/(sq. root of N))

*** For example, to test this hypothesis, the number of lots in each township was counted in 1960 and in 19[7] The number of lots in 1960 was subtracted from the number of lots in 1970 to calculate the paired differe[nce] from 1960 to 1970. These differences for each township were used to calculate the mean and standard deviations of the differences listed in columns one and two.

For the entire sample of townships, the mean percentage of 10-11 acre lots was significantly different between 1960 to 1970 and 1970 to 1980 or 1980 to 1990. However, the mean percentage of 10-11 acres lots during 1970 to 1980 were not statistically different than the mean percentage of lots during 1980 to 1990. These results suggests that the SCA might have some effect on the percentage of 10-11 acre lots. With the SCA enacted in 1968, the 1960 to 1970 period would be the land fragmentation pattern before the Act, while the land patterns in the other two periods would be after the Act.

When examining the differences between the values for the township groups in the 1960 to 1970 time period, the only significant difference was between the low and medium density groups. In 1970 to 1980, there was no significant difference between the low and high density groups. This pattern was repeated in 1980 to 1990.

Based on this evidence both Part A and B of this hypothesis are rejected, suggesting that the pattern of land fragmentation has changed over time. The next step is to identify the impact of factors affecting the land fragmentation process in the sample townships. The Land Division Patterns Hypothesis in the next section focuses on these issues.

5.4 LAND DIVISION PATTERNS HYPOTHESIS

The Land Division Patterns Hypothesis states:

"Land division patterns are impacted by ecological, economical, social, and institutional factors. However, the Subdivision Control Act of 1967 has had no effect on the number of 10 + acre lots."

This hypothesis is tested using the econometric model presented in Chapter 4. The regression model and results of this hypothesis test are presented in the following sections.

Econometric Model

In Chapter 4, an econometric equation modeling land division was specified using the factors identified in Chapter 3. The results of the estimated equation are reported here. Table 5.10 lists the variables used and their descriptions. The methods of deriving the variables were described in Chapter 4.

Table 5.10 Variable Specification for the Land Fragmentation Model

VARIABLE	DESCRIPTION
AGP	The percent of the township's land area devoted to agricultural uses.
D1	Dummy for low density townships, 1 for low density, 0 otherwise.
D3	Dummy for high density townships, 1 for high density, 0 otherwise.
DSCA	Dummy for the SCA, "0" for 1960 and 1970, "1" otherwise.
DCITY*	Distance to a city of 50,000 in 1990.
DFREE*	Distance to a freeway interchange.
EMP	Total employment in the township.
FRMINC	Real average farm income in Michigan (thousands of 1983 dollars).
INCOME	Per capita income by township (thousands of 1983 dollars).
LAND	Total number of acres in the township (thousands).
MEDAGE	Median age of residents in the township.
MORTNOM	Nominal rate of interest on home mortgages.
MORTREAL	Real rate of interest on new mortgages.
PGAS	Average price of gas in Michigan (1983 dollars).
REC	Percent of the township that is either forest or water.
TOTHOU	Total number of households in a township (thousands).
TOTPOP	Total population in a township (thousands).

* There were four townships that had values from 150 to 300 miles while the rest of the townships had values under 68 miles. For those townships greater than 68 miles from either a large city or freeway interchange, the values were changed to 68 thus truncating the data.

Dependent Variable

The dependent variable in the model could be specified in one of three ways. The alternative specifications include: (1) the number of 10-11 acre lots; (2) the acreage in 10-11 acre lots; or (3) the percent of the township's land area in 10-11 acre lots. Regression models were estimated using each of these specifications and the results were compared to determine which dependent variable would be used.

Two equations were estimated for each dependent variable, with interest rates for new mortgages specified as either a real or nominal interest rate. The results from these equations were compared and new equations were estimated using different combinations of variables (i.e., variables that were consistently insignificant and unstable in sign were omitted). The adjusted R^2s, signs of the regression coefficients, and standard errors for each equation, were compared to determine the most appropriate specification of the dependent variable. Based on these results, the number of 10-11 acre lots was selected as the dependent variable.

Deleted Variables

Three variables, DFREE, PGAS, and EMP, were deleted from the model. Two variables, DFREE and DCITY, were specified to measure the influence of the distance from cities or freeways on land fragmentation. It was hypothesized that access to a freeway would reduce traveling time thus increasing demand for lots in an area. DFREE was consistently insignificant and was deleted from the model. The variable, DCITY was retained in the model to measure the effect of distance on land fragmentation.

Another variable designed to measure the cost of travel, PGAS, was also deleted from the model because it was insignificant in all versions of the model. PGAS was defined as a five year moving average of the price of gasoline in the city of Detroit. Possibly it was not descriptive of the price of gasoline in Michigan or that the price of gas was not a factor in demand of 10-11 acre lots.

EMP, the employment rate variable, was the third variable deleted from the model. The EMP variable and the per capita income variable, INCOME, were included as measures of economic ability. EMP was insignificant in most cases and therefore, was not included in the final equations.

Population Testing and Pooling

The test of the Consistency of Land Divisions Hypothesis concluded that the number of 10-11 acre lots being created were sometimes significantly different across the three groups of townships. In light of this result, some question remained about whether these differences should be accounted for when pooling to estimate the regression for the entire sample. To test whether the townships were different, the same equation was estimated using the entire sample, and the three different population density groups. The null hypothesis that all estimated regression coefficients were equal among the four equations can be tested using an F-test as the relevant test statistic (Kementa, 1971). The test results are given in Appendix C.

Since the null hypothesis that all regression coefficients were equal was rejected, this result indicates that some regression parameters were different for some density groups. Therefore, in order to pool the three groups, those variables that had unequal regression coefficients must have a separate variable for each density group. To create these new variables, the variable that was identified as having a different coefficient for each density group, was multiplied by the dummy variables D1 and D3, thus creating two additional variables that would measure the different impact of population density.

To identify which variables had unequal regression coefficients, a test was created using the regression coefficient and the standard error for each variable. A range for each variable was created by adding and subtracting the standard error from the estimated coefficient. If one of the estimated coefficients fell outside the range of the others, then two new variables were created by multiplying this variable by D1 and D3.[1]

Once all coefficients were examined and new variables created, the three density groups were pooled and the equation was re-estimated. The estimated coefficients of the newly created variables were then examined to determine if they were different from one another using the same process as before. If the coefficients on the newly created variables were overlapping, these variables were deleted and the equation was estimated again.

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[1] For example, the estimated coefficient on TOTPOP was 7.839 and the standard error was 2.265 for the low density township equation. The estimated coefficient on TOTPOP was 10.430 and the standard error was 3.174 for the medium density township equation. The estimated coefficient on TOTPOP was .903 and the standard error was .719 for the high density township equation. Since the estimated coefficient on TOTPOP for high density townships was outside the range of the other two, it was concluded that the TOTPOP variable had different coefficients for each density group. Thus, a new variable was created by multiplying TOTPOP by D1 and D2.

Regression Results

Most of the variables specified were time and townships specific. However, the DSCA, MORTNOM, MORTREAL, and FRMINC variables were time specific, with only one value used for these variable in each cross sections (i.e., the MORTNOM variable was 5.492 for all townships in the 1960 sample). It was discovered the model yielded inconclusive results when more than two of these time specific variables were included in the model. Therefore, in reporting the findings of this study, results from four equations were given, with no more than two of these time specific variables included. In the first equation only DSCA included. The second equation includes DSCA and FRMINC. The third equation includes DSCA and MORTNOM and the fourth equation includes DSCA and MORTREAL.

When the regression coefficients were tested for equality using the procedure described in the preceding section, the variables, LAND and TOTPOP were found to be different in all four of the final equations. The variable DSCA was different for the equations, 1 and 4. The INCOME variable was different in all but equation 4. The DCITY and TOTHOU variables were determined to be different in equation 4. However, after pooling and estimating a new equation, the newly created variables in this equation for DCITY and TOTHOU were determined to be similar. Therefore, they were deleted and the equation was estimated again. The results of the four final equations estimated are given in Table 5.11.

Table 5.11 · Estimates of the Land Fragmentation Regression Model

Variable	1	2	3	4
AGP	-0.17 (-0.776)	-0.10 (-0.464)	-0.10 (-0.489)	-0.25 (-1.169)
D1	256.55 (3.768)***	280.60 (4.198)***	280.25 (4.200)***	200.56 (3.254)***
D3	266.54 (3.911)***	280.09 (4.163)***	279.38 (4.160)***	170.39 (2.728)***
DSCA	51.14 (4.805)***	23.63 (1.818)*	15.45 (0.998)	68.12 (6.802)***
DSCAD1	-26.40 (-1.762)*			-37.64 (-2.799)***
DSCAD3	-0.92 (-0.063)			-16.39 (-1.192)
DCITY	-0.10 (-0.475)	-0.12 (-0.568)	-0.12 (-0.574)	-0.20 (-1.005)
FRMINC		5.22 (1.660)*		
INCOME	10.02 (3.959)***	11.80 (4.964)***	11.80 (4.996)***	1.68 (1.191)
INCOMED1	-5.80 (-1.335)	-9.71 (-2.484)**	-9.73 (-2.495)**	
INCOMED3	-9.55 (-3.425)***	-10.74 (-4.080)***	-10.74 (-4.097)***	
LAND	8.91 (3.456)***	9.01 (3.496)***	8.99 (3.494)***	8.65 (3.357)***
LANDD1	-8.98 (-3.485)***	-9.08 (-3.529)***	-9.06 (-3.528)***	-8.72 (-3.385)***
LANDD3	-6.36 (-2.381)**	-6.35 (-2.383)**	-6.33 (-2.379)**	-5.68 (-2.135)**
MEDAGE	-1.16 (-1.597)	-1.14 (-1.604)	-1.17 (-1.650*	-1.82 (-2.375)**
MORTNOM			6.87 (1.909)*	
MORTREAL				5.34 (3.351)***
REC	0.28 (0.905)	0.34 (1.119)	0.34 (1.108)	0.30 (0.959)
TOTHOU	-1.85 (-1.053)	-0.98 (-0.599)	-0.98 (-0.597)	-2.38 (-1.350)
TOTPOP	9.98 (5.850)***	10.02 (6.210)***	9.96 (6.179)***	10.61 (6.297)***
TOTPOPD1	1.38 (0.231)	-0.03 (-0.004)	-0.07 (-0.012)	0.19 (0.034)
TOTPOPD3	-9.77 (-6.187)***	-10.06 (-6.670)***	-10.01 (-6.645)***	-10.43 (-6.727)***
(Constant)	-252.49 (-3.785)	-313.63 (-4.363)	-315.61 (-4.461)	-170.16 (-2.610)
Adjusted R^2	0.59596	0.59557	0.59693	0.59659
F- Statistic	22.66	23.83	23.95	23.92

Numbers in parentheses are t-statistics
Dep. variable = "Number of 10-11 acre Lots"

*** = 1% Significance Level
** = 5% Significance Level
* = 10% Significance Level

Land Division Patterns Hypothesis

The Land Division Patterns Hypothesis was tested using multiple regression analysis. Results from four different equations were reported in Table 5.11.

The dummy variable, DSCA represented the impact of the SCA on the creation of 10-11 acre lots. The SCA was enacted in 1967 with enforcement beginning in 1968. Given the brief period between the start of enforcement in 1968 and the sample data in 1970, the DSCA variable was specified in the model as "0" for years 1960 and 1970 and as "1" for years 1980 and 1990.[2] The estimated coefficient on the DSCA was positive in all of the final equations. The DSCA coefficient was significant at the one percent level in two of the equations and at the ten percent level in another equation. Thus, the null hypothesis is rejected and it can be concluded that the SCA did have a positive effect on the number of 10-11 acre lots in the sample townships.

DSCA was dummied in two equations, implying that the SCA had differing impacts on the different density groups. To determine the impact of the SCA on low density townships, the estimated coefficients for DSCAD1 is added to the coefficient estimated for DSCA. For high density townships, DSCAD3 is added to the coefficient estimated for DSCA. Figure 5.2 shows the impact of the SCA on the different density groups estimated by the four equations.

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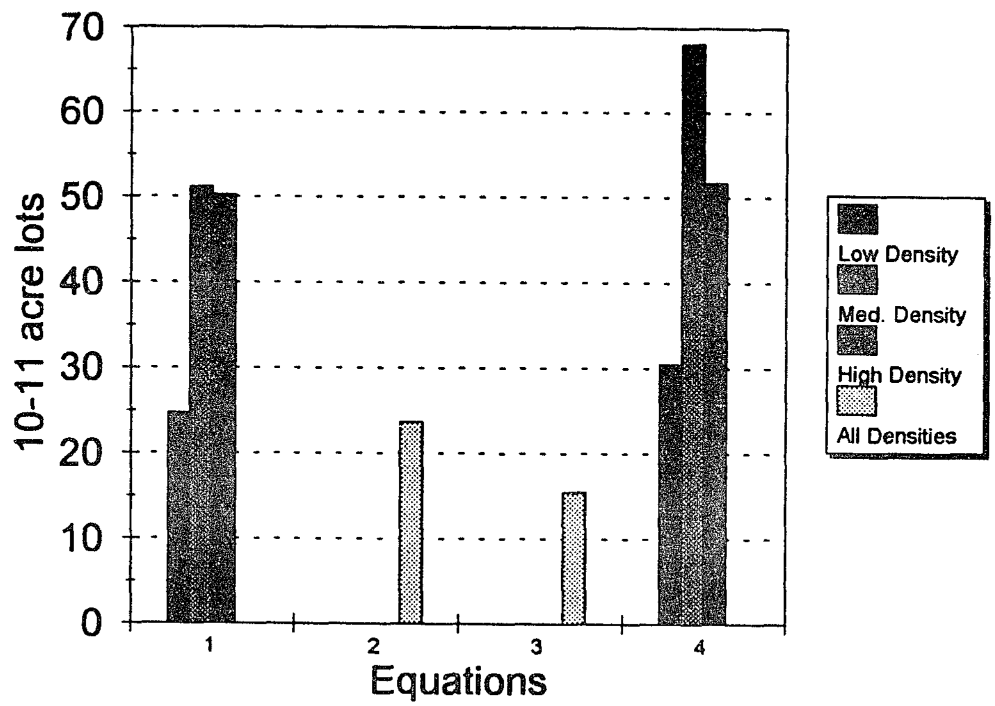
[2] It was assumed that there was no Subdivision Control Act in force during the time period between 1960 and 1970, but the SCA was being enforced after 1970.

Figure 5.2 Estimated Impact of the SCA on Number of 10-11 Acre Lots



Equation 1 includes AGP, D1, D3, DSCA, DSCAD1, DSCA3, DCITY, INCOME, INCOMED1, INCOMED3, LAND, LANDD1, LANDD3, MEDAGE, REC, TOTHOU, TOTPOP, TOTPOPD1, TOTPOPD3
Equation 2 includes AGP, D1, D3, DSCA, DCITY, FRMINC, INCOME, INCOMED1, INCOMED3, LAND, LANDD1, LANDD3, MEDAGE, REC, TOTHOU, TOTPOP, TOTPOPD1, TOTPOPD3
Equation 3 includes AGP, D1, D3, DSCA, DCITY, INCOME, INCOMED1, INCOMED3, LAND, LANDD1, LANDD3, MEDAGE, MORTNOM, REC, TOTHOU, TOTPOP, TOTPOPD1, TOTPOPD3
Equation 4 includes AGP, D1, D3, DSCA, DSCAD1, DSCA3, DCITY, INCOME, LAND, LANDD1, LANDD3, MEDAGE, MORTREAL, REC, TOTHOU, TOTPOP, TOTPOPD1, TOTPOPD3

The regression results indicate that the passage of the SCA caused an increase in the number of 10-11 acre lots. For equations 2 and 3, the results do not differ among density groups and the estimated impacts on the number of 10-11 acre lots are somewhat smaller than for equations 1 and 4. In equations 2 and 3, which includes all townships, the SCA is estimated to have caused the creation of an additional 15 or 23 lots of 10 to 11 acres in size (equations 3 and 2).

In equations 1 and 4, the DSCA variable was dummied when the density groups were pooled. Consequently, there is a separate estimate for each density group. From equations 1 and 4, the range of impact on the number of 10-11 acre lots is 25 or 30 lots for the low density township group. For the medium density group, the impact on number of 10-11 acre lots range from 51 to 68 lots. For the high density group, the estimates range from 50 to 51 lots. Equations 1 and 4 were similar in that they both estimate the impact on the middle density townships to be the greatest.

The results of equations 1 and 4 suggest that more 10-11 acre lots were created in the medium density townships because of the SCA than the other density groups. A possible explanation is the likely differing levels of demand for lots in the different density groups. It is suggested that the demand for lots in the medium density townships is greater than in the low density townships but not as great as in the high density townships. In the high density townships, with the greater level of demand for lots, this would allow the increased costs due to platting be recouped because the higher level of demand allows for higher prices to be charged on the lots.

Impact of Other Factors on Land Fragmentation

The Land Division Patterns Hypothesis focused on the impact of the SCA on land fragmentation patterns, but the impact of other factors on land fragmentation patterns can be calculated from the estimated equations. The impact of the other variables on the number of 10-11 acre lots of the other variables are presented in Table 5.12, .

Table 5.12 Estimated Range of Impact on the Number of 10-11 Acre Lots From the Land Fragmentation Model

			Low Density		Med. Density		High Density	
Variable	Low	High	Low	High	Low	High	Low	High
AGP	-0.25	-0.10						
DCITY	-0.20	-0.10						
FRMINC	5.22							
INCOME	1.68		2.07	4.23	10.02	11.8	0.47	1.06
LAND			-0.06	-0.08	8.65	9.01	2.55	2.98
MEDAGE	-1.82	-1.14						
MORTNOM	6.87							
MORTREAL	5.34							
REC	0.28	0.34						
TOTHOU	-2.38	-0.98						
TOTPOP			9.89	11.36	9.96	10.61	-0.05	0.21

AGP, the variable describing the percent of the township in agricultural land was not dummied in order to be pooled and had negative regression coefficients. As the percent of the township's land area that is agricultural increased by one percent, the number of 10-11 acre lots decreased by .10 to .25. These results would suggest that agriculture is in competition for land for development.

DCITY, the variable measuring mileage to a city of 50,000 people was not dummied and had negative regression coefficients in all versions of the model. Thus, as the distance to a large city increased by one mile, the number of 10-11 acre lots decreased by .10 to .20 lots. This result was as expected, since it was expected that the fragmentation of land would decrease as the distance from an urban area increased.

FRMINC, the variable for average farm income was included only in equation 2 and had a positive regression coefficient. As average farm income per farm increased by 1,000 dollars, the number of 10-11 acre lots increased by 5.22. FRMINC was included in the model because some claim that farmers sell land because of financial pressure. This result would suggest that decreases in income are not a cause of land fragmentation.

INCOME, which is the variable for per capita income, had positive regression coefficients for all three density groups. Thus as the per capita income of the township residents increased by 1,000 dollars, the number of 10-11 acre lots increased by 2.07 to 4.23 in a low density township, by 10.02 to 11.8 in a medium density township, or by .47 to 1.06 in a high density township. These results suggest that the creation of large lots is stimulated by growth in income but the magnitude of that change is dependant on where the land is located.

LAND, the variable for the amount of land in a township had positive regression coefficients for both medium and high density groups and a negative coefficient for the low density group. Thus as the amount of land in a township increased by 1,000 acres, the number of 10-11 acre lots decreased by .06 to .08 in a low density township. Similarly, a 1,000 acre increase in the size of a township increases the number of 10-11 acre lots by 8.65 to 9.01 in a medium density township and by 2.55 to 2.98 in high density townships. As the amount of land in a township increases, the potential for the number of lots of this size increase. The negative coefficient for the low density group may be explained by presence in the sample of the very large townships in the Upper Peninsula that do not face development pressure.

MEDAGE, the variable describing median age of the citizens in the townships, had negative regression coefficients. Thus, as the median age of the residents in a township increased by one year, the number of 10-11 acre lots decreased by 1.14 to 1.82. These results would suggest that as people age, they tend to prefer smaller lots.

REC, the variable describing the percentage of the land in a township that was classified as forest or water had positive coefficients. As the percentage of the township's land in forest or water increased by one percent, the number of 10-11 acre lots increased by .28 to .34. These results suggest that forest and water are not recreational amenities attracting development of large lots.

TOTHOU, the variable describing the number of households, had negative coefficients in all equations. As the number of households in a township increased by 1,000 households, the number of 10-11 acre lots decreased by .98 to 2.38. This is contrary to what was expected since it was expected that as population increased the number of 10-11 acre lots would increase. Though the sign on this variable was the opposite of what was expected, these coefficients were not statistically significant.

TOTPOP, the population variable had positive regression coefficients for all three township groups in most of the results. This variable had a relatively large impact on low and medium density townships but very little impact on high density townships. Thus, as the total population in a township increases by 1,000 people, the number of 10-11 acre lots increased by 9.89 to 11.36 in a low density township, increased by 9.96 to 10.61 in a medium density township, or decreased by .05 to increased by .21 in a high density township. These results indicating a low impact of population on 10-11 acre lots in high density townships suggest that landowners have the ability to recapture the costs of platting in high density townships.

The range of estimated coefficients for variables other than Subdivision Control Act have been reported in this section. The signs of these coefficients were usually consistent with prior expectations and were often significant at the 10 percent level or higher. These results are further proof that the regression equations are a reasonable model of the land division process.

5.5 SUMMARY

This chapter reports the results of the tests conducted on the hypotheses presented in Chapter 4. The amount of land fragmentation was determined by counting the number of unplatted lots under 20 acres on plat maps of each township in the sample. Using these data, the first three hypotheses were tested using trend analysis. Land fragmentation was determined to have occurred in the 72 sample townships during the time period from 1960 to 1990. Furthermore, the fragmentation of land was not consistent across time nor across township groups. Another conclusion was that the percentage of unplatted lots that were 10-11 acres in size being created during the time periods analyzed had increased. Townships with different population densities were found to have dissimilar patterns of land fragmentation. An econometric model was estimated to determine what factors affected this pattern of land fragmentation. The results from this model were presented as four different equations. In all four equations, the Subdivision Control Act had a positive impact on the number of 10-11 acre lots. For three of the equations, the SCA variable was significant at the ten percent level or higher. These results led to a rejection of the null hypothesis that the SCA had no effect on the number of 10-11 acre lots. The results of the regression model indicate that the passage of the SCA increased the number of 10-11 acre lots in the sample townships by 15 to 68 lots per township. In Chapter 6, the conclusions and applications from these results are given.

Chapter 6

CONCLUSIONS AND APPLICATIONS

6.1 INTRODUCTION

This research has examined the impact of the Subdivision Control Act of 1967 (SCA) on land fragmentation in the State of Michigan. This chapter reviews the objectives of this research and summarizes the results of the study. Some policy alternatives for reducing land fragmentation are then discussed. In the final section, suggestions for future research are made.

6.2 RESEARCH OBJECTIVES

Landowners in Michigan are permitted to divide and sell land subject to local zoning ordinances and the conditions stated in the SCA. Rural land, originally surveyed as large parcels suitable for agriculture or forestry, is being divided into smaller lots most commonly used for residences. This fragmentation of land has been viewed as a concern because of its impact on open space, natural resources, and the cost of public service.

A common perception is that the SCA has contributed to land fragmentation by creating an incentive to develop 10 + acre lots. The incentive is created by a provision that allows landowners to avoid platting and the costs of platting, if no more than four lots 10 acres or less are created within any 10 year period.

The public program evaluation technique was used as the framework to analyze the SCA. Using this framework, the impacts of the SCA were measured against the goals the Act set out to accomplish. The goals of the SCA are: "to regulate the subdivision of land; to promote the public health; safety and general welfare; to further the orderly layout and use of land." The manner in which these goals are to be accomplished is by the establishment of plats. In this study, an attempt was made to test whether the SCA had positively affected the number of 10-11 acre lots. No attempt was made to measure the effectiveness of the SCA on platted land divisions.

The first objective of this study was to describe the SCA and identify the statute's objective and potential unanticipated consequences. The second objectives were to describe the land market, identify factors affecting the land market, and form testable hypotheses regarding land division activity. The final objective was to develop an econometric model of the land division process in Michigan and use the model to estimate the impact of the SCA on land fragmentation patterns.

6.3 RESEARCH RESULTS

The Subdivision Control Act of 1967 repealed and replaced the Plat Act of 1929. The common perception is that the SCA created an incentive to create 10 + acre lots because "subdivision" was defined in part as more than four lots that are 10 acres or less. When a land division qualifies as a subdivision the landowner is then required to plat the land division. To avoid qualifying as a subdivision, landowners can create lots of greater than 10 acres and thus avoid the cost of platting.

By comparing the SCA to the Plat Act, this research has shown that the SCA was different from the Plat Act in at least two areas. One, the SCA defined subdivision more precisely than did the Plat Act. The change in definition allowed for stricter enforcement. Secondly, additional language in the SCA increased the cost of platting by changing the required standards. Thus, both the increased enforcement and the higher cost of platting provided an incentive to create 10 + acre lots to avoid qualifying as a subdivision and the necessity to plat.

After examining the history of the SCA, the land market and the land fragmentation process were examined. The factors affecting land fragmentation were classified as ecological (forests, lakes, and rivers), economic (per capita income, employment, interest rates, farm income, the price of gas, and the distance to a freeway interchange or city), social (total population, total number of households, and median age), and institutional (SCA). These factors were used to build an econometric model capable of estimating the impact of the SCA on land fragmentation in Michigan.

To study land fragmentation in Michigan a sample of 90 townships was selected from the 1,241 townships in the State. Population density was used to classify the townships into low, medium, and high density strata. Thirty townships from each stratum were randomly selected. Of the 90 townships selected, 72 had adequate plat maps from which to collect data.

To determine the level and pattern of land fragmentation in the sample townships, the number of lots, 1-19 acres in size in a township were counted using plat maps for the years 1960, 1970, 1980, and 1990. Land fragmentation rates were determined by counting the number of lots in the township in the next period.

Using the data obtained from plat maps on the 72 townships, four hypotheses were tested to determine the rate and pattern of land fragmentation in Michigan. The first hypothesis focused on the change in the number of unplatted lots in the townships over time. It was found that the number of unplatted lots increased from 7,503 in 1960 to 27,221 in 1990. The null hypothesis that the mean number and rate of change of unplatted lots under 20 acres in size was equal during each decade was rejected.

The second hypothesis compared the rate of fragmentation between the density groups. The percentage increase in the number of unplatted lots from 1960 to 1990 was 532 percent in a low density township, 302 percent in a medium density township, and 152 percent in a high density township. The null hypothesis that the mean change in the number of unplatted lots less than 20 acres in size was equal across townships groups was rejected. This is evidence that land fragmentation is not consistent across the state, with more rapid fragmentation occurring in medium density townships.

The third hypothesis investigates the impact of the SCA on the number of 10 + acre lots by testing whether the mean percentage of all new unplatted lots that are 10-11 in size was equal over time and across township groups. The mean number of 10-11 acres unplatted lots created in the time period 1960 to 1970, was 5.5 in low density townships, 21.0 in medium density townships, and 14.4 in high density townships.

During the time period 1970 to 1980, the mean number of 10-11 acre lots created was 18.9 in low density townships, 65.5 in medium density townships, and 23.1 in high density townships. During the time period 1980 to 1990, the mean number of 10-11 acre lots created was 15.6 in low density townships, 42.6 in medium density townships, and 15.4 in high density townships. This hypothesis was rejected, implying that the mean number of 10-11 acre lots created had changed and that these changes were not equal across township groups. The impact of the SCA on the number of 10-11 acre lots was the largest in the medium townships.

Once a pattern of an increased number of 10-11 acre lots had been established a fourth hypothesis was tested to determine the impact of the SCA on land fragmentation. The fourth hypothesis, building on the research on the land market, stated that land division patterns are impacted by ecological, economical, social and institutional factors but that the SCA has had no affect on the number of 10 + acre lots. Using the econometric model, four equations including different sets of variables were estimated. In three of the four equations estimated, the null hypothesis that the SCA had no affect was rejected. The results of these equations indicate that the SCA caused the creation of an additional 15 to 51 lots between 10-11 acres in size per township during the time period from 1960 to 1990.

6.4 POLICY ALTERNATIVES FOR REDUCING LAND FRAGMENTATION

Given the results of this research, policy makers may want to examine the SCA to determine whether formation of a large number of 10-11 acre lots is consistent with the objectives stated in the Act. Amending the SCA to change this pattern of development may be one policy alternative for reducing land fragmentation. Implementing land preservation techniques, such as open space zoning, are another approach to reduce land fragmentation. Possible changes to the SCA and other policy alternatives are considered in the next sections.

One policy option to reduce land fragmentation is to amend the SCA to lessen the incentive to create the 10 + acre lots embedded in the Act. The SCA defines a land division as a subdivision when more than 4 lots, 10 acres or less, are created in a ten year period from a parent parcel. When a land division qualifies as a subdivision, platting is required. Therefore, if individuals want to avoid platting after the fourth split in a ten year period, they must create lots greater than 10 acres.

Three approaches could be used to reduce the incentive to develop 10 + acre lots: (1) change the 10 acre provision in the definition of subdivision; (2) reduce the cost of platting; or (3) decrease the ten year period. These approaches may reduce the incentive to develop 10 + acre lots, but they also may create new incentives that could affect land fragmentation.

Changing the 10 acre provision in the definition of subdivision may create a pattern of lots at the margin of the new standard. For example, reducing the 10 acre standard to 5 acres may lead to a new pattern of development of 5 + acre lots, while raising the standard to 20 acres may cause a pattern of 20 + acre lots. The resultant impact on land fragmentation of these new patterns would depend on the number of lots of this size created and the acreage limit included in the legislation.

Another alternative to amending the SCA would be to reduce the ten year period in which only four lots under 10 acres or less may be created without platting. This may reduce the incentive to create 10 + acre lots, because more lots of less than 10 acres could be created in the same amount of time. The affect of this option on land fragmentation would depend on the number of unplatted lots created.

The third approach of reducing the number of 10 + acre lots would be to decrease the costs of platting. Costs would include the expense, time, and effort required for the platting process plus the required standards for the plat, i.e., road specifications. By lowering the costs to plat, this would reduce the incentive to avoid platting, thus possibly reducing the number of 10 + acre parcels. However, shortening the time frame or changing the required standards may have a negative impact on the intended objectives of the SCA as stated above. For example, the platting process could be shortened by streamlining the process, but this could result in an inadequate review of the plats, possibly leading to poorly designed subdivisions.

Amending the SCA is only one approach to reducing the amount of land fragmented. Other alternatives to reduce land fragmentation are grouped into two categories: limiting or changing the nature of land divisions and enhancing the economic vitality of agriculture. The collective impact of each alternative could vary by location.

Limit or change the nature of land divisions.

There are land preservation techniques that are available under the existing zoning regulations. Zoning has the ability to describe and control land use. However, zoning can be undermined when either zoning is not enforced or when use variances are given.

A common zoning technique is large lot zoning where the minimum lot size is, for example, 10 acres. However, this could compound the problem of land fragmentation because for each lot created, the number of acres fragmented would be relatively large. For example, if the minimum lots were five acres in size, only half as much land would be fragmented as under a 10 acre rule.

Another zoning technique is sliding scale zoning, which allows the landowners to create a certain number of lots based on the size of the original parcel. Large parcels are permitted fewer splits proportionate to total acreage than are small parcels (e.g. A 20 acre parcel might be permitted 4 splits while a 100 acre parcel might be only permitted 10 splits) This would reduce the number of allowable splits and possibly reduce the size of the lots depending on the minimum lot size as specified in the local ordinance. This could result in less land fragmentation.

The objective of cluster zoning is to "cluster" residential development on one portion of the parent parcel while restricting development on the remainder of the parent parcel. This form of zoning is an attempt to maintain open space and the rural character of an area while still allowing a landowner to capture profits from development of the land. The allowable lots would be small, thus reducing the amount of land fragmented.

The restricted development would also eliminate land fragmentation on the remaining original parcel.

Zoning techniques with the present structure are limited by the ability of the township board to pass and enforce the ordinance. Many times such an ordinance is not coordinated with other townships' ordinances. This situation could be modified by changing the enabling laws to decrease the level of autonomy of the townships and increase the standardization of zoning laws among townships. This action could reduce the amount of land fragmented.

Open space preservation techniques, such as purchase of development rights, could also be implemented. Public or private finances could be expended to buy the rights to develop the land. Public financing could be justified if the present use is preserved for the future. Land on which the development rights have been sold could not be fragmented in the future.

Land will have different productivity levels for such inherent features as fertility but often the locational features are the driving force for the value of the property. The question is raised: who will capture the increased value of land located near centers of population or economic activity. The prospect of capturing large profits creates incentives to obtain zoning for maximum development. Schmid (1981) suggests that a tax which captures most of the appreciation gained would reduce the incentive to fragment land. However, public acceptance of such a tax is questionable.

Enhance the economic vitality of agriculture

Enhancing the economic vitality of agriculture has been one approach recommended to limit the amount of agricultural land fragmented. It is argued that agricultural and forest land should be preserved because they are the principle economic base in rural areas, they are renewable resources, they retain natural environmental systems, and they provide open space and rural character.

For this approach to be effective, either the number of land divisions must be reduced or, if there is a division of land, the land use must remain the same. It is often argued that enhancing the economic vitality of agriculture would reduce the number of forced sales due to low profitability, thereby reducing the incentive to sell off road frontage for residence lots. Similarly, when agricultural land is sold, higher profits in agriculture would permit farmers to better compete in bidding for land.

Three methods of enhancing the economic vitality of agriculture are highlighted here. The adoption of a "differential property assessment" can reduce the amount of property tax paid by a farmer, thus improving the profitability of the agricultural firm. Under a differential property assessment, land is assessed according to the value at current use rather than according to market value. One of the criticisms of differential property assessment is the manner in which use value is determined. The very fact that use value is lower than market value is evidence that the property is worth more for another use than it is for agricultural use. Sometimes, differential assessments have restrictions on changes in land use. When there are land use restrictions, it is more likely that land with low development potential will be enrolled. Land with high development potential would probably not be enrolled being that the benefits of lower taxes do not outweigh the potential of capturing increased profits from selling land for development. When the differential property assessment has no corresponding restriction on changes of land use, land that has been assessed at use value would be sold to the highest bidder regardless of uses intended by the purchaser.

Tax credit techniques such as the Farmland and Open Space Act, Public Act 116, 1974, are another method of enhancing the economic vitality of agriculture. Under PA 116, farmers contract with the state to keep their land in agriculture for a minimum of 10 years, in exchange for a limit on the amount of property taxes paid. A lien in the amount of the last seven years of rebated property taxes is placed on the land regardless of length of the contract. The criticism of this approach is similar to that of the differential assessment approach. Those farmers owning agricultural land with high development potential are less likely to enroll in the program. Moreover, all land in PA 116 could be developed at some point in time by paying the lien once the contract has expired.

The Right To Farm Law (RTF) is another attempt to assist agriculture. This bill defines acceptable farm practices and seeks to protect agriculture from nuisance suits and/or reduce the cost of litigation to agriculture. The fact that there is this legislation gives evidence that there are land use incompatibilities.

The question remains whether enhancing the profitability of agriculture is a long term solution to preserving agricultural land. In the land division model developed in this research, farm income was found to have insignificant impact on land fragmentation.

This result suggests that enhancing the profitability of agriculture may have little impact on land fragmentation.

This was an overview of some the options available for reducing land fragmentation. In the next section, suggestions for future research are identified.

6.5 SUGGESTIONS FOR FUTURE RESEARCH

One of the limitations of this study was the inability to easily locate data on land use and some factors that may affect land use. This study was limited to 72 townships because of the time required to count the number of 1-19 acre lots in the township on plat maps (the number of lots in each township had to be counted in 1960, 1970, 1980, and 1990). A larger sample would probably improve the results of the econometric model.

A number of factors were identified as possibly affecting land fragmentation. In two cases (mileage of paved roads in the township and types of local zoning ordinances) data could not be obtained within the time constraints. As a result these variables were not included in the model.

Land use legislation is not unique to Michigan. Examining the impact of laws similar to the SCA in other states may yield additional insights into the land fragmentation process. An examination of other states' laws may indicate how landowners would respond to amendments in the SCA and how land fragmentation might be affected if the SCA is changed.

APPENDICES

APPENDIX A
Sample Townships Included in Study

Township	County	Density Group
Alamo	Kalamazoo	Low
Aloha	Cheboygan	Low
Austin	Mecosta	Low
Bangor	Bay	High
Berrien	Berrien	Medium
Blackman	Jackson	High
Brandon	Oakland	Medium
Brighton	Livingston	Medium
Buchanan	Berrien	Medium
Cannon	Kent	Medium
Cedarville	Menominee	Low
Centerville	Leelanau	Low
Clay	Saint Clair	Medium
Clayton	Arenac	Low
Clinton	Macomb	High
Columbia	Van Buren	Low
De Witt	Clinton	Medium
Delhi	Ingham	High
Dexter	Washtenaw	Medium
Eaton Rapids	Eaton	High
Elbridge	Oceana	Low
Flowerfield	Saint Joseph	Low
Freedom	Washtenaw	Low
Genesee	Genesee	High
Genoa	Livingston	Medium
Green Oak	Livingston	Medium
Gunplain	Allegan	Medium
Hampton	Bay	Medium
Handy	Livingston	Medium
Harrison	Macomb	High
Hartland	Livingston	Medium
Hersey	Osceola	Low
Highland	Oakland	Medium
Howard	Cass	Medium
Independence	Oakland	High
Kimball	Saint Clair	Medium
Lansing	Ingham	High
Lincoln	Berrien	High
Lowell	Kent	Medium
Maple Valley	Sanilac	Low
Marcellus	Cass	Low
Mentor	Cheboygan	Low
Meridian	Ingham	High
Milford	Oakland	Medium
Monroe	Monroe	High
Mount Morris	Genesee	High
Ogden	Lenawee	Low
Orion	Oakland	High
Pentwater	Oceana	Low
Quincy	Branch	Medium
Raisin	Lenawee	Medium
Richland	Kalamazoo	Medium
Robinson	Ottawa	Medium
Rose	Ogemaw	High
Sagola	Dickinson	Low
Sanborn	Alpena	Low
Schoolcraft	Kalamazoo	Medium
Scipio	Hillsdale	Low
Solon	Kent	High
Southfield	Oakland	High
Spring Lake	Ottawa	High
St. Clair	Saint Clair	Medium
St. Ignace	Mackinac	Low
Surrey	Clare	Low
Tallmadge	Ottawa	Medium
Tawas	Iosco	High
Tecumseh	Lenawee	Medium
Thetford	Genesee	Medium
West Bloomfield	Oakland	High
Wheatland	Sanilac	Low
White Lake	Oakland	High
Ypsilanti	Washtenaw	High

APPENDIX B Table 1
Number of Unplatted Lots Counted in Sample Townships in 1960

		Size of Lots in Acres																		
Township	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Alamo	1960	10	15	5	5	17		2	2	3	13	1	2			13	4	3	5	2
Aloha	1960					2				1	1									
Austin	1960										2									
Bangor	1960	45	16	42	11	90	9	3	11	8	35	4	8	2	5	3	3	3	5	4
Berrien	1960	4	7	6	1	14	5	2	8	10	17	2	2	7	1	5	2	4	4	
Blackman	1960		2	2	4	2	2		6	2	11	4	1	3	2	4	1	1	4	2
Brandon	1960		9	6	14	17	7	6	3	7	34	6	4	2	5	5	1		2	3
Brighton	1960	5	7	2	3	10		5	4	7	25	2	2	3	2	3	1			
Buchanan	1960	2	17	8	8	42	10	11	13	4	31	5	5	5	5	11	5	3	3	3
Cannon	1960	25	25	27	31	37	14	5	8	3	39	4	8	3	4	7	7	1	1	7
Cedarville	1960										2									
Centerville	1960			1			3				2		1			2				1
Clay	1960		12	14	16	60	8	10	18	6	28	5	6	10	3	9		3	4	3
Clayton	1960	16	2		1	2	1		1		5	1			2	3		3		
Clinton	1960	20	20	15	1	50	16	10	11	10	29	15	7	3	4	6	3	3		2
Columbia	1960	3	1	1	4	12	1		5	4	25	2	3	1		10		2	5	6
Delhi	1960	30	25	21	17	59	11	8	15	6	28	4	4	2	2	10		1		1
Dewitt	1960	10	15	8	9	19	1		5	6	37	6	2	1	1	3		2	4	1
Dexter	1960		3		1	5	2		3	2	7	2		1	5	2			4	1
Eaton Rapids	1960	4	6	3	2	7			2	3	9		1	1	2	1	1	1	3	5
Elbridge	1960	1	3	1	2	2		3	1	1	4		2			2	1		1	1
Flower Field	1960	6	2	4	3	6	1	1		1	2	1	1	2	1	1	2			
Freedom	1960	5	2	3	3	7		2	2	3	21		4	3		3	1	1	1	2
Genesee	1960	4	8	7	12	51	2		11	4	34	2	8	4	5	19	4	4	1	7
Genoa	1960	6	9	5	2	16	4	2		6	23	2	1	1	3	4	1		1	1
Green Oak	1960	5	5	5	5	10	6	6	7	5	22	3	5	2	3	5	3	2	4	
Gunplain	1960	5	38	8	6	14	5		1	3	18	3	3	2	1	6	2		5	
Hampton	1960	21	21	14	9	33	12	3	9	11	54	6	4	6	3	4	5	3	4	9
Handy	1960	7	5	4	5	10	1		2		8		1		2				3	
Harrison	1960			1	1	5	2	2	2	1		1	2	3		5			3	1
Hartland	1960	2	2	3	3	17	2	1	8	5	26	1	2			3	1	1	1	3
Hersey	1960	3	1	2	1	6					2	1					2	1		
Highland	1960	1	1	13	11	33	5		2	3	13	3	5	1	1	4	5		1	1
Howard	1960		1			5			1	2	15		2	1	2	2	1			2
Independence	1960	2	15	13	8	75	7	10	6	3	60	11	3	4	5	10	7	1	3	2
Kimball	1960	5	10	6	17	107	9	18	9	14	61	1	6	2	5	14	3	3	2	4
Lansing	1960	15	15	13	5	23	7	3	6	3	19	1	4	1	4	3	3	1	6	
Lincoln	1960	8	18	20	17	51	11	12	12	19	69	9	9	5	15	19	9	2	7	6
Lowell	1960	15	23	23	22	12	7	3	12	3	16	4	5	3	4	4	4	8	4	2
Maple Valley	1960																			
Marcellus	1960		2	2	1	4	2	1		2	4		1					1		
Mentor	1960	4	5	1		2		1	3		4			1			1	1		
Meridian	1960	15	20	20	25	30	22	4	10	11	15	7	15	4	5	10	5		3	3
Milford	1960	4	20	21	18	34	8	10	19	8	32	1		1	2	7		4		3
Monroe	1960	8	5	5	2	9	2	1	5	1	5	2	1	1	1	3	1	1	1	1
Mount Morris	1960	2	7	3	5	44	1	1	4	5	40	10	1			4	2	2	3	2
Ogden	1960	5	4	9		3	1		1		2		1			3	1			1
Orion	1960	5	4	12	4	33	11	4	8	6	24	3	7	4	5	6	4	3	8	2
Pentwater	1960				1	8		2			6					2				
Quincy	1960	3	8	6	4	4	6	1	4		5		2	3	3	2	2	3	4	2
Raisin	1960	15	11	15	2	17	3	1	3	4	10	3	3	1		10	5		1	2
Richland	1960	7	8	1	1	20	3	2	4		19		3		1	6	1	1	1	
Robinson	1960	10	17	9	4	23	7	8	4	5	41	4	1	1		8			3	1
Rose	1960			3	2	12	2		1	1	13				1	4				1
Segola	1960	2	13	3	4	6	3		1		6		1		3		4	1	2	3
Sanborn	1960	8	9	3		4			1		3				1			1	2	1
Schoolcraft	1960	5	4	3		2	3	1	2	4	4	3	4	1	3	1			1	3
Scipio	1960			3	1	5	2	1	2		4	2	1		2		2	2		
Solon	1960	8	7	5	5	20		3	1		22		3		1	5	1	1	1	4
Southfield	1960	3	5	5	3	3		1	8	3	9	1	5	3	2	3	1		2	2
Spring Lake	1960		7	10	12	22	10	6	11	6	45	3	2	2	3	15	5	2	4	1
St. Clair	1960	20	15	15	9	9	10	7	7	11	33		5	2	3	5	6	3	5	7
St. Ignace	1960		4	4	2	9		1	1	1	4	2		2	1	2	1		1	2
Surrey	1960					3			2		5	1	1			3	2		1	1
Tallmadge	1960	15	27	10	9	57	5	5	13	22	21	14	6	10	5	14	3	2	1	
Tawas	1960	4	7	2		7			2	1	4			3		1			3	
Tecumseh	1960	5	10	5		6	2				4									1
Thatford	1960	14	20	22	20	72	5	3	8	11	47	4	2	1	2	15	1	6	4	2
West Bloomfield	1960	5	10	8	6	22	8	5	4	4	19	3	3	2	2	8	3	1		1
Wheatland	1960																			
White Lake	1960	7	9	9	9	14	7	4	6	3	29	3	5	1	1	2		2	1	2
Ypsilanti	1960	9	8	8	2	31	9	3	1	1	29	5	9	5		6	2	1	2	4

APPENDIX B Table 2
Number of Unplatted Lots Counted in Sample Townships in 1970

		Size of Lots in Acres																		
Township	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Alamo	1970	6	7	10	2	23	5				24	1	6	4		3	2	1		2
Aloha	1970	1	2	7	10	1					9			1				1		
Austin	1970	15	7	4	2	3	1	1			6						1			
Bangor	1970	3	1	4	5	12			2		7			1	2	1	1		1	
Berrien	1970		1	1	4	1		2	2		5		1			2		1		
Blackman	1970	26	21	12	2	3	4	1	2	2	3		1	1	1	3		2	1	2
Brendan	1970	10	13	4	6	21	10	3	6	5	104	3	3	4	4	3	3	4	3	2
Brighton	1970	20	17	15	10	59	6	6	16	2	54	2	6	3	4	3	1		1	
Buchanan	1970	1	8		3	5	1	1		1	1			1		1	4	1	1	
Cannon	1970	5	5	5	3	8	5	1		2	5	2	1	2			1	1	1	2
Cedarville	1970	2	2		3	3	1	1		1	4	3	1		1	1				1
Centerville	1970	5	5	5		2					5									
Clay	1970	1	3	2		3				1	4		1		1				1	
Clayton	1970	39	4	3	1	6			1	1	7	1				2				
Clinton	1970		8	4	1	13		3		2	5		1			5	3	1	2	2
Columbia	1970	13	12	10	5	2		1			8					2	1	1		2
Delhi	1970	20	20	15	15	11	2		3	1	8	2	1		1	2	2	1	2	4
Dewitt	1970	11	19	4	3	11	1		5		2		1	1						2
Dexter	1970	15	19	1	1	11	2	2	3	3	8			2	1	3			3	
Eaton Rapids	1970	10	15	10	5	10	4		5	2	18	1	3	2		1	1	1		1
Elbridge	1970	5	8	5	1	3														
Flower Field	1970	11	5	1	1	3	1		1		5									
Freedom	1970	8	5	3	1	6	1	5			5	1	1			2				
Genesee	1970	1	3			3	1		1	1	1				1	1			1	
Genoa	1970	16	20	21	10	20	3	4	3	9	41	5	1	2	2	3	1		2	3
Green Oak	1970	10	11	3	10	12	5	3	4	5	21	3	1	5	4	2	2	4		
Gunplain	1970	11	7	3			1		1		11		5		1		2	1	1	2
Hampton	1970	4		3	1	5	1	1	2	1	7			2				3	6	
Handy	1970	16	16	10	3	7		1	4	3	13	1	2	4		1	1			2
Harrison	1970										2									
Hartland	1970	11	15	15	18	17	5	4	2	3	45		2	4	1	3	1	5	1	1
Hersey	1970	3	3	1		2														
Highland	1970	10	10	10	5	50	3	7	9	4	52	3		3	4	5	3	4	3	2
Howard	1970	4	4			8					4	1	2			1	6	1	1	
Independance	1970		8	11	10	26	11	11	3	6	50	5	4	5	1	5	2	3	5	2
Kimball	1970	5	5	5	5	18	1	5		1	11	2	2	3	1	2		1	2	2
Lansing	1970			5		5		1	2		2		1			1				1
Lincoln	1970	4	3	2		1			1		2						1			2
Lowell	1970	5	7	5			4		1	1	14	2	4	3		3	1		2	3
Maple Valley	1970				1	1		1											1	
Marcellus	1970			3		1			2		3								1	
Mentor	1970	9	2	2	1	3	1		1		4									1
Meridian	1970	10	10	10	5	15			3		3		2		1	3				
Milford	1970	15	10	7	15	30	9	3	4	4	60	4	4		4	9		1	3	2
Monroe	1970		1	1		4	2		1		3		3	4	3	2	1		1	
Mount Morris	1970	2	1			3			2	2	7	1					2	1	1	1
Ogden	1970	5	2	2	2	2	3				1									
Orion	1970	10	12	4	3	5	1	1	2		15	6	5	6	4	2	1			3
Pentwater	1970	1	2			3				2	1					1			1	1
Quincy	1970	6	9	3	2	1		2	2	1	4		1	2			1	1		
Raisin	1970	9	4	9	3	5					6		2	1	1	3			2	
Richland	1970	7	10			3	2			1	12	2	1		1	1		1		2
Robinson	1970	10	16	10	2	8	2	3	1	3	15	1	1		2	4	1	1	2	
Rose	1970	14	20	13	2	8	1			1	95	5	1	1	1	1	1			
Sagola	1970	13	10	2	3	6	2	3	2		6	1	2		1	1	2		2	5
Sanborn	1970	6	3	3		4	2	1	2		5	1				1	1		1	
Schoolcraft	1970	8	6	5		2			2		1		3			1	1	1		1
Scipio	1970	4	5			7		3		1	9	1		1		1				
Solon	1970	4	7	4		19	5		2	4	13	1	1		2	1			2	6
Southfield	1970		2	3	2	2	3	3	3	2	6			2	1	1	2		1	1
Spring Lake	1970		2		1	4	1		1		2	1	2	2	1					
St. Clair	1970	15	6	5		9		1	1	1	11	1	3	3	1	1		2		3
St. Ignace	1970	3	6		1	4	3	1	1		3									1
Surrey	1970	1				2					6						1			1
Tallmadge	1970	12	14	9	6	11	5	3	8	7	20	1	6	2	3	6		2	9	1
Tawas	1970	10	22	8	2	1	1	1	1		3					1				4
Tecumseh	1970	2	1	1	5	1	1			1	3		1							2
Thetford	1970	6	6	8	5	12	2			2	12	1				3		1	2	
West Bloomfield	1970	7	8	3	2	4		1	1	1	10	1	2		1	1				1
Wheatland	1970	2	2			1														1
White Lake	1970	3	6	4	2	11		2	5	6	28	2	1	1		3	1	1	4	4
Ypsilanti	1970	8	6	6	6	10	3	2	6	2	16	1	1	5	3	6	1	3	2	1

APPENDIX B Table 3
Number of Unplatted Lots Counted in Sample Townships in 1980

	Size of Lots in Acres																		
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1980	14	11	15	10	25	8	7	6	8	50	4	4	4	1	5	3	1		2
1980	5	3	6		18	1			1	12					1				
1980	11	8	8	5	5		3	3	2	28	1	1	1	1					1
1980	4	1	2	2	13	2	1	3	4	3	1	1	2	1	3		2	3	2
1980	25	28	15	12	15	6	1	5	4	22	3	4	8	1	3	1	4	5	
1980	20	24	20	4	21	3	4	5	6	25	4	4	4	1	8	6	1	1	3
1980	10	15	11	5	310	12	6	5	4	247	14	15	5	12	13	7	7	2	2
1980	17	20	21	20	47	5	4	3	3	88	2	8	2	1	2	2	1	2	1
1980	35	32	14	13	16	7	6	4	4	17	7	7	2	1	5	2	2	2	2
1980	10	15	15	4	26	12	2	2	7	60	4	8	8	1	6	2	3	2	1
1980	2	5	6	2	1	4	2	2	3	6		1			2		1		1
1980	2	5	5	1	5	2	2	2		16	1	4	3	1	3			1	2
1980		6	3	2	8		1	3	3	13	1	2		2	1				
1980		6	1	3		8	3	6	3		1	2	2		1	2	1		
1980		2	4			1			2	6	3	1	1		3		1	1	
1980	10	10	11	7	20					25					1				
1980	9	10	12	11	9	4	4	2	1	29	2	3	1	2	1			4	2
1980	22	20	20	6	3	4	3	3	4	5	4	2	2	1	4	2	2	3	2
1980	17	7	5	9	24	6	7	7	3	61	8	5	4	2	4	4	2	1	3
1980	46	45	43	31	38	17	8	8	2	50	18	3	4	5	3	4	2	4	2
1980	12	11	12	11	6	1	2	3	1	19		4			2		1		1
1980	13	1	1	3	15	2	10	3		23	2	2	1	1	1	2		1	1
1980		7	4	2	4	1	2	2		20	1	2	1		4	3		2	
1980			3		3	4				12	2		1						
1980	13	15	19	2	42	4	5	4	5	88	7	6	2		5	1	1	2	2
1960	10	10	9	11	58	8	4	4	4	64	3	7		6	5	1	2	1	
1980	38	11	11	8	10	4		1	1	38			1		1	2	1		
1980	64	10	5	4	10	1	2	1	5	7	2	1			4	2		2	2
1980	10	7	6	4	27	3	4	3	6	39	1	4	5	3	3	3	2	2	
1980																			
1980	24	24	21	20	26	14	6	5	3	131	7	12	3	2	3		1		1
1980	6	12	10	4	14	6	3	1		30			1		1				3
1980		15	15	10	29	13	5	4	1	111	9	12	7	3	2	2	2	4	2
1980	19	14	18	4	23	2	4	5	4	28	4	4	8	2	7		3	2	1
1980	28	25	28	28	13	5	4	6	4	50	7	6	4	1	9	2	1	1	1
1980	15	12	17	9	41	5	4	11	4	73	5	12	1	5	5	2		3	1
1980				1	1		1			4	1	1			2				
1980	26	14	6	2	10	7	1	3	8	11	1	1	2	4	3	4	3	3	4
1980	20	20	20	11	38	10	4	5	5	68	6	7	3		5	3	3	3	1
1980	6	8	3	5	17	2			2	22	1		1				2		1
1980	10	14	1	2	8	1	3	2	2	19	5	4	3		2	1	1		1
1980	11	10	8	2	13	6		4	3	13			1		1				1
1980	8	5	1	4	2	1	1		3	9	2	2	3	1	2	1		2	2
1980	105	55	57	55	60	6	6	9	7	112	10	8	3	1	9	4	5	1	3
1980			1		5	3	1	2	2	9	2	1	1	1	2			1	1
1980		3	3	2	13	2	3	1		20	2	1	1		4		1	1	1
1980	10	10	10	10	3	3				2			1	1	1				1
1980	5	10	5	5	29	4	10	10	4	19	3	2	3	1	2	1	2	2	1
1980	3	3				1				4									
1980	27	2	4	4	9	5	3	2		7			1	2	1	1	1		1
1980	12	15	15	10	14	7	5	2		20	4	5	3	2	1	1	2		1
1980	10	11	15	1	21	5	5	9	3	78	1	2	3	1	4	1	1	2	
1980	29	37	33	11	51	15	4	9	3	77	1	9	4	4	6	2	3	6	2
1980	7	9	7	1	17	1	6	1	2	41	2	1	2	1	2	2		2	
1980	4	2		6	4	6	1	2	3	30	2	4	4	2	4	1	3	1	
1980	8	26	13	2	5	3	5	10	4	20			1			1		2	3
1980	7	10	11	9	9	3	6	5	3	18	6	2	1	2	4				
1980	3	5	3	8	20		2	3	2	13		1	4	1	1	2	1	1	
1980	13	10	16	11	23	4	7	11	5	51	1	7	5	1	4	1	2	1	2
1980					1	5	2	4	1	4	1	2		2	1		1		1
1980	5	2	2		8	3		2		20	1	1			2			1	2
1980	6	12	9	13	43	21	8	6	17	131	14	11	3	6	11	1	4	5	2
1980	7	5	2	1	3	3	1	1	1	10	1			3	1	1	1	2	2
1980	3	10		3	14					28	1				2				
1980	42	40	33	15	36	18		5	7	26	2	9	3		2	3	2	4	2
1980	12	18	7	3	13	3	5	3	2	40	3	3	5	1	11	1	2		2
1980	15	15	12		4	3			1	18	1	1			6	1			
1980	23	30	25	13	24	2		3	5	39	1			2	2			1	
1980					10	3	1		6	1	2	1	2	1	3			1	1
1980	10	10	5		3		2			5		1							
1980	20	20	15		15	2	1	2		48	5	4	3	2	5	1	4		2
1980	8	10	6	10	33	7	1	4	1	12	3	2	2	2	2	2	4	2	1

APPENDIX B Table 4
Number of Unplatted Lots Counted in Sample Townships in 1990

	Size of Lots in Acres																		
Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1990	15	15	15	15	18	3	5	3	5	25	24	5	5	3	4	1	2		3
1990	2				1					3									
1990	4	2	7	2	1	3	1			7		1	3					1	
1990	1				4	4			3	3	1	1							1
1990	1	9	2	4	4			1		8		1	1					1	
1990	17	17	13	8	6	6	2	3		14	4			1	1			1	
1990	10	8			23			3		43	2	5		3	5	1	2	3	2
1990	3	3	5	4	23	5	2	2	2	83	3	2	3	2	2		2	3	
1990	1	2	3	1	2			1	1	4	2	2	2	1	2	1	1	1	2
1990	4	5	5	2	7	1	1	3	3	76	6	5						2	
1990	1	1						3		10		2			1			1	1
1990	10	10	7	2	8			2		13	3	5	2	3	1		1		
1990	5			3	7	7		2	2	14	2	1	2	1			1		
1990	16	9	1	1	5			1	2	9			3				1		
1990				1	4		1	3	2	3	1	1			1		2		
1990	10	10	15	15	10	2		7		25					3			1	1
1990	7	5			5				3	23	5		2	1	3			2	
1990	10	15	15	2	6	5	2	1	1	8	3		1	1	1		1	1	2
1990	10	10	10	5	6	5	5	4	4	47	10	5	1	2	3				
1990	25	31	25	14	16	10	2		7	24	8	7	4	1	4	1	2	2	
1990	10	5	6	1	5	2		1		4		1		1	2			3	1
1990	7	5	5		11	2	1		1	21	1	3	2		3				1
1990	10	5		1	3	1	3		1	22		5	4		4	1	1	1	1
1990	15	15	15	6	9					10	1	1							
1990	10	10	10	10	17	1	5	2	6	87	7	9	2	3		3	1	1	2
1990	9	7	5	5	26	4		5	4	69	4	5	1	2	4	1	2	2	1
1990	29	23		1	7	2		2		44		1	2		6			3	
1990	23	5	6	1	13	2	5	3	1	16	1	4		2	3		2	4	1
1990	20	20	7	1	16	4	4	3	1	41	2	4	3	3	3	2	1	2	1
1990												1	1						
1990	10	15	15	11	20	5	6	4	2	74	4	6	4	4	4	2		3	1
1990	11	10	10	10	16	2				37	1	4	1	1					2
1990					8					22									
1990	14	12	4	4	10	3	4	6	2	32	3	4	4		6	3			
1990			7		3	2	1	2	1	9	9		5				2		1
1990	5	10	10	10	25	3	1	1	1	48	1	7	1	4	1	3	3	3	3
1990	2	2		1		1				2		1							
1990	3			2	1	2	2	1		4		1		2					1
1990	10	10	13	20	30	14	2	6	4	78	2	5	6	3	1	2	1	1	1
1990	25	9	3	5	11	1	2	1		13	1				3		1	1	1
1990	5	25	1	1	6			1		17			1	2				2	
1990	2	1			1			3		25				1					2
1990	2	2	1					1		1				1	1				1
1990	5	5	3	6	10	7			1	28	3	1	3		1		2		
1990	5	2			6	1	1	2		5	4	2	1	1		2			1
1990	20	20	20		11	3	1		2	35	4	1			2	1			2
1990	10	11	10	6	1					2					1				
1990								1	1		1	1							
1990	3		1		3	1	1		1	3		1	2		1			1	
1990	27	36	7	4	10	2	1	3	1	3	3				1	1			1
1990	15	20	15	10	15	3	4	4	3	30		3	1		1	1	1	2	2
1990	20	20	21	13	17	8	9	8	5	39		12	2		3	1			1
1990	25	30	25	25	19	6	5	7	3	50	2	2				1		4	1
1990	1	6	4	3	13		3	2	5	54		2	3		4		1	2	5
1990	3	5	3	2	7	2	2	3	5	11		3	2		1	3	5		19
1990	17	14	8	4	8	4	3	3		9	1	2	1	1	2	3	1	1	2
1990	10	11	13	9	3	5	2	3	2	9	1	2	2		1	1		1	3
1990	10	12	11	9	10	1	1	1	2	5		1	1		9				2
1990	18	15	15	10	28	5	2	6	2	65	2	3	2	3	3	1			4
1990									1								1		
1990	10	10	10	6	3			2	1	4		4							
1990	10	10	10	10	41	15	8	2	4	80	7	11	6	1	5	1	1	1	5
1990	3	6	9	1	8	1		2	3	15		3		2	2		1	1	3
1990	5	7	6	8	4	4	2	6	1	30	2	2	2	1	7	2		3	
1990	19	19	8		14			2	1	37		1	1			1		1	
1990	16	17	16		10	1				20	1	1	2	1		2	1	2	1
1990	5	5	5		1	1	3	3	3	15	1	3				1	3	1	2
1990	21	20	10	6	15		1	1		22		1		1	7		2	1	2
1990															1	1			
1990	12	8	5		2		1	1	3	4	1				3	1			4
1990	8									10					1				1
1990	10	10	10	8	10	3	1	1		27	2	3		1		1		1	3

APPENDIX C
Results From F-tests Required For Pooling

$$F = \frac{(SSEC-SSE1-SSE2-SSE3)/K}{(SSE1+SSE2+SSE3)/(N+M+P-3K)}$$

F 10,40 = 2.132

EQUATION 1 F= 3.77

SSE1 =	15,033	K=	10
SSE2=	301,245	N=	21
SSE3=	99,528	M=	27
SSEC=	807,846	P=	22

EQUATION 2 F= 3.24

SSE1 =	15,013	K=	11
SSE2=	295,684	N=	21
SSE3=	98,832	M=	27
SSEC=	803,677	P=	22

EQUATION 3 F= 3.24

SSE1 =	14,961	K=	11
SSE2=	294,412	N=	21
SSE3=	98,504	M=	27
SSEC=	800,969	P=	22

EQUATION 4 F= 3.08

SSE1 =	13,022	K=	11
SSE2=	291,966	N=	21
SSE3=	95,605	M=	27
SSEC=	767,953	P=	22

APPENDIX D Table 1
Statistics of Variables Used in Regression Models; MEDAGE and INCOME

		MEDAGE				INCOME			
Township	Density	1960	1970	1980	1990	1960	1970	1980	1990
Alamo	Low	28.3	26.0	23.2	36.2	2,513	2,927	7,246	14,324
Aloha	Low	27.0	26.4	33.3	41.2	1,578	2,045	5,154	10,056
Austin	Low	27.3	26.0	30.2	34.4	1,672	2,380	5,439	10,462
Bangor	High	26.2	25.2	28.6	34.9	2,787	3,297	7,557	14,776
Berrien	Medium	28.9	27.8	30.9	34.7	2,243	2,456	6,047	12,352
Blackman	High	31.0	29.1	30.8	34.5	2,200	2,514	5,863	10,291
Brandon	Medium	24.4	24.1	26.3	30.6	2,468	2,958	8,068	15,874
Brighton	Medium	26.8	25.3	29.1	32.9	2,834	3,682	9,935	20,360
Buchanan	Medium	27.3	26.2	31.9	32.1	2,775	3,038	6,800	14,044
Cannon	Medium	27.0	25.1	29.4	32.6	3,620	4,006	8,824	20,013
Cedarville	Low	42.1	41.4	46.8	44.8	1,784	2,213	6,068	11,165
Centerville	Low	32.3	32.0	29.6	35.1	1,645	2,293	6,206	11,852
Clay	Medium	29.6	32.7	32.5	37.1	3,601	3,408	7,759	16,848
Clayton	Low	27.4	26.5	27.8	33.0	1,527	1,988	4,611	7,578
Clinton	High	22.9	22.7	27.2	32.8	3,079	3,569	8,862	16,864
Columbia	Low	34.5	31.6	32.6	34.9	1,875	2,219	5,226	15,854
De Witt	Medium	24.7	23.9	29.4	34.8	2,678	3,383	8,135	15,275
Delhi	High	28.6	26.5	27.6	32.1	3,138	3,706	8,038	14,505
Dexter	Medium	26.1	24.5	30.1	34.5	2,882	3,678	9,092	19,080
Eaton Rapids	High	28.5	26.7	29.3	34.6	2,321	2,987	7,546	14,194
Elbridge	Low	25.8	24.9	27.5	30.5	1,552	1,826	5,913	8,360
Flowerfield	Low	31.2	25.8	29.2	31.4	2,149	2,562	6,640	12,793
Freedom	Low	24.6	23.1	31.1	36.6	2,568	3,278	8,085	17,611
Genesee	High	30.2	28.2	27.0	32.2	2,573	2,942	7,417	12,531
Genoa	Medium	30.2	28.5	29.6	35.2	2,710	3,522	9,077	21,274
Green Oak	Medium	23.5	22.2	25.8	32.8	2,424	3,150	7,934	17,272
Gunplain	Medium	28.3	27.6	29.7	33.1	2,593	2,903	8,074	14,183
Hampton	Medium	22.2	21.4	28.4	35.5	2,680	3,170	7,355	12,796
Handy	Medium	27.3	25.8	27.0	29.5	2,277	2,958	6,700	13,194
Harrison	High	25.0	24.8	28.4	32.8	3,376	3,913	9,428	18,183
Hartland	Medium	26.7	25.2	27.9	33.7	2,451	3,184	9,069	17,690
Hersey	Low	26.3	25.1	28.6	32.3	2,157	2,752	5,101	8,850
Highland	Medium	25.8	25.5	26.3	30.9	2,659	3,187	7,713	15,716
Howard	Medium	25.6	25.2	31.1	35.8	2,321	3,024	6,837	11,885
Independence	High	23.8	23.5	29.3	34.4	2,989	3,582	9,874	21,271
Kimball	Medium	24.9	27.5	26.8	31.0	2,751	2,604	5,750	11,776
Lansing	High	25.0	23.1	29.8	34.3	3,499	4,132	8,838	15,105
Lincoln	High	33.9	32.6	29.7	34.7	3,051	3,340	8,192	16,231
Lowell	Medium	29.3	27.2	26.8	30.6	2,182	2,415	7,019	14,439
Maple Valley	Low	27.7	25.2	29.6	31.7	1,652	2,536	5,567	11,595
Marcellus	Low	25.2	24.8	29.6	33.2	2,019	2,631	6,044	12,605
Mentor	Low	24.7	24.2	33.6	39.9	2,135	2,767	5,128	7,851
Meridian	High	31.1	28.8	28.0	32.3	3,502	4,136	9,997	20,726
Milford	Medium	37.6	37.2	28.9	33.2	2,912	3,490	9,057	17,745
Monroe	High	23.7	23.1	27.8	31.9	2,750	3,450	7,340	13,277
Mount Morris	High	26.5	24.8	25.5	30.9	2,518	2,880	6,985	12,092
Ogden	Low	21.5	21.3	29.0	32.3	2,222	2,695	7,218	11,336
Orion	High	25.0	24.7	27.5	32.3	2,865	3,434	9,022	17,773
Pentwater	Low	27.5	26.5	41.7	45.1	2,044	2,405	7,275	13,144
Quincy	Medium	39.1	38.1	29.2	32.5	2,762	2,219	6,363	11,794
Raisin	Medium	29.9	29.7	27.2	31.9	2,357	2,858	7,151	12,790
Richland	Medium	30.7	28.2	30.6	34.9	3,111	3,622	9,676	19,401
Robinson	Medium	24.7	23.9	27.2	30.0	2,489	2,807	6,206	13,102
Rose	High	24.5	26.5	33.1	36.4	1,867	2,441	4,480	8,024
Sagola	Low	23.9	24.3	31.4	36.4	2,072	2,526	5,339	9,862
Sanborn	Low	33.4	33.3	28.0	34.4	2,383	2,587	5,845	10,479
Schoolcraft	Medium	38.8	35.6	29.3	33.8	2,714	3,160	7,818	14,315
Scipio	Low	26.6	25.7	28.2	31.8	1,809	2,126	6,130	9,950
Solon	High	26.6	26.3	28.1	32.4	1,790	2,496	6,329	11,494
Southfield	High	25.3	25.0	39.5	42.0	6,430	7,707	18,063	38,418
Spring Lake	High	23.1	22.4	30.6	34.1	3,298	3,719	8,173	17,606
St. Clair	Medium	30.2	33.4	29.6	33.6	2,755	2,608	8,742	15,604
St. Ignace	Low	24.3	25.9	31.0	31.6	2,200	2,450	5,162	8,503
Surrey	Low	24.1	26.1	32.5	36.0	1,630	2,080	5,402	8,985
Tallmadge	Medium	26.3	25.5	26.9	31.3	2,413	2,721	7,249	14,203
Tawas	High	29.3	27.4	33.2	39.3	2,231	2,321	5,491	9,965
Tecumseh	Medium	24.1	23.9	32.8	36.0	2,461	2,984	9,098	17,959
Thetford	Medium	31.8	29.7	25.9	30.8	2,633	3,012	7,621	13,976
West Bloomfield	High	28.6	28.3	32.1	36.7	4,392	5,263	15,124	31,845
Wheatland	Low	26.2	23.6	29.9	30.6	1,296	1,989	5,963	9,992
White Lake	High	25.1	24.8	27.5	32.4	3,031	3,632	8,706	16,750
Ypsilanti	High	26.3	24.7	26.3	29.8	2,763	3,527	8,527	14,977

APPENDIX D Table 2
Statistics of Variables Used in Regression Models; TOTLAB and EMP

	TOTLAB				TOTEMP			
Township	1960	1970	1980	1990	1960	1970	1980	1990
Alamo	748	949	1,385	1,600	729	919	1,316	1,492
Aloha	168	206	294	320	152	186	222	275
Austin	130	183	339	455	119	164	299	415
Bangor	5,722	6,382	8,154	8,191	5,290	5,943	7,128	7,557
Berrien	1,263	1,413	1,816	2,333	1,216	1,366	1,627	2,214
Blackman	4,681	5,295	6,777	6,880	4,444	5,066	6,095	6,381
Brandon	1,259	1,802	4,226	6,547	1,125	1,608	3,782	6,091
Brighton	1,454	2,302	5,294	7,905	1,366	2,186	4,845	7,624
Buchanan	1,272	1,423	1,646	1,805	1,186	1,332	1,470	1,695
Cannon	1,190	1,415	2,617	4,260	1,108	1,310	2,422	4,150
Cedarville	76	78	89	87	58	60	79	79
Centerville	206	252	307	402	193	237	244	363
Clay	34,564	2,375	3,530	4,484	32,939	2,180	2,916	4,193
Clayton	190	213	319	358	176	193	269	301
Clinton	10,899	18,190	35,321	46,602	10,171	17,350	31,735	43,783
Columbia	560	650	823	3,197	533	618	677	2,946
De Witt	3,101	4,166	5,016	5,884	2,918	3,960	4,709	5,617
Delhi	4,344	5,845	8,723	10,615	4,190	5,575	8,097	10,209
Dexter	580	866	1,923	2,443	560	834	1,837	2,408
Eaton Rapids	510	736	1,285	1,620	491	714	1,187	1,568
Elbridge	289	330	367	381	241	283	313	328
Flowerfield	183	257	581	757	183	252	541	688
Freedom	385	574	723	790	371	553	674	773
Genesee	7,735	9,245	10,807	10,798	7,243	8,724	9,190	9,569
Genoa	1,116	1,767	4,243	5,823	1,022	1,636	3,763	5,628
Green Oak	1,764	2,794	4,872	6,228	1,645	2,633	4,407	5,959
Gunplain	1,093	1,331	2,127	2,517	1,056	1,271	1,963	2,393
Hampton	2,194	2,447	4,655	4,706	2,074	2,330	4,106	4,247
Handy	830	1,315	1,978	2,669	764	1,223	1,680	2,440
Harrison	3,867	6,453	11,517	13,611	3,583	6,111	10,327	12,761
Hartland	596	944	2,696	3,763	569	911	2,510	3,537
Hersey	282	320	464	584	279	303	422	517
Highland	2,117	3,029	7,787	9,397	2,000	2,859	6,827	8,859
Howard	1,809	2,313	3,008	3,323	1,732	2,235	2,745	3,115
Independence	4,636	6,635	10,387	13,936	4,278	6,115	9,694	13,283
Kimball	33,283	2,287	2,872	3,632	32,380	2,143	2,473	3,280
Lansing	3,931	5,289	5,539	5,003	3,842	5,112	5,199	4,702
Lincoln	4,170	4,666	6,904	7,399	3,983	4,474	6,444	7,133
Lowell	628	747	1,786	2,579	595	703	1,659	2,465
Maple Valley	80	307	407	492	78	293	351	449
Marcellus	651	832	1,065	1,285	606	782	960	1,200
Mentor	40	49	196	195	35	43	148	176
Meridian	7,865	10,582	15,675	20,084	7,584	10,091	14,935	19,428
Milford	1,876	2,684	4,869	6,510	1,776	2,539	4,442	6,169
Monroe	3,021	3,781	5,038	5,676	2,829	3,658	4,423	5,195
Mount Morris	8,838	10,564	11,511	2,773	8,255	9,943	9,696	2,555
Ogden	454	529	506	515	449	523	465	491
Orion	4,606	6,591	11,151	13,653	4,271	6,106	10,225	12,929
Pentwater	303	346	562	608	284	334	486	560
Quincy	1,320	90	1,953	1,994	1,289	63	1,685	1,850
Raisin	1,454	1,693	2,471	2,824	1,342	1,563	2,243	2,615
Richland	1,146	1,454	2,507	2,906	1,119	1,411	2,428	2,796
Robinson	609	850	1,408	2,059	592	813	1,262	1,978
Rose	213	248	411	418	180	213	352	378
Sagola	297	289	418	493	257	259	372	447
Sanborn	583	598	941	1,049	539	557	759	950
Schoolcraft	1,731	2,197	3,200	3,565	1,678	2,117	3,003	3,369
Scipio	417	477	589	706	399	446	498	647
Solon	206	252	465	635	180	221	408	614
Southfield	4,484	6,417	7,253	7,090	4,383	6,266	7,030	6,881
Spring Lake	2,174	3,036	4,902	5,897	2,115	2,906	4,548	5,651
St. Clair	14,917	1,025	1,675	2,088	13,840	916	1,479	1,952
St. Ignace	236	199	324	435	193	170	247	372
Surrey	540	778	1,167	1,218	512	715	995	1,094
Tallmadge	1,313	1,833	2,977	3,426	1,222	1,679	2,821	3,300
Tawas	408	508	603	679	368	468	517	641
Tecumseh	359	418	750	839	337	392	695	816
Thetford	1,853	2,215	3,767	4,299	1,714	2,064	3,260	3,901
West Bloomfi	7,241	10,363	20,461	30,055	6,984	9,956	19,498	29,007
Wheatland	47	180	261	241	40	149	240	224
White Lake	3,912	5,599	10,593	12,297	3,569	5,102	9,630	11,533
Ypsilanti	9,889	14,759	23,532	25,565	9,173	13,661	20,621	23,948

APPENDIX D Table 3
Statistics of Variables Used in Regression Models; TOTPOP and TOTHOU

		TOTPOP				TOTHOU			
Township	Density	1960	1970	1980	1990	1960	1970	1980	1990
Alamo	Low	1,905	2,492	2,909	3,276	493	641	9,397	1,131
Aloha	Low	274	643	726	707	88	163	252	283
Austin	Low	434	492	898	1,102	111	148	298	391
Bangor	High	11,686	15,990	17,494	16,028	3,275	4,656	5,903	6,039
Berrien	Medium	3,183	3,905	4,302	4,697	914	1,074	1,284	1,544
Blackman	High	16,060	17,060	19,741	20,492	2,988	3,697	5,325	5,988
Brandon	Medium	3,187	4,813	9,526	12,051	822	1,277	2,896	3,980
Brighton	Medium	2,875	5,882	11,222	14,815	787	1,691	3,349	4,711
Buchanan	Medium	2,410	3,252	3,571	3,402	669	948	1,204	1,195
Cannon	Medium	2,525	3,690	4,983	7,928	676	986	1,578	2,574
Cedarville	Low	218	158	212	185	65	76	94	87
Centerville	Low	577	629	709	836	134	137	236	300
Clay	Medium	6,948	6,337	8,518	8,862	2,193	2,095	3,000	3,354
Clayton	Low	572	766	967	908	168	205	300	326
Clinton	High	25,688	48,910	72,400	85,868	6,468	13,026	23,908	32,594
Columbia	Low	1,619	1,951	2,248	6,308	504	572	780	2,412
De Witt	Medium	7,649	9,945	10,038	10,448	2,053	4,106	3,440	4,043
Delhi	High	16,590	13,730	17,144	19,190	4,479	787	6,053	7,014
Dexter	Medium	1,698	2,225	3,872	4,407	476	2,900	1,256	1,584
Eaton Rapids	High	1,597	1,985	2,823	3,003	435	646	849	995
Elbridge	Low	767	918	899	820	215	578	277	284
Flowerfield	Low	722	729	1,290	1,418	215	334	432	473
Freedom	Low	1,065	1,227	1,436	1,486	315	219	486	540
Genesee	High	21,011	25,576	25,065	24,093	5,343	257	8,305	8,830
Genoa	Medium	2,402	4,623	9,261	10,820	719	384	2,996	3,684
Green Oak	Medium	4,631	7,598	10,802	11,604	1,271	6,761	3,193	3,859
Gunplain	Medium	2,796	3,231	4,298	4,754	733	1,457	1,412	1,594
Hampton	Medium	5,387	6,774	10,418	9,520	1,357	2,028	3,765	3,799
Handy	Medium	2,890	3,630	4,681	5,488	854	880	1,580	1,873
Harrison	High	12,910	18,793	23,649	24,685	3,325	1,808	8,677	9,951
Hartland	Medium	1,436	2,574	6,034	6,860	399	1,064	1,744	2,198
Hersey	Low	645	718	1,229	1,455	194	5,519	402	505
Highland	Medium	4,855	8,372	16,958	17,941	1,323	724	5,264	5,898
Howard	Medium	4,622	5,497	6,524	6,378	1,274	227	2,242	2,324
Independence	High	10,890	17,377	21,537	24,722	2,711	2,304	6,652	8,410
Kimball	Medium	6,268	5,963	7,180	7,247	1,594	1,697	2,209	2,430
Lansing	High	14,387	11,145	10,097	8,919	4,071	1,671	4,316	4,029
Lincoln	High	4,462	10,900	13,520	13,604	1,331	178	4,777	5,262
Lowell	Medium	1,567	2,109	3,972	4,774	449	3,705	1,182	1,481
Maple Valley	Low	765	737	1,009	1,022	218	3,260	329	327
Marcellus	Low	1,814	2,033	2,463	2,450	582	630	842	863
Mentor	Low	202	141	462	518	65	247	157	202
Meridian	High	13,884	23,818	28,754	35,644	3,735	618	10,952	13,989
Milford	Medium	5,871	7,256	10,187	12,121	1,568	80	3,260	4,159
Monroe	High	8,343	9,351	11,654	11,909	2,285	6,426	4,121	4,469
Mount Morris	High	20,633	29,349	27,928	6,236	5,177	1,970	8,706	1,876
Ogden	Low	1,305	1,465	1,224	1,146	385	7,585	408	385
Orion	High	11,844	17,096	22,473	24,076	3,170	5,301	7,467	8,548
Pentwater	Low	1,146	1,175	1,424	1,422	394	346	594	612
Quincy	Medium	3,129	233	3,929	4,003	981	415	1,442	1,480
Raisin	Medium	3,061	4,248	5,499	5,648	786	1,077	1,668	1,826
Richland	Medium	2,574	3,728	4,677	5,099	704	94	1,596	1,870
Robinson	Medium	1,618	2,025	3,018	3,925	424	1,201	905	1,165
Rose	High	566	816	1,085	1,260	179	1,061	402	459
Sagola	Low	952	946	1,146	1,168	295	562	402	439
Sanborn	Low	1,413	1,625	2,297	2,196	368	267	762	805
Schoolcraft	Medium	4,418	5,289	6,435	6,705	1,355	306	2,247	2,532
Scipio	Low	1,069	1,283	1,352	1,479	290	468	442	509
Solon	High	2,422	735	987	1,268	658	1,623	327	431
Southfield	High	11,319	17,495	15,031	14,255	3,167	333	5,110	5,530
Spring Lake	High	8,016	8,013	9,588	10,751	2,294	583	3,380	4,121
St. Clair	Madium	2,416	3,303	3,965	4,614	665	4,833	1,283	1,575
St. Ignace	Low	686	547	706	932	199	2,337	226	344
Surrey	Low	1,653	2,291	3,101	3,221	452	910	1,091	1,222
Tallmadge	Medium	3,243	4,883	5,927	6,293	829	159	1,770	1,972
Tawas	High	1,104	1,517	1,463	1,465	299	691	463	532
Tecumseh	Medium	775	1,165	1,480	1,539	211	1,309	474	533
Thetford	Medium	3,843	5,970	8,499	8,333	963	392	2,715	2,825
West Bloomfield	High	14,994	28,574	41,962	54,516	3,929	300	12,877	19,215
Wheatland	Low	544	554	582	513	141	1,613	185	177
White Lake	High	8,381	14,292	21,870	22,608	2,226	7,333	7,037	7,834
Ypsilanti	High	25,950	33,278	44,511	45,307	6,534	4,025	16,162	17,743

APPENDIX D Table 4
Statistics of Variables Used in Regression Models; AGP, DFREE, DCITY, REC, and LAND

Township	Density	DFREE 1960	1970	1980	1990	DCITY	AGP	REC	LAND
Alamo	Low	10.0	3.0	3.0	3.0	9.3	47.51%	32.60%	23,283
Aloha	Low	160.0	12.0	12.0	12.0	160.0	9.87%	70.34%	20,984
Austin	Low	60.0	6.0	6.0	6.0	42.9	21.75%	34.65%	22,892
Bangor	High	30.0	3.0	3.0	3.0	15.7	10.00%	22.43%	9,634
Berrien	Medium	15.0	15.0	15.0	15.0	42.4			
Blackman	High	3.0	0.5	0.5	0.5	29.1	26.61%	19.62%	23,332
Brandon	Medium	30.0	7.0	7.0	7.0	14.0	27.90%	21.71%	22,383
Brighton	Medium	5.0	3.0	3.0	3.0	17.9	8.60%	23.82%	22,117
Buchanan	Medium	18.0	12.0	12.0	12.0	50.5	45.14%	23.76%	22,863
Cannon	Medium	13.0	7.0	7.0	7.0	7.0	29.06%	38.38%	23,872
Cedarville	Low	260.0	160.0	160.0	160.0	260.0	2.81%	81.01%	50,693
Centerville	Low	160.0	60.0	60.0	60.0	160.0	32.45%	39.34%	23,063
Clay	Medium	40.0	9.0	9.0	9.0	21.3	10.58%	22.08%	18,215
Clayton	Low	70.0	8.0	8.0	8.0	48.7	46.05%	40.08%	20,563
Clinton	High	15.0	3.0	3.0	3.0	5.6	10.91%	5.46%	18,114
Columbia	Low	14.0	12.0	12.0	12.0	24.3	27.76%	46.02%	22,657
De Witt	Medium	6.0	7.0	1.0	1.0	7.1	30.07%	18.44%	23,116
Delhi	High	15.0	1.5	1.5	1.5	5.4	48.35%	9.67%	21,118
Dexter	Medium	16.0	6.0	6.0	6.0	13.6	30.01%	31.54%	21,175
Eaton Rapids	High	30.0	15.0	9.0	9.0	14.5	61.63%	16.31%	23,017
Elbridge	Low	15.0	15.0	6.0	6.0	57.8	48.24%	32.09%	23,203
Flowerfield	Low	15.0	4.0	4.0	4.0	18.1	55.60%	28.32%	23,014
Freedom	Low	11.0	6.0	6.0	6.0	12.2	62.04%	17.86%	22,936
Genesee	High	4.0	4.0	4.0	4.0	5.9	18.55%	14.02%	22,896
Genoa	Medium	6.0	2.0	2.0	2.0	24.2	19.28%	26.66%	23,322
Green Oak	Medium	3.0	2.0	2.0	2.0	13.5	16.44%	30.20%	23,714
Gunplain	Medium	6.0	2.5	2.5	2.5	13.1	50.17%	24.60%	23,329
Hampton	Medium	32.0	6.0	6.0	6.0	15.5	67.32%	2.13%	18,808
Handy	Medium	20.0	1.0	1.0	1.0	23.8	61.43%	13.83%	21,083
Harrison	High	16.0	2.0	2.0	2.0	10.2	0.66%	7.26%	9,475
Hartland	Medium	10.0	1.0	1.0	1.0	20.8	27.43%	29.29%	23,850
Hersey	Low	75.0	38.0	8.0	8.0	60.7	26.65%	45.55%	22,628
Highland	Medium	6.0	6.0	6.0	6.0	16.8	21.11%	21.21%	23,141
Howard	Medium	30.0	23.0	23.0	23.0	41.2	54.93%	20.46%	22,709
Independence	High	20.0	1.0	1.0	1.0	8.4	9.87%	22.87%	23,228
Kimball	Medium	45.0	3.0	3.0	3.0	57.5	26.97%	31.62%	23,992
Lansing	High	4.0	1.0	1.0	1.0	3.3	3.71%	9.19%	23,220
Lincoln	High	4.0	1.5	1.5	1.5	49.5	38.29%	14.06%	16,077
Lowell	Medium	1.5	1.5	1.5	1.5	12.2	42.37%	34.25%	21,333
Maple Valley	Low	40.0	30.0	20.0	15.0	40.0	88.55%	5.76%	22,803
Marcellus	Low	16.0	16.0	16.0	16.0	20.5	57.08%	21.31%	21,926
Mentor	Low	150.0	5.0	5.0	5.0	150.0	4.08%	80.34%	22,951
Meridian	High	20.0	3.0	3.0	3.0	6.9	20.65%	15.15%	23,453
Milford	Medium	3.0	3.0	3.0	3.0	15.0	11.55%	25.00%	20,868
Monroe	High	2.0	2.0	2.0	2.0	24.1	57.81%	7.10%	11,377
Mount Morris	High	0.5	0.5	0.5	0.5	5.9	29.69%	8.99%	23,434
Ogden	Low	10.0	10.0	10.0	10.0	36.6	91.28%	6.81%	50,440
Orion	High	26.0	4.0	4.0	4.0	7.3	12.99%	22.67%	22,155
Pentwater	Low	18.0	18.0	3.0	3.0	68.9	0.91%	78.00%	9,090
Quincy	Medium	22.0	5.0	5.0	5.0	40.0	73.87%	15.38%	23,201
Raisin	Medium	15.0	15.0	15.0	15.0	25.1	73.23%	14.04%	23,451
Richland	Medium	9.0	9.0	9.0	9.0	9.3	54.15%	20.69%	23,179
Robinson	Medium	8.0	3.0	3.0	3.0	20.5	36.75%	47.63%	25,646
Rose	High	20.0	20.0	14.0	14.0	69.2	14.42%	66.69%	33,522
Sagola	Low	300.0	150.0	150.0	150.0	300.0	2.15%	84.99%	104,359
Sanborn	Low	90.0	60.0	60.0	60.0	104.4	30.10%	51.86%	28,267
Schoolcraft	Medium	8.0	3.0	3.0	3.0	11.1	59.60%	17.44%	23,047
Scipio	Low	16.0	12.0	12.0	12.0	33.3	67.79%	17.61%	22,680
Solon	High	24.0	3.5	3.5	3.5	17.8	45.71%	31.22%	23,350
Southfield	High	12.0	5.0	5.0	2.0	3.9		0.00%	
Spring Lake	High	15.0	4.0	4.0	4.0	27.1	7.32%	45.02%	21,050
St. Clair	Medium	40.0	0.5	0.5	0.5	30.7	41.87%	21.79%	25,051
St. Ignace	Low	105.0	5.0	5.0	5.0	105.0			
Surrey	Low	75.0	1.0	1.0	1.0	56.8	5.32%	62.87%	22,899
Tallmadge	Medium	4.0	4.0	4.0	4.0	9.6	52.36%	27.09%	21,079
Tawas	High	90.0	30.0	30.0	30.0	61.7	29.24%	48.26%	22,233
Tecumseh	Medium	14.0	14.0	14.0	14.0	21.9	69.01%	11.20%	23,444
Thetford	Medium	7.0	7.0	7.0	7.0	11.1	49.01%	21.98%	22,179
West Bloomfield	High	10.0	5.0	5.0	5.0	5.8	3.59%	24.43%	20,192
Wheatland	Low	65.0	55.0	45.0	37.0	57.2	73.41%	14.48%	23,327
White Lake	High	11.0	11.0	11.0	11.0	10.8	16.20%	29.84%	23,760
Ypsilanti	High	1.0	1.0	1.0	1.0	16.8	28.38%	17.60%	20,391

APPENDIX D Table 5
Statistics of Variables Used in Regression Models;
MORTNOM, MORTREAL, PGAS, CPI_NG, CPI_ALL, and FRMINC

Variable	1960	1970	1980	1990
FRMINC	6,687	8,976	11,343	10,997
MORTNOM	5.492	7.486	10.302	10.194
MORTREAL	3.332	2.886	1.022	6.074
PGAS	30.9	33.8	81.16	98.74
CPI_NG	30.4	40.3	81.9	134.7
CPI_ALL	29.6	38.8	82.4	130.7

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