Economies of Scale in Rental Housing

By
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Bachelor of Arts, Vanderbilt University, 1987.

Submitted to the Department of Urban Studies and Planning
In Partial Fulfillment of the Degree
Of
Master of Science in Real Estate Development
At The
Massachusetts Institute of Technology

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ABSTRACT

People believe that if there are economies of scale at the firm level, then there must also be economies at the asset level. But despite interest, there is no published research on the subject of asset level economies of scale.

The Property Owners & Managers Survey, sponsored by HUD, is a national survey that for the first time allows a cross-sectional study of apartments. The survey provides data on geographic location, revenues, costs and management. Other surveys have focused on highend apartment complexes or low income housing. This survey looks at all levels of housing services and allows a study of property-level economies of scale that cover all levels of the apartment industry.

Economic theory of the firm and its application to housing services is reviewed. The concept and theory of economies of scale are then applied to the apartment complex. Once the theory is reviewed, we look at empirical evidence from POMS to look at the relationship between *operating costs* and *number of apartment units.*

The theory is empirically tested vis-à-vis a regression analysis using *operating costs per apartment unit* as the dependent variable and *number of apartments* as well as other variables as the independent variables. The regression is held constant to allow for a change in *units.* If economies of scale are present, then the *operating costs per unit* must decrease as *units* increase. A graphic representation of the equation demonstrates economies of scale over a limited data range.

Thesis Supervisor: William Wheaton
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CHAPTER 1

INTRODUCTION

Section 1.1: Introduction to the Problem

The real estate market is rapidly changing and becoming more consolidated. The 1990s brought in the era of REITs and large public real estate companies. With this change comes talk about economies to scale for the company. The thought is that if the company is bigger, than it is better because increased size allows lower operating costs. This is the theory that many REITs employ to attract investors. The theory that bigger is better also has been applied to the actual building.

But despite interest, there is no published research on asset level economies of scale.

The Property Owners & Managers Survey, sponsored by HUD, is a national survey that for the first time allows a cross-sectional study of apartments. The survey provides data on geographic location, revenues, costs and management. Other surveys have focused on highend apartment complexes or low income housing. This survey looks at all levels of housing services and allows a study of property-level economies of scale that cover all levels of the apartment industry.

Section 1.2: Objective

This thesis uses the Property Owners & Managers Survey to investigate property-level economies of scale. Economic theory of the firm and its application to housing services is reviewed. The concept and theory of economies of scale are then applied to the apartment complex. Once the theory is reviewed, we look at empirical evidence from POMS to look at the relationship between *operating costs* and *number of apartment units.*

To look at the relationship, we first have to create a regression equation that relates *operating costs per unit* to hypothetical determinants. This equation has *number of units* among these *hypothesized determinants in order to see what happens to operating costs per unit as number* of units increases.

The relationship between *cost per unit* and *number of units* can be presented as a cost curve, once the regression equation holds constant other variables. The hypothesis is that the curve will show economies of scale with a steep slope at the beginning and slowly flattening out at the tail end.

Section 1.3: Thesis Organization

Chapter 2 introduces the theory of the firm. It begins by defining the firm and saying what the purpose of the firm is. Concepts and definitions of total *cost, marginal cost,* and *average cost* are introduced. Subject to the input prices of consumer demand and production technology, the firm is described as trying to maximize profits by minimizing

total average costs. This optimal point is at the intersection of the marginal cost line and average total cost line. The theory is expressed in terms of housing services.

Chapter 3 is an overview of the Property Owners & Managers Survey. The chapter describes the survey as being sponsored by the Department of Housing and Urban Development and having the purpose of gaining a better understanding of the supply side of the rental housing market by interviewing property owners and managers. After a brief statistical description, the survey results are summarized in terms of physical, financial, and management characteristics.

Chapter 4 creates the model and analyzes the regression results. The first section describes the regression model, the questions that it must answer and the data it must use. Sections 4.2 and 4.3 discuss how the observations were screened and the variables were selected. The final section analyzes the results of empirical estimation of the regression.

Chapter 5 discusses economies of scale. The regression model is used to calculate the *operating costs/ unit* as the *number of apartment units* is increased from 5 to 624. The relationship is graphically represented to show that economies of scale do exist within the range of the POMS data.

Chapter 6 is a summary chapter that concludes with the findings of the thesis. Important findings are discussed and any implications of economies to scale are discussed.

CHAPTER 2

ECONOMIC THEORY OF THE FIRM AND ECONOMIES OF SCALE

Section 2.1: Introduction

Chapter 2 introduces the reader to the theory of firm and economies to scale. The theory gives the reader the fundamental understanding of the mechanics and how to view the theories. The objective is having the reader know how real estate and, more specifically, property level assets fit into the model.

The chapter begins with the purpose and constraints of the firm. Then the various concepts of *costs, input and output factors, production decisions* and *diminishing returns* are introduced. A final section discusses economies of scale and why property level assets are expected to have economies to scale.

Section 2.2: The Firm

A business is an entity that is formed to buy and sell products in order to make a profit. The firm's goal is to make a profit through the reduction of costs and an increase in revenues. The real estate company makes its profit by producing and selling housing services. To produce the product, the company uses land, materials and operational items. Housing services are be measured in *units of apartments* and the cost of the inputs is measured in *operating costs per unit.* Because apartments are not all the same, measuring units of production through *apartment* can be limiting. However, standardizing amenity

levels, age, location, geographic location, and other factors controls for the differences in apartments. Given this adjustment, *operating costs per unit* is the best measure of cost.

Constraints

The selling of the product and maximization profits have two constraints. Constraint one is consumer demand. The landlord works within a competitive marketplace. There is a lot of rental housing and there are a lot of renters. Inherent in competitive markets is that there is no monopoly power. There are few, if any, locations where the market is dominated by a company that sets prices and production. Because of this, the landlord is constrained by buyers of rental services wherein the price is manifested through the rental rate.

Constraint two is the firm's cost of production. The firm can sell only to a willing buyer. A firm must decide which products will bring a profit to the firm and allow the firm to maximize profits. To produce the product and make a profit, the landlord must consider the cost of the product and the best combination of inputs.

In deciding the right level of output and combination of inputs, the level of output is determined by the pricing structure of supply and demand. A production function and the cost determine the optimal choice of inputs. The function graphs the relationship between levels of input and quantity of outputs based on technology and not economics. Once the most efficient combination of inputs is determined, the landlord can determine the cost of production. So, in order to maximize profits the firm must decide what combination of

factors of production will minimize costs for a given output. In rental housing, the landlord decides on the best combination of inputs (bedrooms, square feet, location, amenities, Anderson windows, etc.) that will produce the highest rent at the lowest cost.

Costs

There are fixed costs and variable costs. A fixed cost is the cost "associated with inputs that do not vary with the level of production."[1]. When the level of production changes and the amount of inputs change, the fixed cost component does not vary. A fixed input does not change in quantity in the short-run. An example is the maintenance cost of a communal swimming pool. A swimming pool has to be cleaned every day and backwashed once a week. Let us assume that the cost for this maintenance is $1000/month. Assuming standard use by tenants, the amount of labor and material is constant whether there are 50 or 100 units in the complex. So, these costs are fixed at any reasonable number of units. However, there are input costs that go up with an increase in *number of units.* This is seen in Exhibit 2-1.

Variable costs are those can change in the short-run as the level of output changes. If a landlord adds extra apartments to his property, certain costs are likely to rise. The cost of office support staff is an example. The landlord knows that for the first 25 apartments he adds to his complex, he needs one extra staff worker. If the cost of an office worker is $2,000 per month, then each additional apartment costs the landlord $80/month. These costs are seen below in Exhibit 2-1.

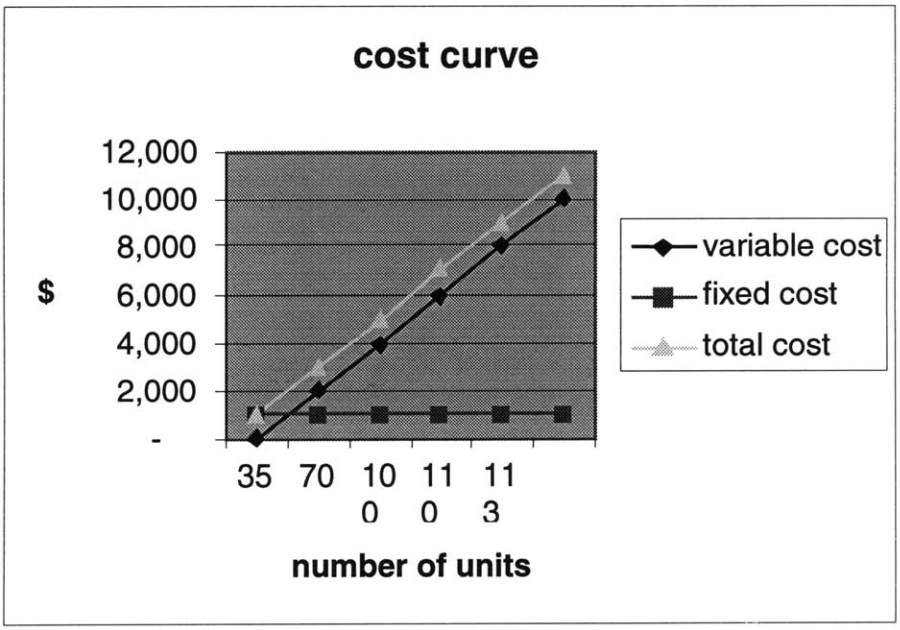
[1] Stiglitz, Joseph E.; Principles of Microeconomics; W.W. Norton & Company, 1997; p. 225.

Costs can also be calculated as total and marginal. "Total costs are defined as the sum of variable and fixed costs."[2] See Exhibit 2-1. These costs measure the expenditure for the respectively named inputs and outputs. Exhibit 2-2 is a graphic illustration of the costs associated with production inputs.

EXHIBIT 2-1

# of output (apartments)	variable cost (staff labor)	fixed cost (pool maintenance)	total cost (f + v)
-	-	1,000	1,000
35	2,000	1,000	3,000
70	4,000	1,000	5,000
100	6,000	1,000	7,000
110	8,000	1,000	9,000
113	10,000	1,000	11,000

EXHIBIT 2-2



[2] Principles of Microeconomics; p. 256.

Marginal cost is "the extra cost corresponding to each additional unit produced."[3] For instance, the marginal total cost equals the difference in the total cost divided by the marginal product. Exhibit 2-3 shows the calculations for marginal total costs.

EXHIBIT 2-3

# of output (apartments)	variable cost (staff labor)	fixed cost (pool maintenance)	total cost (f + v)	marginal total cost
-	-	1,000.00	1,000.00	-
35.00	2,000.00	1,000.00	3,000.00	57.14
70.00	4,000.00	1,000.00	5,000.00	44.44
100.00	6,000.00	1,000.00	7,000.00	66.67
110.00	8,000.00	1,000.00	9,000.00	200.00
113.00	10,000.00	1,000.00	11,000.00	666.67

Another way of looking at costs is through an average per unit cost for total costs. Table 2-4 shows the per unit cost calculations. These costs measure the expenditure for the respectively named inputs and outputs. The following Exhibit 2-4 illustrates the costs associated with production.

[3] Principles of Microeconomics; p. 256.

EXHIBIT 2-4

# of output (apartments)	average variable cost (staff labor)	average fixed cost (pool maintenance)	average total cost (f + v)
-	---------	--------	-------
35.00	57.14	28.57	85.71
70.00	57.14	14.29	71.43
100.00	60.00	10.00	70.00
110.00	72.73	9.09	81.82
113.00	88.50	8.85	97.35

Costs are either implicit or explicit. Explicit costs are the outwardly obvious costs of inputs. The costs of the labor or the wood going into the rocking chairs are both explicit costs. Implicit costs are not direct costs but instead are defined in economic terms as opportunity cost. This is the cost incurred by not using your assets in an alternative use. The landlord who developed an apartment complex had the choice of leasing out the land to another. The lost rent is the opportunity cost or implicit cost. Although implicit costs are not included in accounting records, these costs are real part of doing business.

Production Factors

In the short-run, input factors are either fixed or variable. To increase production in the short-run, the only thing that can be done is to increase the variable production factors.

The fixed factors of production cannot be changed. But in the long run, all factors can be changed. The labor or materials used for the maintenance of the swimming pool is a fixed input of production. To return the example of property management, if to manage an additional apartment requires 2 hours per month, and then the variable labor input per unit per month is 2 hours.

There are two measures of output; one measure is the total output and the second measure is marginal output. Total output is the total number of product produced. Marginal product is "the increased output corresponding to a unit increase in any factor of production."[4] In the following Exhibit 2-5, as the number of variable inputs increase and the fixed input remains constant, the total product increases from 5 to 13. The marginal product increases for each of the first two variable inputs but it decreases thereafter.

EXHIBIT 2-5

# of variable inputs (staff)	# of fixed inputs (pool maint.)	total # of output (# apartments)	marginal product of variable input (apartments)
-	-	-	-
1.00	1.00	25.00	25.00
2.00	1.00	70.00	45.00
3.00	1.00	100.00	30.00
4.00	1.00	110.00	10.00
5.00	1.00	113.00	3.00

[4] Principles of Microeconomics; p. 252.

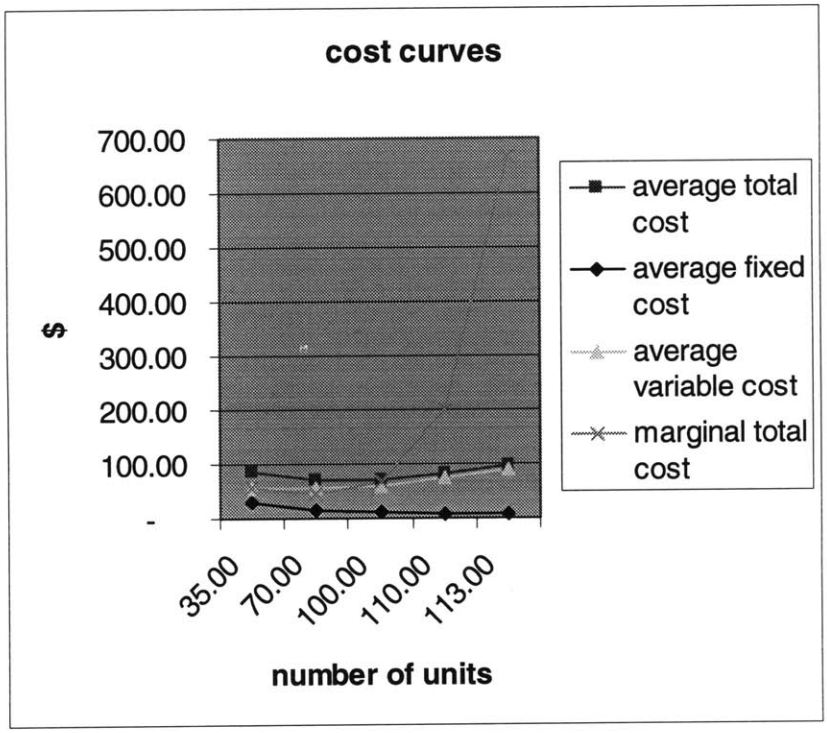
In trying to maximize profits a firm must not only try to maximize revenues through output but also try to minimize costs. There are two types of costs and three ways of measuring the resulting profits. Accounting profits are the difference between revenue (number of product sold x sales price) and the total explicit costs. The economic profit is defined as "revenue minus rents minus implicit costs (opportunity costs of labor and capital)".[5]

Production Decision

The firm production decision can been see in Exhibit 2-6. The firm desires the lowest average total cost. That point is found at the intersection of the marginal cost curve and the average total cost curve. When the marginal cost per unit is lower than the current average cost per unit, the average total cost per unit must continue to fall. But when the marginal cost curve rises above the average total cost curve, then the average cost curve must also begin to rise. This point also holds for the marginal cost curve passing through the variable cost curve.

[5] Principles of Microeconomics; p. 299.

EXHIBIT 2-6



The Law of Diminishing Returns states that "each additional unit of labor generates a smaller increase in output than the last."[6] The above Exhibit 2-6 shows that as more labor is added, the number of apartments per worker increases until the third worker is added. Then the marginal product of labor decreases from 45 to 30. An apartment office can use only so many workers. At some point the workers will start getting in each other's way. It is at this point that diminishing returns occur. This example also shows that diminishing returns is a short-run problem. In the long run the fixed factors of production can be

[6] Principles of Micro Economics; p. 253

changed so that the variable inputs can become more efficient. In our example, the company can increase the size of its office and allow the workers more room.

It is important to determine at what levels of production the average cost of outputs increase, decrease or remain the same. When average costs are decreasing, the firm's "output increases more than proportionately"[7] to input. This is called economies of scale. However, at some point the firm reaches a level where they produce a level of output that is proportionate with the level of input. This phase is called constant returns to scale. When the firm is near full production and there are minimal levels of increased production, the firm experiences diseconomies of scale. This occurs when the number of increased inputs is greater than the number of increased output.

Section 2.3: Hypothesis

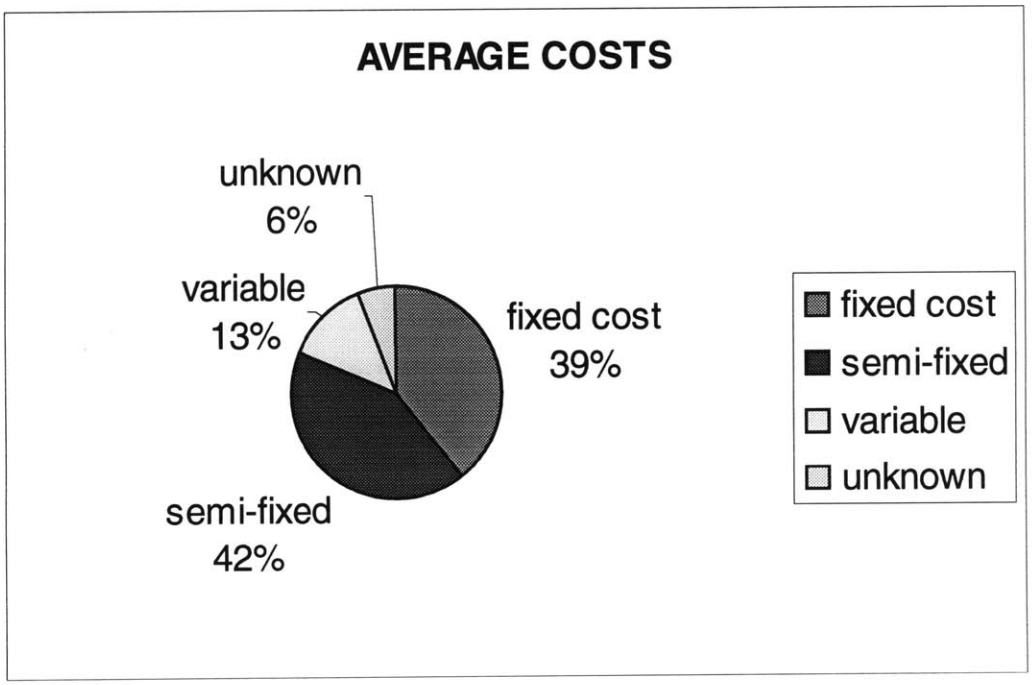
Our hypothesis is that economies to scale do exist in the rental housing market. This thesis studies only those rental properties with five or more units and the hypothesis is meant for only those properties within the POMS.

It is believed that the *average total cost curve* for housing services will have a step slope at the beginning and slowly start to flatten out as the number of apartments increases. The shape that is just described is a normal economy of scale curve.

[7] Principles of Microeconomics; p. 268.

The economies to scale for rental housing are primarily due to the spreading out of fixed costs. Exhibit 2-7shows that the sample of apartments has an 39 % of total costs that act fixed. These are the costs that become spread out over an increased number of units and act to lower the *average total operating costs/ unit.* Some of the fixed costs are for services and some are for maintaining capital assets. Most of the capital assets, which are fixed, do not become strained from the increased number of apartment users. Instead they maintain efficiency and help create economies of scale.

EXHIBIT 2-7



There is also a 42 % of total costs that act somewhat fixed. These are costs that do increase at a slower rate than the *number of units.* These costs help to decrease the *average total operating costs/ unit.* Finally there are the variable costs, 13%, that vary will vary with units and eventually create *marginal diminishing return.*

CHAPTER 3

An Overview of the Property Owners and Managers Survey

The Property Owners and Managers Survey (POMS) was sponsored by the Department of Housing and Urban Development, and conducted in 1995 by the U.S. Census Bureau. The POMS was the first national survey of its kind, providing valuable new information about rental housing in the United States. The purpose of the survey was to gain a better understanding of the supply side of the rental housing market, by interviewing property owners and managers who provide rental housing. The survey asked owners and managers of privately held rental housing questions about structural, financial, ownership and management characteristics of their properties. Owners were also polled about their attitudes about ownership, plans for their properties, and views on governmental regulations.[8]

The universe was approximately 29,300,000 privately owned rental housing units in the U.S. The initial sample was approximately 16,300 housing units, taken from properties included in the 1993 American Housing Survey.[9] A unit (and the property containing the unit) was included in the survey if it was a privately owned rental unit at the time of the 1993 housing survey, and was still a rental in 1995. A unit was considered a rental unit if

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[8] Savage, Howard, "What We Have Learned About Properties, Owners and Tenants From the 1995 Property Owners and Managers Survey," *Current Housing Reports*, U.S. Department of Commerce, Economics and Statistics Administration (October 1998), 1.

[9] *Property Owners and Managers Survey Technical Documentation*, U.S. Department of Commerce, Washington D.C.: February, 1997.

it was currently rented, occupied rent-free by a person other than the owner, or vacant but available for rent. Publicly owned properties (public and military housing, or housing owned by another federal agency) were not included in the survey.[10] Information was collected between November 1995 and June 1996. Separate surveys were given to owners of single- and multi-unit properties. The resulting multi-unit data set contained 5754 observations.

The data permit analysis at either the property or unit level. Information about the location of each property is very limited. Properties are identified as in one of the four census regions (northeast, south, east and west), inside or outside a metropolitan area, and inside or outside a central city. States, metropolitan areas, and cities are not specified. The lack of detailed information about location is one of the most significant limitations of the POMS data, since it does not allow differentiation at the level of the jurisdiction or market area.

Table 2.1: Census Regions

Northeast	Connecticut, Maine, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont
Midwest	Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Nebraska, North Dakota, Ohio, South Dakota,

[10] "Property Owners and Managers Survey: Source and Accuracy Statement," U.S. Census Bureau website (www.census.gov/hhes/www/housing/poms.html). Properties used primarily for vacation homes were also excluded. Note that properties built or converted to rental between 1993 and 1995 were not included in the sample.

	Wisconsin
South	Alabama, Arkansas, Delaware, District of Columbia, Florida, Georgia, Kentucky, Louisiana, Maryland, Mississippi, North Carolina, Oklahoma, South Carolina, Tennessee, Texas, Virginia, West Virginia
West	Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, Wyoming

Source: Technical Documentation for Property Owners and Managers Survey, 1995-1996, U.S. Department of Commerce, Economics and Statistics Administration, Bureau of the Census

The POMS collected information about the following aspects of rental housing:

- *Ownership:* characteristics of owners, ownership structure, attitudes toward the property, and reasons for owning.
- *Property and unit characteristics:* including age of structure, amenities, and recent capital improvements. Also, estimations of current value, value relative to other properties, and recent changes in property value.
- *Financial characteristics:* includes method of and reasons for acquiring the property and mortgage information. The data includes detailed operating income and expense information, including rents from both residential and commercial space, and itemized expenses from the previous year.

- *Management policies:* including procedures for handling maintenance, tenant screening and turnover.
- *Governmental benefits and regulations*: includes property benefits received, such as tax credits and abatements, and participation in the federal Section 8 rental housing subsidy program.

POMS Data Overview

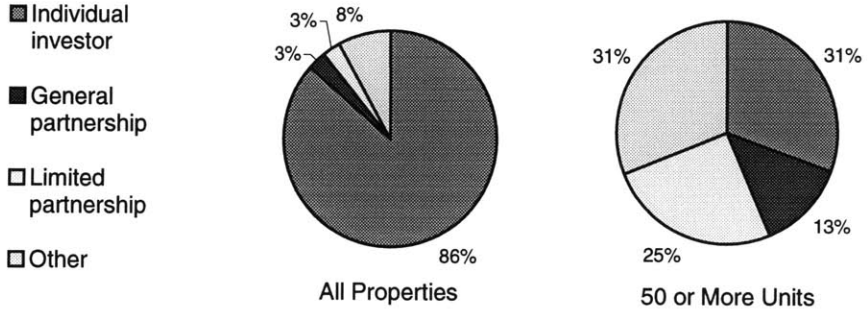
The following summary, unless otherwise specified, presents property-level information based on the entire multi-unit data set. This summary relies heavily on a U.S. Census report, "What We have Learned About Properties, Owners and Tenants From the 1995 Property Owners and Management Survey," by Howard Savage.[11]

Owner Characteristics

Most properties were owned by individual or partnership owners, half of whom owned only one property. However, the breakdown of ownership types varied considerably between small and large properties. Small properties were most likely to be owned by an individual, at 90 percent. In contrast, only 32 percent of the owners of properties with over 50 units were owned by individuals. Larger are more likely to be owned by partnerships (38 percent), corporations (11 percent), or non-profits (6 percent). As of 1995, Real Estate Investment Trusts (REITs) owned a negligible percentage (1 percent) of residential properties in the United States, but because their properties tend to be

[11] Savage, 1.

Figure 2.1: Ownership Type



larger, this represents an estimated 417,612 units (2 percent).[12] Roughly one fourth of multifamily properties were owner-occupied. This percentage was significantly lower for larger properties. 29 percent of small properties (less than 5 units) had owners living on the premises, while this was only true for 3 percent of properties with 50 or more units. Owners of large properties seemed more pleased with their properties, generally. Eighty-seven percent of owners of properties with 50 or more units reported that they would buy their property again. Meanwhile, only about two-thirds of small and medium-sized properties would buy their property again.

The primary reason investors acquired rental property was to receive income from rents, at 33 percent. The second most common reason for acquisition was for use as a residence. Smaller properties were more likely to be bought for this purpose: a third of all properties under 5 units were purchased for use as a residence. Only 10 percent of all

[12]"Multi-family Unit Tables: Owner Characteristics," U.S. Census Bureau website.

owners purchased their property for long-term capital gain. However, 22 percent of properties over 50 units were acquired for this purpose.

Half of multifamily property owners were between 45 and 64 years old, 85 percent were white (94 percent for large properties), 8 percent were African American, 6 percent were Hispanic and 4 percent were Asian or Pacific Islander.

Property Characteristics

As shown in Table 2.2, the distribution of properties among census regions was relatively uniform, with the largest number of properties in the south. Just over half of all properties were located in central cities, and only 10 percent were outside of metropolitan areas. The northeast was the most urban, with 56 percent of properties located in central cities. Of the four regions, the midwest is the least urban, with less than half of all properties located in central cities and 16 percent located in rural areas.

Table 2.2: Location of Multi-Unit Properties

			Distribution Within Region		
	Total	% of Total	Central City	Suburb	Rural
All Properties	5754	100%	52%	37%	10%
Northeast	1348	23%	56%	38%	7%
Midwest	1287	22%	48%	36%	16%
South	1770	31%	54%	35%	11%
West	1349	23%	51%	42%	7%

46% of all units were in properties with more than 50 units in 1995, up from 43 percent in 1991.[13] Larger properties also tended to be newer: 85 percent of properties over 50 units were built since 1960, which was true for only half of properties as a whole. Larger

properties were also more likely to be located in the south and west. While over half of multifamily rental properties are in the northeast and midwest, only about a third of properties over 50 units were located in these regions.

58 percent of multifamily properties made a profit or broke even, and 27 percent had a loss. 16 percent of those surveyed didn't know if the property was profitable during the previous year.[14] Only 3 percent of properties over 50 units reported losses, but a high 37 percent reported that they didn't know whether the property was profitable. Researchers from the National Multihousing Council point out that this may be because the interviews were done in early 1996, before the previous year's profitability was determined.[15]

The most common capital improvements during the years 1990 to 1995 were bathroom renovations, kitchen facility replacements, and heating system upgrades.[16] Only 12 percent of properties included handicap-accessible units.

According to owners, 38 percent of properties housed mostly low-income people, and 39 percent were occupied by mostly middle-income people. Only 3 percent of multifamily properties have mostly high-income renters, and these renters were more likely to be in properties with more units. According to a report by the U.S. Department of Housing and

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[13] "Highlights from HUD's New Survey of Property Owners and Managers," *Research Notes*, National Multihousing Council (February 1997), 1. The 1991 figure was from the 1991 Residential Finance Survey conducted by the U.S. Census Bureau.
[14] U.S. Department of Commerce Press Release, 1.
[15] "Highlights from HUD's New Survey of Property Owners and Managers," 1.
[16] U.S. Department of Commerce Press Release, 1.

Urban Development based on the POMS data, roughly half of multifamily units qualify as affordable according to HUD standards.[17]

Financial Characteristics

Average rental receipts per unit were $5,152.[18] Operating income and expenses varied widely among properties. Yearly median operating expenses per unit were $2,300. Large properties had higher median operating expenses, as $3,300. This is likely due to regional cost differences, and the fact that larger properties tend to be in more expensive cities. Three-quarters of units were in mortgaged properties. Average mortgage expenses were $1,139 per unit, or 22 percent of rental receipts.

Management Policies

About 21 percent of owners reported that they were seeking new tenants at the time of the survey. Approximately one-quarter of properties with less than 5 units rejected tenants in the last two years, and 85 percent of properties with 50 or more units. The main reasons tenants were rejected for apartments were poor credit, insufficient income, and unfavorable references. 55 percent of the owners of multifamily properties were attempting to reduce tenant turnover by redecorating or making other improvements. 27 percent of properties offered rent concessions to retain residents. Larger properties were more likely to offer increased services as a means to retain tenants. Owners at less than one percent of properties were trying to increase tenant turnover.

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[17] "The Providers of Affordable Housing." *U.S. Housing Market Conditions, 4th Quarter 1996*, U.S. Department of Housing and Urban Development, Office of Policy Development and Research, (February 1997), 2. Affordable rental units are identified as those that a family with 50 percent of the HUD-adjusted median income could afford without spending more than 30 percent of their income on rent.

The median amount of gross rental income spent on maintenance was 14 percent. Smaller properties spent a smaller percent of income on maintenance.[19]

Governmental Benefits and Regulations

Overall, 7 percent of properties have Section 8 tenants, with larger properties more likely to participate in the Section 8 program. 4 percent of properties participated in other Federal, state, or local housing programs. Owners of larger properties were much more likely to know about the Section 8 program, at 88 percent. Nearly half of small multifamily property owners did not know about the program.

When asked what governmental regulations made it more difficult to operate the property, property taxes were consistently ranked highest, regardless of size of property. Parking was also listed as a major complaint.

Limitations of the Data

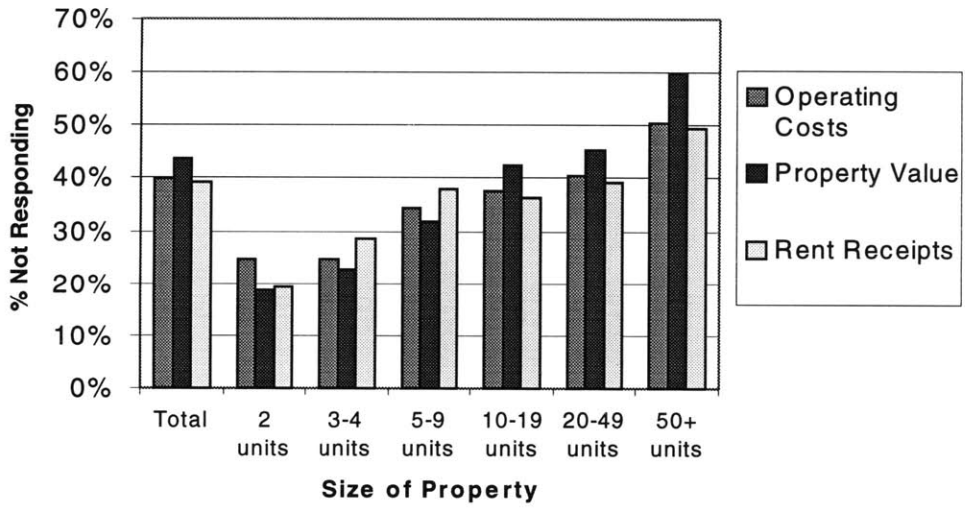
An important consideration in analyzing the data are the rate and pattern of non-response to the survey questions. Few categories were completed by all respondents, and many fundamental questions had high rates of non-response. Financial information, in particular, was frequently not reported. According to the Census, 40 percent of represented units did not provide complete operating cost data.[20] The category most responded to, advertising cost, had a 38 percent non-response rate. Six of the twenty

[18] Emrath, Paul, "Property Owners and Managers Survey," *Housing Economics 45* (July 1997), 7.
[19] Savage, 2.

operating cost categories had over 50 percent non-response rates. When tabulated by property size, the larger the property, the less likely the owner was to respond to operating cost questions.

Tabulation of the survey responses revealed only 32 percent of individual owners responded to all sixteen operating cost categories. This was slightly better than the response rate of properties owned by limited partners (29 percent) and much better than the response rate of real estate corporations (18 percent), the third largest owner type.

Figure 2.4: Non-Responses by Size of Property



[20] "Property Owners and Managers Survey: Source and Accuracy Statement," op. cit.

CHAPTER 4

REGRESSION MODEL & ANALYSIS

The multivariate regression analysis performed has the purpose of exploring economies of scale within rental housing services. As the number of units increases, all else equal, do operating costs per unit decrease? Over what range do they decline, and at what level of output are they exhausted? These are the fundamental questions that Chapter 4 attempts to answer.

This chapter describes the model, how it was built, and the information it uses. The last section discusses the regression results and the influence of the explanatory variables on *operating costs per unit.* In analyzing the variables, heavy emphasis is placed on concepts in Chapter 2.

Section 4.1 describes what the model must control for and how the scale economies question will be addressed. Section 4.2 discusses how the observations were screened, and Section 4.3 introduces the variables used in the regression.

Section 4.1: Model

A regression equation is a mathematical relationship that describes how a number of independent variables affect another stand-alone variable called the dependent variable. The equation reads as follows:

$$Y = \text{constant} + B1*x1 + B2*x2 + B3*x3 + \ldots\ldots$$

The explanatory variables on the right side, x1 and x2 …, are hypothesized determinates of operating cost per unit. The coefficients for the independent variable, B1 & B2 …, each indicate the effect on the value of the dependent Y. The y-intercept is the constant term.

Since a regression equation measures the influence that one variable has on the dependent variable while the influence of other variables are held constant, the variables on the right hand side should cover as much of the variation in the Y-value as possible.

In creating a model to test for the hypothesis, the prime dependent variable is *operating costs per unit.* The model has to test if, as the number of units increased, the operating costs/unit decrease or increase. And, it has to explain the shape of the curve. Economies of scale can be seen most simply as output (number of apartments) on the x-axis and the cost/ unit of production on the y-axis. Additionally, *number of units* appears in a quadratic form because this functional form can capture a downward slope that gets

In selecting the remaining variables, it is helpful to think of what types of factors might strongly influence the dependent variable. There are four basic groups of characteristics that do this*: location/neighborhood, physical characteristics, ownership/management, and tenant characteristics.*

Location/market: What is needed from the location variables is the ability to control for regional and metropolitan influences. Wage rates differ greatly from area to area, and this difference can influence the operating costs through general labor, cleaning costs, and maintenance work. Additionally, the costs of supplies and other commodities might be higher and thereby affect other operating costs of the apartment complex. The region may climatic influences. The southern apartments predominantly use air conditioning and northern apartments use heat. The air conditioners are much more mechanical and will break down more often and result in higher repair costs. So, it would be nice to be able to control for regional variations.

Neighborhood factors are also important. If the apartment is in a run down area, the landlord may not have the incentive to put money into the property and thus artificially lower the operating costs. Additionally, there may be regulatory issues that affect the operating costs. Often times, large cities have strict regulation requirements pertaining to the environment or to an overtaxed utilities. California and Florida are notorious for water reduction plans that affect a landlord in negative ways. Neighborhood variables are necessary.

Physical Characteristics: Physical characteristics are critical differences among apartment complexes. The structural and mechanical quality of the property affects the maintenance, utility, and turnover costs. Amenities are another physical characteristic that has implications. Without controlling for amenities, the costs of swimming pools, and athletic facilities that are associated with large complexes will be factored into the operating costs. An amenity variable will control for all the different items in housing services.

Ownership/Management Characteristics: Ownership and management issues are pertinent to *operating costs/ unit.* Some owners might be experts in real estate management while others are just beginning to learn. Large management companies may receive discounts on services and supplies that would affect *oc/u.* Additionally, it would be good to know if the site had on-site management as this item presumably allows closer supervision of daily costs and management.

Tenant Characteristics: Tenant mix and related information are critical. Depending on the type of tenant, operating costs can differ substantially. If there are two equally sized apartment complexes, and one rents to individuals who continually abuse the property and the other complex rents to responsible individuals, then the latter is going to have lower operating costs.

A successful model must incorporate several things. The model must take the form of a quadratic equation with the *number of units,* and control for the five characteristics as stated above. All of the above information is not available in the POMS but much of it can be obtained and proxies can be used for some of the remaining questions.

Section 4.2: Selecting Observations

Because the Property Owners and Managers Survey is less than ideal with respect to the variables used and the response rates, special care taken in selecting appropriate data for this thesis.

Screening out observations from the entire data set was a two-part process. The initial screen was for observations that had full information on certain critical variables. These variables are *operating costs, region, metro area, vacancy questions,* and *year built.* The second part of the process was to screen the first cut of observations for appropriately sized properties.

Step One: Screening Observations Through Five Critical Variables

The first screening was for five critical variables: *operating costs, number of units, the year built, region, and metro.* If any respondent did not provide complete data for these variables, the observation was excluded. This process reduced the number of observations from 5,754 to 1,371.

Economies of scale means that the cost of producing a single output decreases with an increase in the level of output. The traditional means of graphing the relationship is with the *cost of inputs/unit of output* on the y-axis and the *level of output* on the x-axis. As discussed in Chapter 2, the cost for the inputs of production will be measured in *operating costs / unit.* The level of output is measured in the *number of apartments.*

To measure *operating costs/unit,* it is necessary to be accurate in the calculations of operating costs. There are twenty-two different operating costs that are listed. From these numbers it is possible to calculate the sum.

The critical reason for accurate and complete operating costs is that the properties need to be honestly compared. Some properties have high operating costs and others have low operating costs. If an apartment has the utilities supplied in the rent, then utility costs for the apartment complex will be unusually high compared to a complex that has tenants paying for their own utilities. Operating costs vary widely between apartments and leaving out some of the operating costs will badly skew the results.

Once of the most important variables is *oc/u.* The first cut of observations was for properties that did not answer every question on the component costs of *oc/u.* As described in the next paragraph, operating costs are used in calculating the dependent variable. Of the twenty operating cost questions, eighteen were used in screening and testing. The excluded two questions related to mortgage interest and mortgage insurance, which customarily are not considered to be operating costs.

testing. The excluded two questions related to mortgage interest and mortgage insurance, which customarily are not considered to be operating costs.

Likewise, it is critical to know the number of apartments in each and every complex used in the data. If part of the data is missing, or inaccurate, then the *operating cost/unit* will be artificially high. And the results would show that the economies to scale are less substantial than they actually are.

The number of units in a property was critical. When economies of scale for apartment complex size is discussed, the explanatory variable is *number of units*. However, the *number of units* was not supplied directly. The number of apartment units was calculated from survey questions. The survey asked for: 1) the number of occupied units; 2) the number that were vacant and for sale; 3) the number that were vacant and for rent; 4) the number that were vacant and for sale or rent; 5) the number of units vacant and not available; 6) the number that were furnished; and, 7) the number of units that were rent free (usually used for maintenance or managerial workers as part of compensation). To calculate the number of units in any one property, items 1 through 5 and number 7 were summed. The methodology is seen in Exhibit 4-1.

EXHIBIT 4-1

OCCUPIED	VACANT FOR SALE	VACANT FOR RENT	VACANT FOR SALE/RENT	VACANT NOT AVAIL	RENT FREE	# UNITS
5	0	0	1	0	1	7
7	0	9	0	0	0	16
2	0	0	0	0	0	2
3	0	2	0	0	0	5
6	0	4	0	0	0	10
8	1	8	0	0	0	17
4	0	0	3	0	0	7
5	5	6	0	0	0	16
100	0	0	0	0	0	100

Another variable that needs to be screened for is *year built.* It has a special relationship to the production function. The production function is a relationship between inputs and outputs and is not based on economics but on technology. With an increasing technology, the number of inputs can be reduced for a given number of outputs. Or the efficiency of the inputs is greater and leads to lower operating costs.

For apartments, the production function describes the relationship between the number of inputs (windows, doors, heaters, air-conditioners, etc.) and the number of output with advances in energy efficiency and the longevity of mechanical equipment. However, these advances also increase the number of mechanical systems within any one building. This means that newer buildings have more moving parts and more items to break and/or

maintain. The age of the building also affects the required maintenance. Older buildings generally require more maintenance because they were built with lower building standards, older materials, and systems. The lower building standards create a higher occurrence of settling which means that floors sag, and gaps in doors and windows occur. The older materials mean that roof flashing and coverings wear out, pipes rot and corrode and electric is inadequate or faulty.

In addition to *operating costs* and *number of units,* there are three other variables for which screening occurs. They are *year built, metropolitan location and region.* The first variable, *year built,* is a proxy for the production function. The second and third variables, *region* and *metro,* provide location information necessary to control for geographic differences. Such differences show up in costs, building size, etc. For instance, the Northeast has higher costs and smaller properties than does the South. It is absolutely necessary to control for these items in the regression analysis. Without doing so opens up the analysis to grave differences in the quality, cost and supply of housing services. So, if any observations excluded information from the survey on this area, the apartment was dropped from the list of observation.

have aberrant cost characteristics. EXHIBIT 4-2 shows comparative figures for "under 5 units" versus "more than 4 units." The operating costs are much lower for the smaller group, which is probably due to the fact that most of the properties are individually owned and accounting records are sparse and/or inaccurate. Work often is performed by the owner but not paid for; and, therefore there is no accounting for the labor cost. Larger properties have a significantly higher percentage of management companies doing the work, and the companies do charge and account for labor. This difference also is seen in such items as supplies. One exception to this cost anomaly is property taxes and insurance costs. This brings the point that clearly defined costs are accounted for by the small owner while incidental or time costs are not. When properties with less than five units were removed from the data set, the number of observations dropped from 1,371 to

operating cost/ unit	more than 4 units	less than 5 units
mean labor	51.14	301.54
median labor	0.00	109.69
mean supplies	58.42	80.36
median supplies	0.00	27.27
% managed by a company	3%	27%

854. Bogdon and Ling (1998) used 853 observations to calculate NOI cashflows.

Section 4.3: Selecting Variables

There are 854 observations and 222 available variables for each observation. This section describes the variables, their expected influence on the dependent variable and their

descriptive statistics. The variable selection process seeks to provide control variables for the five characteristics listed in Section 4.1: *Location/Market, Physical Characteristics, Ownership/Management,* and *Tenants.*

Location/Market Characteristics: The differences across geographical locations are expected to influence *operating costs/ unit.* Section 4.1 discussed the wage, cost, regulatory and climatic differences. In order to catch the differences wages, costs, and climatic differences, dummy variables were created from the POMS data. There are five dummy variables that combine regions and metropolitan area. These variables have been combined with *region* and *metro*, except for the *rural.* There were not enough observations for rural in each of the four regions. *Rural* is listed alone and is the excluded variable. To control for some of the regulatory issues that arise in different markets, an index of regulatory controls was created. The variables capture the presence of regulations on water, utilities and other areas. Utility restrictions may mean landlords pay for utilities with one master-meter.

Rent control is used as a location variable. Properties with rent control are income constrained and the owners must watch costs as the sole way to increase *net operating income.* It is expected that rent control properties have lower *operating costs/ unit.* Rent is included because rents tend to be higher in properties that are nicer or in expensive areas such as New York City. Here, rent is acting as a proxy for high levels of housing services and for high rent districts, both of which tend to have higher operating costs. All of the variables are listed, along with their descriptive statistics, in Exhibit 4-3.

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The expected effect of all of the regional combinations is positive. The rural areas are expected to have the lowest *operating costs/ unit. Rent control* will have a negative coefficient. However, the presence of regulations and restrictions will have a positive effect. *Rent* is expected to have a positive coefficient because high rents are indicative of high cost of living areas and of nicer properties. These nicer properties have more housing services, which increase *operating costs/ unit.*

EXHIBIT 4-3

	Variable	N	Minimum	Maximum	Mean	Std. Deviation
	operating costs/ unit	570	107.5	11323.65	2669.832	1434.223863
	number of units	570	5	624	85.37895	104.3014267
	units squared	570	25	389376	18149.27	40539.50518
location/market						
	rent	570	100	1699	493.7386	222.0703907
	northeast/midwest-city	570	0	1	0.277193	0.448005752
	northeast/midwest-subs	570	0	1	0.147368	0.354784156
	south/west-city	570	0	1	0.282456	0.450589462
	south/west-subs	570	0	1	0.161404	0.368225873
	regulatory restrictions inde	570	0	3	0.108772	0.363676164
	rent control	570	0	1	0.231579	0.42221189
physical						
	built pre50s	570	0	1	0.266667	0.442605059
	built in 50s and 60s	570	0	1	0.331579	0.471194084
	built in 70s	570	0	1	0.280702	0.449736731
	built in 80s and 90s	570	0	1	0.210526	0.408040545
	amenity index	570	0	14	4.670175	2.888676451
	upgrade index	570	0	7	1.063158	1.25607579
ownership/mgmt						
	utilities supplied/rent	570	0	5	2.489474	1.003015525
	maintenance plan	570	0	1	0.857895	0.349464752
	management company	570	0	1	0.250877	0.433898746
	owner paid for labor	570	0	1	0.25614	0.436883653
	individual owner	570	0	1	0.452632	0.498188375
	nonprofit owner	570	0	1	0.063158	0.243460393
	company owned	570	0	1	0.480702	0.500066286
	value	570	15000	26000000	2754085	3948527.502
tenant						
	turnover less than 20%	570	0	1	0.636842	0.481332209
	turnover 20-50%	570	0	1	0.236842	0.425518015
	turnover above 50%	570	0	1	0.091228	0.288186074

Physical Characteristics: Physical characteristics will play a large role in operating costs and there is a great need to control for this factor. Construction methods and materials have improved over the years, making buildings more efficient and, in some cases, requiring even more upkeep. In addition, there is physical depreciation that has occurred in various stages according to the age of the property. To capture both of the items, dummy variables have been created. The are four *Year built* variables and the excluded case is *built pre50s.* The quality of the building is addressed by an index of upgrades. A final item that is controlled for is amenities. As discussed in Section 4.1, the amenities level has to be controlled for because of the extra costs associated with the amenities. There are seventeen amenities that are controlled for in an *amenity.* Another item controlled for is *Number units.* This item is necessary because it is the means by which economies to scale are measured. This variable is continuous in our regression. The last variable is *Unit squared.* This item is not meant to control for any variances. Its purpose is to create a quadratic equation for the production function that forms a downward slope that gets flatter and flatter. *Utilities included in rent* is included to control for properties that pay tenant utilities as opposed to properties paying for just common area utilities. This can be a significant cost in older buildings that have common heating and cooling systems.

The expected effect of *Built5060s, Built70s, Built8090s, amenity index* is negative. The new technology should lower *operating cost/ unit. Number of Units,* also should have a negative effect. The hypothesis of the paper is that as the number of apartments increase, the *oc/u* should decrease. *Units squared* should have a positive sign. *Utilities supplied*

should have a positive coefficient. Finally, the *amenity index* should have a positive effect on *oc/u.* The costs should rise as the number of amenity increase.

There are several items that are not being controlled for and are not available in the POMS data. Some of the items are important. They are such items as square feet of space, number of bedrooms, number of bathrooms, number of floors, and the quality of the apartment. The only item to be controlled for that has a proxy is quality of apartment. A stand in for this quality measurement is *Security* which is included in the *amenity index.* The security guards at site are generally found only in nicer complexes. The other items are not available in any form. They have been listed in the AHS, however the link between the AHS and POMS is blind. So much of the square footage type information can only be estimated.

Ownership/Management/Financial: Several dummy variables have been included to capture the effects of different management and ownership style. In creating the model, Section 4.1 stated the need to understand the experience level of the owners/managers. Professional managers presumably have greater level of skill in managing properties and should do a better job than owners who manage it themselves. To capture this effect, a dummy variable, *Management company*, is created. Three dummy variables control for size and ownership. One variable counts *Individual owners,* another controls *Corporate owners*, and the third measures *Nonprofit owner.* The excluded case is *Corporate Owner.* Three extraneous but important dummy variables are *Maintenance, Owner paid salary,* and *management company.* The latter controls for deferred upkeep and helps measure for

quality differences. The implication is that if the landlord has a maintenance plan, the property may have been kept in good shape. *Owner paid salary* is to capture differences that may occur in labor costs that do not get accounted for. Although this problem was partially addressed in the screening for property size, it is again addressed.
It is expected to control for buying power and management expertise. *Value* controls for net operating income. It is reflective, no of the level of housing services but of operating cost containment and rent maximization.

Individual owner, Nonprofit owner, Owner paid wage, would be expected to have positive signs. *Resident manager, Management company,* and *Maintenance* are expected to have negative signs. *Value* will have a negative sign.

Tenant Characteristics: There are three variables that control for any possible differences in tenant characteristics. The dummy variables control for differences in tenants. The turnover rate is grouped by *turnover<20%, turnover 20-50%* (excluded variable), and *turnover >50%.* Either that the property is overcharging for the space or that the tenants cannot afford to stay in the apartment and are vacating for whatever reason. High turnover rates have dramatic affects on operating costs because apartments need to be repainted, recarpeted, and holes in walls fixed.

Turnover >50% has an expected positive coefficient. Because the excluded dummy variable for turnover is *Turnover 20%-50%,* the expected sign for *Turnover <20%* is negative.

Regression Model

The new regression model, taken from the above variables (listed in Exhibit 4-3) and placed into the quadratic form described in Section 4.1 gives regression equation that can estimate the coefficients for the determinants of *oc/u.*

From this output it will be possible to analyze the central hypothesis. In the Section 4.5, the model will be analyzed and compared to the expected coefficients.
However, the whole point of this model is to be able to test the hypothesis that *operating cost/ unit* decrease when the *number of units* increases. Chapter V will test and analyze this hypothesis.

Section 4.4: Regression Results

This section analyzes the results of the regression equation. A discussion of the variables' statistics and its relation to the expected sign and significance are performed. The discussion will take the same form as Section 4.3. EXHIBIT 4-4 contains the results of the regression equation.

EXHIBIT 4-4

Variable	B	Std. Error	Beta	t	Sig.
(Constant)	1155.624	325.6336		3.548847	0.00042
number of units	-3.542487	1.751411	-0.257621	-2.022648	0.043596
units squared	0.001267	0.003603	0.035807	0.351575	0.725293
location/market					
rent	2.018324	0.252806	0.31251	7.983674	8.41E-15
northeast/midwest-city	424.9489	184.3014	0.13274	2.305728	0.0215
northeast/midwest-subs	448.0735	205.4056	0.11084	2.181408	0.029579
south/west-city	105.8589	181.8622	0.033258	0.582083	0.560751
south/west-subs	251.6674	205.2404	0.064614	1.226208	0.220649
regulatory restrictions index	176.8548	143.2897	0.044845	1.234246	0.217642
rent control	450.6395	134.4953	0.132661	3.350597	0.000862
physical					
built in 50s and 60s	-124.6775	164.5731	-0.040961	-0.757581	0.449028
built in 70s	-183.8508	159.5933	-0.057651	-1.151995	0.249827
built in 80s and 90s	-374.5107	179.9349	-0.106549	-2.081367	0.037866
amenity index	9.542675	18.63614	0.01922	0.512052	0.608822
upgrade index	39.54272	43.07688	0.034631	0.917957	0.359047
ownership/mgmt					
utilities supplied/rent	281.0432	56.29457	0.196546	4.992368	8.04E-07
maintenance plan	9.661767	154.5011	0.002354	0.062535	0.950159
management company	64.62182	129.2544	0.01955	0.499958	0.617306
owner paid for labor	-316.8947	124.449	-0.09653	-2.546382	0.011158
individual owner	-461.1199	128.2967	-0.160173	-3.594169	0.000355
nonprofit owner	72.34073	226.6081	0.01228	0.319233	0.749672
value	6.81E-05	2.42E-05	0.187464	2.815444	0.005047
tenant					
turnover less than 20%	-188.326	125.1513	-0.063203	-1.504786	0.132957
turnover above 50%	-22.35425	203.9408	-0.004492	-0.109611	0.912758

R	R Square	Adjusted R Square	Std. Error
0.553184	0.306013	0.276779113	1219.698

Location/Market Characteristics: Out of four dummy variables for geographic location, only two are significant. The *Northeast/Midwest-city* and *Northeast/Midwest-suburb* were significant with respective significance of .0215 and .0295. And large positive *Bs* of 425 and 448 respectively. All of the other areas had significance above .22 and a positive coefficient. What this indicates is that there is large variation across the Northeast/Midwest regions versus any of the other regions and cities. Though the South/West areas had low *t-stats*, their coefficients are positive. The results are consistent with the idea that the rural areas have the lowest operating costs. *Regulations index* is not quite in the significant range and it does have a positive coefficient. *Rent* has a Beta of 2.01 and is highly significant at a *t-stat* of 8.41-15. This indicates that increasing rents helps explain increasing operating *costs/ unit.*

Physical Characteristics: The signs for *year built* are all negative and in absolute terms increase with more recently built properties. The negative signs and increasing coefficients indicate that the more modern buildings have lower. As expected, the *number of units* has a negative coefficient and is significant. And while *units squared* has an expected positive coefficient, it is not significant. Suprisingly, while amenity index is positive, the variable is not significant. These finding is consistent with Bogdon and Ling.[21] In looking at Bogdon and Ling, NOI and Gross Rent values, they found that amenity index was not statistically significance. The *upgrades index* was not significant and it had an unanticipated positive coefficient. One explanation for this sign might be that the cost of the upgrades shows up in *other costs*, which is a component of *operating*

[21] Bogdon and Ling, "The Effects of Property, Owner, Location, and Tenant Characteristics on Multifamily Profitability;" Journal of Housing Research, V.9, Issue 2; pp. 285 – 315.

costs/ unit. Another possible explanation is that the upgrades in the last year were expensed rather than capitalized.

Management/Financial/Ownership Characteristics: There are three out of the seven variables that do not have statistical significance: *current maintenance plan, nonprofit ownership,* and *under company management. Under company management* has an unexpected positive coefficient and suggests that non-company run properties have lower *operating costs/ unit.* But what this might suggest is that the non-company run properties do not properly account for many costs and thereby inaccurately decreases their *operating costs/ unit.*

There are four significant variables: *value, utilities supplied in rent index, individual owned,* and *owner paid wage for work.* The coefficients of *owner paid for work,* and *individually owned* are of interest. These variables have an unexpected negative coefficient which may reflect the fact that small individual owners may not record all their costs. *Value* has a positive Beta, .0000681 and a *significance* of .005. The positive Beta indicates that valuable properties have high *operating costs/ unit* because of extra housing services.

Tenant Characteristics: Interestingly, none of the tenant variables had any statistical significance. It is realistic and to be expected that the tenant mix has an impact on the *operating costs per unit* but those variables are not in the data.

CHAPTER 5

ECONOMIES OF SCALE

As is seen in the previous chapter, there are various determinants of *Operating costs per unit* for apartments. Though the regression shows the relationship between the various determinants, the one that this section focuses on is *Number of units.* As has been previously discussed, the two variables that show economies to scale for rental housing are *Operating costs per unit* and *Number of units.* The chapter shows that there are economies to scale, and attempts to explain what are some of the components that create decreasing average total costs.

Economies of scale shows that when the firm's average total costs are decreasing, the "output increases more than proportionately."[22] For apartment complex, the complex's average total operating costs is decreasing for each succeeding apartment. The relationship of *Operating costs per unit* and *Number of units* can be estimated through the regression equation set up in the Chapter 4. The regression equation allows all of the explanatory variables to be held constant while *Number of units* and *units squared* are adjusted. In changing *the Number of units,* it is possible to measure its the effect on *Operating cost per unit.* This relationship can be graphically represented. If economies to scale do exist, then the shape of the graph should be concave and downward sloping.

[22] Principles of Microeconomics,; p.

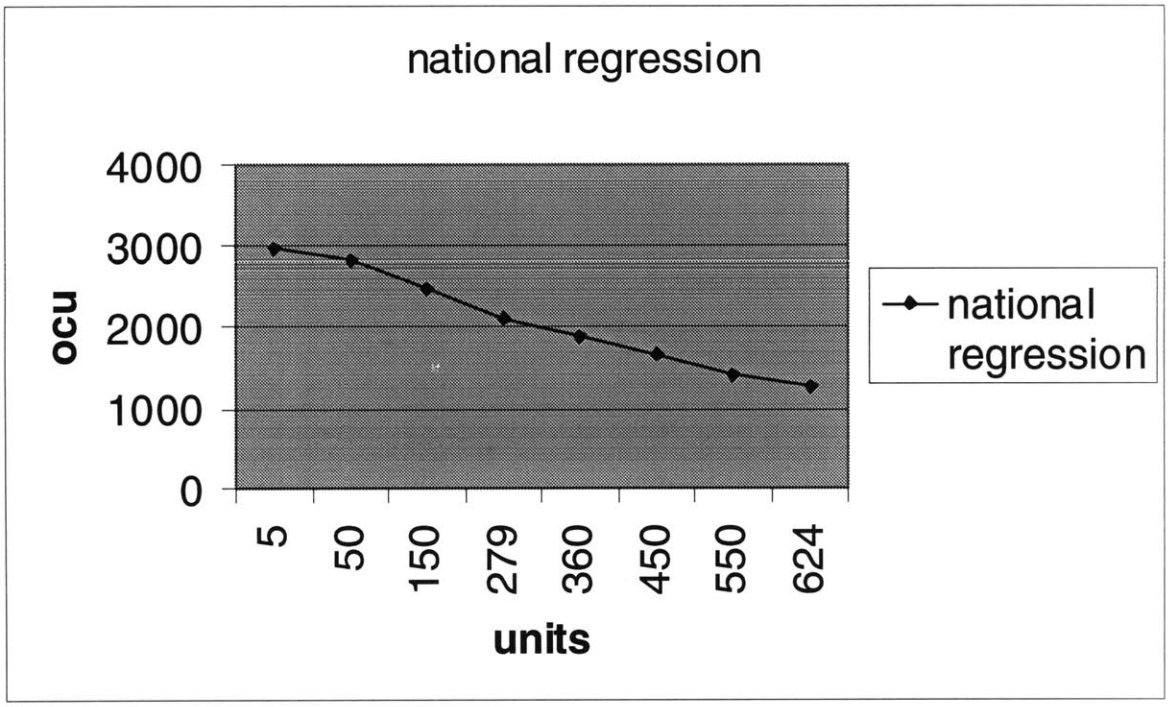
A number between 5 and 624 is plugged into *Number of units* and *units squared* in the regression equation to calculate *Operating costs per unit*. Exhibit 5-1 shows the equation for *Operating costs per unit*.

EXHIBIT 5-1

OCU = 2982.656 - 3.54249 (UNITS) + 0.001267 (UNITSQD)

As the number of units is increased, all else equal in the equation, the average total operating costs per unit decreases. The graphic representation for the relationship is also shown in Exhibit 5-2. The downward sloping curve shows that economies to scale exist. It is important to note that the regression and analysis is good for only the range of units used in the data set. The highest number of units in the data set is 624.

EXHIBIT 5-2

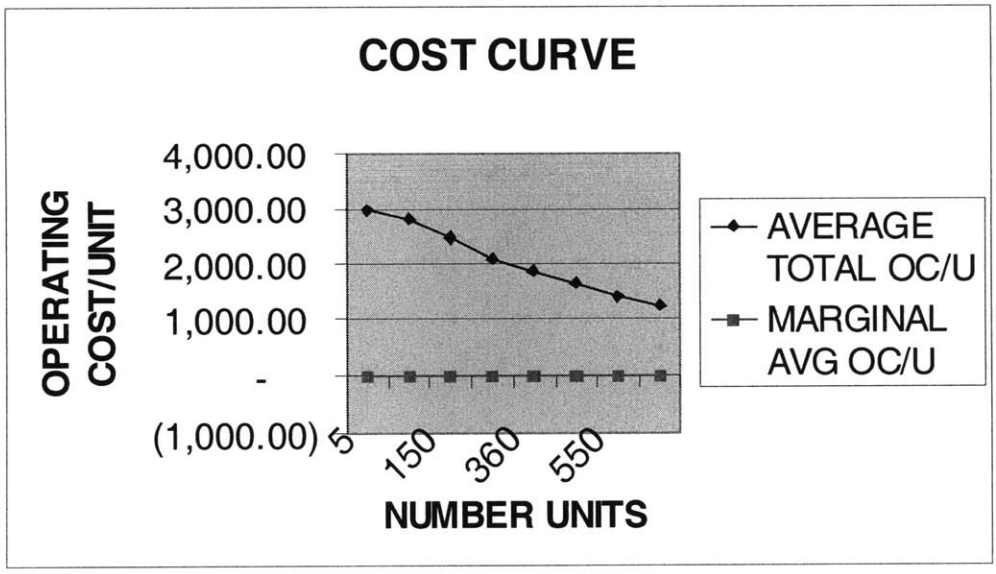


At the beginning of the curve, there are decreases in the *marginal average total cost/ unit.* These large changes create the slope at the beginning of the *cost curve.* At the end of the *cost curve* the slope will start to flatten out because of the quadratic equation and we see that the marginal returns are much less. This relationship and shape is what is normally expected. The marginal cost for the mean number of units is given in Exhibit 5-3.

UNITS	UNITS OPERATING COST/UNIT	UNITS - 1 OPERATING COST/UNIT	MARGINAL AVERAGE COST/UNIT
5	2,964.98	2,968.51	(3.53)
50	2,808.70	2,812.12	(3.42)
150	2,479.79	2,482.95	(3.16)
279	2,092.91	2,095.75	(2.84)
360	1,871.54	1,874.17	(2.63)
450	1,645.06	1,647.46	(2.40)
550	1,417.49	1,419.64	(2.15)
624	1,265.40	1,267.36	(1.96)

The relationship between the *average total operating cost/ unit* and the *marginal average total operating cost/ unit* is shown in Exhibit 5-4.

EXHIBIT 5-4



Operating Costs:

Economies of scale exist because the cost per unit of input decreases as the number of outputs increase. Up to this point, Chapter V has shown that such a relationship exists; however, it has not been shown why the cost/production relationship occurs. The reason is that there are two types of costs, *fixed* and *variable,* and they behave differently when production increases.

Fixed inputs are those inputs of production that do not change in quantity as the level of output increases or decreases. Variable inputs do change in quantity as the level of output increases or decreases. The cost associated with each factor of input is either a fixed cost or variable cost. The total cost of the output is the sum of the fixed and variable costs. So as the level of input increases, the fixed cost/ unit of output gets smaller. While the variable cost may increase, decrease, or remain constant. It is the combination of these items that determine if economies of scale exist. In the case of housing services, the fixed costs are a large percentage of total operating costs, and the effect is to create lower costs/unit as output increases.

Operating costs are either fixed or variable. But some of the costs may act a little like fixed costs and a little like variable. The operating costs supplied in POMS fits this description. And sometimes, it is not possible to tell which type of cost it is. Exhibit 5-5 shows the operating costs and how variable or fixed the cost is. The pie charts in Exhibit 5-6 show the break down for the various costs. On average, for all of the property sizes the unknown costs are 6%. This operating cost in the POMS is listed as *other costs*, and

EXHIBIT 5-5

		5 TO 9	10 TO 24	25 TO 49	50 TO 99	100 TO 14	150 TO 29	300 TO 62	AVERAGE
	PROPINS	8%	7%	5%	5%	4%	4%	4%	5%
	RETAXES	23%	22%	18%	17%	17%	14%	19%	18%
fairly	**LABOR**	1%	7%	8%	15%	15%	20%	18%	12%
fixed	**ADVERT**	1%	1%	1%	1%	1%	2%	2%	1%
cost	**TRAVEL**	2%	1%	1%	0%	0%	0%	0%	1%
	LEGAL	2%	3%	3%	2%	1%	1%	1%	2%
	sum	37%	40%	36%	40%	38%	41%	43%	39%
	OTHRINT	2%	2%	0%	0%	0%	0%	1%	1%
mid	**REPAIRS**	27%	19%	19%	16%	13%	15%	13%	17%
range	**UTILITIES**	19%	17%	18%	19%	18%	21%	19%	19%
variable	**GROUNDS**	2%	2%	2%	2%	3%	3%	3%	2%
cost	**SUPPLIES**	3%	3%	4%	3%	3%	3%	2%	3%
	sum	53%	41%	44%	41%	36%	41%	37%	42%
	REFERLS	0%	0%	0%	0%	0%	0%	0%	0%
variable	**TRASH**	2%	2%	2%	2%	2%	2%	2%	2%
cost	**CLEAN**	3%	2%	4%	2%	2%	2%	2%	2%
	COMMISN	0%	0%	1%	1%	0%	0%	0%	0%
	MGMT	3%	9%	9%	8%	9%	8%	9%	8%
	sum	8%	14%	15%	12%	13%	13%	13%	13%
?	**OTHRCST**	2%	5%	5%	7%	12%	5%	6%	6%
	sum	2%	5%	5%	7%	12%	5%	6%	6%
sums		100%	100%	100%	100%	100%	100%	100%	100%

without knowing what costs comprise it, the variableness of it cannot be determined. It is quite possible that this is the catchall category for managers who are not certain where to put certain unusual costs.

Semi-Fixed Operating Costs: The semi-fixed costs comprise approximately 42% of the total operating costs. This means that as the number of units increases, these costs begin to spread out among the larger number of units and decreases the *per unit* cost. For instance, *Other interest,* is considered a semi-fixed cost. In the real estate industry interest is usually for fixed assets which by nature do not change in quantity in the short-run. Utilities are another example of a semi-fixed cost. Generally, the utility costs for an apartment complex are for the upkeep, maintenance, office and common areas. Although, these items are slightly affected by an increase in units, they will not go up less than in proportion.

The repair costs for the complex will act a little like fixed costs. While it is true that the number of repairs for units will go up, there is still repair work for the common areas. Additionally, the labor cost, which is the largest percentage of repair cost, does not go back proportionately. Grounds cost, defined as those costs associated with common areas and grounds upkeep is considered a semi-fixed cost. When the number of units is increased, a building site tends to become denser. This means that while the use of the

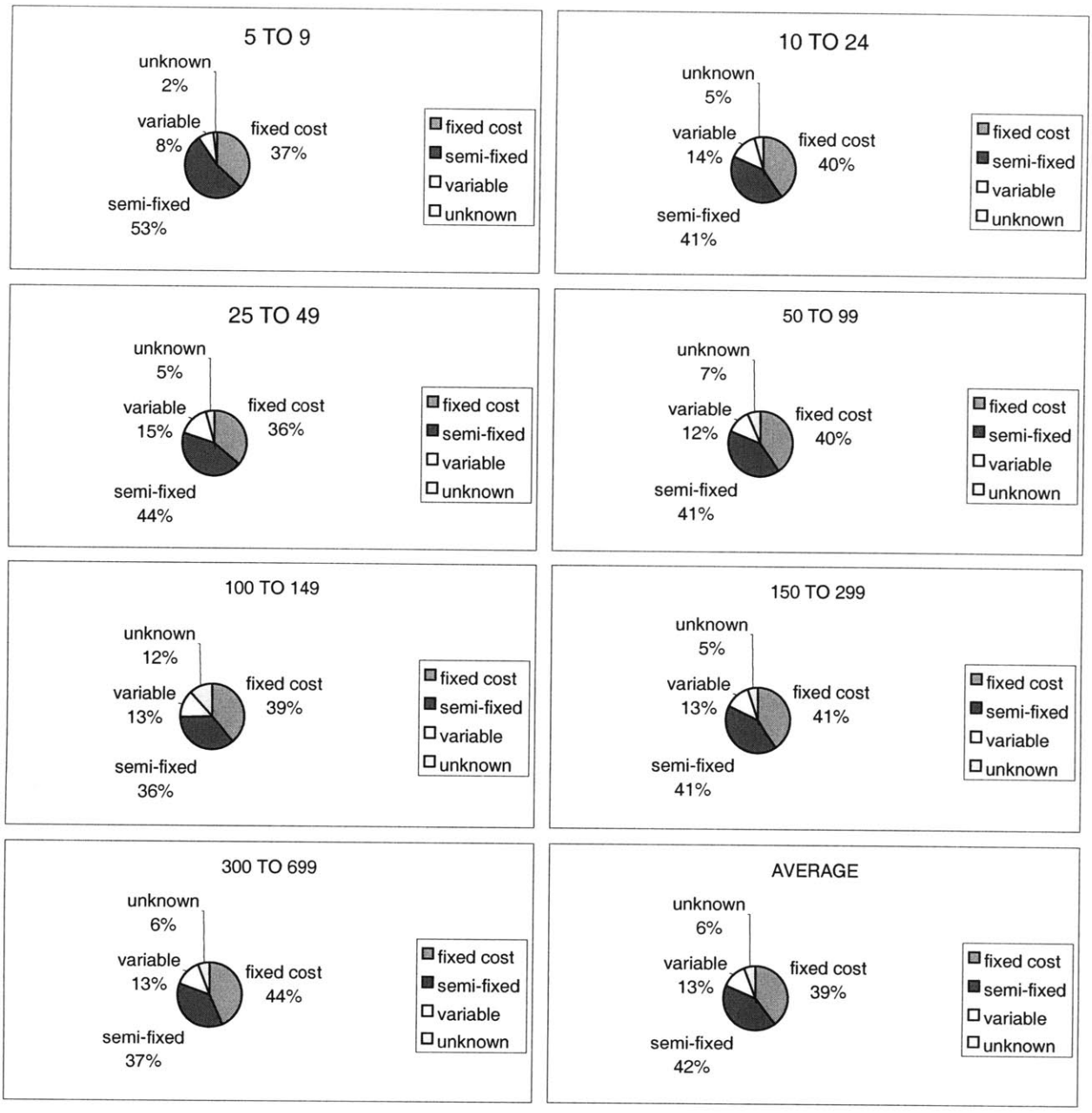

5 TO 9
unknown 2%
variable 8%
fixed cost 37%
semi-fixed 53%
fixed cost
semi-fixed
variable
unknown
10 TO 24
unknown 5%
variable 14%
fixed cost 40%
semi-fixed 41%
fixed cost
semi-fixed
variable
unknown
25 TO 49
unknown 5%
variable 15%
fixed cost 36%
semi-fixed 44%
fixed cost
semi-fixed
variable
unknown
50 TO 99
unknown 7%
variable 12%
fixed cost 40%
semi-fixed 41%
fixed cost
semi-fixed
variable
unknown
100 TO 149
unknown 12%
variable 13%
fixed cost 39%
semi-fixed 36%
fixed cost
semi-fixed
variable
unknown
150 TO 299
unknown 5%
variable 13%
fixed cost 41%
semi-fixed 41%
fixed cost
semi-fixed
variable
unknown
300 TO 699
unknown 6%
variable 13%
fixed cost 44%
semi-fixed 37%
fixed cost
semi-fixed
variable
unknown
AVERAGE
unknown 6%
variable 13%
fixed cost 39%
semi-fixed 42%
fixed cost
semi-fixed
variable
unknown

EXHIBIT 5-6

common areas increases, the amount of common area does not increase. For instance, just because a complex has more units does not mean that the complex has more a proportionately more amount of lawn space. So we see that yard work may not at all be variable. Lawn care is just one item that comprises *grounds cost*, but it is represent the correct way of looking at *grounds.*

Supplies is the last item that comprises the semi-fixed costs. Supply cost act a little bit fixed and a little variable. The only way that supplies will go up in an equal amount with *number of units* is if all of the supplies are for tenants. But again many of the supplies are not for tenants but for common areas and office supplies.

Fixed Operating Costs: There are six operating costs, which loosely can be defined as fixed. Although none of these costs are fixed costs in the strictest of definitions, they have a large fixed-cost component. In thesis research conducted by Nadine Fogarty, it was found that *Real Estate Taxes* per unit decrease with an increase in *number of units.* Given this fact, Property *Insurance* per unit must also decrease because insurance is based on value as is real estate taxes. *Advertising* and *Travel* would not go up in proportion to *Number of units.* Advertisements on the radio can be for 100 or 500 units and the cost does not vary. *Travel costs* are similar in nature to *Advertising costs* because the cost of travel is the same whether the person is traveling on business for 5 or 624 apartments. And if the cost of travel is for auto maintenance, then the case still holds. If a complex has a maintenance man, he is going to drive to the hardware store three or four

times a week. And if he buys extra repair supplies for another forty or fifty apartments, his cost of travel is not increasing. In fact it is decreasing on a *per unit* basis.

Legal costs is the last item that acts like a fixed cost. Most legal cost is fixed in nature. The primary components of legal costs are creating or reviewing the standard tenant contract, income tax work, subcontractor contract review, property tax appeals, and tenant delinquency work. While tenant delinquencies do go up lock step with *Number of units*, it is not the significant part of the total legal bills.

As is seen with all of the operating costs that are fixed in nature, the *cost per unit* actually decreases with increases in *Number of units.* This group comprises 39% of the total operating costs. These costs are a primary reason that economies of scale occur for housing services. The 39% of total costs is diluted among the increased number of units.

Variable Operating Costs: The variable costs make up only 13% of the total operating costs. These costs, on a per unit basis, are not diluted with an increase in the number of apartments. Often times variable costs will increase its *costs/unit* because the product is being used in an inefficient way. The five cost items listed do not increase to a greater proportion than does the *Number of units.* Referral fees would tend to go up evenly with *Number of units*. If the referral payout rate is 1 per 50 apartments, then whether there are 5 units or 624 units, the ratio is still the same. It is interesting to note that in POMS the average for operating cost for referrals is 0%. So in the data set used for this thesis, *Referral costs* do not have any affect on *operating costs. Trash costs* are fairly variable.

The cost goes up incrementally but it still goes up very closely with the *Number of units. Cleaning costs*, on a subcontract basis, are based on unit pricing so that this cost would go up lock step with *Number of units.* The Commission *cost* is based on a rent or unit basis so that there is no scale effect at all caused by *Commissions. Management costs are* charged as a percentage of revenues and revenues will increase in proportion with rents, which is virtually the same as *Number of units.* The variable costs listed in POMS do not increase with increasing number of apartments. This means that these costs tend not to pull the cost curve back up at the tail end of the data range.

The last remaining cost in the POMS operating cost section is *Other cost.* The components of this cost category are unknown and as such, no determination can be made as to the affect of it costs in the shape of the cost curve. But at 6% of total of total operating costs, this percentage is not significant.

The shape of the cost curve is convex and sloping downward. The curve is most steep from 150 to 300 units. The curve slightly decreases in slope as the effect of fixed and semi-fixed operating costs diminish. Starting at the 500-unit range the tail starts to flatten out. At some point beyond the 624-unit range, the tail will probably start to flatten out. The regression is not set up to allow for projecting costs beyond the data set. It is likely that at some distant point the cost curve will because of overworked or inefficient input uses.

CHAPTER 6

CONCLUSION

The Property Owners & Managers Survey, sponsored by HUD, is a national survey that for the first time allows a cross-sectional study of apartments. The survey provides data on geographic location, revenues, costs and management. Other surveys have focused on highend apartment complexes or low income housing. This survey looks at housing services and allows a study of property-level economies of scale that cover all levels of the apartment industry.

The theory of economies of scale and its application to property-level assets was reviewed. It was seen that theory lends itself quite well to practice. One of the main reasons economies of scale exist is because of fixed costs and its dilutive affect on operating costs as the number of units increase. From the data supplied, it could not be determined with certainty, which of the supplied costs were fixed and which were variable. However, it is clear that certain of the costs do have characteristics similar to fixed costs while others have characteristics similar to variable. Chapter 5 discussed which of the POMS supplied operating costs can be considered fixed, variable, and semi-fixed.

The regression analysis looked at the determinants of *operating costs/ unit*. The intent of the regression was to show which variables influenced the dependent variable and to control for those influences. Once the regression controlled for various influences on

oc/u, it was possible to keep constant all other variables except for *number of units* and *number of units squared.* This new equation allows all of the other variables to move the cost curve up and down but not affect the shape.

With an adjusted-R2 of .27, the equation did an acceptable job of estimating costs. *Year built* and *amenity index* were expected to have a significant affect on *operating costs/ unit.* It turned out that only one of the *built* dummy variables was significant. However, the coefficients for the *year built* variables were are negative and increasingly negative, as the buildings become newer. This was not a surprise. *Amenity index* was a variable that was expected to be the most significant. It was not statistically significant and this finding is consistent with Bogdon and Ling.[23]

Another unexpected finding was that individual owners, as opposed to companies, tend to have lower *operating costs per unit.* It was expected that the larger companies, with their increased and cumulative experience would be able to contain costs more than the individual owners would. Part of the explanation may lay in the fact that only 3% of the smaller properties have professional management companies. 27% of the larger properties have professional management companies. It is quite possible that the management companies account for labor, supplies and other items that go unaccounted for in the smaller, individually owned properties.

[23] Bogdon and Ling; "The effects of Property, Owner, Location, and Tenant Characteristics on Multifamily Profitability; Journal of Housing Research, Volume 9, Issue 2. pp. 285 – 315.

For the purposes of economies of scale, when the regression was defined, the resulting equation was:

Operating costs/ unit = 2982.656 - 3.54249 (units) + .001267 (units squared).

The graphic representation demonstrates economies of scale over the limited data range. The curve starts out slow and at 200 units begins to increase. Then at 360 units the slope starts to decrease.

The derivative of the curve of is as follows:

$$0 = -3.54249 + .003 \text{ (units)}.$$

This equations shows that the slope is decreasing until 1,180.83 units. At that point, the slope is zero. Though it is not statistically correct to measure out beyond the data set, 624 units, it is clear that the curve does not minimize until a large number of units is introduced. Ideally, the data would be large enough to allow the reader to see decreasing returns to scale. However, in this limited data set, that did not happen. The slope decreases until 1,180.83 units and at that point the slope is zero

This limitation points out a major flaw in the POMS data. The POMS data has a high rate of nonresponse. Further enhancing the problem is the fact the properties are blind responses. The survey would be much more useful if there was further refinement of the

location variables. The POMS data set is new and relatively unexplored. Initial research in this paper and two others have encountered difficulties with nonresponse, lack of location variables, and quality of rents. None the less, the survey provides much information that was never available.

BIBLIOGRAPHY

Bogdon, Amy S., and Ling, David C.,."The Effects of Property, Owner, Location, and Tenant Characteristics on Multifamily Profitability," *Journal of Housing Research* (Volume 9, Issue 2, 1998), pp. 285-316.

Emrath, Paul, "Property Owners and Managers Survey," *Housing Economics 45* (July 1997),7.

"Highlights from HUD's New Survey of Property Owners and Managers," *Research Notes,* national Multihousing Council (February 1997), 1.

"Property Owners and Managers Survey: Source and Accuracy Statement," U.S. Census Bureau website (www.consus.gov/jjes/www/housing/poms.html).

Property Owners and Managers Survey Technical Documentation, U.S. Department of Commerce, Washington D.C.: February, 1997.

Savage, Howard, "What We Have Learned About Properties, Owners and Tenants From the 1995 Property Owners and Managers Survey," *Current Housing Reports,* U.S. Department of Commerce, Economics and Statistics Administration (October 1998).

Stiglitz, Joseph E., *Principles of Microeconomics.* New York:W.W. Norton & Company, 1997.

"The Providers of Affordable Housing." *U.S. Housing Market conditions, 4th Quarter 1996,* U.S. Department of Housing and Urban Development, Office of Policy Development and Research, (February 1997),2.

U.S. Department of Commerce Press Release, 1.