LIFE-CYCLE COST ANALYSIS OF HOME-OWNERSHIP

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ABSTRACT

This research analyzes various economic and cost parameters to comprehend life-cycle cost of home buying and home ownership. The framework of this study lies in the fundamental concepts of life-cycle cost analysis, time-value of money, opportunity costs, cost forecasting, and inclusion of cradle-to grave expenses and revenues. This work was aimed for the benefit of first-time homebuyers as well as owner-occupied homeowners. A life-cycle cost analysis methodology has been developed, which can be used as a tool for informed decision making. The bottom line of this methodology is to alter various parameters in order to find the lowest possible equal uniform net final monthly expense (EUNFME). This methodology does not consider any elements that cannot be converted into monetary value such as psychological and social values.

An Excel spreadsheet program was developed to organize the calculations and analysis according to the developed methodology. Then, program codes were written in Matlab, which was used in analyzing a typical purchase scenario, using relevant data for a median priced single-family house located in O'ahu, Hawai'i. Relevant economic time series data were collected and used for cost forecasting, price escalation, and to calculate real rate of return. The analysis of the typical example varied multiple purchasing conditions such as mortgage interest rate, discount points, size of down payment, and alternative investment opportunities to arrive at a rational buying decision. Buying versus renting analysis was also included in the purchase evaluation.

Buying a house is a complex process, a marriage between comforts of a facility and financing in a property. Analysis of the example indicated that in order to minimize the equal uniform net final monthly expenses, buyer should explore conditions that reduce opportunity losses and maximizes the economic returns. Some of these conditions are: (i) paying least amount of down payment when CD rates are higher than mortgage rates, (ii) exploring a suitable combination of mortgage rate and discount points that optimizes the economic benefits. The trends of the results are independent of the purchase price of the house, but are dependent on all the other purchase parameters.

Purchasing an owner-occupied house may bring some tax return, but benefits are often overemphasized. Similarly, buying a house as an investment alternative was not found to be attractive under many conditions. The housing affordability index (HAI) put out by the realtors is found to be more liberal in the absence of comprehensive life-cycle cost consideration of home-ownership. In many occasions renting a house could serve the needed functional purpose and may prove to be economically more attractive than an owner-occupied house.

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CHAPTER 1: INTRODUCTION

1.1 Background

For the average home-owner, buying a house was the single largest investment of their lives. The decision to become a home-owner has far-reaching consequences that include an extended commitment of the family's future income. When choosing to buy a house, people generally think of the down payment and monthly mortgage payments as their major liabilities. However, there are many other recurring ownership and occupancy costs such as property tax, insurance premiums, maintenance, and the monthly operational expenses like utilities and public services. In most cases, buyers fail to realize that ownership and occupancy costs lead to a compromising of their standard of living, including a decreased ability to spend on everyday items such as food, clothing, transportation, recreation, entertainment, medical care, childcare, education, and other unforeseeable expenses.

For most home-owners, their house is a shelter that provides peace of mind and a financial asset that provides equity. Equity is the value of a house minus any liens against it. Mortgages are not the only liens. In most cases, when home-owners apply for loans their house is used as collateral, and in case of loan default, the lenders may force the home-owner into court to settle the debt. There are considerable debates about whether home-ownership is defined as consumption or as investment (Waldrup et al., 2005). If home-ownership involves acquiring a consumer good, this good must be financially viable, economically sustainable, and emotionally satisfying. If it involves an investment of capital, then there must be a return on the investment. In ideal circumstances, an owner-occupied home provides equivalent services and physical comfort to its occupants, as would renter-occupied housing. This then leads to the question of whether one should own or rent a house. How should one arrive at a rational decision when faced with the choice of buying versus renting? Why should one opt to buy instead of rent a house, or vice versa?

Home-ownership is a dream in American society and it is taken as a measure of success in one's life. It shows a commitment towards strengthening families and becoming a good citizen in the community. Living in an owner-occupied house is a life satisfaction that creates a greater control over one's own living environment and responsibility towards family and the neighborhood. Home-ownership leads to improved levels of social, psychological, emotional and physical health. These non-economic factors contribute to the pride of home-ownership, and it is priceless.

Some individuals' rationalization for becoming home-owners include the pride of ownership and other emotional factors, including social and psychological values, while others see buying a house as acquiring equity. While pride of ownership, peace of mind, and the satisfaction of living in one's own home are important considerations, financial viability is ultimately the bottom line. Those who are faced with these questions should consider the economic factors prior to the non-economic ones.

Although non-economic factors such as the pride of ownership and the feeling of being secure in one's own home should not be discounted, it is impossible to evaluate both the economic and the non-economic aspects of home ownership on the same scale. The research in this paper focuses primarily on economic factors, on minimizing the costs and maximizing the benefits of home-ownership during the entire ownership period, by considering cradle-to-grave expenses and the time value of money. In essence, this is a Life-Cycle Cost (LCC) analysis of home-ownership, beginning when a house is selected for purchase and then continuing through its ownership and occupation until the moment it is resold or otherwise disposed of.

By definition, LCC deals with future costs and the future is uncertain. The uncertain future involves risk, and in the case of home-buying, it implies risk in investment. This research attempts to study the comprehensive Life-Cycle Cost of home purchase and home-ownership in order to develop a reliable methodology for buyers' decision making.

1.2 Significance of the study

According to the U.S. Census Bureau (U.S. C.B. (a), 2008), out of the total of 128.7 million existing housing units in the U.S. in the fourth quarter of 2007, little more than 58% (75.2 million units) were owner-occupied, while 28% were renter-occupied and 14% units were year-round vacant. In the meantime, 16% (about 2.2 million), of the vacant housing units were on sale. During the same period, the median and average prices of sold houses in the U.S. were $247,500 and $305,900, respectively (U.S. C.B. (b), 2008). From this data, it can be estimated that the housing sale and purchase business in the U.S. amounts to $6.73 trillion on an annual basis, as recorded for the year 2006.

According to the Department of Business, Economic Development and Tourism (DBEDT, 2007) there were 227,888 owner-occupied housing units in Hawai'i with an average household size of 3.07 people. In 2006, the home-ownership rate in the state of Hawai'i was nearly 60%, and according to research carried out by Prudential Locations, the number of single-family units sold in the state of Hawai'i during the year 2006 was 7,547 with a median sales price of $599,900 (DBEDT, 2007). This indicates that the annual transactions on single-family home sale and purchase in the state of Hawai'i amounted to about $4.5 billion as recorded for 2006, more than half of which occurred in O'ahu alone.

In Hawai'i, mortgage lender Freddie Mac (2007) alone has invested nearly $17 billion in home loans during the last 10 years, serving more than 73,000 home-owners. In 2006, it disbursed more than $3.3 billion - nearly 73% of the total home sale and purchase transactions - as home loans, adding more than 11,000 new home-owners in Hawai'i. The number of single-family units sold in O'ahu increased nearly three-fold during the last decade, reaching 4,679 in 2005 compared to 1,637 in 1995 (DBEDT, 2007).

In the present context of ongoing record-high numbers of loan delinquencies and foreclosure rates, it is of a great interest to understand the home-ownership costs in greater detail. A Life-Cycle Cost analysis of home-buying will prove useful towards determining what cost elements constitute the major and maintained financial burdens for home-owners and how these elements affect home-ownership sustainability. This research will contribute toward better understanding the role of each cost element and cash flow item likely to occur in each phase of the home-ownership life-cycle, starting from purchase and ending with resale.

1.3 Purpose of the research

An LCC analysis of home-buying is based on a key concept of economics, namely, the time value of money - a theory well-defined and extensively applied in business, investment analysis, and everyday life. A consideration of the time value of money involves a range of economic variables, such as interest-rates, inflation rates, and lost opportunity costs in order to compare the amount of money that will be spent over an extended number of years. This research aims to develop an LCC model for the home-buying decision and presents an analysis methodology. LCC is considered to be a suitable tool for assessing alternatives at any discrete period of the life cycle of an asset (Cole and Sterner, 2000). The flexible character is an attractive feature of LCC analysis for using it in home-buying and home-ownership.

The primary objective of this study is to develop a simple-to-use and reliable home-buying LCC analysis methodology, a deterministic model that considers the cradle-to-grave ownership expenses. Such a model shall be based on the fundamentals of engineering economy, considering all aspects of the time value of money for any expenses likely to occur at any time during the ownership period. The proposed model developed in this research will integrate all the basic elements and the fundamental theory of the time value of money to account for each item in the LCC of home-ownership in order to derive certain economic parameters measured in constant dollars. The model will demonstrate framework for a systematic and logical accounting of costs (tangible costs, intangible costs, and lost opportunity costs), and will forecast home-ownership expenses. Such a methodology will calculate the equal uniform monthly cost of ownership for given ownership period.

These elements will assist home-owners in foreseeing the long-term financial burden involved in sustaining their home-ownership. This marks the major difference of the proposed model from the other existing LCC models discussed in the next chapter.

This study aims at discovering certain characteristics of home-buying that optimizes the economic attractiveness. Renting a house as an alternative to home-ownership will also be analyzed. The need for research, problem statement, and framework of this research are elaborated under the scope of research in Chapter 3.

LCC analysis involves a cumbersome numerical process. Therefore, automation of the computation will enhance the analysis process, making decision-making faster and more efficient. The home-buying LCC analysis has been programmed in Excel to demonstrate how LCC can be performed using commonly available spreadsheet programs. A numerical program has also been written in *Matlab*. Developing two programs, i.e., Excel Spreadsheet and *Matlab*, will also serve as a basis for verification of results for accuracy, consistency and reliability.

In the absence of appropriate tools and techniques for forecasting future costs, the home-owners often tend to control expenses as they occur. The intent of this study is to develop a model that can help home-owners manage their ownership expenses proactively rather than reactively as they occur. Furthermore, the study presents a simple and easy-to-understand investment analysis technique that helps homebuyers and developers become aware of ownership costs, and show how investment attractiveness can be assessed. Thus, the major objective of this research is to develop a LCC analysis model, with specific focus on home purchase from home-owners' perspective. It will also be instrumental in assessing ownership affordability, in defining maintenance, in replacement and capital improvement strategies, and in working out financing arrangements well in advance. Furthermore, this research will also contribute to establishing LCC as a methodology for achieving sustainability, particularly from a cost-management perspective, in varieties of facilities and asset ownerships.

1.4 Organization of the Dissertation

This dissertation is arranged into 13 chapters. Chapter one provides the introduction into the subject matter, significance and purpose of the research undertaken as part of this dissertation.

Chapter two discusses the background, development, and various models of life-cycle cost analysis, and its application in home-ownership. This Chapter is part of the literature review.

Chapter three defines the need for research, problem statement and scope, and framework of the current research.

Chapter four highlights the basics of the home-buying process and path to home ownership.

Chapter five explores the life-cycle cost of home-ownership, starting from the acquisition phase through the occupancy, operation and maintenance of the facility until the property is disposed off. Various cost and revenue items relevant for phase home-ownership are described in this chapter.

Chapter six highlights the affordability aspect of home-ownership. Various affordability indices are briefly discussed and explained including the comparing buying versus renting.

Chapter seven recapitulates the fundamentals of engineering economics and time value of money. This chapter discusses various interest rates, opportunity costs, inflation-free interest rate and after tax rate of return in case of opportunity costs.

Chapter eight dwells with cost forecasting. Various cost escalation rates including consumer price index (CPI) and other price escalation rates are discussed and determined using the historical data.

Chapter nine explains the methodology developed and applied in further analysis of home purchase. This chapter describes the calculation methodology employed in analyzing the life-cycle cost analysis of home-buying. The model developed in this chapter is the contribution of this research.

Chapter ten explains the organization and structure of computer programs developed based on the life-cycle cost analysis for home-buying analysis. This chapter contains two sections: Excel and Matlab programs.

Results of an example of home purchase are presented in Chapter 11, and the analysis and discussion of the results are presented in Chapter 12. Finally, conclusions of this research are presented in Chapter 13.

CHAPTER 2: DEVELOPMENT OF LIFE-CYCLE COSTING THEORY

2.1 History and Definitions

The concept of Life-Cycle Costing (LCC) came about during World War II in the procurement of weapons and weapon support systems used by the U.S. Department of Defense (DoD) (Kabbani,1993). The DoD further developed the LCC theory in the early 1960s to increase the cost effectiveness of their procurements policies, which were widely discussed by Metzler (1974), Gansler (1974), Earles (1974), Dixon & Anderson (1976), Caver (1979), and Dighton (1980). The first to employ such ideas extensively were the Japanese, mainly to overcome the devastation of World War II, and to revitalize their economy thereafter by saving costs in the long term (Emblemsvag, 2003, p3). Then, the LCC was applied by U.S. civilian industries starting with alternative energy design options in buildings in the late 1970s (Cole and Sterner, 2000).

Prior to the 1970s, procurement decisions were based solely on capital costs. There was a school of thought known as "Terotechnology" which believed that there were better ways of making decisions than based on capital costs (Boussabaine and Kirkham, 2004). The argument was that spending more in capital cost would result in savings in the long term when compared with cheaper alternatives. This marked the beginning of the LCC concept.

Although the principles of LCC are founded on long established theories of engineering economy, mathematics and risk analysis, its application in civil engineering is still under development (Pelzeter, 2007). The objective of any engineering activity has always been to analyze and determine how physical factors can be designed and arranged towards creating utility in a manner that satisfies the need at the least possible cost. From this perspective, a concept of LCC was always involved in engineering designs. It was always believed that economic competitiveness could be achieved and enhanced through a life-cycle approach to engineering (Fabrycky and Blanchard, 1991). Despite such a deep rooted engineering economic philosophy, engineers have emphasized the early phase of the product life-cycle, focusing mainly on early design, acquisition and its immediate performance, and neglected the overall life-cycle performance, economic factors and operational outcome at the later stage of the product life-cycle (Fabrycky and Blanchard, 1991).

Nevertheless, the shortfall in civil engineering was gradually realized and engineers have started viewing the system from a top down, integrated, life-cycle perspective. In the early 1970s, the term *cost-in-use* appeared in the literature, which referred to as operational costs of assets. The weakness of the cost-in-use model was its inability to forecast future costs (Boussabaine and Kirkham, 2004). With recognition that forecasting was an essential component, the concept of LCC emerged as a new methodology of cost appraisal by the late 1970s. In 1977, the UK Department of Industry published one of the earliest definitions of life-cycle costing as follows (Boussabaine and Kirkham, 2007):

A concept which brings together a number of techniques – engineering, accounting, mathematical and statistical – to take account of all significant net expenditures arising during the ownership of an asset. Life-cycle costing is concerned with quantifying options to ascertain the optimum choice of asset configuration. It enables the total life-cycle cost and the tradeoff between cost elements, during the asset life phases to be studied and for their optimum selection use and replacement.

Similarly, in 1977, the American Institute of Architects defined LCC as follows:

A technique that allows the assessment of a given solution or choice among alternate solutions on the basis of considering all relevant economical consequences over a given time.

The U.S. General Services Administration (U.S. GSA, 1992) defines the Life-cycle Cost as:

The summation of all costs over the useful life of building, system or product. It includes all relevant costs to the Government to acquire, own, operate, maintain and dispose of a building, system or product for a specified period of time, less any salvage value.

The U.S. President's Executive Office of Management and Budget (EOMB, 1993) defined the life-cycle cost as follows:

> *The total cost of a system, building, or other product, computed over its useful life. It includes all relevant costs involved in acquiring, owning, operating, maintaining, and disposing of the system or product over a specified period of time, including environmental and energy costs.*

The latest edition of the Defense Acquisition Guidebook (U.S. DoD, 2004) makes reference to Life-Cycle Costing as being a total ownership cost and defines it as follows:

> *Life-cycle cost consists of research and development costs, investment costs, operating and support costs, and disposal costs over the entire Life-cycle. These costs include not only the direct costs of the acquisition program, but also include indirect costs that would be logically attributed to the program.*

Nowadays, varieties of terminologies such as *Whole Life-Cycle Costing*, *Whole-Cost Accounting, Total Cost of Ownership, New Generation Whole Life-Cycle Costing*, *Whole-Life Costing*, and *Whole-Life Appraisal* can be encountered in literature. Some authors consider that *Whole-Life Appraisal* differs from *Whole Life-Cycle Costing* in the sense that *Whole-Life Appraisal* takes into consideration both cost and performance at the same time (Flanagan et al., 2005). According to the Draft version of ISO 15686, the expression of *Whole-Life Cost (WLC)* is used mainly in the United Kingdom and Canada (Pelzeter, 2007). Obviously, the performance and cost should go hand in hand and costing alone without performance does not meet the intent of investment. Sometimes WLC is understood as the entire physical life span rather than just the economic life span.

Thus, the underlying concept of value for money, the combined initial and consequential costs consideration, has not changed since the introduction of the LCC technique.

From the above definitions, it can be easily understood, interpreted, and summarized that the LCC is a systematic assessment of all relevant costs and benefits associated with acquisition, ownership, and disposal of an asset that evaluates economic performance subject to functional and operational requirements throughout the entire life-cycle starting from cradle to grave. Such an assessment process assists in evaluating alternatives, and hence in minimizing total expenditure through proper appraisal of costs over the anticipated life span. The principles of LCC can be applied from the simplest to the most complex product. For example, when purchasing a new car, one may consider several factors such as fuel economy, insurance, maintenance, availability of replacement parts, amount of down payment required, original price, mortgage liabilities, comfort, and so forth. Implicitly, this is already an application of the LCC concept. Similarly, this approach can be applied in any procurement, whether it is the purchase of a pencil or of a building costing millions of dollars.

There is numerous studies found in the literature on how LCC can be used as an engineering economic analysis tool, including works by Dhillion (1989), Fabrycky & Blanchard (1991), Bull (1993), Emblemsvag (2003), Bussabaine & Kirkham (2004), and Pelzeter (2007).

2.2 A Review of Life-cycle Cost Models

Regardless of the type, purpose or size of a product, life-cycle can be phased in different parts based on the activities as depicted in Figure 2.1. This figure was developed by Fabrycky and Blanchard (1991) to illustrate a characteristic cumulative life-cycle cost related to different phases of a typical product life-cycle. The indicated costs, in the illustrative figure, are only reflective, and the costs may occur at different magnitude at different phases of life-cycle.

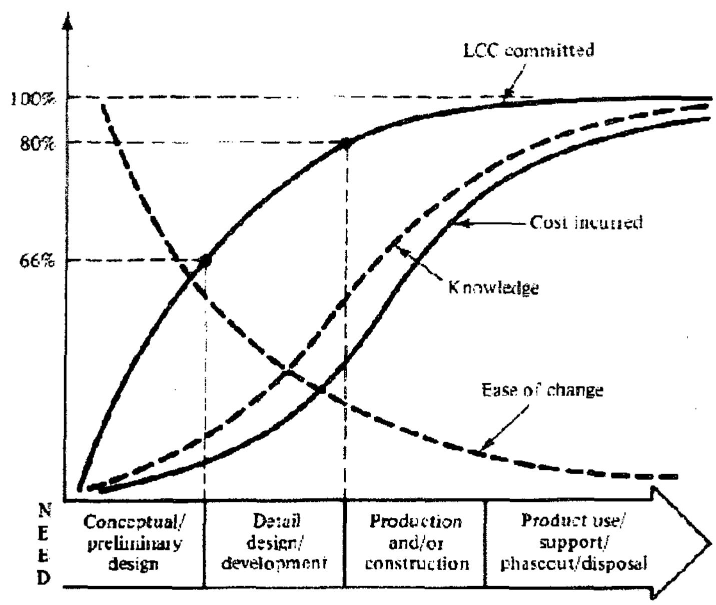

Figure 2.1: Characteristic cumulative life-cycle cost of a product during its life-cycle (source: Fabrycky and Blanchard, 1991)

In the mean time, the line representing the "ease of change" indicates that it is much easier to control the ownership cost at the early stage of the life-cycle, than at later stage, and thereby emphasizing the proactive approach of cost management. This is particularly useful in the case of a home-ownership that the life-cycle costs can be managed at the stage as early as during the process of property selection and purchase decision.

Similarly, the Figure 2.2 illustrates occurrences of costs at different stages of ownership period and emphasizes that the cost occurred at later stages might become larger in magnitude than the costs at initial stages. The easily visible portion of the costs occurred during acquisition phase could only be a small fraction of the whole life-cycle costs, and to the dismay of the owner a major portion may occur at a later stage of the life-cycle period (PCPU, 1992).

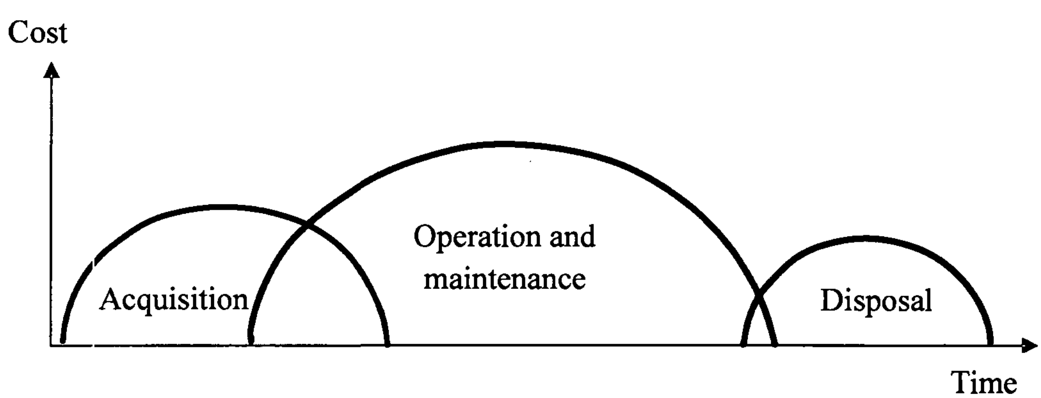

Figure 2.2: Typical life-cycle cost profile (source: PCPU, 1992)

The graphical representation, frequently referred to in various literature, depicts an "Iceberg Analogy" - a popular metaphoric illustration among researchers is shown as Figure 2.3 (Flanagan et al, 1983; Fabrycky &Blanchard, 1991; PCPU, 1992). This figure is adapted for the home-buying situation and highlights the danger of poor cost management if only the tangible costs are accounted for, when making a purchase decision.

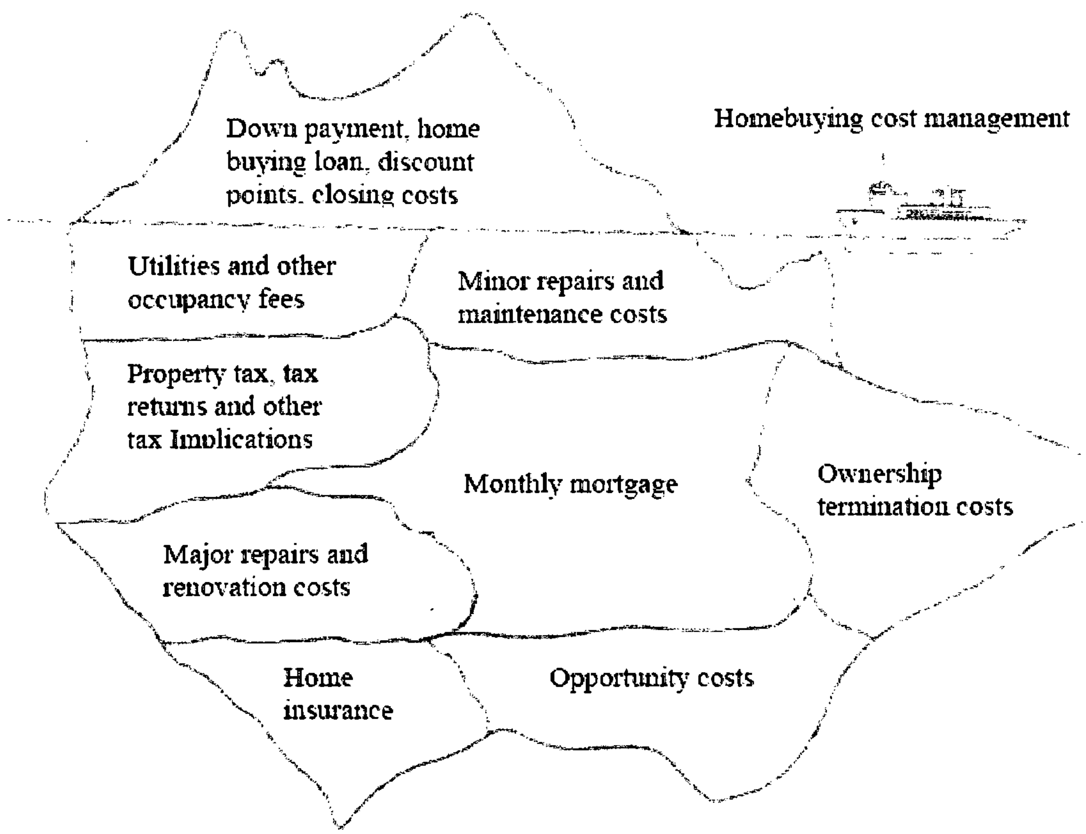

Figure 2.3: The problem of life-cycle cost visibility of home ownership (modified from Flanagan et al., 1983)

Metaphorically, this figure indicates that the entire life-cycle costs are often not easily visible, particularly those related to system operation, maintenance and support. The varieties of cost elements shown in the iceberg analogy are only illustrative and they are not universally applicable. However, the analogy provides a basis for identifying invisible costs of the system or asset being studied. It is considered in this study that buying a house is not an exception and the graphical models of life-cycle cost analysis discussed above provide good reason for investigating the life-cycle cost of home-ownership as early as during the home-buying process.

The basic premise of life-cycle costing model is founded on engineering economic principles, especially investment decision methods. There are varieties of life-cycle cost analysis models available in literature, but there lacks a standard model that is universally suitable. This is mainly due to the fact that each life-cycle cost analysis problem is unique and case specific.

Dhillon (1989) has summarized basic and common models that were developed during 1970s and 80s. These models can be divided into two major categories: 1) general life-cycle cost models; and 2) specific life-cycle cost models. The general models, also known as non-specific, are not tied to any specific system or equipment, while specific cost models are developed to address equipment or system specific life-cycle cost analysis. Some of the major models are summarized in the next section.

2.2.1 General Life-cycle Cost Model I:

A model was developed by the U.S. Navy for their major weapon system, and it consisted of five major cost components (Dhillon, 1989) as follows:

$$L_{cc} = RDC + OSC + ASC + IC + TC \tag{2.1}$$

where, L_{cc} is the life-cycle cost,

RDC is the research and development cost,

OSC is the operation and support cost,

ASC is the associated system cost,

IC is the investment cost, and

TC is the termination cost.

2.2.2 General Life-cycle Cost Model II:

According to the ASTM E917-89 (Kabbani, 1993), life-cycle cost analysis can be accomplished using either the total Present Worth Method or Annualized Method of economic calculation and the model was expressed algebraically as:

$$PVL_{cc} = \sum_{t=0}^{N} \frac{C_t}{(1+i)^t} \tag{2.2}$$

where,

PVL_{cc} is the life-cycle cost expressed in Present-Value,

C_t is the sum of all relevant costs occurring in year t,

N is the length of study period, years, and

i is the discount rate.

2.2.3 General Life-cycle Cost Model III:

The model discussed by Locks (1978) has three major components, namely procurement cost, initial logistic cost, and recurring cost. This model does not consider termination costs.

$$L_{cc} = PC + \mathrm{ILC} + \mathrm{RC} \tag{2.3}$$

where,

L_{cc} is the life-cycle cost,

PC is the procurement cost,

ILC is the initial logistic cost

RC is the recurring cost.

2.2.4 General Life-cycle Cost Model IV:

The life-cycle cost model developed by the U.S. Army (Dhillon, 1989) is made up of three major components, including investment cost (IC), research and development cost (RDC), and operating and support cost (OSC). This model does not consider termination costs.

$$L_{cc} = IC + \mathrm{RDC} + \mathrm{OSC} \tag{2.4}$$

The investment cost is composed of factors such as transportation, production, cost of data, initial training, non-recurring investment costs, spare parts, system test, and evaluation, site operation, engineering cost, project management cost, and any other investment costs. Similarly, operation and support cost is made up of indirect support operation cost, consumption cost, depot maintenance cost, personnel cost, material modifications, and other direct support costs.

2.2.5 General Life-cycle Cost Model V:

A model concerning life-cycle cost of systems proposed by Dickinson (1976) has four major components, namely failure cost (FLC), operating cost (OPC), and the initial cost (ITLC). This model also does not consider the termination cost as follows:

$$L_{cc} = FLC + \mathrm{OPC} + \mathrm{ITLC} \tag{2.5}$$

In the equation (2.5), the cost of average failure (CAF) is estimated by the following expression (Dickinson, 1976):

$$CAF = PC + NRC + SOC + RC \tag{2.6}$$

where,

PC is the cost of parts,

NRC is the non-redundancy cost, the losses incurred by not incorporating redundancy in the equipment or in the system,

SOC is the cost of stock out, and

RC is the repair cost.

2.2.6 General Life-cycle Cost Model VI:

Blanchard (1978) developed a life-cycle cost model with four major components, i.e., research and development cost (RDC), production and construction cost (PCC), operation and support cost (OSC), and retirement and disposal cost (RADC):

$$L_{cc} = RDC + PCC + OSC + RADC \tag{2.7}$$

where,

RDC is the sum of planning, design, test and evaluation, research, software development and management costs,

PCC is the component of the production and construction cost, which includes manufacturing, quality control, construction, engineering, production analysis and production support,

SOC is the cost component of system/product distribution, sustaining logistic support, system/product operations, and

$RADC$ is the cost component for ultimate retirement cost, reclamation value, cost of disposal, and unscheduled maintenance actions.

2.2.7 General Life-cycle Cost Model VII

Tague (Davis and Skinner, 1989) developed a general model for life-cycle cost analysis as follows:

$$L_{cc} = \mathrm{C_{MD}} + \mathrm{M_{MQ}} + [\mathrm{m}\{\mathrm{C_{MSM}} + \mathrm{C_{BP}} + \mathrm{C_{cc}}\}] \tag{2.8}$$

where,

L_{cc} is the life-cycle cost,

C_{MD} is the cost of module development,

M_{MQ} is the module qualification cost,

m is the quantity of systems to be purchased,

C_{MSM} is the life-cycle module cost of system modules,

C_{BP} is the cycle back panel cost for system, and

C_{cc} is the life-cycle card cage cost for system.

2.2.8 General Life-cycle Cost Model – Aircraft Logistics Costs

The United States Air Force (Dhillon, 1989) developed a life-cycle costing methodology that has been widely used for aircraft related logistics cost estimating. Mathematically, the total logistics support cost (TLSC) was given by:

$$TLSC = \sum_{j=1}^{11} LSC_j \tag{2.9}$$

where,

LSC_j are eleven cost elements, namely fuel, facilities, software support, on-equipment maintenance, management and technical data, pipeline and replacement cost, support equipment, off-equipment maintenance, spare engines, inventory and supply management, personnel training, and training equipment.

2.2.9 Specific Life-cycle Cost Model – Fleet of Aircraft

This specific model was developed for estimating retrofitting a system of avionics for aircrafts fleets (Andrew et.al, 1974; and Regulinski & Gupta, 1983) as shown below:

$$L_{cc} = \left[\sum_{j=1}^{k} (CSR_j + CM_j) \right] + CHP + RFC \tag{2.10}$$

where,

L_{cc} is the life-cycle cost,

CSR_j is the cost associated with spares replacement for operational year j,

CM_j is the cost associated with maintenance for operational year j,

k is the number of years,

CHP is the hardware procurement cost,

RFC is the retrofit cost made up of cost for inspection, installation, engineering, testing and drafting.

2.2.10 Specific Life-cycle Cost Model – Electric Motors

This specific model was developed for estimating life-cycle cost of electric motors (Ganapathy, 1983) which is given below:

$$L_{cc} = MAC + MOC \tag{2.11}$$

where,

L_{cc} is the life-cycle cost,

MAC is the acquisition cost of the motor, and

MOC is the operating cost of the motor.

In the equation (2.11), it was assumed that the motor maintenance cost is negligible, and the present worth of operating cost ($MOC_{\,j}$) for each year *j* was calculated by:

$$PW_j = MOC_j \left[\frac{1}{1+i}\right]^j \qquad (2.12)$$

where,

PW_j is the present worth of $MOC_{\,j}$,

i is the interest rate, fraction

If the operational life of the motor was ***n*** years, the total present worth (TPW) of the operating cost can be given by the following equation:

$$TPW = MOC_1 \left[\frac{1}{1+i}\right]^1 + MOC_2 \left[\frac{1}{1+i}\right]^2 + MOC_3 \left[\frac{1}{1+i}\right]^3$$

$$+ \ldots + MOC_n \left[\frac{1}{1+i}\right]^n \qquad (2.13)$$

$MOC_{\,j}$ is the motor operating cost in year $j = 1, 2, 3, \ldots, n$.

For further analysis it was assumed that, in constant dollars, the operating cost does not vary much during the operational life of the equipment, yielding:

$$MOC = MOC_1 = MOC_2 = MOC_3 = \cdots = MOC_j \quad (2.14)$$

However, this model introduces an escalation factor (ESF) in order to adjust the price escalation during the operational life of the equipment and thus equation (2.13) was rewritten as:

$$TPW = MOC\left[\left(\frac{1+ESF}{1+i}\right)^1 + \left(\frac{1+ESF}{1+i}\right)^2 + \left(\frac{1+ESF}{1+i}\right)^3 + \ldots + \left(\frac{1+ESF}{1+i}\right)^n\right] \quad (2.15)$$

2.2.11 Specific Life-cycle Cost Model - Car

This specific model was developed for estimating life-cycle cost of a car (Bhuyan, 1982), and the life-cycle cost was defined as:

$$L_{ccc} = AC_c + \sum_{i=1}^{NL}(SMC_i + OC_i + URC_i) + DC \quad (2.16)$$

where,

L_{ccc} is the life-cycle cost of the car,

AC_c is the acquisition cost of the car,

NL is the life time of the car in years,

SMC_i is the scheduled maintenance cost (tune up, lubrication, etc) of the car for year i; $i = 1, 2, 3, \ldots, NL$.

OC_i is the operating cost (tire, gas, oil, etc) of the car for year i; $i = 1, 2, 3, \ldots, NL$.

URC_i is the scheduled repair cost (dependant on the failure rate of the model) of the car for year i; $i = 1, 2, 3, \ldots, NL$.

DC is the disposal plus any other cost (if any)

2.2.12 Specific Life-cycle Cost Model – Healthcare Facility

This specific model was applied in estimating life-cycle cost of a healthcare facility (Eddins-Earls, 1981), and it was written as:

$$L_{CCHCF} = CC + OC \tag{2.16}$$

where,

L_{CCHCF} is the life-cycle cost of healthcare facility,

CC is the capital cost, made up of costs such as financing cost, indirect cost, denial of use cost, land acquisition cost, direct construction or purchase cost, collateral equipment cost, alteration and replacement cost, demolition and site preparation cost.

OC is the operating cost, consisting of costs such as utilities and fuel costs, equipment (furnishing) and maintenance costs, structural maintenance costs, heating system costs, cleaning costs, restoration costs, fire protection costs, painting costs, incinerator and trash removal, air conditioning and ventilation system operation and maintenance cost, plumbing and sewer cost, electrical system operation and repair cost.

2.2.13 Specific Life-cycle Cost Model – Smart Infrastructure Systems

El-Diraby and Rasic (2004) developed a model for managing life-cycle cost of smart infrastructure systems. A smart infrastructure system is a combination of structures intelligent enough to monitor its own environment and be able to respond to dynamic conditions. The life-cycle cost was as follows:

$$L_{sis} = C_a + C_i + C_p + C_m + C_t + C_e + C_s + C_d \qquad (2.16)$$

where,

L_{sis} is the life-cycle cost of a smart infrastructure system,

C_a is the acquisition cost,

C_i is the installation cost,

C_p is the operation cost,

C_m is the maintenance cost,

C_t is the downtime cost,

C_e is the environmental impacts cost,

C_s is the obsolescence cost, and

C_d is the disposal cost.

2.2.14 Specific Life-cycle Cost Model – University Building

Bromilow and Pawsey (1987) developed a mathematical model to plan and estimate long term resource requirements for repair and maintenance of a university building. They applied present value approach to calculate the total life cost, and the model was written as follows:

$$S_T = C_0 + \sum_{i=1}^{n} \sum_{t=1}^{T} C_{it}(1 + r_{it})^{-t} + \sum_{j=1}^{m} \sum_{t=1}^{T} C_{jt}(1 + r_{jt})^{-t} - C_d\,(1 - r_d)^{-T} \tag{2.17}$$

where,

S_T is the present discounted total life-cycle cost over period T,

C_o is the procurement cost at time t=0,

C_{it} is the annual cost at time t ($0 \leq t \leq$ T)

i is the support function ($1 \leq i \leq$ n), which is continuous over time

C_{jt} is the maintenance cost at time t of support function ($1 \leq j \leq$ m),

r_{it} *and* r_{jt} are the discount rates applicable to support functions *i* and *j* respectively over time period *0* to *T*,

d is the value of asset on disposal, less cost of disposal.

r_d is the discount rate applicable to asset disposal value over period *0* to *T*.

C_d is the disposal cost,

2.3 Application of Life-cycle Costing on Home-ownership

The building industry has gradually adopted life-cycle costing techniques. In 1972, Dell'Isola promoted value engineering that included life-cycle cost analysis in the construction industry (Kabbani, 1993). In 1977, the American Institute of Architects

(AIA) published a set of guidelines "Life-cycle Cost Analysis: A guide for Architects" indicating where and when the LCC technique can be used in planning and the design process. Currently, several U.S. Federal Agencies, such as the Environmental Protection Agency (EPA), the Department of Energy (DoE), and the Department of Defense (DoD), require LCC in their programs. It is the policy of the U.S. Government that all public buildings be designed with the objective of achieving lowest life-cycle cost for taxpayers, considering the long-term operations, and maintenance of the facilities (U.S. GSA, 2003).

The LCC of a building is a complex process, and individual studies may focus on a particular aspect of building components. A lot of work has already been done covering the design phase of a building, several aspects of materials life-cycles, environmental sustainability, and energy conservation (Bamford et.al, 2000; Kong and Frangopol, 2003; Osman and Ries, 2004; Horvath and Guggemos, 2006).

The LCC analysis of residential buildings has been studied since the emergence of LCC technique, and it has covered a wide range of LCC issues. In recent years, researchers have focused on specific components of LCC elements such as maintenance cost of deteriorating structures, energy systems in building, environmental sustainability and facility management costs (Kirkham el al. 2002; Kong and Frangopol 2003; Lu et al. 2000; Osman and Ries 2004). Research has been advanced on life-cycle environmental impacts of utilities such as use of water and electricity in buildings (Arpke 2005; Ochoa et al. 2002). Similarly, studies have also been undertaken to examine the life-cycle impacts of building design and construction process, materials and life-cycle costs of individual components such as roofing (Ballensky 2006; Bilec et al. 2006; Cole & Sterner 2000).

Other notable studies on LCC were on certain plants and equipment installed in building systems such as cooling systems, compression and refrigeration systems and their reliability (Newmann and Fenton, 1993; Doi, 1996). The works accomplished by Wu et al. (2006) highlighted the impact of reliability of cost on each stage of the life-cycle of building system, in order to improve the functional performance. They suggested that the data analysis should be applied in reliability and maintainability design, and to develop maintenance policies of a building system.

Himmelberg et al. (2005) suggested that the annual cost of home-ownership could be calculated as sum of six components, representing both direct costs and offsetting benefits as:

$$Annual\ cost = Pr + P\omega - P\tau(i + \omega) + P\delta - Pg + P\gamma \quad \ldots\ldots\ldots\ldots\ldots (2.18)$$

where,

P is the property value,

r is the interest rate

ω is the property tax rate

τ is the income tax rate

i is mortgage interest rate

δ is the annual depreciation rate

g is the capital gain

γ is the risk premium

In this model of annual ownership cost, first of all the rational of first term Pr is not explained. If this was meant to account for opportunity loss of the investment, then it is misleading because, normally, home-owners do not pay 100% of the property value upfront as down payment. Secondly, the depreciation of property value is taken as maintenance cost, and this will not correctly reflect actual costs, because depreciation/appreciation of property value and physical need for repair and maintenance are two different cost items and one related to market situation and another is related to life-cycle period of the entire home-ownership and physical condition of the property.

Comprehensive studies on LCC analysis towards the direction of investment appraisal of an entire project or a building were done by several researchers, notably Flanagan et al. (1987), Marshall (1987), and Ranasinghe (1996). These studies were limited to theoretical discussions, and their applications to home-buying analysis was lacking.

Bromilow and Pawsey (1987) developed a theoretical life-cycle model of a building to estimate long term resource requirement from a maintenance and rehabilitation point of view. This model considered the time value of money in the life-cycle cost analysis of maintenance costs, and suggested sinking fund approach is suitable as a long-term maintenance strategy. Some researchers have focused their works on forecasting accuracies, application of probabilistic modeling and propagating uncertainties, and data collections aspects of life-cycle cost analysis (Kirkham 2005; Kirkham et al. 2002; Kishk

2004). This was motivated by the fact that forecasting involves uncertainties, and therefore the larger the historical data set used, the better the accuracies of the cost analysis. LCC is a data intensive process especially in a complex system like a building, and the final results are highly dependent on availability and reliability of the input data (Glusch and Baumann, 2004).

Despite the extensive research works accomplished during the last three decades, and recognition of the role and importance of LCC, its practical relevance is still at a moderate level and it has not achieved the status of a common tool (Pelzeter, 2007). Most likely, this is due to the fact that it requires handling and processing of a large quantity of data, and in the absence of standardized procedures, its application remains unexplored.

Researchers such as Alberts and Kerr (1981), Ermer et al. (1994), Goodman (2003) and Jud et al. (2006) started specific studies related to investment appraisal of single-family home ownerships. However, these studies have not fully integrated the concept of life-cycle cost analysis of home-buying that can directly and comprehensively address the homebuyers' perspective with respect to life-cycle ownership liabilities and opportunity costs. Li and Yao (2007) developed a life-cycle model to study the effects of house price changes on household consumption and welfare.

Forty years ago, Shelton (1968) undertook a study comparing the cost of renting versus owning a house. That study offered some framework for cost comparison and indicated that the major factor that should guide renting versus owning decision is the duration of tenancy. Since this research was accomplished much earlier than life-cycle cost theories were published, a holistic approach in cost analysis was obviously missing.

Ownership of any items involves three major cost components: 1) acquisition cost, 2) operation & maintenance, and 3) disposal or retirement costs. The integration of all these costs, commonly known as "cradle-to-grave costs" is referred to as life-cycle cost. Studies have shown that potential buyers are not always aware of the adverse financial liabilities that may arise due to ownership of certain items (Liebermann and Ungar, 1999). The acquisition cost of a product or a facility can often represent less than half of the total ownership costs. Research indicates that although the initial acquisition cost is the largest single cost, in the case of buildings, it was less than 50% of the total life-cycle cost (Flanagan 1989). According to Flanagan's study, for example, an elderly person's home running costs were up to 70% of the total life-cycle cost, for a 40-year ownership period.

The intent of the proposed research is to understand and explore the life-cycle cost of home-ownership, from the perspective of a new homebuyer who is about to acquire a property for their own residential purposes. Buying a family home is a commitment to future expenses. Once the procurement is finalized, the home-owner has little or no control on the part of life-cycle costs.

The costs of building construction and materials are escalating at a progressive rate with rapid rises of energy cost, materials, and wages of labor. Effective utilization of resources and green construction is a new pressing concern for home-owners. The impact of these and other economic and social factors has attracted the use of life-cycle cost analysis technique as a method of calculating the total cost of ownership over the life span of the asset (Brown and Yanuck, 1985). A home-owner, may encounter the reality that the structure, utilities and components are functional but it requires substantial renovation to upkeep the house standards. Refurbishment, upgrading and maintenance costs may not become obvious to the new owner at the time of acquisition, but these costs become liabilities when such works have to be undertaken at a later stage as and when such works become inevitable. Therefore, it is vital to assess the existing condition of the property, desirably at the time of property selection, to identify anticipated future costs as a decision process.

The LCC process helps home-owners to forecast ownership liabilities, compare alternatives for investment and make an economically sensible and viable decision. Most homebuyers would be interested in knowing about the future liabilities of ownership and lost opportunities while they seek appraisal of whether or not to invest their money in home-buying.

The question of whether an owner occupied house should be considered as an investment portfolio or not is still being debated (Waldrup et al., 2005). Some argue that a home is frequently someone's most important investment, because it provides healthy returns via leverage, appreciation, tax deductibility of interest, and an absence of capital gains upon sale. Others contemplate that homes are a consumption item. In their article, Waldrup et al. (2005) have defended that buying a house is an investment, and compared against stock or bonds, renting and even the reverse mortgage. Their focus of discussion was to justify that buying a house is an attractive investment due mainly to tax benefits than covering all aspects of home-buying life-cycle costs.

Although home-ownership expenses are a large expense item of the average American household, there is a paucity of rigorous and life-cycle cost analysis addressing the homebuyers' perspective supporting the decision-making process practically. Therefore, this research intends to fill that gap.

CHAPTER 3: RESEARCH SCOPE

3.1 Research Needs

Literature review, discussed in chapter two, revealed that studies on home-buying or home-ownership life-cycle cost analysis were very scarce. The publications covering topics similar to the proposed research include Shelton (1968), Alberts and Kerr (1981), Ermer et al. (1994), Goodman (2003), Waldrup et al. (2005), and Jud et al. (2006). Although Shelton's was the only publication related to the core of this research, most of the LCC related questions were left untouched because large parts of the LCC theories were not available at the time his work was published in 1968. Therefore, the concept of life-cycle cost analysis was not integrated in his research. The other researchers have covered specific aspects of home-buying or home-ownership, leaving the holistic scenario unattended from the perspective of life-cycle cost analysis.

Although the subject of home-buying and home-ownership is a very common issue that concerns nearly all average American homebuyers and home-owners, there is a paucity of rigorous methodology that helps to explore and analyze life-cycle costs addressing the homebuyer's holistic perspective. None of the above research has addressed the buyer's perspective such as what percentage of down payment maximizes the buyer's net worth for given mortgage conditions, or how affordable are the total ownership expenses. LCC analysis of home-buying and home-ownership is an area which is not fully researched yet. During the last several decades, LCC analysis models have been developed for various facilities, plants and equipment, but an LCC model for home-buying, that considers cradle-to-grave expense home-ownership, was not found in published literature.

3.2 Problem Statement

Finding a suitable and economically affordable home is a daunting task, and it is characterized by hopes and aspirations, fears and uncertainties. There are several economic parameters that make the home-buying decision process very complicated and hard to understand. For a reliable and holistic analysis, all the economic parameters that influence the time value of money, and the cost elements that influence the ownership expenses must be comprehensively considered, and weighted by employing an economic analysis model that is appropriate and capable of analyzing LCC. Therefore, an LCC analysis methodology, specific for home-buying and home-ownership is being studied in this research.

The home-buying LCC analysis model or methodology developed by this research will be able to answer some of the pertinent questions that a homebuyer may raise, such as what the percentage of down payment relative to the acquisition cost that best serves the buyer. What ownership period will maximize the buyer's net worth? What mortgage interest rate and discount points will minimize the overall expenses of ownership? What are the hidden benefits or expenses of home-ownerships and how do they influence the overall return on investment? Is buying and owning a house affordable? Whether a person should buy a house or rent? What should the home-owner's maintenance and renovation strategies be in view of affordability? When is the best timing for selling or refinancing the house and at what conditions? These are some of the questions that this research will attempt to answer by following a rigorous LCC analysis.

3.3 Research Framework

The notion of the present research is to address the average home-owner, i.e. a first time homebuyer who wants to purchase a single-family residential house, for his or her own occupancy. Since ownership costs vary from location to location, this study has chosen the state of Hawai'i, and in particular, the Honolulu area to focus on. However, major economic indicators such as inflation rate and interest rates are based on national statistics. Some other data utilized in this model of life-cycle cost analysis are obtained from sources such as both national or local mortgage brokers, real estate agents and the relevant business information available in public domain.

Although the physical life of a house normally goes beyond 50 years, for the purpose of economic analysis, a maximum of 30 years in the life-cycle period will be considered in this research. The maximum life-cycle period is considered 30 years, because this is the typical length of time for most mortgage payment. However, homebuyers may refinance a number of times within this physical life of the home or even terminate the home-ownership at any time. Therefore, the methodology developed in this study will be capable of analyzing any span of the economic life-cycle.

Life-cycle cost elements considered and analyzed in this research are fully discussed in Chapter 5. The major thrust of this research is to present a methodology that can reliably adjust the time value of money for all present as well as future costs for a realistic assessment of all cradle-to-grave expenses at a given point in time. To this effect, all cost items warrant adjustment for inflation, escalation, and opportunity cost of the capital, and thus cost forecasting is involved in the analysis. Regression method of forecasting will be applied as part of the economic analysis.

As an alternative to home ownership, renting a property will be analyzed. Such a comparison will highlight the economic merits and demerits of owning versus renting a property, and thus giving potential home-owners the ability to make an informed decision.

Affordability is an important aspect in the home-buying process. The buyer's present as well as long-term future income level must be considered against the life-cycle home ownership expenses. It is up to the buyer to make such a self-assessment of his or her continued employability in maintaining existing or higher incomes.

The major elements of the scope covered under this research are presented in a diagrammatic form in Figure 3.1. The elements forming part of this research are shown inside the circle. The elements indicated outside of the circle will not form part of this

Pride of ownership, reverse mortgage, statistical and probabilistic analysis; determination of physical life span of house or its components, amenities, structure or materials, accidental costs, new construction and or demolition of a house.

Single-family house, Honolulu, HI;
Max 30 years of economic life cycle period;
Deterministic analysis of life cycle costs;
Initial (acquisition) costs; primary mortgage;
Ownership costs (repair, maintenance, utilities)
Ownership termination (resale);
Property tax, income tax, capital gain tax; home insurance;
Cost forecasting;
Sensitivity analysis;
Renting as an alternative to ownership;
Computer programs: Excel and Matlab.

Life-cycle cost of green construction, energy saving, comfort, safety, security, environmental aspects and structural health of the facility or its components, sub-prime or secondary market of home loan, annually readjusted mortgage (ARM), high rise condominium, condominium style town houses, leasehold ownership, capital improvement, refinancing and equity loans.

Figure 3.1: Schematic diagram of research scope

study. Some of the elements concerning purchasing and owning a family house, but outside of this research, are as follows:

1. Pride of ownership aspects of a home purchase that includes social, psychological and emotional values will not be considered in this research because these elements cannot be converted into economic terms, and the focus of this research is founded on economic analysis.
2. Analysis of reverse mortgage will not be included, because, it is one of the ownership termination options, and this topic itself can be a self-contained research theme. The intent of this life-cycle cost study is to consider once and forever sale of the property.
3. Sub-prime mortgage or secondary market of home loan is beyond the scope of this research. Similarly, this research will consider only fixed mortgage interest rate, and the condition of buying a home with adjustable-rate mortgage (ARM) will not be discussed.
4. The approach of this research is motivated by deterministic methods and therefore probabilistic and statistical analyses are not envisioned.
5. Determination of physical life span of house or its components, life-cycle costs related to new construction and/or demolition or green construction, energy saving, comfort, safety, security, environmental aspects, and structural health of the property, defects of amenities and/or its components are beyond the scope of this research.

6. It is beyond the objective of this research to uncover all possible onetime expenses and/or accidental costs and to itemize them. For example, modification or upgrade of amenities such as garage, kitchen, bathroom, or anything similar will not be covered by this research. Similarly, for example, repairing termite damage due to lack of maintenance will fall outside of the study's scope, or damage due to uninsured items or deliberate and willful damage. However, property insurance will be included in the analysis.
7. High-rise condominium or condominium style town house, and leasehold ownership are also beyond the scope of this research. However, fee simple ownership or equivalent may be addressed by this research.

CHAPTER 4: HOME-BUYING BASICS

The process towards home-ownership is fairly complex. This chapter provides an overview of the home-buying process and all steps towards home ownership. The home-buying process starts from that point in time when a person desires to buy a house for family occupancy. From this point onwards, the person (homebuyer) starts searching for a suitable property, contacts a real estate agent and arranges necessary funds to enable the property acquisition.

Based on literature research, and conversation with real estate agents and mortgage brokers, a schematic flow chart of the home-buying process is drawn as shown in Figure 4.1 (Garton-Good, 2006; Summers, 2006; FirstWeber, 2008; Rancho, 2008; Findlay, 2008; Oscar, 2008, MLSHomeQuest, 2008). Normally, the homebuyer contacts a real estate agent for assistance throughout the process, starting from the search for a suitable property and loan, up to the closing of the deal. During this process a variety of institutions will be involved in realizing the transaction, and the transfer of property ownership from a seller to a buyer. Once a suitable property is identified, the buyer and the seller will conclude a written agreement and the buyer will deposit a small amount of money in an escrow account as a commitment for buying the selected property. If the buyer walks away from the deal, the amount deposited in the escrow account will be paid to the seller without any further dispute. If the buyer continues with the purchase, the amount deposited in the escrow account will be considered as a portion of the down

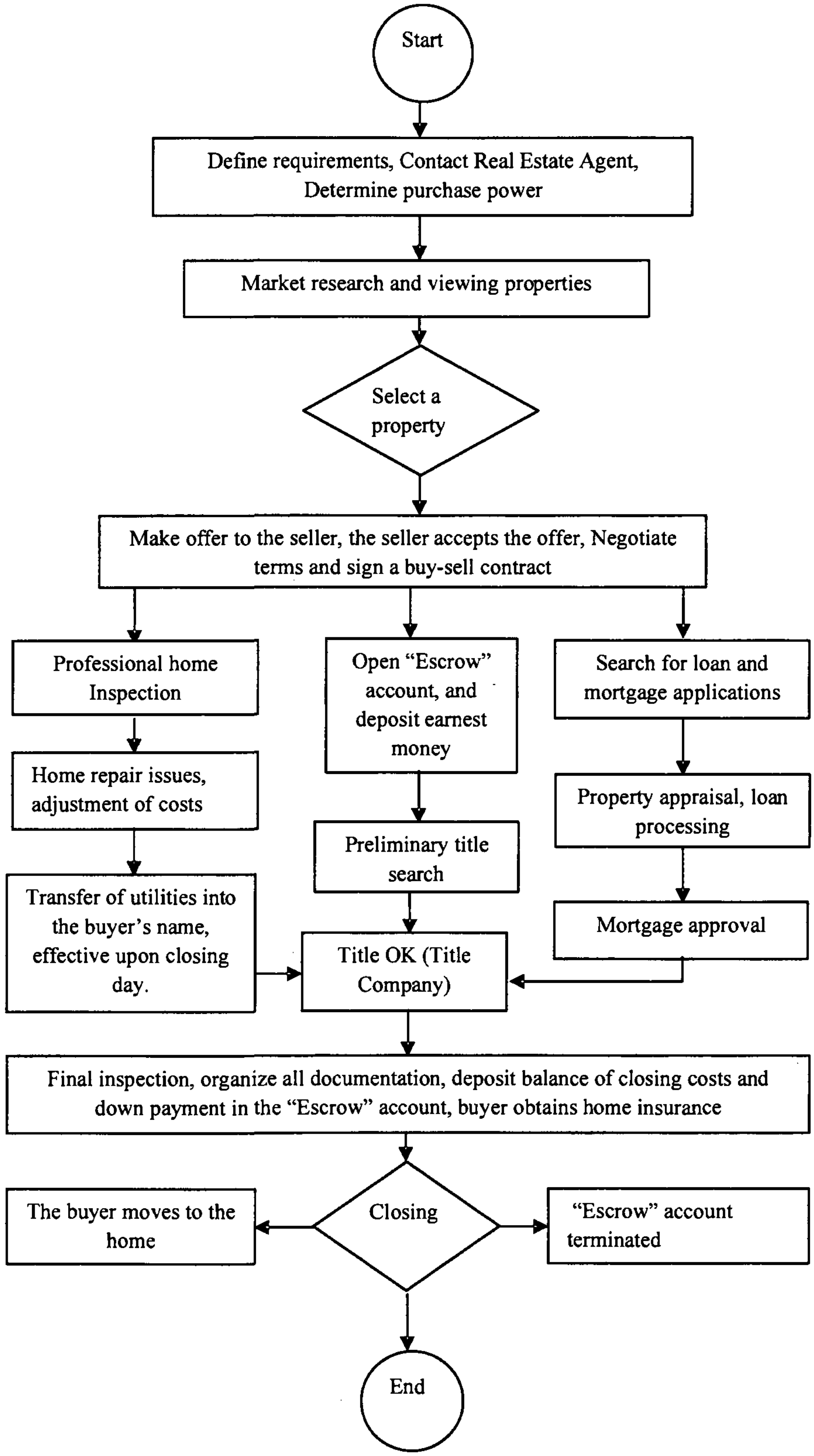

Figure 4.1: Schematic flow chart of home-buying process.

payment. After a small sum of money is deposited into the escrow account, the Escrow Company, also known as the Title Company, will investigate any title liens and ownership clearance. In the meantime, the buyer will apply for loans.

The buyer may hire professional home inspectors to identify any defects, substandard items and pertinent repair needs of the property for final negotiation of the sales price. Such an inspection could be instrumental in identifying the items that may need periodic and/or long-term repair maintenance, replacement, refurbishment or upgrading to satisfy the buyer's needs. For the reference of this research, a standard, home inspection format was obtained from a general home inspector practicing in Hawai'i - Building Specs Hawai'i (2008). This format complies with the codes and standards of the National Association of Home Inspectors, and the following components are normally inspected and evaluated by the professional home inspectors:

1. Ground condition
2. Foundations
3. Crawlspaces & basement
4. Exterior surfaces
5. Roofs
6. Decks/porches/patios
7. Doors, windows
8. Attic
9. Garage or carport

10. Safety
11. Kitchen and appliances
12. Bathrooms
13. Interior
14. Electrical connections
15. Plumbing
16. Gas services
17. Cooling systems
18. Fireplace/ chimney/ environmental

Once the lender approves the home loan, the title is confirmed to be clean, and defects and repair issues of the property are negotiated; ownership of the utility items such as electricity, water, and sewer can be transferred from the seller to the buyer from a specified date, usually the Closing Day. As indicated in the flow chart, on or before the Closing date, the buyer has to deposit the full amount of down payment and all other closing costs into the Escrow account. On the Closing day, documents are signed by the seller, the buyer, the Escrow/ Title Company, the lender, and the Real Estate Agents for formal transfer of home-ownership.

The mortgage lending process is one of the most cumbersome items in the home-buying process, and it is not obvious to most first time homebuyers (Garton-Good, 2006). In the United States, there are three main players in the mortgage market: 1) primary lenders,

2) the secondary market, and 3) the private mortgage insurance market (Garton-Good, 2006 and Summers, 2006).

The **primary lenders** are the mortgage brokers, mortgage bankers, banks and credit unions who directly deal with individual mortgage borrowers to negotiate the terms and accomplish the mortgage transactions. The national market is commonly known as **secondary lenders** where residential mortgages are assembled into pools and sold to investors. Three main players in the U.S. secondary market are: 1) the Federal National Mortgage Association (FNMA) known as "Fannie Mae", 2) the Federal Home Loan Mortgage Corporation (FHLM) known as "Freddie Mac", and 3) the Government National Mortgage Association (GNMA) known as "Ginnie Mae." Besides these federal agencies, there are some private mortgage companies who play the role in the secondary market. These secondary lenders assure that mortgage originators, have access to pools of investment capital managed by varieties of funds such as pension funds, insurance companies, and other institutional buyers of mortgage-backed bonds across the nation. This system assures adequate supply of mortgage financing regardless of the location.

Private mortgage insurance market is comprised of various companies who insure against the borrower's default and thus provide security to the lender's investment. The necessary premium is normally paid by the borrower as part of the mortgage payment, if applicable. Generally, mortgage insurance is required on all conventional loans with a less than 20% down payment.

CHAPTER 5: HOME-OWNERSHIP LIFE-CYCLE COSTS

5.1 Home-ownership Life-cycle

In life-cycle cost analysis, the whole life of the facility is a key factor, and therefore it is imperative to establish the life-cycle period. The home-buying process evolves from a desire to own a family house for a variety of reasons, and thereby conceptualizing and planning home ownership. Searching for suitable homes and exploring resources to expedite the acquisition process is the first step towards home-buying and it is the start of life-cycle of home-ownership.

During the occupancy period, the owner has to maintain the standard of the amenities, and ensure that all essential services are available in the house to provide livable conditions. This phase can be broadly categorized as operation and maintenance phase of the home-ownership life-cycle. Occupancy is the longest period in the ownership life-cycle.

A concept of ownership period or study life is introduced to replace the whole life of the property. This is the economic life or a life determined by investment or mission of the facility rather than its physical life expectancy (Dell'lsola and Kirk, 2003). This allows an analyst to consider the unique nature of frequent ownership change through sale and purchase. The final phase is the resale or disposal of the property to terminate right of occupancy and ownership.

Thus, home ownership life-cycle can be broadly categorized in three phases:

1. Acquisition phase,
2. Ownership and occupancy phase, and
3. Termination or resale phase.

5.2 Life-cycle costs

The home ownership life-cycle cost elements are considered primarily for U.S. home-owners, and specifically for the State of Hawai'i. Variation of life-cycle cost items within the U.S. is negligible, although the magnitude of expenses may vary from state to state or from one geographic location to another, even within the territory of a state. Such variations are influenced mainly by the standard of local economy, and governing local laws and regulation of the jurisdiction. Property values significantly vary from city to city, and it is higher in urban areas than in the rural districts. Although the federal income tax is consistent throughout the nation, state income tax rates vary from state to state. The property tax rates differ from county to county even within the territory of a state. Not all home ownership life-cycle cost items are obvious and tangible. Dell'Isola and Kirk (2003) suggested the following life-cycle cost categories that can be considered in LCC of facilities like a building:

- Initial Costs: Construction, Fees, Other Initial Costs
- One time Cost: Replacement, Alterations, Salvage, Other One-Time Costs
- Annual Costs: Operations, Maintenance, Financing, Taxes, Insurance, Security, Other Annual Costs

- Functional Use Costs: Staffing, Materials, Denial of Use, Other Functional Use Costs

Since this research is aimed at analyzing a purchase of a readily built house, construction related costs are not relevant, and instead home acquisition cost based on the purchase price of the property forms part of the initial costs. Obviously, costs such as down payment, discount points, closing costs, and amortization (mortgage) of loan are the initial costs in case of a house purchase (Miller & Geltner 2005).

Although the list suggested by Dell'lsola and Kirk (2003) provides a solid basis to recognize the life-cycle cost elements, it does not consider the termination cost at the end of the life-cycle period. In case of home-buying and home-ownership, the revenue earned after resale, i.e., salvage value, forms a significant cash flow item. This study considers several other cost items that are easily tangible and not so tangible cost and revenue items, such as opportunity costs, tax implications and other expenses that are not part of home purchase or ownership cost, but originated in connection with the ownership of a house. All such cost and revenue items of home-ownership are outlined below.

5.2.1 Acquisition Costs:

These are the costs incurred from the moment when a potential home buyer starts the home search and buying process until the moment he or she obtains the key to the house. Research shows that typically, first-time home buyers tend to purchase a property worth 85% of the prevailing median price (DEBDT, 2008).

Research and study costs: These costs are those incurred while exploring suitable funding possibilities, contacting real estate agents and establishing what is affordable and desirable. The present study neglects these costs, but suggests that when it is a significant amount, it would be worth including in the analysis.

Sales price of the property: This is the main item of acquisition costs, which is later distributed as down payment and monthly mortgage. This is the market value of the property, which is largely dependent on geographic location, home size, quality of construction and materials used, neighborhoods, school quality, convenience of public facilities, population growth, and economic activities in the proximity.

Buyer's Closing Costs: These are the expenses, over and above the price of the property value (sales price) that a buyer has to pay in order to complete the real estate transaction. This is the cost incurred due to the administrative procedures and services provided by various agencies and authorities in the process of loan approval, property inspection, title search and the services rendered for ownership transfer. Although buyers and sellers may often negotiate the closing costs as part of their deal, the buyer is the one who takes most of the closing costs (Summers, 2006). A detailed discussion on closing costs can be found in literature such as Summers (2006), Gorton-Good (2004), and online (Freddie Mac, 2008; Quickenloans, 2008; Bankrate, 2008). According to Freddie Mac (2008), closing costs generally range between 2% to 7% of the property value and depend on the mortgage type, and are a subject of negotiation to a limited extent.

Normally, closing costs are calculated by title companies after the purchase deal is finalized and all relevant costs are submitted by the concerned parties. For example, inspectors should provide the inspection fees and the insurance company should provide the premium to be paid by the new owner. Lewis (2007) classified the closing costs into three categories:

1. Origination fee charged by the mortgage lenders,
2. Title and settlement fees charged by third parties, and
3. Taxes and prepaid items such as home-owners insurance, association fees and prorated fees.

Bankrate (2007) conducted an online survey and collected good faith closing costs from all 50 states, and found that a homebuyer in Honolulu who borrows a loan amount of \$200,000 had to pay an average closing cost of \$7,854, as itemized in Table 5.1. This is approximately 3.92% of the property cost.

When the discount points are taken separately, the average closing cost for Honolulu purchase totaled \$7,057 against the loan amount of \$200,000. This leads to an assumption that average closing costs are approximately 3.53% of the loan amount, in the case of a Hawaiʻi real estate transaction. If the purchase price is taken as Oʻahu's median single-family size, i.e., \$630,000 with conventional 20% down payment, the required loan amount is \$504,000. With the assumption of 3.53% rate, the closing cost amount will be approximately \$17,784.

In order to verify the above assumption, a quick survey was undertaken and necessary financial data were collected from open houses at random in Mānoa Valley (Honolulu), during mid March 2008. According to an estimate provided by a mortgage broker,

Table 5.1: Average home-buying closing costs in Hawai'i and in the U.S. (source: Bankrate, 2007)

Item	Hawai'i	U.S. Average
Origination fee		
Points *	$796.50	$710.94
Application fee	$635.00	$438.21
Commitment fee	$565.00	$565.72
Document preparation fee	$285.00	$187.24
Funding Fee	--	$225.00
Origination or lender's fee	$995.00	$1,114.81
Processing fee	$210.00	$370.93
Tax service	$67.00	$66.28
Underwriting	--	$246.84
Wire transfer	$25.00	$29.23
Title and closing		
Appraisal	$500.00	$325.98
Attorney, closing, settlement fee	$423.33	$343.89
Credit report	$6.00	$12.00
Flood certification	$9.50	$11.10
Pest, and other inspection†	$50.00	$49.95
Postage, courier	$50.00	$28.30
Survey†	$100.00	$134.85
Title insurance	$625.30	$707.30
Title work: title search, plat drawing, name search, endorsements	$250.00	$197.71
Government fees		
Recording fee	$94.25	$95.12
City/county/state tax stamps/intangible	$162.50	$1371.49
Pre-paid	$1,304.39	$1,468.55
Escrow	$700.00	$707.65
Total cost	**$7,853.77**	**$9,409.09**

* Points are explained in the following paragraph and normally taken out of closing costs.

† These costs appear to be too low compared to average market rate in Honolulu. It was understood that the normal range of these costs is minimum $250 and maximum $500.

with the assumption of conventional loan arrangement (20% down payment, 30 years fixed at mortgage rate 6.25%) for a house priced at $935,000, the closing cost will be in the range of $15,200. This was approximately 2.0% of the loan amount or 1.625% of the sales price.

Discount Points: These are special charges that a borrower has to pay in order to accept mortgage loans. By definition each mortgage discount point is equal to 1% of the total amount mortgaged (Smith, 2008). For example, on a $100,000 home loan, one point is equal to $1,000. Points are considered as prepaid interest, and lenders use it to increase their yield from the loan (Gorton-Good, 2004). The purchase of each point lowers the mortgage interest rate. Therefore, points and mortgage interest rate are tied together in mortgage negotiations. In future discussions, mortgage discount points will be referred to simply as points.

Mortgage interest rate and points are adjusted on a daily basis, and it normally varies from lender to lender. However, the variation between the lenders is very small because the competitive market condition. On a typical day of March 13, 2008, the schedule of mortgage interest rate combined with the points at the Indymac Bank was as shown in Table 5.2. This was obtained from a local mortgage broker who mentioned that such information are generally emailed to mortgage brokers by banks on a daily basis, and may not be easily found in the public domain such as the internet. Based on these data, a graph was drawn to visualize the relationship between mortgage and the points as shown in Figure 5.1.

Table 5.2: Typical mortgage interest rate and points for 40, 30 and 15 years fixed rate mortgage term. (source: Indymac Bank)

Nominal annual mortgage interest rate	Points		
	40 year	30 year	15 year
7.750	-3.765	-5.390	-5.195
7.625	-3.331	-4.956	-4.708
7.500	-3.258	-4.883	-4.684
7.375	-3.067	-4.692	-4.644
7.250	-2.655	-4.280	-4.420
7.125	-1.892	-3.517	-4.018
7.000	-1.730	-3.355	-4.004
6.875	-1.405	-3.030	-3.925
6.750	-0.898	-2.523	-3.634
6.625	-0.697	-2.322	-2.885
6.500	-0.435	-2.060	-2.837
6.375	-0.043	-1.668	-2.686
6.250	0.524	-1.101	-2.294
6.125	0.775	-0.850	-2.000
6.000	1.096	-0.529	-1.881
5.875	1.542	-0.083	-1.627
5.750	2.192	0.567	-1.161
5.625	2.683	1.058	-1.138
5.500	3.099	1.474	-0.966
5.375	3.690	2.065	-0.678
5.250	4.519	2.894	-0.169
5.125	5.270	3.645	0.130

Depending upon the interest rates, as shown in the Table 5.2, negative points also prevail in lending practice. In essence, the negative points are the credit to the borrower and can be utilized in paying off purchase related closing costs. The negative points are never paid in hard cash, but the borrower may benefit from it, if she or he is searching for a supplement cash reserve for down payment and closing costs. The penalty is a higher mortgage interest rate for the life of the mortgage.

There are more than 40 mortgage lenders locally available in the Hawai‘i market. Their mortgage interest rates and points are generally unique, based on their terms and conditions, market conditions and the borrower's credit worthiness. A list of these Mortgage Lenders was published in the online version of the Honolulu Advertiser on March 13, 2008.

Figure 5.1: A typical mortgage interest rate and points for 40, 30 and 15 years of fixed rate mortgage term. (source: Indymac Bank)

Down payment: It is the home buyer's initial investment, a fraction of the purchase price that has to be paid at the time of ownership transfer, in addition to the closing costs discussed above. According to Freddie Mac (2008), a down payment is usually between 3% and 20% of the total cost of the home price. There are no fixed rules or a set formula on how much down payment has to be paid. The size of down payment depends on the buyer's credit history, income, the selling price of the house, and the type of mortgage. It can be as low as 0%, but an immediate consequence would be a higher mortgage interest rate than normal, and thus paying higher monthly mortgage payments (Colfax, 2008).

Conventionally, mortgage lenders require at least 20% of the purchase price as down payment. When down payment is less than 20%, lenders may raise the mortgage interest rate, and the borrower will be required to purchase private mortgage insurance (PMI) to protect the bank in case of homebuyer's default on loan payment. When PMI is required, it is added either to closing costs or monthly mortgage payment. Twenty percent down payment is based on a historical experience of mortgage companies that when houses are sold under foreclosure, investors recover only about 80% of the house price (Summers, 2006; Gorton-Good, 2004).

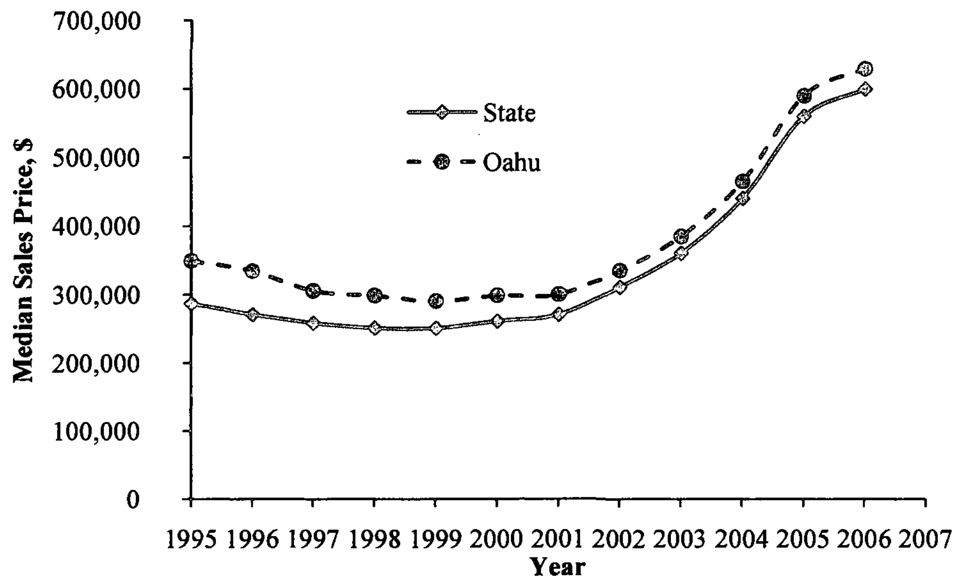

Figure 5.2: Median sales price of single-family homes in the state of Hawai'i and in the island of O'ahu (source: DBEDT, 2007)

A set of time series data of median sales price of single-family homes for the state of Hawai'i and for the island of O'ahu is shown in Figure 5.2 (DBEDT, 2007). In 2006, the median resale price of a single-family house was $599,900 for the state of Hawai'i and

$630,000 for O‘ahu. With the conventional rate of 20%, the down payment would be $120,000 and $126,000 for the state of Hawai‘i and for O‘ahu respectively.

5.2.2 Monthly and Annually Recurring Ownership Costs:

These are the expenses, recurrent, during the entire ownership and occupancy period. Main ownership costs are monthly mortgage payments, utility bills, repair and maintenance, insurance, and property tax. These costs are divided into three categories: monthly, annual, and periodically recurring costs.

Monthly Mortgage: It is the home-owner's most daunting, regular, and largest monthly expense item. The loan borrowed to buy the house is also a lien on the property (the same house), and the mortgage must be paid in monthly installments over a set period of time as part of a loan repayment scheme to avoid foreclosure. Usually, home loans are set for 30 years and each installment of mortgage paid includes interest and a portion of the principal. The amount that goes to interest decreases over time, while the amount that contributes principal payment increases. The principal paid becomes the home-owner's equity on the house.

In 2006, the 30-year fixed nominal annual average mortgage interest rate was 6.58%. With the conventional rate of 20%, down payment, and for a median sale price of a single-family house in the state of Hawai‘i ($599,900) and O‘ahu ($630,000) the monthly mortgage (property tax and insurance excluded) was calculated to be $3,059 and $3,212 respectively.

Utilities Expenses: A home-owner is liable to pay for services such as heat, electricity, gas, water, sewage, trash disposal, cable television, and telephone. The expense items such as heat and electricity may vary seasonally. Average annual expenditure on utilities, fuels, and public services of a housing unit was $2,813 for a typical house in Honolulu for 2004 to 2005 as shown in Figure 5.3.

For the same period, median money income of a household in the state of Hawai'i was $59,586. Thus, nearly 4.72% of the median household income was spent on utilities, fuels, and public services alone.

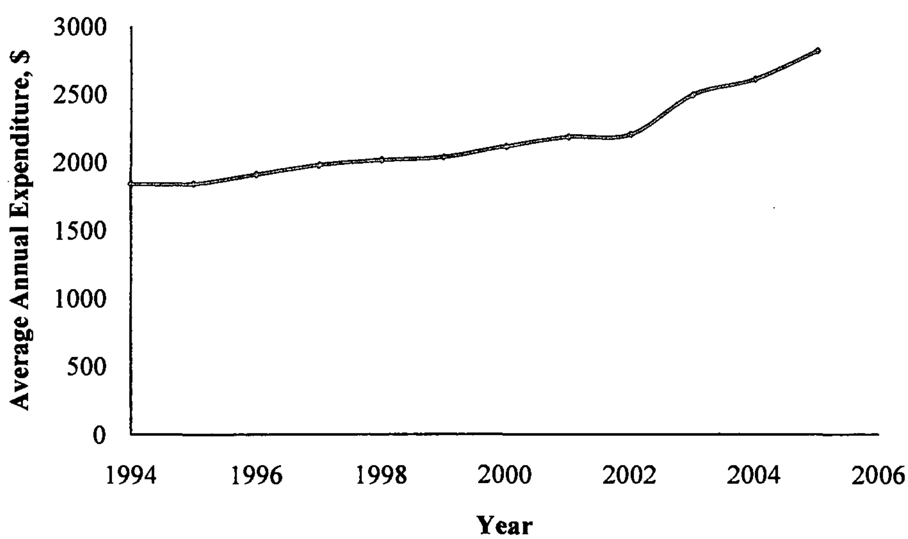

Figure 5.3: Average annual utilities, fuel and public services expenses for a typical single-family home in Honolulu (source: DBEDT, 2006)

Minor Repairs and Maintenance: A home-owner should expect some minor repair and maintenance work every now and then, if not every month, no matter how new a house is. These expenses include electrical and plumbing repair, interior and exterior upkeep, landscaping and repairing unexpected minor damages, wear and tear. Some examples of such minor works items are: clogged kitchen sink, leaking water taps, broken knobs on stoves, torn fly net, and so forth. It is assumed that such repairs and maintenance have to be done in order to maintain a constant quality of housing standard, and not for the purpose of capital improvement or upgrading of amenities.

Such repair and maintenance costs are often more difficult to estimate because standards of materials and construction quality vary from house to house. Even the costs may vary depending upon the severity of the problem and the home-owner's desired quality standard of the repair works. Also it depends on the ability of the owner to perform these minor repairs themselves, or requires a contractor to do the repair works. Therefore, to a great extent these cost are the best estimate derived from certain engineering judgment.

Association Fees: In planned communities, association fees are charged for services rendered to the home-owners, other than the utilities, such as security, surveillance of the neighborhood, common area maintenance, termite and insect control, snow removal, a community swimming pool, recreation center and the like. Such costs are specific to location and it could vary from nothing to several hundred dollars per month.

Access Gasoline Expenses: This is not a common and obvious expense. In this study, it is assumed that a person used to live in a rented apartment closer to his work place, before buying a house. The purchased house is located at a longer commuting distance thus incurring more expenses due to additional mileage of driving. The situation may be reverse if the newly bought house is closer to workplace than the rented apartment. Here, the intent of this item is to indicate and account for additional expenses (or cost saving) incurred in connection with the purchase of house, which is not an explicit expense of home-buying. An arbitrary assumption is made in this paper that an additional expense of certain dollar amount is incurred to pay the required gasoline for commuting extra mileage every month. It has to be noted that such expenses could even be negative.

Real Estate Tax: This is the ad valorem (of value) tax popularly termed as property tax that home-owners must pay to local government annually based on the fair market value of the property they own. The taxing authority either performs or requires the owner to assess the market value of the property in order to determine monetary value of the tax. Property taxes vary between states and jurisdiction of counties. For an average home-owner in the Honolulu County, the current annual property tax rate is $5.55 per $1,000 value of the property (County of Honolulu, 2006)

Home Insurance: Most lenders require that home-owners purchase at least a basic home insurance policy that covers damages caused by fire, smoke, hail, wind, falling objects, theft, vandalism, frozen pipes, overflowing steam from air conditioners and water heaters, automobile and airplane impact. Depending on the geographic location of the house, additional policies may also be required to cover liabilities for accidents that may occur within the property, and to insure against damages caused by Mother Nature, such as hurricanes, floods, earthquakes, landslides, or lava flow commonly termed as an "act of god."

According to the National Association of Insurance Commissioners, in 2006, average home-owner's insurance policy known as 'HO-3', for Hawai'i residents was $837/year (III, 2007). This was confirmed by another local insurance company's website information, which indicated that average home-owner's insurance policy is $69.76/month (HHI, 2008). The HO-3 home-owner's insurance policy package covers most of the common risks, but excludes all of the "act of God" events and damages caused by war and nuclear accidents. A limited time series data of average annual home insurance premiums is presented in Figure 5.4.

The average flood insurance premium for a property located in Mānoa Valley of Honolulu in 2004 was $309/year, as set by the Federal Emergency Management Agency (Adamson, 2004). According to a brief survey done by staff reporters of Honolulu Advertiser in 2006, a mainland based insurance company provided a policy package at the cost of $919/year to cover $250,000 worth of property value that insured against earthquakes, lava flow, flood and landslide damages (Wiles and Dayton, 2006). On the Big Island (Hawai'i), average home-owners policy was estimated to be in the range of $1,000 per year that covered lava flow, fire and other general risks, excluding hurricane and earthquake damages (Dayton, 2008). Based on the information provided by Hawai'i's State Insurance Commissioner, in 2006, average annual hurricane insurance premium for Hawai'i was estimated to be $2.6/$1000 of property value to cover appraisal value of the house (Wiles, 2006).

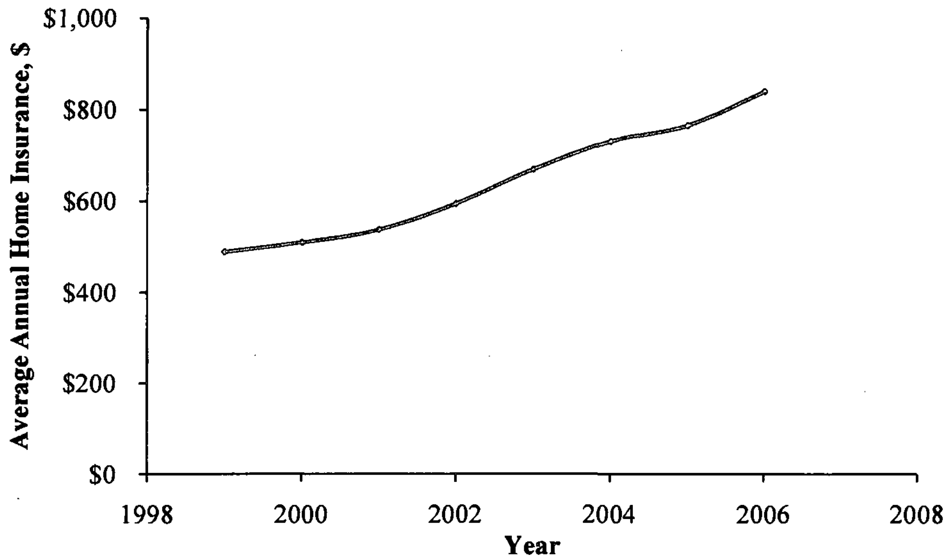

Figure 5.4: Home-owners insurance expenditures (source: III, 2008)

5.2.3 Periodic Repair and Replacement Costs

Major Repairs: A home-owner must expect some major repair and maintenance works during the home-ownership period that warrants significant expenses. Such major repairs are not for capital improvements, but to maintain the initial standard and comfort of living in the house at the same level as it was envisaged during the acquisition phase. Some obvious examples of such major repair and replacement items may constitute repainting the house, replacing doors, windows, roof, gutter, kitchen sink, dishwasher, refrigerator, washing machine, dryer, air-conditioning, heating system, electrical wiring, plumbing, and so forth.

It would be a great financial hardship, if a homebuyer becomes a cash poor home-owner, and his or her finances haven't improved by the time major repairs are expected.

A conscious buyer must determine house health by hiring experts such as termite inspector, structural engineer, materials engineer, geotechnical engineer, and professional home inspectors to find any defects, major repair and replacement works anticipated in the foreseeable future. Property defects have to be treated as a serious concern for homebuyers as well as for home sellers in Hawai'i (Scontras (a), 2007).

The number and timing of major repair and replacement works largely depends on the age of the house, the quality of construction and the materials used. Each and every component of the house has to be examined and its expected useful life span and frequency of replacement must be decided on a case-by-case basis.

The National Association of Home Builders carried out a comprehensive study sponsored by Bank of America and published a report indicating life expectancy of a variety of home components (NAHB, 2007). The survey includes 25 different categories of various components such as home appliances, cabinet and storage, concrete and masonry, doors, windows, electrical and lighting, faucets and fixtures, structural systems, heating ventilation and air conditioning, roof, wall, ceilings, and flooring. Life expectancy of more than 200 products and materials are listed in the report. Although the effective life span of these components largely depends on the quality of work, maintenance, climatic condition and the intensity of use, the NAHB report may serve as a good reference for home inspection checklists (Scontras (b), 2007). When such references are carefully integrated with the home inspectors checklist, home-owners may benefit by identifying long-term as well as short-term repair and maintenance need and thus being able to account likely costs.

Repair and replacement costs are estimated on the basis of life expectancy of the components and materials, state of health of the item under question, ambient conditions, and predicted failure.

An obvious advantage of undertaking life-cycle cost analysis at the time of home-buying is to have a good insight into the future status of the property, both in terms of the physical maintenance required and the cost involved. If assessment of the structures, components, amenities, and installations are preciously inspected and their expected life is established, renovation and major maintenance strategies can be easily worked out at the early stage of the ownership life-cycle plan financing strategies accordingly.

As part of this research, this author contacted a professional home repair consultant, Mr. John Packo of Metis Consulting Services in Honolulu, who provided an average ballpark cost breakdown of some of the replacement and repair works of single-family houses based on his work accomplished in 2007 and 2008 in the Honolulu area, as shown in the Table 5.3.

For the purpose of this research, the baseline cost for roof replacement and repainting the interior will be used to perform life-cycle cost analysis of a median priced single-family house, in Chapter 12.

Table 5.3: Baseline costs of some major home repair items (source: Metis Consulting Services, Honolulu).

Work items	Materials cost, $	Labor cost, $	Total cost, $
Kitchen refurbishment	20,000	10,000	30,000
Roof replacement	2,000	8,000	10,000
Bathroom renovation	2,500	5,000	7,500
Repainting the interior	500	4,000	4,500

Capital Improvements: Any repair, maintenance, and extension of amenities and structures that increases the value and prolongs the physical life of the property are considered capital improvements. Some examples of capital improvements are: addition of a room or a bathroom, remodeling of kitchen, building a swimming pool, installation of a deck. These costs will not be investigated, and fall beyond the scope of this research.

5.2.4 Ownership Termination Costs and Incomes

The final phase in the life-cycle of home-ownership is the termination by reselling the property. In essence, this is the salvage value often termed as residual value of the property. During this stage, there are two main cash flow items: (1) selling costs and (2) income after resale, i.e., resale value. Selling costs consist of two parts: Advertisement cost and the seller's closing costs. Real estate brokers suggest that average selling costs may range from 1% to 7% of the sales price (Colfax, 2008).

Advertisement Cost: As a for-sale-by-owner, the most common way to advertise the property is by listing it in the Multiple Listing Service (MLS). The MLS is a directory, normally controlled by the local Association of Realtors, and used by real estate agents to announce homes, for sale. This is done only through a licensed real estate broker. The MLS cost may range anything between a couple of hundred dollars as flat fee and up to 6% of the selling price as commission to realtors. The sellers may minimize the realtor commission by paying a flat fee ranging from $200 to $600 to list the home in the Hawai'i's MLS. If the property is sold without any further services of a realtor, the seller may avoid paying a commission.

Seller's Closing Cost: It is not a definitive cost item as it was the case with buyer's closing costs. In some cases, during the negotiation process, a buyer may ask the seller to pay their closing costs, and if agreed, the buyer's closing costs becomes the seller's closing costs. One of the significant closing costs is likely to be the Realtor's fee or the broker's commission if the transaction is being materialized utilizing such services; this could be as large as 6% of the sales price. Besides that, seller's closing cost may come from varieties of items such as cost of survey, mortgage paid off verification fee, unpaid mortgage, title update fees, property transfer tax, association transfer fee, attorney's fee, clearance of utility dues, home inspection fees, move out costs, and credit to buyer for anything that needs repair. Termite treatment and some repair works may have to be done before closing. A more detailed list of seller's closing cost can be found in Glink (2008).

Resale Value: This is the revenue after resale, based on the fair market price at the time of sale. Since this is a forecast, at least in this case study, it has to be derived based on appreciation or depreciation rates. In the case of a home, well maintained and kept at the standard of the initial stage, the property is more likely to be appreciated than depreciated. However, appreciation rates largely depend on housing supply and demand and economic health of the location. Most likely, interest and inflation rates are the key driving elements of property value appreciation.

5.2.5 Home-buying and Home-ownership Tax Advantages

Myths exist among many of the first-time home-owners that all costs related to home-ownership are tax deductible (Bell, 2008). Literature review indicated that there are few tax breaks, subject to qualifying conditions such as that the home under question must be the primary residence of the home-owner. The details of the qualifying conditions and the full details can be found in Internal Revenue Service (IRS) publications (IRSa, 2007; IRS b2007; IRS c, 2007). According to the IRS, the tax-deductible items applicable for first-time home-owners are mainly points, mortgage interest (including mortgage insurance premium) and real estate property tax (the property tax). Similar to the federal rules, the state of Hawai'i laws also allow tax breaks on discount points, mortgage interest and the property tax. The other expenses such as closing costs, down payment, earnest money, home insurance, utilities, basic maintenance, and repair or home improvement are not tax deductible.

Discount Points: According to the IRS definitions, these are the charges paid by home-owners in the process of securing a home loan, and they may also be called loan origination fee, maximum loan charge, loan discount, or discount points. In order to be eligible for tax deductions, the points must be paid as per the established business practice in the area of transaction. When points are overly paid in contrast to the standard practice, the home-owner would not be allowed to take the payment as tax deductibles. In certain cases, points are treated as pre-paid interest and must be deducted over the life term of the mortgage, on a pro-rated basis. However, a first-time home-owner may be eligible for tax deduction for full amount of points if the conditions as set by IRS are satisfied (IRS b, 2008).

Mortgage Interest: There is another myth among first-time homebuyers that the entire mortgage payment is tax deductible. According to the IRS guidelines, the loan taken to purchase the house, termed as "home acquisition debt," if fully amortized, only the interest portion of the mortgage payment is a fully tax deductible item, subject to certain qualifying conditions (IRS b and IRS c, 2007). The total amount of home acquisition debt, to qualify for tax deduction purposes, must be less than one million dollars or $500,000 if married couples filing tax separately. Above these ceilings, tax exemption does not apply for the portion crossing the limit. As for tax year 2007, the standard deductions, if not itemized, are $5,350 for singles and $10,700 for couples who file tax returns jointly.

Mortgage insurance premiums, if paid in connection with home acquisition debt, may also be included as tax deductible. Similarly, any loan amount in excess of what was spent to purchase or improve the home, termed as "home equity loan," can also be treated in the same way as the home acquisition debt, which is often the case with refinancing. To be eligible for mortgage interest deductible, the home equity debt should not exceed $100,000 or the value of the property, whichever is smaller. Since refinancing is not within the scope of this research, it will not be considered further.

IRS requires that at the end of each tax year, the lender (the mortgage holder) must provide a "Mortgage Interest Statement" on IRS Form 1098, and the same has to be attached when filing the tax return. Due to the nature of amortized loan, the tax-deductible amount will keep decreasing as you pay off the principle, and thus the interest portion of mortgage payment becomes smaller.

A mortgage broker explained to this author that typically 5 to 7 years is good time to refinance the loan, mainly to take advantage of tax returns on mortgage interest.

Real Estate Tax: The taxes paid to the local or state government are also fully deductible, if it is based on the assessed value of the real estate property. The tax paid must be for the welfare of the general public and not for the services rendered to the home-owner (IRS b, 2007).

Capital Gains Tax: The capital gains tax (GCT) is largely determined based on initial purchase cost, capital improvements made during the ownership period and the property value when sold. Capital gains (losses) on the sale of the house equal the sale price minus the adjusted basis cost of the property. According to IRS definition, adjusted basis is the purchase cost plus the capital improvements, less any applicable depreciation and casualty losses claimed for tax purposes (IRS a, 2007). Capital gain tax (GCT) is charged by IRS as well as by the State of Hawai'i against the profit made after the property is sold.

The federal law allows an exemption of up to $250,000 of gain (single) or up to $500,000 of gain (married) subject to the home-owners have owned and occupied the sold property for at least two out of the past five years (IRS a, 2007). Otherwise, the capital gain will be fully taxed as regular income, according to applicable tax brackets. Since this study is aimed at families of median income, it is assumed that they fall under the 15% tax bracket category in case of Federal Income Tax.

Similar to the federal exemption, Hawai'i law also allows an exemption of up to $250,000 of gain (single) or up to $500,000 of gain (married) subject to the home-owners if have owned and occupied the sold property for at least two out of the past five years (Department of Taxation, 2007). Otherwise, the capital gain will be taxed as regular income tax, according to applicable tax brackets. Since this study is aimed at families of median income, it is assumed that they fall under the 7.25% tax bracket category.

CHAPTER 6: HOME AFFORDABILITY

6.1 General

Housing affordability is a direct concern of three different types of occupants: 1) First-time home-buyers, 2) Existing Home-owners and 3) Renters. Initially, this chapter focuses on the perspective of first-time home buyers as well as existing home-owners. Then renter's affordability will also be discussed as a comparison of buying versus renting scenarios.

Buying a home is a long-term financial commitment. Not all expense items are tangible at the beginning, and not all buyers are conscious of all tangible and intangible future expenses when deciding on a home purchase. Housing affordability is important because a large share of household income is to be devoted to home ownership. According to the Consumer Expenditure Survey (DBEDT, 2008), in 2006, on average a home-owner spent about 33.1% and a renter spent about 36.5% of total household expenditure on housing alone. Such expenses were mainly on mortgage, utilities, maintenance, insurance, and tax. The only way to analyze the financial onus is to itemize the cradle-to-grave ownership expenses, i.e., the life-cycle cost, and to assess as to how these costs can be paid off without facing a risk of foreclosure or facing an undesirable economic hardship in a foreseeable future.

Obviously, the next logical question is whether the home-owner has enough economic leverage, the affordability, to overcome the challenges of buying, maintaining, and sustaining the ownership of a house. This must be considered along with other regular living expenses - the non-housing consumptions such as food, medical care, education, recreation, child support, transportation, and so forth. Research indicates that potential buyers, as consumers, are not always aware of the adverse financial outcomes that may stem from their purchase decisions. Liebermann and Ungar (1997) found that consumers find it difficult to cope properly with intertemporal choices involving LCC considerations. Intertemporal choice is the economic term that describes how an individual's current decision affects their future options.

The question of affordability does not end with full pay off of the mortgage, but it continues even afterwards throughout the ownership period. Many home-owners end up being in a "house rich but cash poor," also known as "house poor," situation during their retirement age, because home equity generally cannot be used to pay for daily living expenses, and expenses such as maintenance, property taxes can become a burden relative to their income (Holt, 1994).

House poor is a situation when the home-owner is compelled to spend a large proportion of his or her total income on home ownership, including mortgage payments, property tax, home insurance, maintenance, utilities, and fees. In such a state, they face financial hardship due to lack of cash for other essential financial obligations such as automobile, medical care, purchases, vacation, and family recreation. House poor is a typical situation when people are over ambitious and own a house beyond their affordability means either due to poor financing planning or as a consequence of unexpected unemployment.

This situation had led to the introduction of new type of home loan arrangement commonly known as reverse mortgage. Reverse mortgage is a special privilege available to senior citizens (62 years and over) that lets a home-owner convert his or her home into cash. In a normal mortgage, the home-owner makes a monthly payment to the lender as partial payment of the loan and interest. Once the full amount of loan is paid the property is released from the lender and the homebuyer becomes the sole owner. In a reverse mortgage, the home-owner makes no payments and all interest is added to the lien on the property. Moreover, a qualified home-owner may receive monthly payments, or a bulk payment of the available equity percentage. The money obtained from reverse mortgage, can be used for any purpose, and thus improving home-owner's situation from becoming a house rich cash poor. The loan ends when the home-owner dies, sells the house, or moves out of the house. At that point, the reverse mortgage can be paid off with the proceeds of the property sale.

Since study of reverse mortgage is not the purpose of this research, analysis of reverse mortgage is excluded in this research. Information on reverse mortgage may be found from the U.S. Department of Housing and Urban Development (US DoHUD, 2008).

6.2 Home-ownership Affordability Index (HAI)

HAI is one of the common measures of affordability, normally monitored by organizations, such as National Association of Realtors (NAR), U.S. Department of

Housing and Urban Development (HUD), and various Banks in the U.S.. It is a measure of median household income against the income required to buy a median-priced house. This index tracks whether housing is affordable for the typical household.

According to the National Association of Realtors (2008), the HAI index is calculated by employing the following relationship:

$$HAI = \frac{MFI}{12 * 4 * PMT} \quad (6.1)$$

Where,

MFI is the gross annual median family income, and

PMT is the monthly mortgage payment for a typical 30-year mortgage (360 months) it is calculated as:

$$PMT = 0.8\, x\, MHP \left[\frac{(i/12)(1+\frac{i}{12})^{360}}{(1+i/12)^{360}-1} \right] \quad (6.2)$$

Where,

MHP is the median home price, and

i is the nominal annual mortgage interest rate.

The factors 12 months and 4 times in equation (6.1) are derived from an assumption that reasonable mortgage burden should not be more than 25% of gross household income. For example, in order to qualify for a credit worth of $1,000 monthly mortgage, the borrower must have a gross monthly income of at least $4,000 or higher.

For a 30-year pay off term with fixed nominal mortgage interest rate (i) compounded every month, the monthly mortgage (PMT) is calculated using equation (6.2). The factor 0.8 in the equation (6.2) is based on the assumptions that 20% of the price is covered by down payment and 80% is from loan.

A higher HAI ratio indicates relatively more affordability. A ratio of 1 indicates that median-family income is just sufficient to purchase the median-priced home. When the ratio falls below 1, the typical household has less income than necessary to purchase the typical house. An index above 1 signifies that family earning the median income has more than enough income to qualify for a mortgage loan on a median-priced home, assuming a 20% down payment. For example, a composite HAI of 1.2 means a family earning the median family income has 120% of the income necessary to qualify for a conventional loan. An increase in the HAI, then, shows that this family is more able to afford the median priced home.

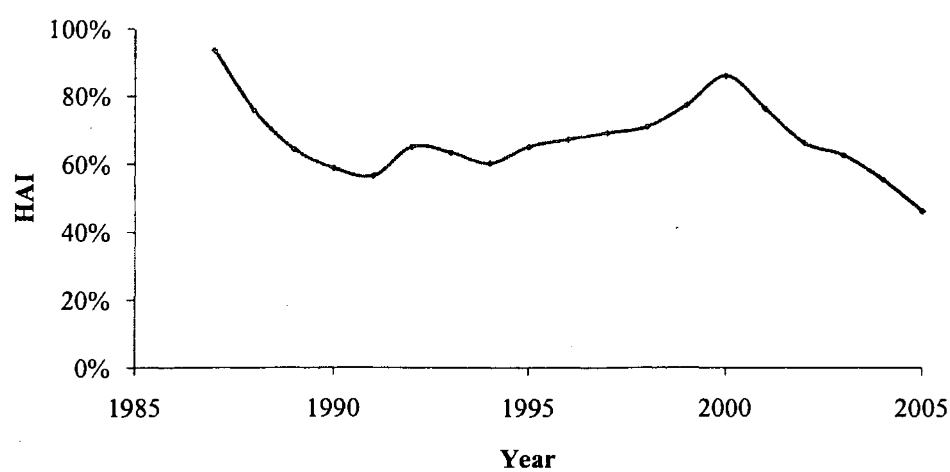

Figure 6.1: HAI for the state of Hawai'i (source: DBEDT, 2007)

Based on the above assumptions and 6% mortgage interest rate, HAI was calculated for the state of Hawai'i, using the median household income and median sales price of a single-family house, resulting in the graph shown in Figure 6.1. The Figure 6.1 indicates that during the past three decades, Hawai'i homes were never affordable for the median household income. The HAI sharply decreased especially after 2000.

6.3 Median Multiple

Median Multiple is another measure of housing affordability index, used by a variety of realty surveys such as Demographia and Pavletich Properties (Demographia, 2008). Median multiple is calculated by dividing the median house price by the annual median household income. A higher median multiple means that the housing affordability is inferior. A lower median multiple shows favorable affordability. Demographia developed a rating system to compare housing affordability as given in Table 6.1.

Table 6.1: Housing affordability ratings (source: Demographia, 2008)

Rating	Median multiple
Severely unaffordable	5.1 and over
Seriously unaffordable	4.1 – 5.0
Moderately unaffordable	3.1 – 4.0
Affordable	3.0 and less

Demographia (2008) carried out an extensive survey covering a total of 227 cities in Australia, Canada, Ireland, New Zealand, the UK, and the U.S., and tabulated the national median multiple, as shown in Table 6.2. According to the national median multiple the U.S. falls in the moderately unaffordable rank, whereas Canada is the most affordable and Australia is the least affordable. The same survey found that among the least affordable 50 cities, 14 of those cities are in the U.S., generally in California, Hawai'i and the U.S. East Coast. The five least affordable among the 227 cities are all located in California and Hawai'i with the median multiple as 10 or above, as shown in Table 6.3.

Table 6.2: National median multiple

Country	Number cities surveyed	Median multiple
Australia	28	6.3
New Zealand	7	6.3
UK	28	5.5
Ireland	6	4.7
USA	129	3.6
Canada	29	3.1

Table 6.3: Median multiple of top 5 least affordable cities

City	Median multiple
Los Angeles, CA	11.5
Salinas, CA	10.9
San Francisco, CA	10.8
Honolulu, HI	10.3
San Diego, CA	10.0

Among the top 50 least affordable cites, 14 are from the U.S., with median multiples being more than 6, and they are: Los Angeles, CA (11.5), Salinas, CA (10.9), San Francisco, CA (10.8), Honolulu, HI (10.3), San Diego, CA (10.0), Santa Rosa, CA (8.5), Palm Beach, FL (7.1), Riverside-San Bernardino, CA (7.1), Santa Barbara, CA (7.1), New York, NY (7.0), Stockton, CA (6.4), Vallejo, CA (6.4), Boston, MA (6.1), and Fresno, CA (6.1). Other cities among the top 50 least affordable cities are: Mandurah, Australia (9.5), Sydney, Australia (8.6), Vancouver, Canada (8.4), London, UK (7.7), Melbourne, Australia (7.3), and Auckland, New Zealand (6.9).

It is interesting to note that Youngstown, Ohio (1.9) is the second most affordable city, after Thunder Bay of Canada (1.8), and these are the only two cities with median multiple less than 2. Other most affordable U.S. cities are Fort Wayne (IN), Flint (FL), Toledo (OH), Indianapolis (IN), Rochester (NY), Wichita (KS), Akron (OH), Buffalo (NY), Detroit (MI), Grand Rapids (MI), Lansing (MI), Dallas (TX), Dayton (OH), Huntsville (AL), and Omaha (IA), all with a median multiple of 2.5 and less.

At the higher end, there are limitations to affordability — especially as credit standards tighten, commodity prices go up and salaries barely increase. From the above discussion it is evident that housing affordability is directly related to home-owner's income, other expenses, and the geographic location.

Addressing the housing crisis, on behalf of the Federal Government, the U.S. President Mr. George W. Bush, said "We should not bail out lenders, real-estate speculators or those who made the reckless decision to buy a home they knew they could never afford."

(Phillips et at., 2007). It is evident that affordability is a crucial decision element in the home-buying process, and every home-owner must make a conscious effort to recognize his or her affordability status. It is obvious, that longer amortization periods, higher down payments and lower interest rates will reduce the size of monthly mortgage payments, and thus increase the affordability index.

The question of housing affordability originates mainly from two factors (Quigley and Raphael, 2004). First of all, buying a house is the single largest expenditure of an average homebuyer, and approximately 25% of household income is spent on mortgage payment. Secondly, the median home price increases faster than the median income of an average household. Nevertheless, the affordability index based on income alone could be a misleading indicator, because aggregate home-ownership rate is also gradually increasing.

Li and Yao (2007) developed a life-cycle model and studied the effects of house price changes on household consumption and welfare. They found that although the aggregate consumption and welfare effects are small, non-housing consumption of young and old home-owners is more responsive to house price changes than middle-aged home-owners. They concluded that while old home-owners benefit from house price appreciation, renters and young home-owners are worse off. Most likely, young home-owners have liquidity constraints because of their steep income profile and lack of access to credit. Whereas, an old home-owner has a short expected life horizon and hence is more likely to capture the house wealth gain and increase non-housing consumption.

On one hand, affordability has always been a problem for low-income, young and first-time homebuyers. On the other hand, as the affordability dwindles, home sellers suffer because they find it harder to trade up (Simon, 2005). Simon suggests that as the affordability keeps decreasing the renting option becomes increasingly attractive in the market.

6.4 Mortgage Severity Index (MSI)

The recent mortgage crisis in the U.S. market, often referred to as "sub-prime" crisis, among others, has been a consequence of liberal home loan practice that overlooked the qualifying income of the borrower. One report, as an example, indicated that in California, a prime borrower with a household income of $90,000 was allowed to buy a house priced at $1,000,000 with less than 5% down payment (Greenberg, 2007). This is 11 times the household income, i.e. median multiple being 11, an extremely unaffordable case. With the assumptions of loan term of 30 years, and fixed nominal mortgage interest rate of 6% compounded monthly, the monthly mortgage payment was calculated to be approximately $5,700. Whereas, the borrowers qualifying income was only $1,875, just one third (HAI = 33) of what was normally required to be ideally affordable.

This leads to the concept of mortgage severity index (MSI). The MSI indicates how much of the total available income of a median family goes towards the home ownership, not just the mortgage payment. Home-ownership expenses include all unavoidable items in connection with occupancy and ownership liabilities such as utilities, basic home repair and maintenance, insurance, and taxes. These expenses must be considered comprehensively throughout the life-cycle period and converted and aggregated so that it can be quantified in terms of average monthly liabilities. Then it can be added to the regular mortgage amount to find the total ownership costs. The MSI is a ratio of total ownership cost and the family income. This is a new concept developed as part of this research.

6.5 Buying versus Renting

Although buying versus renting is a classic problem, there are no universal solutions to this problem. The advocates of home-ownership emphasize that it is a means of saving and a factor for social stability, while the equally articulate advocates of renting argue that the long-term costs for lower income home-owners are greater than those of the renter. Obviously, comparisons showing the advantage of home-ownership, without considering the life-cycle liabilities would have little rationale. Similarly, there are unique expenses on renting house, such as vacancy and default rental, which are ultimately borne by the renters anyway. Renter occupied houses are susceptible for higher maintenance costs than owner occupied houses, due to frequent turnover higher wear and tear (Shelton, 1968). Therefore, neither side can win the argument without rigorous analysis. Moreover, the situation is so complex that it is impossible to consider all social, psychological, and behavioral factors in such analysis.

On the buying side all the expenses such as down payment, closing costs, points, expenses of repair maintenance, utilities, home insurance, and property tax are added and tax benefits are deducted to find the ownership expenses. On the renting side rental and utilities are added to find the renting expenses. The motivation for buying a house is that after the loan is fully paid, the buyer becomes the home-owner, whereas in the case of renting, the renter never becomes a home-owner. Some argue that if one is clever enough to buy low and sell high, one should own, whereas if the situation is reverse, then one should rent.

The advocates of renting consider that a house is an ordinary good, and the average real return for houses must be competitive to any other investment opportunities. According to research carried out by Robert Shiller, between the period of 1890 and 2004 real house returns were nearly zero, except for two short periods, one soon after the World War II and another after 2000 (Hough, 2008). Whereas, for the same period the real returns from stocks were about 7%. According to Hough (2008), since 1890, house prices outpaced the inflation only during these two brief periods, bringing real return of approximately 0.4%.

While buying a house people do not normally consider the returns. For most home-owners, the pride of ownership and the comfort of living in an owner-occupied house are more important than economic returns. Obviously, it may be a nicer place to live in an owner-occupied house than a rented house. But what are the economic liabilities of becoming a home-owner compared to a renter? What is more affordable? What is cheaper depends on the price trends on both buying and renting options. Although, having an owner-occupied home could be a dream for many, it may not be simply affordable for everyone because home-ownership requires a certain amount of down payment, steady income, and credit worthiness.

6.6 Rental Housing Affordability

There are several approaches of measuring rental housing affordability. According to the DBEDT (2008), the most common methods of assessing renter's affordability include:

a) Rent-to-Income (RTI) ratio,
b) Residual Income (RI),
c) Supply-Demand Mismatch (SDM),
d) Housing Wage (HW), and
e) Median Ratios Comparison (MRC).

The rent-to-income ratios can be found by dividing the rental expenses (including utilities) by the household income. It can be separated for type of rented units (single-family, multiple families) or by the number of bedrooms in a rented house. Conventionally, households having RTI ratios 30 percent or above are often considered to have an affordability problem. If the RTI ratio is 50 percent or above, it is considered to be severely cost burdened (Belsky et al, 2005). When calculating the RTI ratio, the current rent and income are used. Therefore, it measures the affordability at the current time.

The residual income is another approach of measuring rental housing affordability that considers income minus the rental payment. This approach focuses on the absolute amount leftover after housing expenses (including utilities), rather than the share of income allocated to housing. This approach was initially developed by Stone (1993) and it was further elaborated by Nelson (1994), and they classified that with too little left over to meet basic needs as being "shelter poor."

The supply-demand mismatch approach measures the number of households with incomes at or below a particular threshold level compared with the number of rental housing units with rents that are equal or below 30 percent of the threshold income. Typical income threshold fractions are taken as 30, 50, 80 and 100 percent. In order to apply this approach, for example to examine the rental affordability in Honolulu at or below 50 percent, first of all the number of households in the area with income at or below 50 percent of the median income has to be counted. According to American Community Survey (ACS), there were 299,217 households in Honolulu in 2006, and 76,300 households (25.5%) had a household income of less than $35,000. This income threshold is about 55% of the median household income of the year. Since data for 50% income threshold ($31,686) was not readily available and it was not possible to separate from the available number of households, the threshold rent was calculated for 55% income threshold as follows:

55% threshold of the median income = $35,000

30% of the threshold = 0.3 x 35,000 = $10,500.

Monthly threshold rent = $10,500/12 = $875.

To apply this approach we need the number of rental units available in the area at the rate of $875/ month so that it can be compared against the number of households to examine the supply-demand match. Such information was not available for Honolulu.

The housing wage approach measures the rent of a standard, modest quality rental unit with either 1 or 2 bedrooms in the area compared to the multiples of full-time minimum wage work it would require to afford that unit, while assuming rent accounted for 30 percent of income. For example, in 2006, in Honolulu, fair market rent was $1,348 for a one-bedroom unit and $1,630 for a two-bedroom unit. With the prevailing $7.25 per hour minimum wage, the fare market rent of one-bedroom unit needs 3.69 full time minimum wage, while 4.46 full time minimum wage jobs to cover the rent for two-bed room, assuming the full time job is 8 hours per working day, and 21 working days a month.

The median ratios comparison approach compares the median rent to median household income. In this approach, the affordability is measured by the share of income that the median household would have to spend to rent a median rental unit. Alternatively, average rent and typical household income may also be used to calculate the affordability index by this approach. This approach is very similar to RTI, or can be taken as a special case of RTI.

CHAPTER 7: TIME VALUE OF MONEY

7.1 Fundamental Concepts

Time value of money is a well-established and fundamental concept in engineering economic theories. Elaborated discussions on time value of money can be found in many engineering economic textbooks such as Canada et al. (1996), Newnan (2002), Sullivan et al. (2006), and Blank and Tarquin (2008). This serves as a fundamental basis for analyzing the life-cycle costs of home ownership. Three main aspects of time value of money are:

- **Growth of Capital:** The money can be used as capital or investment to produce more wealth in the form of profit or benefit over time. Therefore, use of capital has a cost.
- **Purchasing Power:** Money spent in different years has different purchasing power.
- **Opportunity Cost:** It is always possible to invest or spend money in varieties of alternatives, and the amount of profit or benefit is dependent on the alternative chosen.

In life-cycle cost analysis, investment is expected to bring some returns over the period of time, and it must be quantified. Similarly, money spent during the life-cycle period have different purchasing power, and the expenses must be compared in purchasing power terms, usually in constant dollars. Opportunity lost, the cost of an alternative that must be forgone due to the action that an alternative was not chosen must also be considered for fair evaluation of return. These concepts will be applied in the present life-cycle cost analysis methodology.

Actual Dollars: The monetary amount received or disbursed at any point in time unadjusted for any price changes or purchasing power. The actual dollars are also known as "nominal dollars," "then-current dollars," "current dollars," "future dollars," "escalated dollars," and "inflated dollars."

Constant Dollars: The monetary amount expressed with reference to a base year and adjusted for price changes from a base year to compare hypothetical purchasing power between different time periods. The base year can be arbitrarily selected, which is often called time-zero. Base year is normally the starting point of a given investment project. The constant dollars are also called as "real dollars", "deflated dollars," "today's dollars," and "zero-date dollars." To make valid comparisons of monetary amounts over time, constant dollars method is used in this research.

7.2 Capital Growth

In Engineering Economic theory, time value of money is a concept that explains how and why the value of money changes over time, by comparing present cash outlays to future expected returns. When one borrows a sum of capital, a certain fee is charged for its use, often called interest. The fee charged for the use of capital is also defined as cost of capital. For example, if a principal amount of P dollars is borrowed at a point in time with interest (profit or growth) rate of i%, per unit of time, compounded discretely, then by the end of n^{th} period the borrower is expected to return a sum equivalent to F, calculated as:

$$F = P(1+i)^n \qquad (7.1)$$

In generic engineering economic code, this expression is frequently written as:

$$F = P(F/P, i, n) \qquad (7.2)$$

When, future value is given, present worth is calculated as:

$$P = F(1+i)^{-n} \qquad (7.3)$$

In generic engineering economic code, this expression is frequently written as:

$$P = F(P/F, i, n) \qquad (7.4)$$

This is the foundation of the engineering economy theory and it is extensively used in various forms within this research. Two of the most common variations of the above equations are amortization and sinking fund.

7.3 Amortization

Amortization is a gradual and systematic method of periodic payment that will repay the principal and the interest earned within a specific future date. It is a uniformly distributed amount paid at the end of each interest period, for a definite time period (n) in order to fully pay the debt. Each installment of payment includes a portion of the principal (P) and the full amount of interest earned until that payment period. If the interest rate is (i%) and compounded discretely at the end of each interest period, the amount of amortization (A) can be calculated as:

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] \quad \ldots \quad (7.5)$$

In generic engineering economic code, this expression is frequently written as:

$$A = P(A/P, i, n) \quad \ldots \quad (7.6)$$

Sometimes, it is also known as annuity or capital recovery amount. To be more precise, capital recovery costs take into account loss of value in asset or depreciation. In real estate terms, the annuity is commonly known as mortgage.

7.4 Sinking Fund

Sinking fund is a method of setting aside uniformly distributed amount of money over time to raise a definite amount of fund accumulated in the future for paying off the principal of a debt when it is due. In other words, it is a periodic payment that will accumulate by a specific future date to a specified future value. For example, a home-owner plans to replace his roof at an interval of (n) years, and each replacement costs F amount of money in current dollars at the time of replacement. With earning capital of each deposit (interest) being i% per year and compounded discretely each year, the home-owner may deposit an equal amount of money (A) at the end of each year in order to raise F to pay the cost of the roof replacement at the time of work done. The amount of money that has to be deposited at the end of each year, the sinking fund, can be calculated using the following relationship:

$$A = F\left[\frac{i}{(1+i)^n - 1}\right] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7.7)$$

In generic engineering economic code, this expression is frequently written as:

$$A = F(A/F, i, n) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7.8)$$

7.5 Inflation Rate

Inflation rate measures the general price level of consumer goods and services relative to the previous year. Inflation is measured in terms of the rate of change in consumer goods price. Historically, price change or inflation has always been positive. Negative price change, which is known as deflation, is rare. If prices increase (decrease), the purchasing power of money is reduced (increased). There are several ways of measuring inflation. One of the most common methods is the Consumer Price Index (CPI). The CPI measures price variations associated with domestic production of goods and services. In this research inflation is defined in terms of CPI.

Historical CPI index for the US was obtained from the U.S. Bureau of Labor Statistics (LBS, 2008) for the period starting from year 1913 as shown in Figure 7.1. As can be seen in the figure, the CPI index has increased significantly since 1970. Based on the observed trend lines, an average annual CPI growth rate was calculated for three different periods, namely from 1913 to the end of World War II, from the end of the World War II to 1970, and the period between 1971 – 2007. The CPI growth rates for these three periods are as shown in table 7.1.

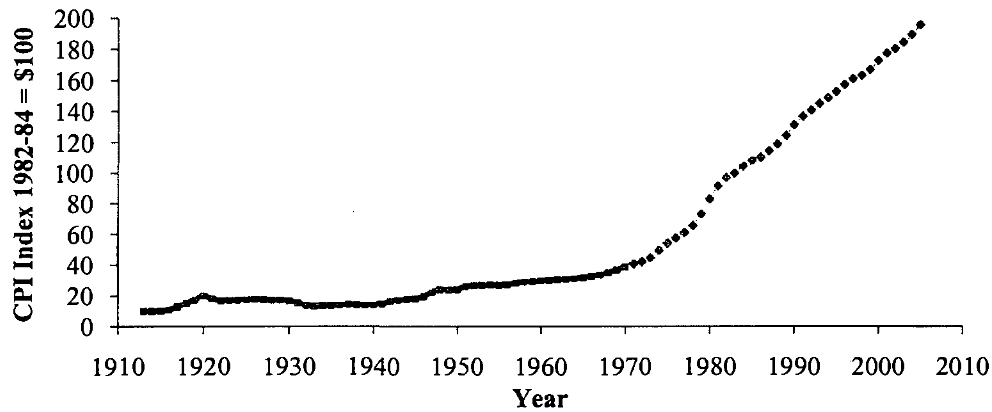

Figure 7.1: CPI Index (1982-84 = $100) for all urban consumers (source: BLS, 2008)

Table 7.1: CPI growth rates in various periods during 1913 - 2007

Period	CPI indices (1982-84 = 100)	Average annual growth rate (%)
1913 - 1945	9.9 - 18.0	1.89
1945 - 1970	18.0 - 38.8	3.12
1970 - 2007	38.8 - 207.342	4.63
1913 - 2007	9.9 – 207.342	3.29
1945 -2007	18.0 - 207.342	4.02

7.6 Price Escalation Rates:

Escalation refers to increase in the cost of equipment, material, labor or service due to change in price over time. For long-term projects, escalation becomes a significant factor, especially when considering life-cycle costing. Escalation is used mainly to estimate future costs, but it can also be used to determine equivalent present value of past expenses. Normally escalation rates are calculated from historical data for each cost item. There are mainly three factors that influence the escalation rate: changing technology, availability of materials and labor, and general inflation. The calculation of escalation rate for building construction has to account for composition of these factors. For example, if a repair item comprises 40% labor costs and 60% material cost of the total cost, and escalation rates for labor and material costs are 8% and 6% respectively, the composite escalation of the work item would be calculated as follows:

Labor cost escalation = 40% X 8% = 3.2%

Material cost escalation = 60% X 6% = 3.6%

Composite escalation for labor and material = 3.2% + 3.6% = 6.8%.

Historical Producer's Price Index (PPI) for maintenance and repair construction was obtained from the BLS (2008), for the period between 1987 and 2007, as shown in Figure 7.2. Data for earlier years were not available. The base year 1986 index was taken as 100. The PPI index by the end of 2007 was 184.3. The historical PPI data indicate that the annual average price escalation of maintenance and repair construction materials was 2.95%.

Assuming the labor and materials contributions to be 50-50 in the total cost of maintenance and repair cost, and if CPI inflation is taken as 4.63% (1970-2007), then the cost escalation rate can be calculated as the average of PPI and CPI growth rates:

$$\frac{4.63 + 2.9}{2} = 3.8\%$$

It has to be noted that contribution of labor and materials is not always as 50-50 in all repair and maintenance items.

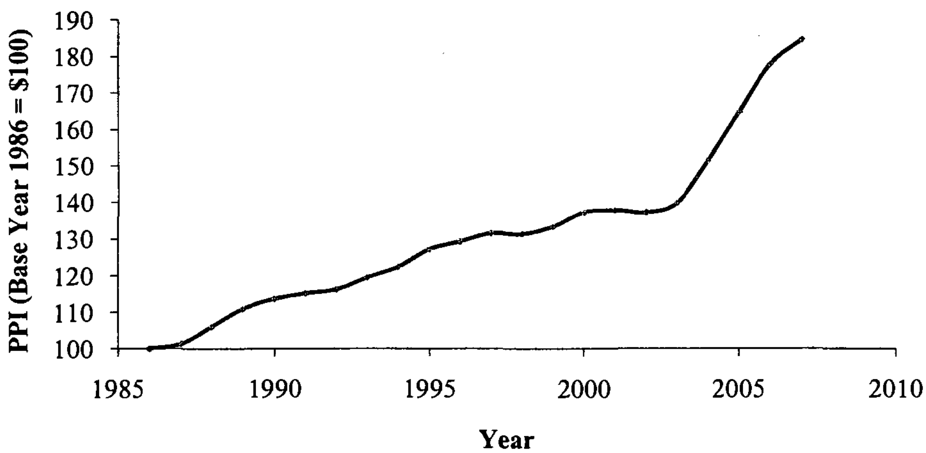

Figure 7.2: PPI for maintenance and repair construction

7.7 Discount Rate

Discount rate is also often referred to as deflation rate. It is the opposite of inflation or escalation. This can be a confusing term when it is interchangeably used with interest rate, inflation rate, and escalation rate. The major difference is that when present value is given, interest rate, inflation rate, and escalation rate is employed to calculate the future worth, and when future value is given, and the present worth has to be determined, in terms of constant dollars, then the discount rate is equal to inflation rate.

7.8 Opportunity Cost

It is widely accepted that capital is a limited resource. Any investment decision, that has two or more choices, involves opportunity cost. It is the cost of an alternative that must be forgone due to the action that that alternative was not chosen. For example, if return on capital by investing in stocks is 2% versus a certificate of deposit (CD) earning 5% interest over a year, the opportunity costs of investing in stock would be are 3%, calculated as a difference between 5% returns for CD minus 2% returns for stocks.

The concept of opportunity cost, or lost opportunity is often used in investment analysis. This research applies the opportunity cost in life-cycle cost analysis. By including not so obvious return to capital such as lost income, the proposed approach in this study provides a holistic consideration of investment analysis.

7.9 Mortgage Interest Rate

It is the market rate of interest on home loans. The mortgagor as a borrower of capital has to pay mortgage interest as cost of capital and paid to mortgagee – the lender. There are two types of mortgage interest rates: a) Fixed rate mortgage and b) Adjustable rate mortgage (ARM).

A fixed rate mortgage is the most common type that has a fixed interest rate for a given duration of terms where the mortgage payment for the entire term of the loan (usually 30 years) is uniformly distributed. Contrast to fixed rate, ARM rate can change over time, causing monthly payment to either increase or decrease. According to mortgage brokers, fixed rate mortgage is preferred by most of the homebuyers in Hawai'i. Normally, ARM rate is lower during the initial few years and then it gets higher in later years, causing the monthly mortgage to increase. Therefore, ARM is attractive for borrowers, who expect their income to increase in the next few years.

National historical time-series data on conventional fixed rate mortgage (FRM) interest rate, for the period of 1961 -2007 were obtained from the US Federal Reserve Board (FRB, 2008), as shown in Figure 7.3.

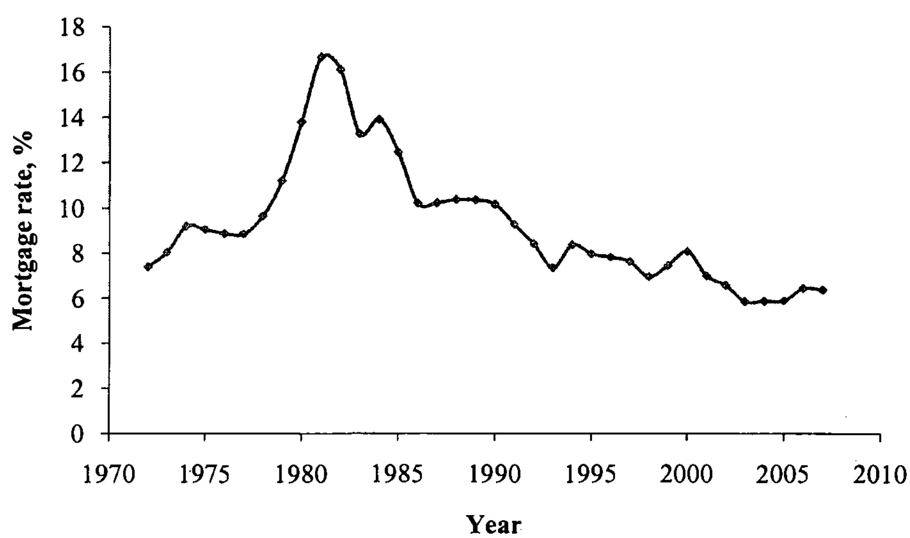

Figure 7.3: FRM conventional home mortgage interest rate (source: FRB, 2008)

Based on the historical data, during the last 30 years the FRM rates ranged between 8-17% annually. In 1981, the CD rate was almost 17% and during 2003-2005 CD rate was at the lowest point as low as 6%. The average rate for the period was 9.23%.

7.10 Certificate of Deposit (CD) Interest Rate

CD rate is a market interest rate. A CD is a savings account entitling the bearer to receive certain interest rate for a predetermined maturity period. CDs are generally issued by commercial banks and insured by the Federal Deposit Insurance Corporation (FDIC), making them a virtually risk-free investment. Since 1983, interest rates on deposits are deregulated and the amount of minimum deposit is lowered. The term of a CD can be as short as one month and minimum deposit can be as small as $500. Fixed interest rates are common, but variable interest rates are also available. CD accounts have been a highly popular investment alternative among the risk averse American consumers.

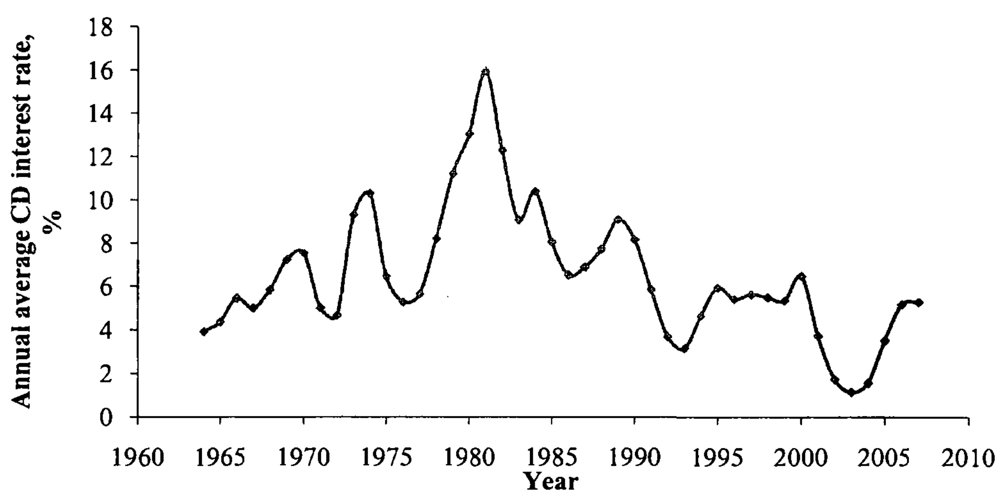

Figure 7.4: Average annual rate on 3-month negotiable CD (source: FRB, 2008)

National historical time-series data of the annual average CD interest rates, based on 3-month negotiable secondary market, for the period 1964 -2007, were obtained from the FRB (2008) and shown in Figure 7.4. The trend indicates that over the last 40 years the rates of interests on CDs ranged between 2% - 16% annually. The CD rate was the highest at almost 16% in 1981 and the lowest at a little more than 1% in 2003. The average annual rate for the period was 6.5%.

7.11 Inflation-free Interest Rate (Real Rate of Return)

With inflation, the value of interest earned diminishes. The inflation free interest rate is the rate that represents the earning power as well as the purchasing power of money. This is an abstract rate that does not exist in financial transaction and it is not quoted or provided by any bankers or investors. This must be calculated. Following Thuesen and Fabrycky(1989), Sullivan et al. (2006) and Park (2007) if the market interest rate is (*i*), and inflation rate is (*f*), the inflation-free interest rate or real interest rate (*i'*), the relationship between these three rates is as follows:

$$1 + i = (1 + f)(1 + i') \qquad (7.9)$$

From the equation (7.9) it can be easily derived that:

$$i' = \frac{i - f}{1 + f} \qquad (7.10)$$

Therefore, when computing equivalences in the constant dollars, inflation-free rate has to be applied. If analysis of time value of money is consistently done either in actual dollars or in constant dollars, then the equivalent amount in base year (time zero) has to be equal. It can be done in two ways. The first approach is to utilize the equation (7.3), using the combined interest rate (*i*). The second approach converts the actual dollars to constant dollars by first discounting at inflation rate (*f*) and then finding the equivalence of constant dollars at time zero, by discounting again using real interest rate (*i'*) as follows:

$$P = \frac{F}{(1+f)^n(1+i')^n} \quad \text{.......} (7.10)$$

7.12 Adjusted After-tax Rate of Return

When, opportunity loss has to be considered, after-tax analysis is essential. In this situation, the discounting rate has to be adjusted so as to exclude the tax paid amount in the real rate of return. This is done in the following manner:

At the beginning of a discrete year (BOY), present worth of cash flow is defined. Then the future worth the cash flow is calculated after tax at the end of the given year (EOY). Rearranging the equation (7.1), the adjusted after-tax interest rate (rate of return) is calculated as follows:

$$i_a = e^{\left[\ln\frac{F}{P}\right]/n} - 1 \quad \text{.......} (7.11a)$$

or

$$i_a = \sqrt[n]{\frac{F}{P}} - 1 \quad \text{.......} (7.11b)$$

where,

P is the initial capital paid at the beginning

F is the after tax future value at the end of *n* period

CHAPTER 8: COST FORECASTING

8.1 General

Forecasting is a significant component of life-cycle cost analysis. Future costs such as maintenance and operation of the house, resale value of the property and all other future expenses must be estimated using appropriate forecasting techniques. The purpose of this chapter is to highlight forecasting as an important element in life-cycle cost analysis and to explain the forecasting methods applied in this research. However, it is beyond the scope of this study to research what constitutes best forecasting method and the accuracy of different forecasting methods. Detailed discussions on forecasting methods and their accuracies can be found in literature, such as Soares et al. (2007), Mead (2000), Makridakis et al. (1993), Makridakis and Hibon (1979), and Jain (1988).

According to Ostwald (1984), forecasting can be classified in two types: technical forecasting and business forecasting. Technical forecasting includes predicting durability of materials, the need of maintenance and replacement of equipment and materials. Technical forecasting plays a vital role in life-cycle cost analysis of an object such as a house. It is a very extensive topic in itself and therefore further discussion on technical forecasting is beyond the scope of this research. A schedule of life expectancy of materials and equipment used in home construction can be found in publications such as NAHB (2007) and US DHUP (2002).

Business forecasting comprises the economic and market variables, such as price of materials, cost of labor, and cost of capital. Every major engineering decision is influenced by business forecast. The conventional approach of business forecasting is to extrapolate historical data into the future using certain mathematical relationship commonly known as regression analysis. Regression analysis can be linear and nonlinear (Makridakis et al., 1993). Some of the most commonly used regression models are linear, lognormal, polynomial, and exponential. Although regression analysis may not be as accurate as other sophisticated forecasting techniques such as fuzzy models and artificial neural networks, it is considered to be simple but reasonable forecasting tool in business forecasting (Ostwald, 1974).

Mead (2000) identified three distinct groups of business forecasting methods: naïve method, exponential smoothing, and auto-regressive moving average method (ARMA). The naïve approach uses a long run average of historical data to estimate future values. These methods are variations of a common business forecasting method known as time series analysis. A time series is a set of sequential data points, measured at uniform and successive time intervals. In econometrics, the time series technique is used as a common forecasting model and it is considered to be accurate enough for business forecasting (Boussabaine and Kirkham, 2004).

In this study, both regression analysis and time series methods are used in order to illustrate one of the many ways of forecasting. The actual future prices of consumption items must be determined as accurately as possible to get reliable estimates of life-cycle costs. The fact is that life-cycle costs can never be 100% accurate if future costs are not known precisely, but it is never possible to predict future costs accurately. Thus, the best that can be done is to make progressions of past trends to arrive at future costs. Of course, there are different models—simple and complex—for predicting future trends, but no one model can be used in all cases. It must be noted that in the face of the unpredictability of world events, forecasting always carries uncertainties and some inaccuracies regardless of complexities and sophistications of methods are used.

8.2 Forecasting Inflation Rate

In order to forecast the inflation and discounting (deflation) rates, time series data of the Consumer Price Index (CPI) were obtained for the period after World War II, as discussed in the previous chapter. Based on the observed trend line, as shown in Figure 8.1, the year 1971 was taken as the cut off CPI data point, as a starting point for forecasting inflation rate using regression and time series data. The year 1971 was taken as the starting point, mainly for the reason that the U.S. economy entered into the gold standard in that year. The CPI indices for years 1971 and 2007 were 40.5 and 207.34, respectively, (1982 = 100). Considering annual compounding growth from 1971 to 2007, the annual average CPI inflation rate was found to be 4.64%. Based on the data, regression lines were drawn, and equations and correlation coefficient (R^2) were obtained using the Excel's trend line as a computation tool, as shown in Figure 8.1. The linear and the lognormal trend lines were overlapped in the graph. The estimated linear regression equation is as follows:

$Y = 4.67X - 9170$ .... (8.1)

$R^2 = 0.995.$

Where, Y denotes CPI, X is year, and R^2 is coefficient of determination.

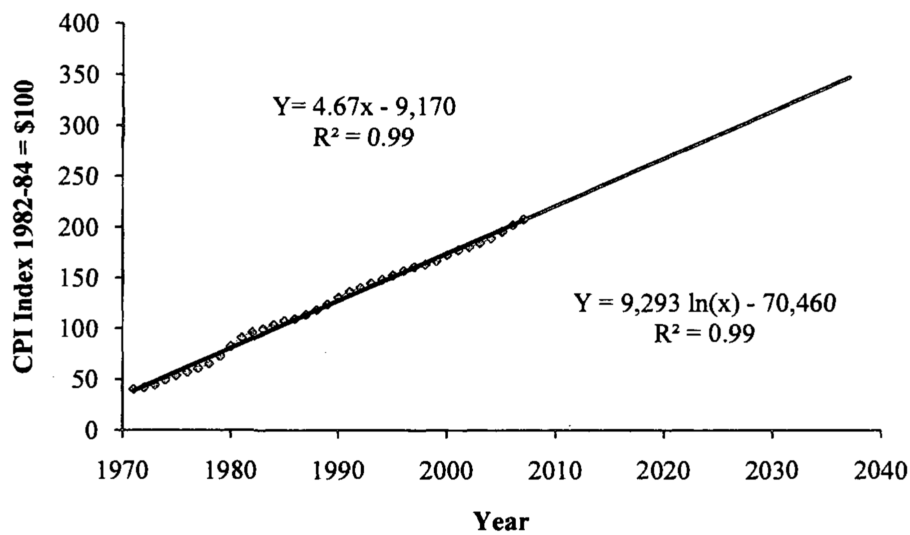

Figure 8.1: Forecast of CPI index

Similarly, the estimated lognormal regression equation is as follows:

$Y = 9{,}293\ (\ln X) - 70{,}460$ .... (8.2)

$R^2 = 0.996$

Where,

Y is the CPI index

X is the year, and

R^2 is coefficient of determination.

Based on the linear regression forecast, the CPI index for the year 2040 was calculated as:

$Y_{2040} = 4.67\,(2040) - 9170 = 357.26$

Thus, with the base index of 207.34 for 2007, and using the linear equation (8.1) average annual inflation rate between 2007 and 2040 was calculated to be 1.66%.

With lognormal regression (equation 8.2), the forecast for the CPI index for the year 2040 was calculated as follows:

$$Y_{2040} = 9{,}293\,(\ln 2040) - 70{,}460 = 358.01$$

Based on the lognormal regression forecast the annual average inflation rate for the period of 2007 to 2040 was estimated to be 1.67%.

From these two calculations, it can be easily forecast that average annual CPI inflation for the next 30 years or so will be in the range of 1.7%. This rate is very similar to what was observed during the period between World War II and until the introduction of gold standard in U.S. economy. However, it should be noted that this is only one of the various forecasting techniques and the answer obtained in this way should not be taken as an absolute, and the only answer. Moreover, judgments based on the historical rate and other socio-economic factors should also be applied in combination with these calculations, to establish an acceptable forecast.

In this study, lognormal regression (equation 8.2) will be used to forecast inflation rates for any periods as required.

8.3 Forecasting Escalation Rate for Home Maintenance Costs

The forecast of house maintenance cost escalation rate will be based on the producer's price index (PPI) and CPI. The PPI indices represent the price change of specific materials at producer level, whereas the CPI incorporates the general market inflation at the consumer level as well as increase in labor cost.

As we have noticed in the previous chapter (Figure 7.2) the time series data of PPI index were available only for the last 21 years. Furthermore, the trend indicated that there has been a sharp rise of price during the recent few years particularly since 2003. Therefore, a straightforward method of lognormal or other types of regression analysis may not provide a satisfactory forecast. In order to observe the forecasting tends, initially a lognormal forecasting model was used and the regression line (a) was drawn as shown in Figure 8.2.

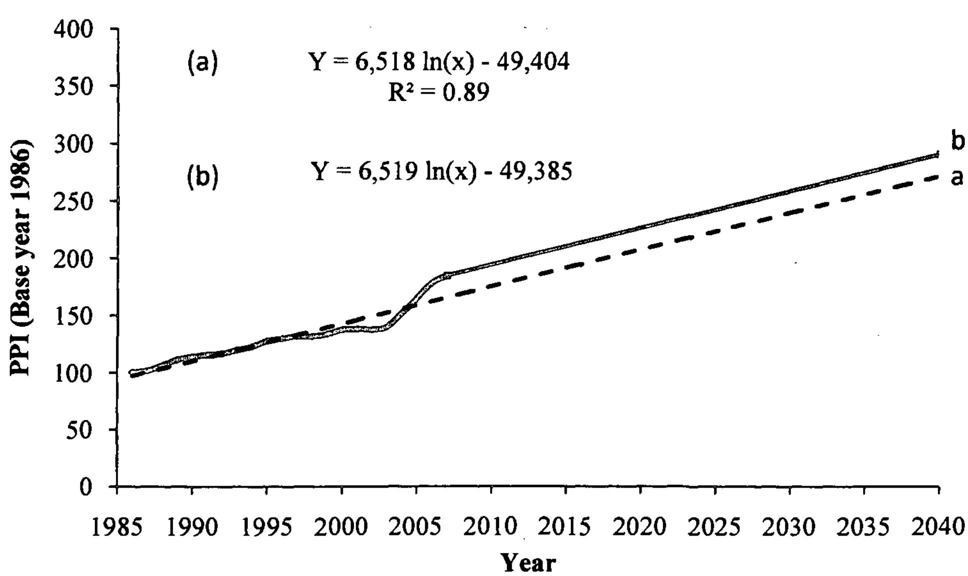

Figure 8.2: Forecast of PPI index for maintenance and repair construction

Using the forecasting tools of the Microsoft Excel a lognormal regression equation (8.3) for the trend line (a) was estimated as follows:

$$Y = 6{,}518\,(\ln X) - 49{,}404 \quad \text{(8.3)}$$

$R^2 = 0.89$

Since the regression line (a) did not reflect the current PPI index level, an adjustment was made to match and provide continuity from the latest data point, assuming that prices will not decline, but always follow upward direction. The regression line was moved upward as shown by line (b) parallel to line (a), and forecast point was started from the latest real data point. This is an accepted forecasting practice often described as manipulation of graphical information (Jain, 1988). This incorporates the mathematical results and intuitive manipulation of the mathematical results to produce more logical outcome. Simultaneously, the regression equation was also adjusted to reflect the line (b) as:

$$Y = 6{,}518\,(\ln X) - 49{,}385 \quad \text{(8.4)}$$

Based on this lognormal regression forecast, the PPI index for the year 2040 was calculated using the equation (8.4) as:

$$Y_{2040} = 6{,}518\,(\ln 2040) - 49{,}385 = 290.30$$

Thus, the expected PPI index for the year 2040 is 290.30. Now, annual escalation rate, for the forecast period of 2007 to 2040 can be calculated based on the PPI index of year 2007 (184.30) and the calculated value for year 2040 (290.30). In this manner, annually compounded average rate of PPI escalation rate was forecast to be about 1.39%.

As discussed in the previous chapter, the average escalation rate for maintenance, repair and replacement costs can be established as the average of the CPI and PPI forecast rates if PPI index was relevant only for the materials and components of construction. BLS (2008) has started reporting of PPI for repair and maintenance construction since 1986 and therefore these data were used in this analysis instead of averaging the CPI and PPI. Therefore, equation (8.4) will be used for forecasting all home maintenance related escalation rates for various periods as required.

8.4 Forecasting Escalation Rate for Utilities Expenses

Historical data on average annual expenditure on utilities, fuels and public services for a typical housing unit in Honolulu were used to forecast the escalation rate (Figure 8.3). Only 12 data points were available for the period of 1994 to 2005 (DBEDT, 2008). A lognormal regression equation was estimated based on the historical data and a line was drawn showing the forecast trend as depicted in the Figure 8.3. The lognormal regression equation generated by the Excel graphical tool was:

$$Y = 164{,}255\ ln(x) - 1{,}246{,}280 \quad (8.5)$$

$R^2 = 0.89$.

Since the regression line passes from a point lower than the current existing expenditure level, the regression line was shifted upwards to adjust the current expenses level with an assumption that prices will not fall below the current level, but will continue its upward tendency. The adjusted regression equation is shown in line (b), whereas line (a) shows the Excel generated trend.

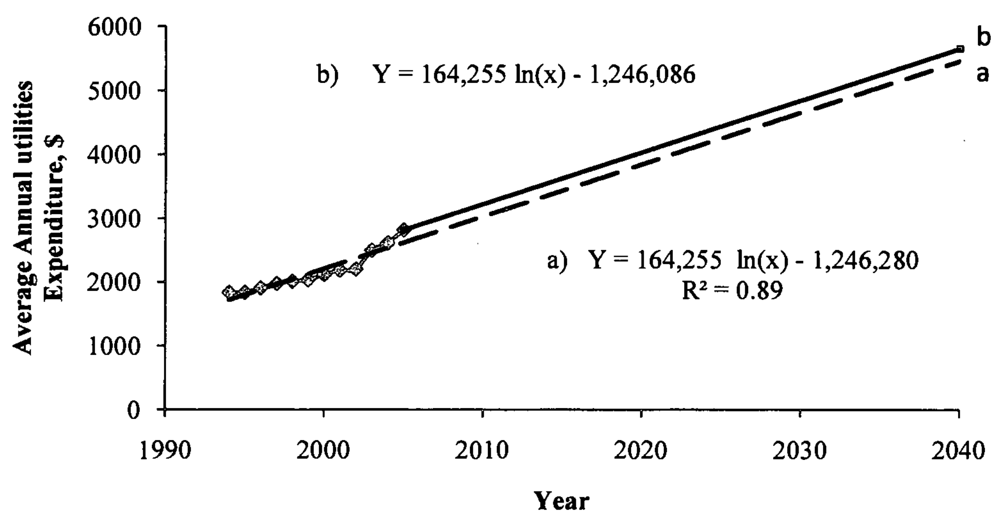

Figure 8.3: Forecast of utilities, fuels and public services costs

The average annual utilities, fuels, and public services expenses for 2005 were $2,813.00. Using the regression equation (8.5), the cost was calculated for 2005, in order to determine and adjust the difference between the continuous and the dashed regression lines as follows:

$$Y_{2005} = 164{,}255\ ln(2005) - 1{,}246{,}280 = \$2618.24$$

Thus, the difference was 2,813.00 – 2,618.24 = $194.76, and this is the amount of adjustment made by shifting the intercept of the regression line upwards. The adjusted new regression is:

$$Y = 164{,}255\, ln(x) - 1{,}246{,}085 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8.6)}$$

Using the adjusted equation (8.6), let's calculate the price level for year 2040.

$$Y_{2040} = 164{,}255\, ln(2040) - 1{,}246{,}085 = \$\,5654.56$$

Using the compounding growth method, the annual average escalation rate during the period of 2005 to 2040 was forecast at 2.22%. In this study, equation (8.6) will be used for forecasting utilities cost escalation rates for various periods as required.

8.5 Forecasting Escalation Rate for Home Insurance Costs

Based on the available time series data (DBEDT, 2008), a forecast of price escalation rate was performed using lognormal regression, as shown in the Figure 8.4.

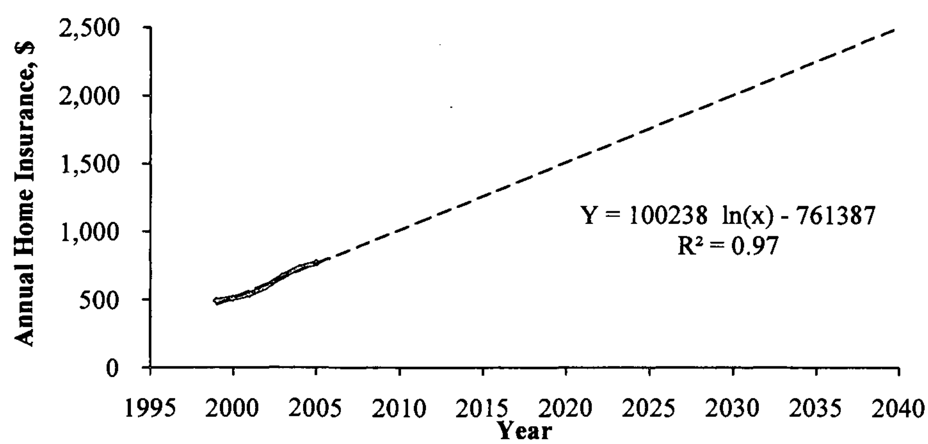

Figure 8.4: Forecast of average insurance

According to the procedures described in previous section, the forecast equation was obtained as:

$$Y = 100{,}238\, ln(X) - 761{,}387 \quad \ldots\ldots \quad (8.7)$$

$$R^2 = 0.97.$$

Using the lognormal equation (8.7), and the base cost of $764.00 at the end of year 2005, annual home insurance premium for year 2040 is forecast at $2,497.11. Thus, the annual average escalation rate of home insurance premium for the next 30 years or so will be in the range of 3.4%. Equation (8.7) will be used for forecasting escalation rate of home insurance costs.

8.6 Forecasting Property Appreciation Rate

A recent study carried out by Harding et al. (2007) found that for a typical single-family house adjusted house price inflation over the 1983 to 2001 period averaged approximately 2.63 percent per year nationally, whereas 0.75% was the real annual appreciation of homes. The same study found out that a typical single-family home depreciates at roughly a 1.9% rate per year, and with such a basis, after 50 years, a home would depreciate roughly by 60%.

The historical records of home sales price are the basis for forecasting the property appreciation rate. The time series data of median and average sales prices of existing single-family homes for the island of O‘ahu obtained from Honolulu Board of Realtors (2008) as shown in Table 8.1 and are depicted in Figure 8.5.

Average annual compounding appreciation rate of the average sales price was calculated to be 6.34%, for the period between 1985 ($205,400) and 2007 ($794,183). Similarly,

Table 8.1: Sales price of single-family homes in O'ahu (source: Honolulu Board of Realtors, 2008

Year	Average price, $	Median price, $	Change in median price,
1985	205,400	158,600	
1986	211,100	171,200	7.90%
1987	281,963	190,200	11.10%
1988	312,300	210,000	10.40%
1989	372,361	270,000	28.60%
1990	498,511	352,000	30.40%
1991	432,338	340,000	-3.40%
1992	411,868	349,000	2.60%
1993	436,898	358,500	2.70%
1994	423,371	360,000	0.40%
1995	429,613	349,000	-3.10%
1996	409,411	335,000	-4.00%

Year	Average price, $	Median price, $	Change in median price,
1997	380,507	307,000	-3.30%
1998	370,021	297,000	-2.40%
1999	377,497	290,000	-2.40%
2000	406,331	295,000	1.70%
2001	375,857	299,000	1.40%
2002	418,231	335,000	12.00%
2003	479,377	380,000	13.40%
2004	591,354	460,000	21.10%
2005	744,174	590,000	28.30%
2006	778,393	630,000	6.80%
2007	794,183	643,000	2.10%
2008	-	620,00	-3.60%

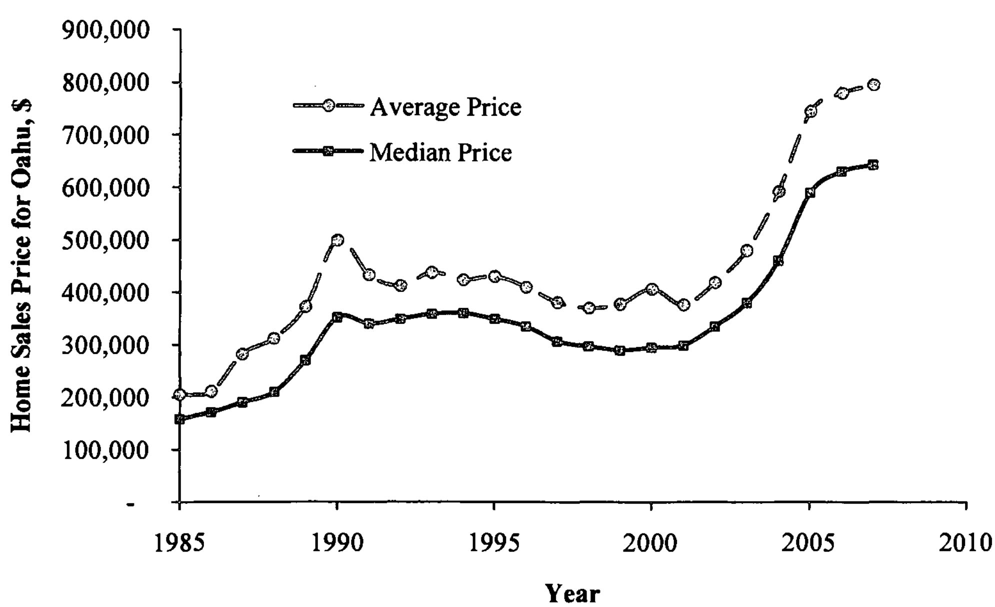

Figure 8.5: Median and average sales price of existing single-family homes in O'ahu (source: Honolulu Board of Realtors, 2008).

average annual compounding appreciation rate of the median sales price was 6.57% from 1985 ($158,600) to 2007 ($643,000). During the period of 1990 to1999 ($352,000 vs. $290,000), the median sales price of single-family houses depreciated at an average annual rate of 2.13%, whereas, during the period of 1988 to 2003 ($380,000 vs. $210,000), the annual average property appreciation rate was 4.03%.

From these calculations as well as from Figure 8.5, it is clear that the average and median prices follow a very identical pattern of fluctuation. Since both prices follow the same tendency, either one could be used for forecasting purpose. It is normally assumed that the average price can be more easily skewed to the high side by a few very high priced homes sales. Therefore median sales price is used in this analysis. Based on the historical data for the last 23 years, the following lognormal regression equation was used to forecast price appreciation.

$$Y = 30{,}338{,}120 \; ln(X) - 230{,}189{,}670 \qquad (8.8)$$

$R^2 = 0.63$.

From Figure 8.5, it can be seen that single-family mean prices fluctuate with a tendency to rise and fall. The median price continuously went up from $158,600 in1985 and reached a peak price of $360,000 during1994. Then, the median price declined until it reached a record low at $290,000 during 1999. Since then the median price increased constantly and reached the apex at $643,000 during 2007. According to the projection made by the University of Hawai'i Economic Research Organization, the single-family home median price will decline in the range of 2.3% to 3.2% during the year 2008 and 2009 (Gomes, 2008). The O'ahu single-family median price has already dropped to $620,000, nearly 3.6% decline during the first quarter of 2008. This is a clear indication that the cycle of decline has started and it may continue for another few years before it picks up again.

Based on the above observation, it can be speculated that the average period of rise and fall of the median price lies somewhere in the range of 7 to 8 years. Although, the R^2 value is rather low at 0.63 for the equation (8.8), as seen in the Figure 8.6, it is clear that the median price fluctuates along the lognormal regression line, in the long-term. Therefore, for the purpose of this research, it was assumed that lognormal equation (8.8) represents long term trend for median single-family prices on O'ahu. However, the fluctuating property of the curve warrants that the forecast for the immediate next few years must be used with caution. Most likely, the median price will tend to meet the lognormal regression line within the next few years. If the economic cycles follow the historical trend as we have observed during the past 25 years, the price appreciation rate may remain negative for another 6 to 9 year period. However, in this research it was assumed that the median house will keep decreasing at the rate of 2.5% per year until the line (b) meets the lognormal regression line (a), as shown in the Figure 8.6.

From Figure 8.6, it is also noticed that the actual price and lognormal forecast lines crossed each other in year 1988, 1996 and 2004, which is at an interval of about eight years. Based on this trend it can be inferred that these two lines will cross each other in the next few years. Calculations indicated that the line (a) and the line (b) meet sometime during the first quarter of 2011, and the convergent value of sales price would be approximately \$577,000. After the convergence, it was assumed that the price would follow the regression line instead of deepening further.

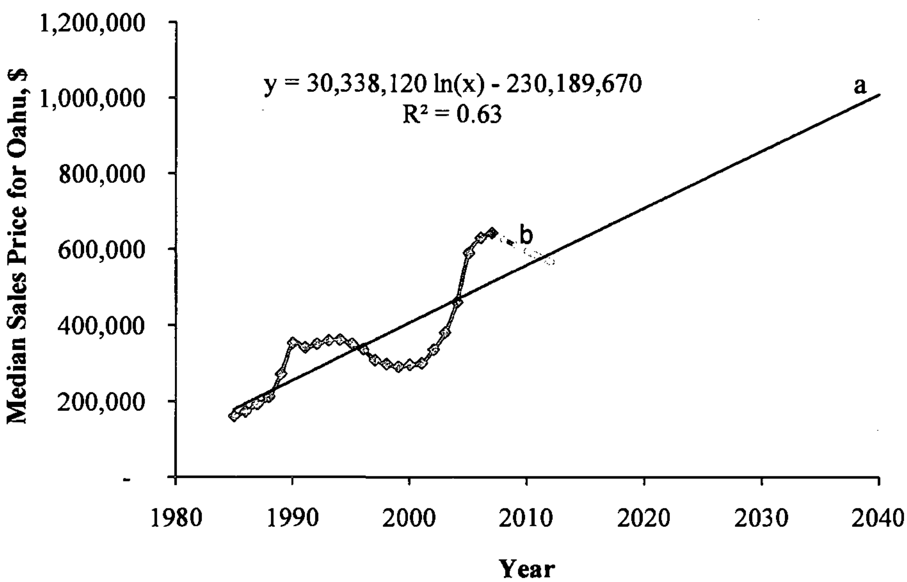

Figure 8.6: Forecast of median price escalation rate for single-family homes in O'ahu

Using equation (8.8), the single-family home median sales price for year 2040 was calculated to be approximately \$1,008,000. Based on this result and taking the median sales price of \$643,000 at the end of 2007, long term overall annual average compounding appreciation rate was calculated to be 1.37%.

Table 8.2: Forecast of median sale price of single-family homes in O'ahu (current $)

Year	Actual	Forecast with 2.5% decline *	Forecast by equation (8.8)*
2007	643,000	-	-
2008	620,000[†]	627,000	513,000
2009	-	611,000	529,000
2010	-	596,000	544,000
2011	-	581,000	559,000
2012	-	567,000	589,000

*The median price for each year was rounded to nearest thousand dollars.

[†]observed during the first quarter of the year.

8.7 Forecasting Gasoline Prices

Using the time series data of Annual Average Gasoline Retails Price a graph was drawn showing the historical pattern of gasoline price in the U.S. retail market as shown in Figure 8.7 (EIA, 2008). Considering annual compounding, the annual average national price escalation of gasoline was seen to be 5.4% for the period of 1978 to 2006. The data further indicated that the gasoline price has been constantly increasing since 2002, and the annual average escalation from 2002 to 2008 was 16.3%. Past records and current trends indicate that oil price is likely to escalate somewhere in the range of 5.4% to 16.3% during the next several years.

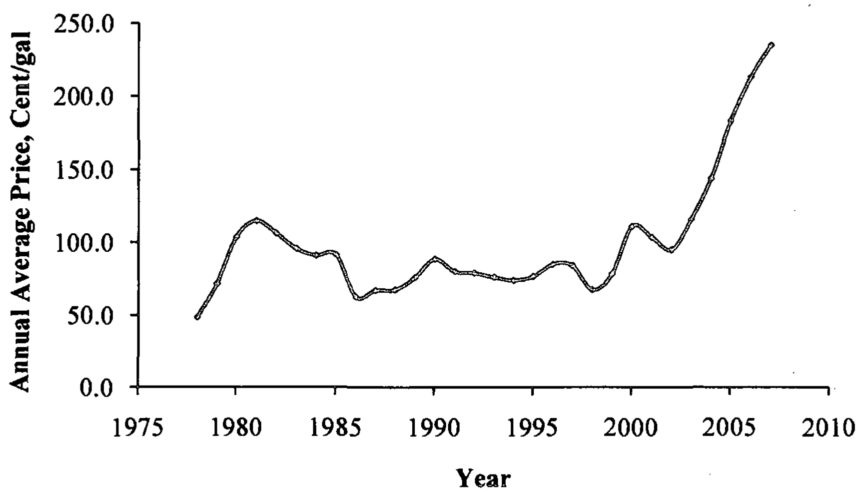

Figure 8.7: U.S. annual average gasoline retails sales price (source: EIA, 2008)

$$Y = 0.38X^2 - 1{,}494\,X + 1{,}485{,}615 \quad (8.9)$$

$R^2 = 0.71$

Where, Y is the forecast of gasoline price and X is the year.

Similarly, a lognormal model yielded the following equation with a low R^2 value of 0.35.

$$Y = 5706\,ln\,X - 43252 \quad (8.10)$$

The lognormal regression (equation 8.10) was not considered reliable without further modification because it yielded a rather low forecast in the present context when the retail gasoline price has already crossed $4/gal during the summer 2008. For example, the forecast price in 2040 was about the same as 2007, which does not appear to be a reliable forecast. The second degree polynomial was better than the lognormal fit. Although the currently gasoline prices are skyrocketing in the long term, the prices are expected to stabilize. The author believed the second degree forecast equation needed some

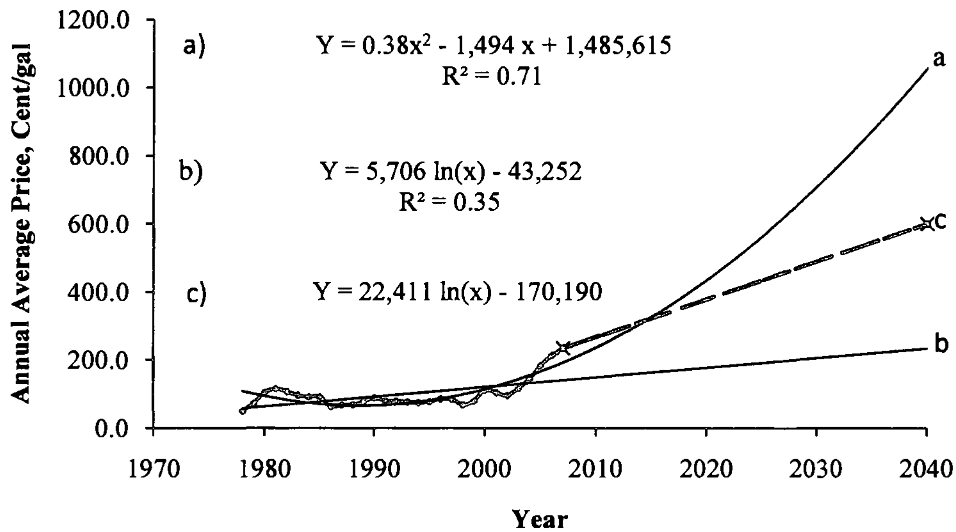

Figure 8.8: Forecast of U.S. gasoline price escalation

adjustment in order to accommodate the current price level. The difficulty is that no other simple model can provide a reasonable answer, not to mention that gasoline prices are deeply linked to world politics, which is immensely uncertain. Therefore, for the purposes of this research, a new equation was developed as an average of equations (8.9) and (8.10) and drawn as line (c) as shown in Figure 8.8. This line starts from the price level at the end of year 2007, and the trend is taken approximately as average of the lognormal and the second degree polynomial line. Thus the adjusted new lognormal equation is as follows:

$$Y = 22{,}411\, lnX - 170{,}190 \qquad (8.11)$$

The adjusted lognormal equation (8.11) provides an average compounding annual escalation rate of 2.83% for the period of 2008 to 2040. Considering the volatility of gasoline prices, 2.83% annual price escalation rate may be considered as a moderate escalation in long term and henceforth may be acceptable.

The forecasts made by various organizations, including the U.S. Energy Information Administration (EIA) illustrate the volatility of oil price. For example, for 2010, the projected price ranges from $28 to $48 per barrel (EIA, 2006). The crude oil prices reached a peak of $147.27 per barrel during mid July 2008 averaging at $99.65 for the year 2008 (Herald Tribune, 2008; InflationData, 2009). In light of such a skyrocketing oil price, in November 2008, International Energy Agency (IEA) revised its forecast for the price of a barrel of oil in 2030 from $108 to just over $200 in nominal terms (Herald Tribune, 2008).

Taking $99.65/barrel as baseline price at the end of 2008 and $200/barrel as forecast for 2030, the projected price escalation is approximately 3.2% per year. It has already been observed that the crude oil price plummeted to $33/barrel in December 2008. Considering such uncertainties, the forecast of annual increase of 2.83% in the gasoline price as given by equation (8.11) could be considered a reasonable prognosis. Therefore, In this study, equation (8.11) will be used for forecasting gasoline price escalation rates for various periods as required.

8.8 Forecasting Escalation Rate for Property Tax

The property tax rate for Hawai'i was continuously decreased since 1973 until 1999 at an average annual rate of 5.8%. After 1999 it was slightly increased with change in legislation, at an average rate of 1.45% per year. A graph was drawn utilizing the historical data as shown in Figure 8.9 (County of Honolulu, 2008).

With the given historical trend, no mathematical model would be able to provide any reliable forecast. However, it can be noticed that these rates have more or less stabilized in recent years, and therefore, for this study, the property tax rate shall be kept constant as it was seen stabilized during the last decade. In the current politico-economical climate of Hawai'i, tax rates are expected neither to rise nor to fall sharply. Recently, the Honolulu City Council voted to keep the same rate as the last year (Boylan, 2008). Therefore, in this study, the latest rate of \$5.55 per \$1,000 property value (0.555%) will be used in further costs analysis.

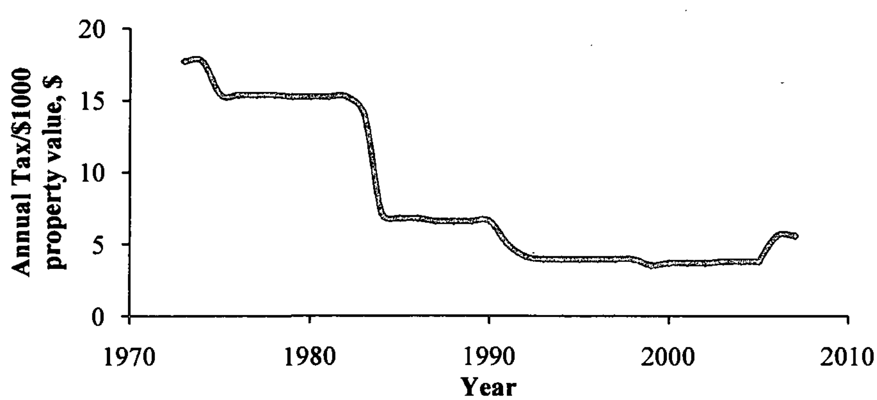

Figure 8.9: Historical property tax rate for home-owners (source: County of Honolulu, 2008)

8.9 Forecasting Rental Rate Escalation

In order to evaluate the renting option, escalation rate for single-family house rent was also considered. The time series data were obtained of median gross rent for Honolulu as shown in table 8.1 (DBEDT, 2008). The historical data indicated that during the period between 1970 and 2006 annual average growth of rent was 6.6%, and it has always been an upward movement. With this rate, the estimated median gross rent for the year 2008 is approximately $1,500.

Table 8.3: Median rent for single-family house/condominium in Honolulu (source: DBEDT, 2008)

Year	Median gross rent, $
1970	130
1980	276
1990	663
2000	802
2006	1,300

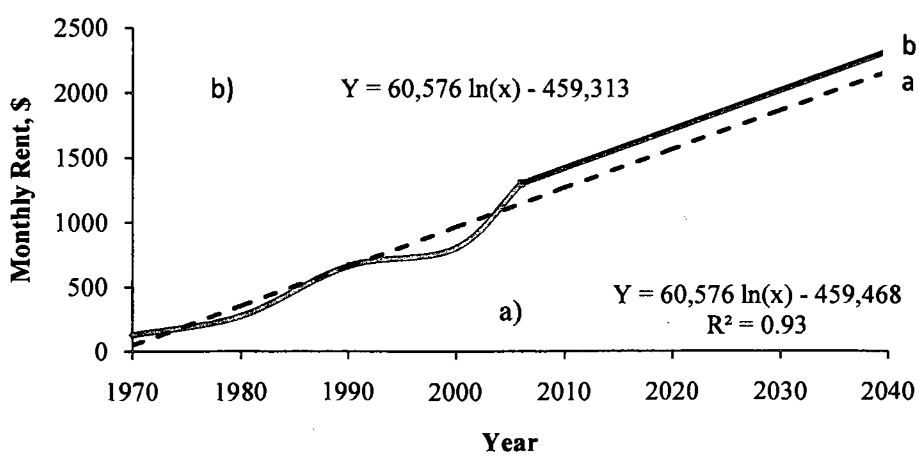

Figure 8.10: Forecast of median gross rent in Honolulu

A lognormal forecast yielded the following equation with, $R^2 = 0.93$:

$$Y \;=\; 60576 \, ln\, X - 459468 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8.12)}$$

where, Y is the median gross rent per month and X is the year.

The historical data indicated that the rental price never declined. The annual average growth rate for the period of 1970 to 2006 was calculated to be 6.6%. Based on this growth rate, the median monthly rent in 2030 will be about $6,027. Considering the growing demand of housing in Honolulu such an escalation cannot be overruled. However, a moderate forecast can be made somewhere along the trend line drawn by the lognormal equation (8.12) with some adjustment for the current price level. Based on this approach a new line (b) is drawn starting from the latest data point as shown in the Figure 8.10 and the adjusted lognormal equation is as follows:

$$Y = 60{,}576 \, lnX - \; 459{,}313 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(8.13)}$$

For a long-term duration of 2008 to 2040, this forecast provides an average annual compounding escalation rate of 1.68%. For the purpose of this study, equation (8.13) will be used for forecasting house rent escalation rates for various periods as required.

8.10 Forecasting Median Family Income

The time series data of the median income of four-person families in Hawai'i were obtained for the period of 1974 to 2005 (DBEDT, 2006) as shown in Figure 8.11. The median income was $17,068 in 1974 and $79,240 in 2005. Thus, the annual increase on family income was 5.07%. Following this trend, the median family income of a family is expected to be \$93,600. A lognormal forecast of the median income of four-person families yielded the following equation with $R^2 = 0.99$:

$$Y = 3{,}866{,}717\, ln(x) - 29{,}324{,}485 \quad \ldots\ldots (8.14)$$

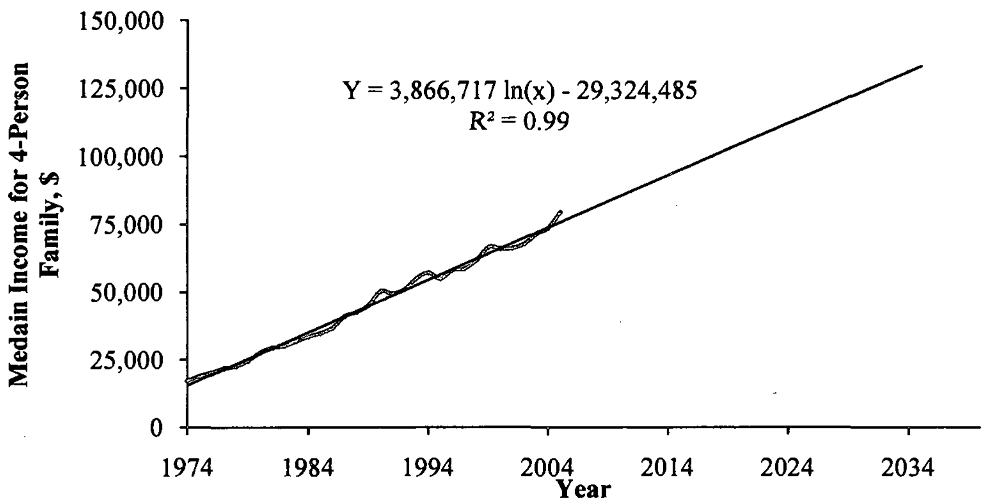

Figure 8.11: Median income of four-person families in Hawai'i

The historical data indicated that the median income has a tendency of growing continuously. The forecast of the median income of four-person family in 2030 will be nearly \$123,600 with an average annual growth rate of 1.93%. Therefore, in this study, equation (8.14) will be used for forecasting median income of four-person families for various periods as required.

8.11 Summary of Forecasting Regression Equations

As discussed and illustrated in the preceding sections, lognormal equations used in this study are summarized here for easy reference:

CPI inflation:

$$Y = 9{,}293\ lnX - 70{,}459 \quad (8.2)$$

All types of home maintenance costs:

$$Y = 6{,}931\ lnX - 52{,}515 \quad (8.4)$$

Utility expenses:

$$Y = 164{,}255\ lnX - 1{,}246{,}085 \quad (8.6)$$

Home insurance premium:

$$Y = 100238\ lnX - 761387 \quad (8.7)$$

Property appreciation rate:

$$Y = 30{,}338{,}118\ lnX - 230{,}189673 \quad (8.8)$$

Gasoline prices:

$$Y = 22{,}411\ lnX - 170{,}190 \quad (8.11)$$

Property tax escalation rate: 0%

Rental rate:

$$Y = 60{,}576\ lnX - 459{,}313 \quad (8.13)$$

Median family income:

$$Y = 3,866,717\, lnX - 29,324,485 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (8.14)$$

Based on the above equations, escalation rates were calculated for the next 5, 15 and 30 years starting from year 2009. These results are presented in Table 8.3.

Table 8.4: Summary of cost escalation forecast for the next 5, 15, and 30 years staring on 2009.

Item	Equation used	5 year	15 year	30 year
CPI Index	8.2	2.06%	1.87%	1.66%
PPI index	8.4	1.73%	1.60%	1.44%
All home maintenance costs	8.4	1.73%	1.60%	1.44%
Utilities	8.6	2.47%	2.22%	1.93%
Home insurance	8.7	4.71%	3.90%	3.16%
Property appreciation	8.8	2.48%	2.22%	1.93%
Gasoline	8.11	4.00%	3.39%	2.81%
Rent	8.13	2.08%	1.89%	1.67%
Median family income	8.14	2.21%	1.99%	1.76%

CHAPTER 9: HOME-OWNERSHIP LIFE-CYCLE COST ANALYSIS MODEL

9.1 Background

There are many different aspects of life-cycle cost (LCC) analysis, and it is very easy to be overwhelmed and deviate from the strategic direction while undertaking life-cycle cost analysis (Fabrycky and Blanchard, 1991). Therefore, at the initial stage it is imperative to establish strategies and objectives. LCC is a cost centered engineering economic analysis that systematically determines all costs encompassing within the specified period of life-cycle (Bull, 1993). In case of home-buying or home ownership, LCC analysis involves the systematic consideration of all relevant costs associated with the acquisition, ownership and occupancy of the property, and the termination costs including the benefits gained at its disposal (Arditi and Nawakorawit, 1999).

Future costs are analyzed using engineering economic theories and mathematical forecasting techniques. This process allows evaluation of all cash flows that occur at different stages of ownership period, with the due consideration of time value of money. The present worth and annualized methods are the two most common approaches used in life-cycle cost analysis (Dell'Isola and Kirk, 2003), and the methodology developed in this chapter adopts both methods. In essence, the model henceforth is a cost model, based on the techniques of engineering economy.

By definition, a cost model consists of mathematical relationships represented in terms of a sequence of logical methodology and outputs are derived based on the inputs (DoE, 1997). Inputs are normally quantities, prices, and rates. The complexity of cost models depends significantly upon the complexity of the system being analyzed. A generic cost analysis model must satisfy the requirements such as accuracy, transparency of the cost structure, dynamic in the sense that it is capable of adapting to new knowledge for continuous use (Layer et al, 2002). However, where future costs are involved, uncertainties prevail.

Cost analysis models can be classified mainly in 3 types: conceptual, analytical, and heuristic (Kolarik, 1980; Gupta, 1983). Conceptual models are qualitative approaches that describe general functional relationships, based on a set of hypothesis or rules. Such models are good for outlining macro level relationships with minimal details, and can be instrumental in describing problems or strategies. But, these models have limited ability to quantify or perform cost analysis.

Quantitative models based on certain mathematical relationships are generally known as analytical models (Layer, 2002). Analytical models show a detailed cost analysis structure. Such models provide closed form outputs, i.e., the solution prescribed by equations, and certain assumptions. Analytical models that determine precise outcomes based on known relationships and input parameters, but without use of random or stochastic variation, are known as deterministic models (Gujarati, 1995). In such models, given inputs will always produce the same outputs. In contrast, mathematical models that use a range of input values as variables in order to evaluate the system in the form of a probability distribution of outputs are known as probabilistic or stochastic models. In either case, whether deterministic or probabilistic, modeling is an evolving process, and it can be improved gradually based on experience and possibly with inclusion of additional factors. The success of any model is measured not only by accuracy of its outcome or predictions but equally on the basis of its simplicity and easy to use features (Edwards & Hamson, 1994). The cost elements and items applied in the model must be derived or based on the reality and depicted in detail in order to expose the cost drivers (Layer et al., 2002).

Heuristic models are less structured analytical models that provide solutions relatively faster, but with lower accuracies, and do not guarantee optimal solution (Gupta, 1983). Sometimes, these models can also be called as "rules of thumb," "educated guesses," "intuitive judgments," or simply as "common sense."

In this research, initially, a conceptual model, a schematic relationship of all major cost elements and activities, has been developed to explain overall objectives and visualize the home-buying life-cycle cost elements. Then the analytical model has been described in the form of a methodology that discusses step-by-step procedure of performing engineering economic calculations in detail. Based on the methodology, excel program has been developed to perform initial level of analysis. Then, a numerical program has been written using the Matlab codes.

9.2 Conceptual Model

The conceptual model of life-cycle cost analysis, discussed in this chapter, integrates all individual elements of time-value of money, and assesses cradle-to-grave expenses of

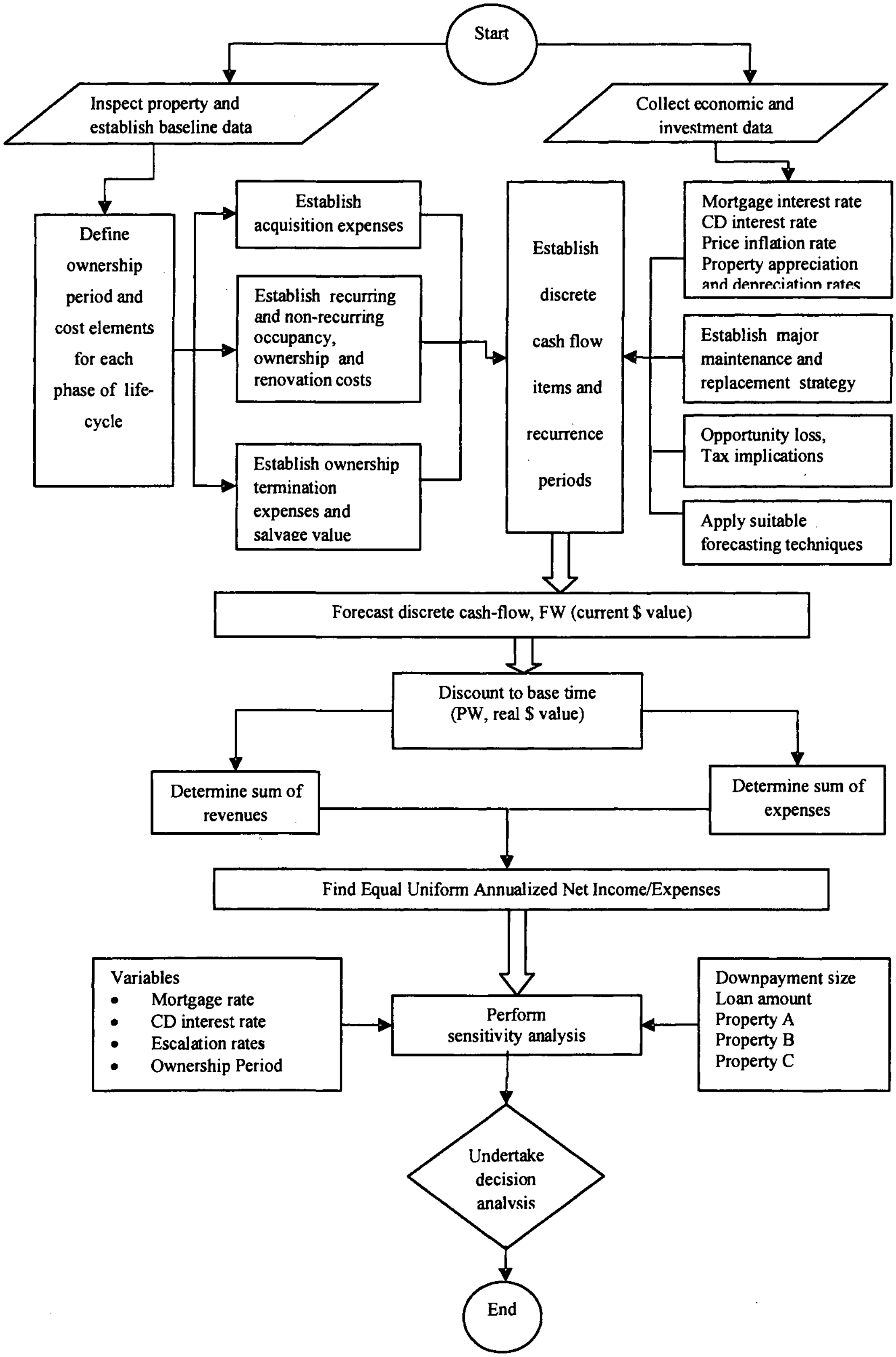

Figure 9.1: Conceptual model of life-cycle cost analysis of home-ownership.

home-ownership from buying until resale. The schematic form of the model depicting a system of ownership elements is shown in Figure 9.1.

The qualitative model, based on theories of engineering economy, reflects the life-cycle characteristics of home-ownership. This model adopts the present value approach to calculate the total cost over the ownership period. It applies a forecasting technique to estimate escalation of future costs in actual (current) dollars. All actual cash flows have to be accounted for loss of opportunity and appropriate tax implications need to be determined for each discrete period. After tax future worth cash flows should be discounted for each period in order to determine equivalent present worth dollars. Then the equivalent present worth is distributed equally over the ownership period to find Equal Uniform Annualized Net Expenses (EUANE) in constant dollars. This approach is based on the generic principles of engineering economy widely discussed in textbooks, such as Thuesen & Fabrycky (1989), Dhillon (1989), Eschenbach (1989), Canada et al.(1996), Newnan (2002), Sullivan et al. (2006), and Hartman (2007).

Although time-value of money and consideration of opportunity costs is a conventional engineering economic theory, the model developed here has not been developed before. Those principles are fundamental to the calculation of inflation and time value of money. However, what is new in this work is that all those principles have been brought together along with a comprehensive set of cost parameters to create a reliable decision support system based on financial analysis.

Once the EUANE is determined, sensitivity analysis can be performed for variables such as mortgage interest rate, CD interest rate, escalation rates, amount of down payment, life-cycle or ownership period and compare alternatives.

9.3 Cost Breakdown Structure (CBS)

Identifying all cost elements in a systematic approach and establishing a cost breakdown structure is useful in life-cycle cost analysis (Fabrycky and Blanchard, 1991). A logical division of cost items, functional activities, and elements of system leads to objective oriented cost assessment and analysis. The purpose of this discussion is to develop and describe the LCC methodology suitable for home-buying and home-ownership. With this in mind, a simplified CBS has been developed for each phase of the home-ownership as shown in Table 9.1.

Table 9.1: Simplified cost breakdown structure of home-ownership

Acquisition phase	Occupancy phase	Disposal phase
1. Initial studies 2. Down payment 3. Discount points 4. Closing costs 5. Loan	1. Mortgage payment 2. Utilities expenses 3. Repair and maintenance 4. Insurance 5. Property tax 6. Opportunity lost 7. Reroofing 8. Repainting 9. Opportunity losses 10. Income tax 11. Tax return	12. Resale cost including advertisement cost, realtor's fee and any other closing costs if any. 13. Income after resale 14. Capital gain tax

9.4 Life-cycle Cost Analysis Methodology for Home-buying

There are four steps required to undertake life-cycle cost analysis (Treloar et al., 2000): 1) define life-cycle phases to be considered, 2) quantify direct and indirect inputs for each phase of life-cycle, 3) valuation or cost assessment, and 4) interpretation of results. Based on these key steps, a detailed computational methodology has been developed. The methodology discussed in this section assumes the deterministic behavior. The deterministic model is chosen instead of probabilistic one, because the simulation has to be performed under certain restricted range of variables, and in which case the results provided by the probabilistic model has to be scrutinized by sensitivity analysis (Giordno et al., 2003). For simplicity in this research deterministic approach has been adopted instead of probabilistic analysis. Moreover, in the given scenario, probabilistic approach does not add much value in the output or analysis results, when a deterministic output provides a straight forward decision analysis.

The methodology developed and described here is a dynamic and discrete model. It is a dynamic model because it considers the time value of money. It is a discrete model because expenses are accumulated and paid either at the end of each month or every year throughout the ownership life-cycle. All the cash flows occur at the end of each discrete period.

A standard cost analysis approach of treating all expenses as positive and all revenues and incoming funds as negative expenses has been applied. This convention is used both in graphical representation as well as in computations. In cash flow diagrams, expenses are shown in upward and revenues are shown in downward directions. The step-by-step life-cycle cost analysis computations are explained below.

Step 1: Establish input parameters

- Home-ownership (life-cycle) period (n), months
- Mortgage interest rate (i), %
- Certificate of Deposit (CD) interest rate (k%):
- Annual inflation (CPI inflation) rate (f%):
- Annual price escalation rates (e_i%) for each cost element listed under occupancy phase as shown in cost breakdown structure (Table 9.1)
- Appreciation/depreciation rate of the property (r%),
- Baseline monthly recurring occupancy costs (BM_i), i.e., utility, home repair and maintenance and all other costs, all in present value, $.
- Baseline semi-annually and annually recurring costs (BA_i), such as home insurance, property taxes, and other expenses, all in present value, $.
- Seller's closing cost (SCC), in present value term, $

Step 2: Develop major maintenance replacement and capital improvement strategy.

- Develop strategy for major renovation and replacement, by identifying the items and their frequency of replacement.
- Define baseline cost (BR) of each replacement items, in present value term, $/unit

Step 3: Determine initial home-buying costs.

- Purchase (sales) price of the property (SP), $
- Down payment (DP), $
- Mortgage amount, the loan (P), $
- Discount points (PT), $
- Buyer's closing costs (CC), $

A typical cash flow diagram on the closing day of home-buying is shown in Figure 9.2

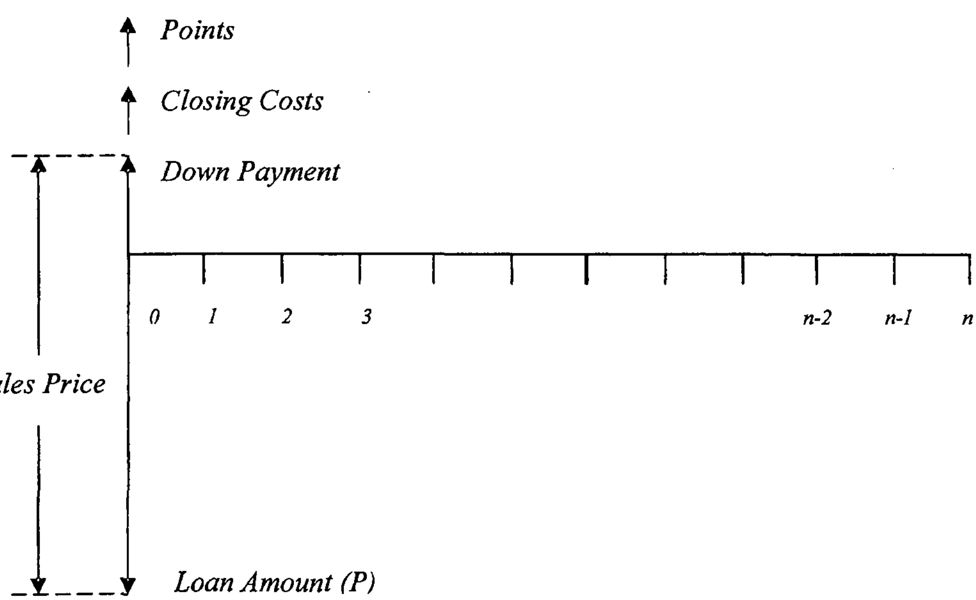

Figure 9.2: Cash flow on the closing day of home-buying

Step 4: Determine monthly mortgage.

Monthly mortgage (M), in annuity term is calculated as:

$$M = P\,(A/P, i\%, n) \quad \text{(9.1)}$$

where,

P is the loan amount,

i% is the effective monthly interest rate and

n is the interest period in months.

A typical mortgage payment cash flow diagram is shown in Figure 9.3:

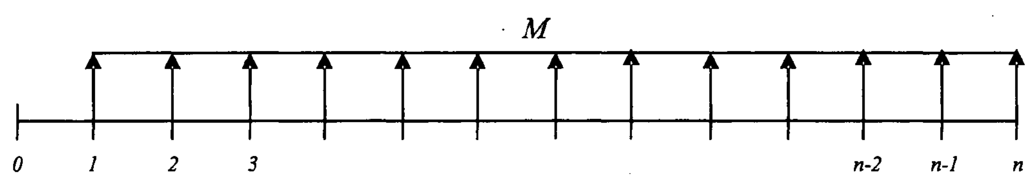

Figure 9.3: Cash flow diagram of mortgage payment

Step 5: Determine monthly recurring expenses.

Forecast all monthly recurring expenses (FM_i) based on the established base line monthly costs (BM_i) and appropriate escalation rates (e_i) as:

$$FM_i = BM_i\,(F/P, e_i\%, n_i) \quad \text{(9.2)}$$

Each monthly expense has to be forecast and handled individually, because escalation rates may vary from item to item.

Step 6: Determine semi-annually and annually recurring expenses.

Forecast all annually recurring expenses (FY_i), based on the established baseline costs (BY_i), and appropriate escalation rates (e_i) as follows.

$$FY_i = BY_i(\mathrm{F/P}, e_i\%, \mathrm{n}) \quad \text{(9.3)}$$

When the entire monthly and the yearly expenses are determined the cash flow diagram for a typical year will be as shown in Figure 9.4.

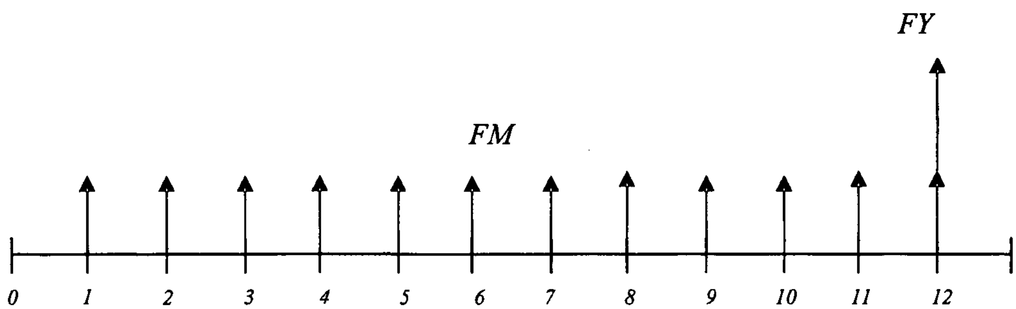

Figure 9.4: Cash flow diagram of monthly and yearly expenses for a typical year

Step 7: Determine periodic major maintenance and replacement expenses.

All expenses for major maintenance and replacement works need to be forecast based on the established strategies. For example, if the homebuyer considers that the roof has to be replaced at every 15 years interval, then the cost of roof replacement at that time (in current dollar) has to be determined. If the assumed ownership period is 30 years, depending upon the age of the roof at the time of home-buying, it may have to be replaced twice. Similarly, if the house has to be repainted every 5 years, then such costs may occur up to a maximum of 6 times during the ownership period. Based on the strategy (frequency of replacement) and baseline costs of these replacement works (BR_i), future value (FR_i) must be calculated individually in current dollar terms as follows:

$$FR_i = BR_i(F/P, e\%, n) \quad \text{(9.4)}$$

In the above example, let's assume that at the time of home purchase, the roof and painting was brand new. The cash flow diagram indicating reroofing cost (FR_{roof}) and repainting cost (FR_{paint}) for an ownership period of 30 years will be as shown in the Figure 9.5.

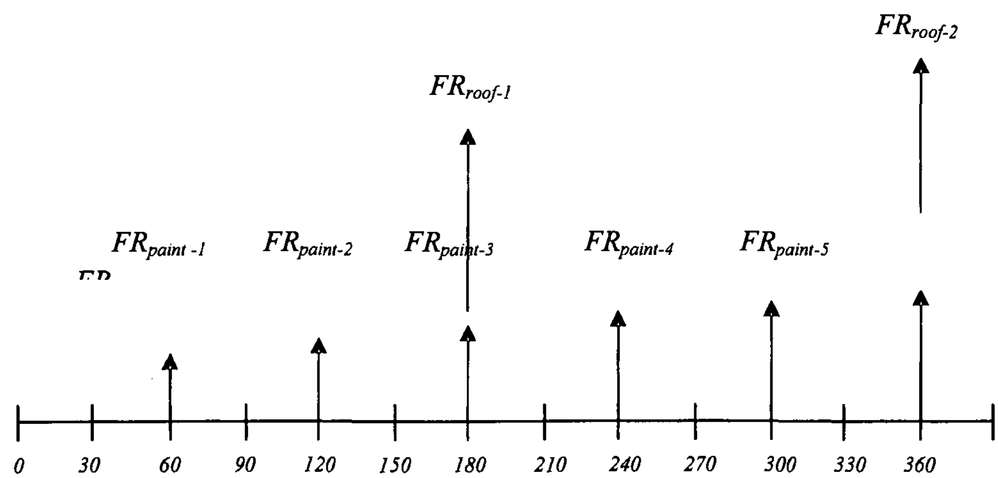

Figure 9.5: Cash flow diagram of reroofing and repainting costs

Step 8: Determine opportunity costs:

Opportunity costs are calculated based on CD interest rate as discussed in the previous chapter. Following expenses are subject to calculation of opportunity costs:

- Down payment
- Discount points
- Closing costs
- Mortgage payment
- All monthly recurring expenses
- All semi-annual and annual expenses
- All periodic replacement and repair expenses

Opportunity costs are calculated based on the assumption that expenses are deposited in a CD account as an investment. Thus the funds spent otherwise are capable of earning an annual nominal interest rate of k%. All opportunity costs (interest earned) are accumulated at the end of each discrete year. Then, appropriate income tax must be deduced from the interest income so as to find net opportunity loss. This process has to be continued until the end of life-cycle period for each expense item.

For example, opportunity loss of down payment is calculated in the following manner. First of all, future value (FV_1) of the down payment (P_1) at the end of the first year, compounded monthly for n = 12, is calculated with k% nominal market interest rate (CD interest rate) using the following relationship:

$$FV_1 = P_1(F/P,\ k\%/12, 12) \quad \text{(9.5)}$$

Then, taxable interest earned (I_1) during the first year is calculated as:

$$I_1 = FV_1 - P_1 \quad \text{(9.6)}$$

Income tax at the end of 1st year (IT_1) paid at a rate of (τ) is calculated as:

$$IT_1 = \tau(I_1) \dots\dots (9.7)$$

Thus, opportunity (net interest) loss in the first year (OL_1) is calculated as:

$$OL_1 = I_1 - (IT_1) \dots\dots (9.8)$$

After tax running capital at the end of 1st year (or at the beginning of 2nd year is calculated as:

$$P_2 = FV_1 - IT_1 \dots\dots (9.9\ a)$$

Or,

$$P_2 = P_1 + OL_1 \dots\dots (9.9\ b)$$

Equation (9.20a) and (9.20b) yield same results and therefore using either of the two equations is acceptable.

In the similar manner, opportunity loss for the 2nd year and the after tax capital at the end of the year is calculated as follows:

$$FV_2 = P_2(F/P, k\%/12, 12) \dots\dots (9.10)$$

The taxable interest earned (I_2) during the 2nd year is:

$$I_2 = FV_2 - P_2 \dots\dots (9.11)$$

Income tax at the end of 2nd year (IT_2) paid at a rate of (τ) is calculated as:

$$IT_2 = \tau(I_2) \dots\dots\dots (9.12)$$

After tax capital at the end of 2nd year (or at the beginning of 3rd year is calculated as:

Thus, opportunity (net interest) loss in the 2nd year (OL_2) is calculated as:

$$OL_2 = I_2 - (IT_2) \dots\dots\dots (9.13)$$

After tax capital at the end of 2nd year (or at the beginning of 3rd year is calculated as:

$$P_3 = FV_2 - IT_2 \dots\dots\dots (9.14\,a)$$

Or,

$$P_3 = P_2 + OL_2 \dots\dots\dots (9.14\,b)$$

In this manner, after tax next capital (P_{n+1}) at the end of the life-cycle period (n) has to be calculated as:

$$P_{n+1} = FV_n - IT_n \dots\dots\dots (9.15)$$

The actual dollar value of the opportunity loss by the end of life-cycle period is calculated as follows:

$$OL_{dp} = P_{n+1} - P_1 \dots\dots\dots (9.16a)$$

Alternatively, the opportunity loss may also be determined as a cumulative interest loss for the life-cycle period calculated as:

$$OL_{dp} = \sum_{i=1}^{n} OL_i \quad \ldots \ldots (9.16b)$$

Equations (9.27a) and (9.27b) yield same results and therefore using either of the two equations is acceptable.

The opportunity loss at monthly, semiannual, and annual basis should be calculated in the same manner. It has to be noted that the expenses paid during a year must be considered at the end of the year interest earning and taxpaying calculation.

For example, the loss of interest on mortgage (M) paid can be calculated as following:

$$FV_1 = M(F/A, k\%/12, 12) \quad \ldots \ldots (9.17)$$

where,

FV_1 is the future value of mortgage (M) paid during the 1st year, compounded every month at a nominal interest rate (k%).

Interest earned I_1 during the first year is:

$$I_1 = FV_1 - 12M \quad \ldots \ldots (9.18)$$

Income tax (IT) at the end of 1st year (IT_1) paid at a rate of (τ) is calculated as:

$$IT_1 = \tau(I_1) \ldots\ldots (9.19)$$

After tax capital at the end of 1st year (or at the beginning of 2nd year is calculated as:

$$P_2 = FV_1 - IT_1 \ldots\ldots (9.20)$$

Then, the future worth at the end of 2nd year is calculated as:

$$FV_2 = P_2(F/P, k\%/12,12) + M(F/A, k\%/12,12) \ldots\ldots (9.21)$$

where,

M is the monthly mortgage.

Interest earned I_2 during the 2nd year is:

$$I_2 = FV_2 - P_2 - 12M \ldots\ldots (9.22)$$

Income tax (IT) at the end of 2nd year (IT_2) paid at a rate of (τ) is calculated as:

$$IT_2 = \tau(I_2) \ldots\ldots (9.23)$$

After tax capital at the end of 2nd year (or at the beginning of 3rd year is calculated as:

$$P_3 = FV_2 - IT_2 \ldots\ldots (9.24)$$

In this manner, after tax next capital (P_{n+1}) at the end of the life-cycle period (n) has to be calculated as:

$$P_{n+1} = FV_n - IT_n \quad \text{......} (9.25)$$

The actual dollar value of the opportunity loss of mortgage paid by the end of the life-cycle period is calculated as follows:

$$OL_{mortgage} = P_{n+1} - P_0 \quad \text{......} (9.26)$$

where,

P_0 is the original loan amount.

Following the same methodology, opportunity loss has to be calculated for each expense item, including down payment, closing costs, discount points, all monthly recurring expenses, all annual and semi-annual recurring expenses, and periodic repair and replacement expenses.

Step 9: Determine tax returns:

***a)* Tax return from mortgage interest**

Determine total amount of interest paid as part of the mortgage payment for each year. With nominal mortgage interest rate (i%), initial loan amount (P_0), and the monthly mortgage (M), the amount of mortgage interest paid by the end of first month (MI_1) is calculated as follows:

$$MI_1 = \frac{i}{12} P_0 \quad \text{......} (9.27)$$

Now, at the beginning of the 2nd month the principal loan amount (P_1) becomes:

$$P_1 = P_0 - (M - MI_1) \quad (9.28)$$

The amount of interest paid at the end of 2nd month (MI_2) is calculated as:

$$MI_2 = \frac{i}{12} P_1 \quad (9.29)$$

And the remaining principal loan amount at the beginning of the 3rd month (P_2) is calculated as:

$$P_2 = P_1 - (M - MI_2) \quad (9.30)$$

In this manner the interest paid and principal loan remaining has to be calculated for each discrete month consecutively. Then, the total amount of mortgage interest paid at the end of first year (MI_{y1}) can be calculated by accumulating the interest paid over the 12 months, or as many number of months in a given tax year:

$$MI_{y1} = \sum_{m=1}^{12} I_m \quad (9.31)$$

The tax return ($TR_{MI\text{-}y1}$) for the first year is calculated as:

$$TR_{MI-y1} = \tau(MI_{y1}) \quad (9.32)$$

where, τ is the applicable income tax rate.

In the similar manner tax return amount has to be calculated for each discrete year up to the end of the ownership period.

It is assumed that applicable tax returns are received on the last day of April for the previous tax year. The amount received as tax returns is invested at a market rate (CD rate) and the capital growth continues.

b) Tax return from discount points and closing costs

The tax return on the discount points (TR_{points}) is calculated as follows:

$$TR_{points} = \tau(PT) \quad \text{……………………………………………………} \quad (9.33)$$

where,

PT is the original amount of discount point paid at the time of closing.

Similarly, the tax return on the closing costs (TR_{cc}) is calculated as follows:

$$TR_{cc} = \tau(CC) \quad \text{……………………………………………………} \quad (9.34)$$

where, ***CC*** is the original amount of closing costs paid at the time of closing.

c) Tax return from property taxes

Tax return from property tax is also calculated in the same manner as for discount points and closing costs. The only difference is that discount points and closing costs are one-time expenses, and therefore tax return from these items is receivable only once in the life-cycle. Since property tax is paid every year, tax return from property tax is receivable every year during the ownership period.

Tax return from property tax ($TR_{property\ tax}$) for each tax year is calculated as:

$$TR_{property\ tax} = \tau\,(PTX) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9.35)$$

where,

PTX is the amount of property paid for a discrete year.

Step 10: Determine salvage value upon ownership termination:

Forecast seller's closing cost:

$$Seller's\ Closing\ Costs = \rho\ (Resale\ Price) \quad \ldots\ldots\ldots\ldots \quad (9.36)$$

where, ρ is the the seller's closing costs rate.

Resale price of the property is forecast using the original sales price and the property appreciation rate ($a\%$) for a given ownership period using the following relationship:

$$Resale\ Price = \ (F/P\,, a\%, n) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9.37)$$

Remaining loan to be paid:

This value has to be calculated by using equations (9.28) and (9.30) for each interest period up to the end of the ownership:

$$Remaining\ Loan\ (RL) = P_{n+1} = P_n - (M - MI_n) \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9.38)$$

Salvage value (S) is calculated by deducting all termination expenses from the income after sale. The only income item in this case is the resale price (RP). The termination related expenses are: remaining loan to be paid if any (RL), seller's closing cost (SCC) including cost for advertisement and the capital gain tax (CGT). This relationship can be written as:

$$S = RP - (RL + SCC + CGT) \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (9.39)$$

The cash flow upon ownership termination shall be as shown in Figure 9.6:

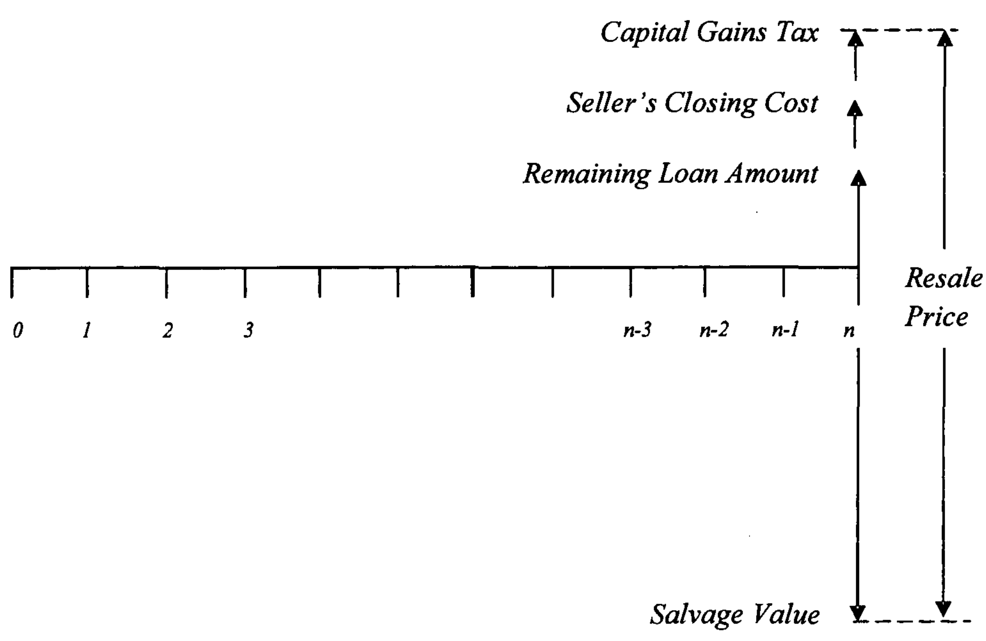

Figure 9.6: Cash flow diagram upon resale of the house

The capital gain tax (CGT) is calculated as follows:

$$CGT = r_{CGT}\left(RP - SCC - RL - SP - PT - CC - EX_{CGT}\right) \ldots\ldots\ldots\ldots\ldots (9.40)$$

where,

r_{CGT} is the capital gain tax rate

RP is the resale price

SCC is the seller's closing cost including advertisement costs

RL is the remaining load to be paid

SP is the original price of the house paid while acquiring the house

PT is the original amount of discount points paid while acquiring the house

CC is the closing cost paid while acquiring the house.

EX_{CGT} is the capital gain tax exemption; 500,000 for married couple tax filing jointly, and 250,000 for singles.

Step 11: Determine net future value of each and every expense and revenue items:

Once all expenses are itemized and dealt for discretely for adjustment of opportunity loss, income tax and tax returns. After adjustment, net future worth of each and every expense items is calculated as actual dollars at the end of the life-cycle period.

Step 12: Calculate Equivalent Present Worth of all Expenses:

The future values calculated should be converted into equivalent present worth. For this purpose, after-tax adjusted market interest rate has to be applied as a discounting rate.

$$PV_0 = FV_n(P/F,\ i_a\%, n) \quad \text{(9.41)}$$

where,

$i_a\%$ = adjusted after tax interest rate as discussed in Chapter 7(refer to derivation of equation 7.11), and calculated as.

$$i_a = e^{\left[\frac{ln\left[\frac{F}{P}\right]}{n}\right]} - 1 \quad \text{(9.42)}$$

where,

F is the future value after at the end of the year after tax deduction and

P is the starting value

n is the interest period.

Step 13: Determine EUME, EUMR, and EUNFME:

Once the *PV* is obtained in real dollars, the EUME (Equal Uniform Monthly Expense) is simply *PV* divided by *n*. Stated in engineering economy terms, (EUME) is calculated for each expense item using the traditional engineering economy formula:

$$EUME = PV\ (A/P, i'_a\%, n) \quad \text{(9.43)}$$

where,

A = equal uniform monthly expense amount, in real dollars,

PV = present value in real dollars of each expense items

i'_a = adjusted after tax real interest rate calculated as follows by taking inflation (f) and adjusted after tax rate of return (i_a):

$$i'_a = \frac{1+i_a}{1+f} \quad \text{(9.44)}$$

Equal Uniform Monthly Return (EUMR) is calculated as follows:

$$EUMR = S\,(A/F, i'_a\%, n) \quad \text{(9.45)}$$

The equal uniform net final monthly expense (EUNFME) is the difference between the EUME and EUMR.

$$EUNFME = EUME - EUMR \quad \text{(9.46)}$$

EUNFME is the measure of "inflation-free" home ownership expenses that incorporates all cradle-to-grave expense and revenues for the entire ownership period distributed equally over each month. This is the decision-making parameter being sought. In this study, EUNFME is taken as the measure of investment attractiveness. The smaller the EUNFME, the better are the home ownership expenses.

The economically attractive home ownership must minimize the EUNFME. The calculation of EUNFME is the standard engineering economic approach of annual worth for comparing alternatives. This method is preferred against comparing present worth or future worth because it is relatively easy for the homeowners to compare this value against his other monthly expenses and the income. EUNFME is also more advantageous against present when it comes to comparing life-cycle period of different duration.

Step 14: Perform sensitivity analysis:

Sensitivity analysis is performed against different assumptions on the amount of down payment, CD and mortgage rates, at varied intervals, to obtain an understanding of their effect on EUNFME. Sensitivity analysis can be performed for any other desired parameters that influence the EUNFME such as tax rates, income, and other operational expenses.

Step 14: Undertake decision analysis:

After performing sensitivity analysis, decision analysis may be undertaken by comparing various output parameters of the alternatives being considered.

9.5 Affordability Analysis – Mortgage Severity Index (MSI)

For the purpose of this research, short-term and long-term affordability of home-ownership will be analyzed based on the ownership expenses against the income of the home-owner. This will be done in the following manner. First of all equal uniform net final monthly expenses (EUNFME) of home ownership will be calculated as discussed in section 9.3. Similarly equal uniform net final monthly operational expenses (EUNFMOE) will be calculated by summing up equal uniform monthly expenses (EUME) of all items that are relevant for occupancy and ownership phases only, but excluding the expenses of the acquisition and termination phases (down payment, closing cost, points, salvage value, seller's closing cost, capital gain tax, and the remaining loan to be paid).

The equal uniform net monthly income (EUNMI) will be determined after adjustment of income tax and inflation for the anticipated home-ownership period. The calculation of EUNMI will follow the same procedure of adjusted after-tax analysis as it was done for the home-ownership expenses. Then, the mortgage severity index (MSI) may be calculated utilizing the EUNFME, EUNFMOE and EUMI as shown below:

$$Ownership\ MSI = \frac{EUNFME}{EUMI} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9.47)$$

$$Operational\ MSI = \frac{EUNFMOE}{EUMI} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (9.48)$$

A figure has been drawn to illustrate the relationship of ownership and operational MSI with respect to expenses at various life-cycle phases as shown in Figure 9.10

The ownership MSI indicates how affordable is the home ownership on a long term basis based on the cradle-to-grave life-cycle cost of the home ownership. The operational MSI indicates severity of maintaining the home-ownership liabilities and occupancy costs, after it has been acquired, and until it has been completely paid off or terminated.

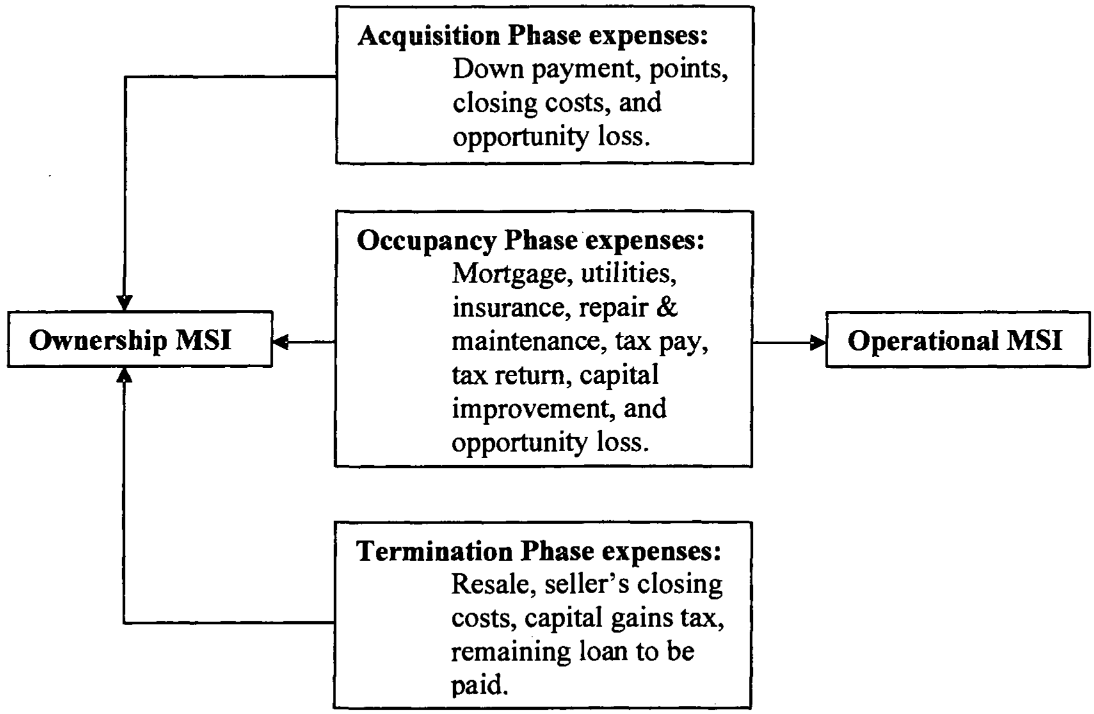

Figure 9.7: Relationship of MSI and expense items at various life-cycle phases

If the MSI is equal to 1, all incomes are just enough to sustain the home-ownership and nothing is left for other expenses such as food, recreation, transportation and other day-to-day activities for the home owner. The smaller the MSI, the better is the home-ownership affordability. If the HUD assumption (mortgage burden not being more than 25% of the gross household income) is followed, most likely the operational MSI should be kept less than 0.5 to be reasonably comfortable. It has to be noted that MSI is independent of investment return, and it is solely dependent of purchase price, loan, operational and maintenance cost, and, more importantly, the income of the home-owner.

9.6 Buying versus Renting Analysis Methodology

Conceptually, the methodology for analyzing the life-cycle cost of renting option will be the same as for home ownership. The only difference between home ownership and renting is the number of expense items. In the case of renting, basically, there are only two expense items, and they are: 1) monthly rent and 2) utilities. Normally, expenses related to repair, maintenance, insurance, and property tax are the liability of the home-owner rather than the renter. An equal uniform net final monthly renting expense (EUNFMR) can be easily calculated following the same methodology as discussed in the previous section and taking the appropriate expenses into account. By performing the life-cycle cost analysis of renting, a potential home buyer may compare the attractiveness of home ownership against the renting. In this study, buying-renting ratio (BRR) will be adopted for easy comparison of the alternatives and the ratio will be calculated as follows:

$$BRR = \frac{EUNFME}{EUNFMR} \quad \text{(9.49)}$$

Where,

EUNFME is the equal uniform net final monthly expenses of home ownership, and

EUNFMR is the equal uniform net final monthly expenses of renting.

If the BRR is equal to 1, both options, buying as well as renting, are equally attractive. Whereas if the BRR greater, better is the renting option and vice versa. Thus, BBR helps the buyer to make an informed decision.

As an alternative, a renter may wish to analyze the severity of renter-ship in the same manner as home-ownership. Renting severity is an index that measures the economic burden of leasing a house in contrast with the income. The Renting Severity Index (RSI) may be calculated as:

$$RSI = \frac{EUNFMR}{EUMI} \quad \text{(9.50)}$$

Where,

EUNFMR is the equal uniform net final monthly expenses of renting

EUMI is the equal uniform net final monthly income of the renter.

Thus, the model developed in this research may assist the homebuyer to make an economic evaluation of his home-ownership affordability based on the given type of property, and his or her prevailing income situation. Similarly, a buyer may compare renting option as an alternative to home-ownership.

CHAPTER 10: COMPUTER PROGRAMMING

10.1 General

The life-cycle cost analysis model discussed and developed in chapter 9 was programmed in Excel and Matlab. Initially, an Excel spreadsheet program was developed to establish the general framework for computation. The Excel program was helpful in visualizing the complexity and the details of the computational process involved according to the described methodology. After a satisfactory computational model was developed in Excel, a Matlab program was written to automate the computation, replicating the Excel program. Unlike the Excel spreadsheet program, Matlab is more versatile and flexible, and thus, a user of the program may easily be able to analyze any purchase scenarios by executing the same program in a short period of time.

10.2 Excel Programming

Based on the methodology discussed in the previous chapter, a computational program was developed in Excel spreadsheet and each of the expense and revenue items were discretely analyzed for a given ownership period. To address the unique nature of the cash flows, each and every expense and revenue items were programmed in discrete worksheets. In this way, implications on opportunity loss/gain as well as appropriate taxes were easily accounted for in order to aggregate the life-cycle costs in the form of EUNFME. This ensured the reliability of the result outputs, and made it easy to cross check any manual errors. An example format of such a calculation sheet is presented as

Figure 10.1 for utility expenses. The excel worksheet is self-explanatory. In this and any other worksheet, A to T, opportunity loss/gain of the particular cost item is analyzed, in actual dollar value for a given ownership period.

Then the computation results of baseline expenses, cost escalation rates used in the calculation, future worth (actual $), equivalent present worth, subsequent opportunity loss/gain, and equal uniform monthly expense (EUME) were summarized for each and every item as a detailed summary sheet as shown in Figure 10.2 for home-buying. In a similar manner, necessary spreadsheets were developed to analyze the rental expenses and family income as shown in Figure 10.3 and 10.4, respectively.

In order to present the key output results against the input variables, an input-output sheet was organized as a front page as shown in Figure 10.5. In the input-output sheet, all variables used in the analysis and key output indicators such as monthly mortgage value, aggregated other monthly expenses, revenue after resale, EUNFME, buying-renting ratio (BBR), and mortgage severity indices were presented.

On the left hand side of the input-output sheet as shown under the heading of "INPUT DATA" house description, purchase conditions such as down payment, loan amount, mortgage rate, points, buyer's and seller's closing costs can be entered as desired by the user. Similarly, the economic variables such as CPI inflation rate, market interest rate (CD rate), various home ownership related cost data and their escalation rates could be entered as they are relevant for a given scenario. Similarly, up to two major renovation items can also be analyzed using the current Excel program, and for the demonstration

Sheet D: Opportunity Loss for Mortgage

Original Loan Amount (P)	496,000
Monthly Mortgage	2,974
Equivalent Present Worth	165,966
EUME	2,834

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i_a%, n)
14,909	12,758	218

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	2.06%	0.172%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	1.90%	0.16%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	2.06%	0.17%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	0.98%	0.08%

[1]	[2]	[3]	[4]	[5]
		Without Opportunity Loss, Actual $		
Year	Monthly Mortgage Payment, Actual $	BOY	During the Year	Future Worth, EOY
		$[5]_{n-1}$	12 x [2]	[3]+[4]
0	NA	0		0
1	2,974	0	35,685	35,685
2	2,974	35685	35,685	71,370
3	2,974	71370	35,685	107,056
4	2,974	107056	35,685	142,741
5	2,974	142741	35,685	178,426

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
	With Opportunity Loss at CD Interest Rate, Actual $													
Year	BOY Running Capital	Mortgage	FVn of Monthly Mortgage for Year n	FVn of Running Capital for Year n	Mortgage w/o Interest	Running Capital w/o Interest	Interest from Current Year's Mortgage	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i_a%, n)	[7]x(F/P, i_a%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	2,974	36,468	0	35,685	0	783	0	783	174	609	609	36,294	36,294
2	36,294	2,974	36,468	37,772	35,685	36,294	783	1,479	2,261	503	1,758	2,367	73,737	73,737
3	73,737	2,974	36,468	76,741	35,685	73,737	783	3,004	3,787	843	2,944	5,311	112,367	112,367
4	112,367	2,974	36,468	116,945	35,685	112,367	783	4,578	5,361	1,193	4,168	9,479	152,220	152,220
5	152,220	2,974	36,468	158,422	35,685	152,220	783	6,202	6,984	1,554	5,430	14,909	193,336	193,336

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [23] = [24]			3.122%
[7]x(F/P, i_t%, n)	[8]x(F/A, i_t%, n)	[21]+[22]	[20]
-	36,295	36,295	36,294
37,443	36,295	73,738	73,737
76,073	36,295	112,367	112,367
115,926	36,295	152,220	152,220
157,041	36,295	193,335.62	193,335.62

Figure 10.1: Excel spreadsheet for analysis of mortgage payment, for home-ownership period of 5 years

Summary Sheet: Homebuying Expenses 5 year

(F/P, e%, n) (P/F, i,%, n) (A/P, i',%, n) (A/P, i',%, n) EUME

	Cash Flow Items	Occurance	Baseline Expenses, $	Cost Escalation (e%)	Future Worth, Actual $	Equivalent PW, $	Opportunity Loss (Gain), PW $	Expenses (Revenues)	Opportunity Loss (Gain)	Total
	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Acquisition Phase					FW (F/P, i,%, n)				
A	Down payment	Once	124,000		20,924	124,000	17,901	2,124	307	2,431
B	Buyer's Closing Costs	Once	9,300		1,569	9,300	1,343	169	23	182
C	Points	Once	9,920		1,674	9,920	1,432	170	25	194
	Acquisition Phase Subtotal		143,220		24,197	143,220	20,675	2,453	354	2,807
										0
	Occupancy & Ownership Phase									0
D	Mortgage expenses	Monthly	2,974		193,336	178,426	12,758	2,834	219	3,052
E	Utilities	Monthly	220	2.47%	14,396	12,350	974	211	17	228
F	R&M	Monthly	150	1.65%	9,533	8,184	650	140	11	151
T	Maintenance fee (Condo only)	Monthly	0	1.65%	0	0	0	0	0	0
G	Excess gasoline	Monthly	50	4.00%	3,447	2,959	230	51	4	54
H	Home insurance	Six-Monthly	700	4.71%	7,691	6,602	576	113	10	123
I	Property tax	Yearly	3,441	0.00%	18,611	15,899	1,014	272	17	290
J	Tax return from discount points	Once	0		(2,553)	(1,895)	(296)	(32)	(5)	(37)
K	Tax return from mortgage interest	Yearly	(6,585)		(34,876)	(27,500)	(2,439)	(470)	(42)	(511)
L	Tax return from property tax	Yearly	0		(4,497)	(3,555)	(305)	(61)	(5)	(66)
M	Reroofing	Every 15 years	10,000	1.7%	0	0	0	0	0	0
N	Repainting	Every 5 years	4,500	1.7%	4,894	4,192	0	72	0	72
	Occupancy Phase Subtotal		15,450		209,962	195,634	13,162	3,129	225	3,354
	Termination phase									
O1	Salvage Value (Resale Price)	Once	(620,000)	2.63%	(705,933)	(603,943)	0	(10,344)	0	(10,344)
O2	Seller's Closing Costs	Once	37,200	6.00%	42,356	36,237	0	621	0	621
O3	Capital Gain Tax	Once	0	22.25%	0	0	0	0	0	0
O4	Remaining loan to be paid	Once			461,550	394,867	0	6,763	0	6,763
	Termination Phase Subtotal		(582,800)		(202,027)	(172,839)	0	(2,980)	0	(2,980)
	Grand total					166,044	33,838	2,622	579	3,201

	[7]	[8]	[9]
Equal Uniform Total Monthly Expenses	13,529	631	14,160
Equal Uniform Total Monthly Return	(10,907)	(52)	(10,959)
Equal Uniform Net Final Monthly Expenses	2,622	579	3,201

Figure 10.2: Detailed summary of expenses and revenue for home-ownership period of 5 years

Summary Sheet: Rental Expenses

Renting period:	5	years

(F/P, e%, n) (P/F, i_a%, n) (A/P, i'_a%, n) (A/P, i'_a%, n) EUME

	Cash Flow Items	Occurance	Baseline Expenses, $	Cost Escalation (e%)	Future Worth, Actual $	Equivalent PW, $	Opportunity Loss (Gain), PW $	Expenses	Opportunity Loss (Gain)	Total
	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Q	Monthly Rental	Monthly	2,500	2.08%	161,284	148,978	5,962	2,453	98	2,551
R	Utilities	Monthly	220	2.47%	14,386	13,354	515	219	8	228
	Grand total				175,670	162,332	6,477	2,672	107	2,779
				Equal Uniform Net Final Monthly Rental Expenses				2,672	107	2,779

Figure 10.3: Renting analysis for renting life-cycle period of 5 years.

Summary Sheet: Family Income
Period of income, years: 5

(F/P, e%, n) (P/F, i_a%, n) (A/P, i'_a%, n) (A/P, i'_a%, n) EUMI

	Cash Flow Items	Occurance	First Year, Annual Income, $	Increase in income (e%)	Final Year, Annual Income, $	Equivalent PW, of all years, $	Opportunity Loss (Gain), PW $	Income	Opportunity Loss (Gain)	Total
	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
S	Monthly Rental	Monthly	83,413	2.21%	93,047	325,701	0	5,449	0	5,449
	Grand total				93,047	325,701	0	5,449	0	5,449
				Equal Uniform Monthly Income (EUMI)				5,449	0	5,449

Figure 10.4: Family income analysis for life-cycle period of 5 years.

SUMMARY SHEET: Ownership Period 5 Years

INPUT DATA

Purchase Condition		
Items	Unit	Amount
House Description		
Sale Price	$	620,000
Down Payment		
% of Sales Price	%	20%
Down Payment	$	124,000
Loan		
Loan Amount	$	496,000
Annual Mortgage Interest Rate	%	6.00%
Payback period (n_1)	Year	30
Points		
% of Loan Amount	%	2.00%
Points Amount	$	9,920
Buyer's Closing Costs		
% of Sales Price	%	1.50%
Closing Costs, amount	$	9,300
Ownership starting year		2009
Ownership period (n_2)	year	5
Seller's Closing Costs		
Advertisement Cost	$	0
Realtor's Fee as % of Sales Price	%	5.00%
Other closing cost if any as % of SP	%	1.00%
Income Tax Rates		22.25%
Federal	%	15%
State of Hawaii	%	7.25%
Capital Gain Tax Rates		22.25%
Federal	%	15%

Economic Variables			
Items	Unit	Amount	Recommended values
Annual CPI Inflation Rate	%	2.06%	2.055%
Market Interest Rate (CD rate)	%	4.00%	10.000%
Cost Escalation Rates:			
Property Tax	%	0.00%	0.000%
Maintenance Costs and Fees	%	1.65%	1.646%
Utilities (electricity, water, gas)	%	2.47%	2.475%
House Insurance	%	4.71%	4.713%
Gasoline	%	4.00%	4.004%
Property Value Appreciation Rate	%	2.6300%	2.632%
Baseline Monthly Expenses:			
Maintenance Fee (Condo only)	$	0	0
Repair and Maintenance Cost	$	150	
Utilities (electricity, water, gas)	$	220	
Gasoline	$	50	
Baseline Annual Expenses			
Property Tax Rate, Honolulu County	$	0.55500%	
Home Insurance	$	1337	
Reroofing - Baseline Rate	$/sft	10,000	
Repainting - Baseline Rate	$/sft	4,500	
Rental Option			
Monthly Rental Expense	$	2500	
Annual Rental Escalation Rate	%	2.08%	2.08%
Utilities (electricity, water gas)	$	220	
Median Family Income			
Median Family Income	$	83,413	83,413
Annual Increment of Income			

Output Data

Output Data		
Equal Uniform Ownership Monthly Expenses:		
Monthly Mortgage (Actual $):	$	2,974
Other expenses	$	302
Monthly Operational Expenses (EUNFMOE)		3,354
Revenue on Resale after 30 years		
PV of Total Incoming Funds (After Resale)	$	(603,943)
Equal Uniform Monthly Net Return	$	(2,960)
Upon Resale		
Equal Uniform Total Monthly Expenses	$	14,160
Equal Uniform Total Monthly Return	$	(10,959)
Equal Uniform Net Final Monthly Expenses (EUNFME)	$	3,201
Buying Vs Renting		
Buying: Euel Uniform Net Final Monthly Expenses (EUNFME)	$	3,201
Renting: Equal Uniform Monthly Rental Expenses (EUMRE)	$	2,788
Buying/Renting Ratio : EUNFME/EUMRE		1.15
Equal Uniform Monthly Income (EUMI)	$	5,449
Mortgage Severity Index (MSI)		
Ownership MSI: EUNFME / EUMI		0.59
Operational MSI: EUNFMOE / EUMI		0.62

Figure 10.5: Input-output sheet of Excel program for home-ownership period of 5 years.

Table 10.1 List of Excel worksheets for the ownership period of 5 years

Input Output	SUMMARY SHEET: Ownership Period 5 Years
Summary Home-buying	Summary Sheet: Home-buying Expenses
Summary Rental	Summary Sheet: Rental Expenses
Summary Income	Summary Sheet: Family Income
A	Sheet A: Opportunity Loss for Down Payment
B	Sheet B: Opportunity Loss for Closing Costs
C	Sheet C: Opportunity Loss for Discount Points
D	Sheet D: Opportunity Loss for Mortgage
E	Sheet E: Opportunity Loss for Utility Expenses
F	Sheet F: Opportunity Loss for Monthly Repair and Maintenance Expenses
G	Sheet G: Opportunity Loss for Excess Gasoline Expenses
H	Sheet H: Opportunity Loss for Home Insurance Expenses
I	Sheet I: Opportunity Loss for Property Taxes
J	Sheet J: Tax Return from Discount Points
K	Sheet K: Tax Return from Mortgage Interest
K1	Sheet K1: Loan Repayment Calculation
K2	Sheet K2: Tax Return on Mortgage Interest detailed calculation
L	Sheet L: Tax Return from Property Tax
M	Sheet M: Opportunity Loss for Reroofing Costs
N	Sheet N: Opportunity Loss for Repainting Costs
O	Sheet O: Termination of the Poperty - Revenue and Expenses
P	Sheet P: Calculation of Cost Escalation Rates
Q	Sheet Q: Rental Expenses and Opportunity Costs
R	Sheet R: Rental Utility Expenses and Opportunity Loss
S	Sheet S: Annual Median Family Income
T	Sheet T: Opportunity Loss for Monthly Maintenance Fee

purposes, in this research reroofing at the interval of 15 years and repainting at the interval of 5 years was included in the program consistently as described in the methodology. As many other major repair and maintenance items may be included in the program as desired by the user, but that will require additional worksheets. Similarly, family income, income tax rate, property tax rate, and capital gain tax rate has to be entered as input as shown in the worksheet. On the right hand side of the input-out sheet under the heading of "OUTPUT" results will be displayed as soon as the input variables are entered.

All of the cost analysis worksheets (sheet A to T) are linked with the input-output sheet so as to receive relevant input data and to display output results. This required a total of 26 spreadsheets and each of these sheets are identified in the Table 10.1.

Initially, an Excel program was set up for three different discrete ownership periods, i.e., 5 years, 15 years and 30 years. Later on, for the purpose of tallying Matlab results additional programs were developed for 3 years, 11 years, 19 years and 26 years as well. As an example, a complete set of an Excel program for ownership period of 30 years is presented as Annex A. These sheets are self-explanatory.

10.3 Matlab Programming

The Matlab program was written resembling the methodology described in section 9.2 to 9.4 and replicating the Excel program described in the previous section of this chapter. The benefit of the Matlab program is such that any input values can be easily entered without any program modification, which was not possible in Excel. For example, in Excel, separate spreadsheets had to be created for each ownership period. Therefore, the spreadsheets for the 5 year, 15 year and 30 year ownership period were developed discretely. Whereas, in Matlab, any such variables can be entered as input, and the calculations can be performed promptly, without initiating any changes in the program. Additionally, Matlab would eliminate any manual errors that could have been made easily while creating an individual spreadsheet, once the program is verified for its accuracy and finalized. Furthermore, presentation of graphical output was made easier and various sensitivity graphs could be drawn automatically without any extra handling of the output data.

10.3 Verification of Matlab and Excel Results

Initially, during the development phase of the Matlab codes, accuracy of the program was verified against the results obtained in Excel for 5, 15, and 30 years of ownership period, for each and every item against the detailed Summary Home-buying of the Excel output (Figure 10.2). Essential variables such as purchase price (frequently referred to as sales price), CD interest rate, mortgage interest rate, and size of down payment were randomly altered and the Matlab output results for EUNFME were verified against that of Excel program. Once the Matlab program code development was completed, additional Excel spreadsheet programs were created discretely for 3 years, 5, years, 11 years, 15 years, 19 years, 26 years, and 30 years ownership period for three different conditions and the results for EUNFME were obtained discretely and tabulated as shown in Table 10.2. Such a tabulated comparison confirmed that Matlab results are fully reliable as the results tally against that of Excel.

Table 10.2: Excel and Matlab compatibility verification results, EUNFME, $

Owner-ship period, years	Condition 1: SP = $500,000 CD = 5%, MR = 6% DP= 20%		Condition 2: SP = $1,000,000 CD = 2%, MR = 9% DP= 30%		Condition 3: SP = $200,000 CD = 9%, MR = 3% DP= 50%	
	Excel	**Matlab**	**Excel**	**Matlab**	**Excel**	**Matlab**
3	2491	2491	4533	4506	1788	1788
5	2390	2390	4194	4177	1770	1770
11	2487	2487	3951	3951	1826	1826
15	2647	2647	3991	3991	1908	1907
19	2769	2769	3917	3917	1962	1962
26	2926	2926	3848	3848	2038	2038
30	3064	3064	3856	3856	2090	2090

10.3 Organization of Matlab Program

There are 33 different Matlab code files. These files are categorized based on the sequence of their execution. First order code file is the user interface file which is the starting step. Second order files are executed and activated based on the information entered by the user responding to first order file. The third order files are linked with second order files, and generate necessary input data. Using the input data collected by third order files, second order files perform the calculation by utilizing the fourth order code files. These files are listed below:

First order code file – user interface

1. User_Interface_File.m

Second order code files – main body of the program

2. Main_CDRate.m
3. Main_Down payment.m
4. Main_Ownership.m
5. Main_Buying_Renting.m

Third order code files – Input files

6. Input_CDRate.m
7. Input_Down payment.m
8. Input_Ownership.m
9. Input_BuyingRenting.m

Fourth order code files - functions

10. adj_real_rates.m
11. adj_real_ratesMortgage.m
12. best_adj_rate.m
13. best_adj_rate_taxreturn.m
14. best_adj_rateAnnualExp.m
15. best_adj_rateMonthlyExp.m
16. best_adj_rateSixMonthlyExp.m
17. calc_escrate.m
18. calc_fv_woint.m
19. Capital_gain_tax.m
20. Forecasting_Coefficients.m
21. income_calcs.m
22. mortgage.m
23. opp_loss_ins.m
24. opp_loss_monthlyExp.m
25. opp_loss_monthlyExpRent.m
26. opp_loss_mortgage.m
27. opp_loss_ptax.m
28. opp_loss_taxretur_mortgage.m
29. opp_loss_taxreturn_proptax.m
30. opp_loss_taxreturn_pt.m
31. Periodic_RandM.m
32. Property_Resalevalue.m
33. Renting.m
34. Sellers_Closing_Cost.m

All of these code files are presented as Annex B. Functionality, order of execution and the relationship between these files are briefly discussed in the following section. A schematic flow chart of the relationships of these files is displayed in Figure 10.6.

User interface file: This is the first order code that a user should execute this file using the Matlab software in order to perform the life-cycle cost analysis. Based on the user's choice one of the following files will be executed as desired by the user, and menu for selecting the appropriate program will be displayed in the interactive screen.

There are four different second order code files. They are the main body of the program, and by executing the first order code file, one of these files will be activated and executed. They are:

- **Main_CDRate.m:** A code file that performs the life-cycle cost analysis of home purchase, and displays a graph of CD Rates along the X-axis and EUNFME along the Y-axis. The numerical values of EUNFME and other results may be easily retrieved from Matlab workspace. This file will collect required input data through interactive screen by internally executing "Input_CDRate.m" file.
- **Main_Down payment.m:** A code file that performs the life-cycle cost analysis of home purchase, and displays a graph indicating down payment sizes along the X-axis and EUNFME along the Y-axis. The numerical values of EUNFME and other results may be easily retrieved from Matlab workspace. This file will collect required input data through interactive screen by internally executing "Input_Down payment.m" file.

- **Main_Ownership.m:** A code file that performs the life-cycle cost analysis of home purchase and displays a graph of Ownership period in X-axis and EUNFME along Y-axis. The numerical values of EUNFME and other desired economic indicators may be retrieved by going to workspace of within the Matlab. This file will collect required input data through interactive screen according to the format and layout designed in "Input_Ownership.m" file.
- **Main_Buying_Renting.m:** A code file that performs the life-cycle cost analysis of home purchase and displays a graph of Ownership period in X-axis and EUNFME along Y-axis. The numerical values of EUNFME and other desired economic indicators may be retrieved by going to workspace of within the Matlab. This file will collect required input data through interactive screen according to the format and layout designed in "Input_BuyingRenting.m" file.
- **Functions – the fourth order files:** There are a total of 25 function codes, which are part of the main program, but organized as separate files in the directory. These files will be utilized several times while executing one of the main code files.

Appropriate comments are inserted in the each of these code files, where necessary and appropriate, explaining what the codes do in a particular section of the program. Any programmer, who is familiar with the language of Matlab, may understand these codes without any difficulties. It should to be noted that the life-cycle cost analysis program written in the language of Matlab is very users-friendly. A user can enter any desired input values through interactive Matlab window and either a graph is drawn or the results will be displayed in the computer screen, depending upon choice entered by the user.

Thus, a user may conduct sensitivity analysis in order to evaluate various alternatives of either home purchase or home-buying vs. renting an apartment. CPI index and other price escalation rates were programmed in the Matlab using the equations shown in Table 8.2 of Chapter 8.

Appropriate coefficients are stored in the file "Forecasting_Coefficients.m," which will be utilized by the program as they are required in the calculation process. Then, the escalation rates will be calculated using the codes contained in the file "calc_escrate.m." These codes can be changed by only those who are expert Matlab user.

A flow diagram of the computer program has been drawn to illustrate functional relationships of the codes file as shown in Figure 10.6. This only depicts the sequence of use of the Matlab code files rather than life-cycle cost analysis methodology. For the flow diagram of the home-buying life-cycle cost analysis methodology flow diagram, please refer to Figure 9.1. The functional relationship flow diagram explains the structure of the Matlab code files and the flow of codes written based on the described methodology.

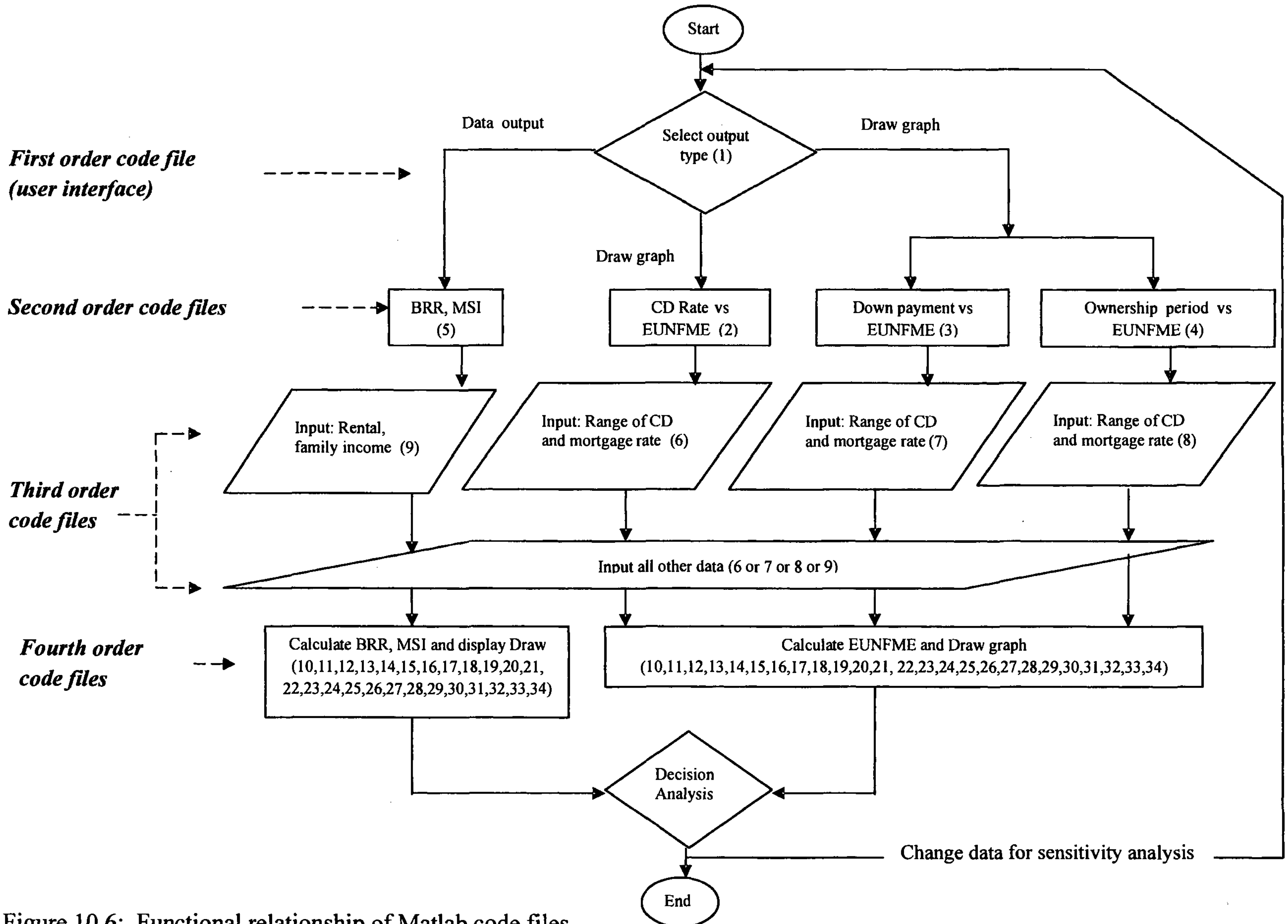

Figure 10.6: Functional relationship of Matlab code files

CHAPTER 11: RESULTS

11.1 General

This chapter demonstrates an application of the life-cycle cost analysis model for home-buying or home-ownership. For this purpose, the cost data and a purchase condition of a median-priced single-family house have been used. Every home purchase is a unique transaction, and can rarely be replicated exactly. Although the life-cycle cost items are common in each home purchase, their magnitude and duration may vary from buyer to buyer, and from property to property. Therefore, in order to make the analysis simple and straightforward, median priced home and buyers with a median family income are assumed. All other home ownership expenses used in the analysis are averages for single-family homes. Home-buying life-cycle cost analysis presented below was performed using the Matlab program.

11.2 Illustration: Purchase of a Median Priced Single-family House in O‘ahu

The current median sale price of a single-family home was assumed to be $620,000 (see page Chapter 8). Other parameters and input data assumed and used in this illustration were derived and discussed in Chapter 8. The analysis assumed a 30- year fixed mortgage rate. Most of the input parameters used in this home-ownership life cycle cost analysis are property and location specific such as median sales price, property tax and median rent of single-family house. Whereas, some other input parameters are buyer specific, such as the buyer’s credit worthiness, median family income, and income taxes.

These input data, used in this example of purchase analysis are taken for O'ahu as summarized in Table 11.1.

Table 11.1: Input data for purchase example

S.No	Cost item	Unit	Values
1	Home sales price	$	620,000
2	Ownership period	Years	5 to 30
3	Down payment (as % of sales price)	%	10 to 100
4	Nominal mortgage interest rate	%	4 to 9
5	Discount points (as % of loan amount)	%	2
6	Nominal market interest rate (CD rate)	%	2 to 8
7	Buyer's closing costs (% of sales price)	%	1.5
8	Realtor's fee (%of sales price)	%	5
9	Seller's other closing cost (%of sales price)	%	1
10	Baseline utilities costs	$/month	220
11	Baseline maintenance & repair costs	$/month	150
12	Baseline gasoline expense	$/month	50
13	Baseline home insurance	$/year	1337
14	Annual property tax (as % of property value)	%	0.555
15	Income tax rate (as % of income)	%	22.25
16	Reroofing costs/ every 15 years	$	10,000
17	Repainting costs /every 5 years	$	4,500
18	Capital gain tax (as % of capital gain)	%	22.25
19	Median family income	$/year	93,600
20	Median rent of single-family house	$/ month	1,500

In the purchase analysis, equal uniform net final monthly expenses (EUNFME) were calculated as a fundamental parameter for the comparison of purchase conditions. Initially, four major variables including market interest rate (CD rate), mortgage interest rate, down payment size, and the ownership period were assumed to vary in the analysis. All other parameters were considered as fixed.

For this purpose, the CD rate was assumed to be in the range of 2% to 8%, the mortgage interest rate in the range of 3% to 9%, the down payment size in the range of 10% to 100%, and the home ownership period in the range of 5 years to 30 years. However, it was possible to vary any other input parameters and analyze their sensitivity to EUNFME. Forecasting of CPI inflation and other price escalation rates were programmed in Matlab using the equations derived in Chapter 8 and summarized in Section 8.11 (page 124). It is also possible to change the coefficients or replace the equations, if the analyst is not satisfied with these equations.

11.3 Structure of the Results

The results obtained from the Matlab program are categorized mainly in the following four groups:

a) EUNFME versus CD rates for various mortgage rates
b) EUNFME versus down payment rates for various mortgage rates
c) EUNFME versus ownership periods for various mortgage rates
d) Mortgage severity indices
e) Renting severity index, and
f) Buying versus renting ratio.

These results are presented below using tables as well as graphs.

11.3.1 Results of EUNFME versus CD Rates for Various Mortgage Rates

For these results, the CD and the mortgage interest rates were taken as main variables, while all other parameters are fixed. The results were obtained for varying ownership period of 5 years, 15 years, and 30 years, in combination with varying down payment size of 20%, 50%, and 10%.

In this category, a total of nine sets of results were obtained as shown in Table 11.2 to Table 11.10. Using these results, graphs were drawn subsequently to visualize and comprehend the influence of CD and mortgage rates on EUNFME. Such graphs are presented as Figure 11.1 to Figure 11.9.

Table 11.2: EUNFME vs. CD rates for various mortgage rates with 20% down payment, and 5 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,773	2,076	2,384	2,696	3,010	3,327	3,646
3	2,015	2,322	2,634	2,950	3,270	3,593	3,918
4	2,251	2,560	2,876	3,196	3,520	3,847	4,177
5	2,484	2,796	3,114	3,438	3,766	4,098	4,432
6	2,732	3,048	3,371	3,700	4,034	4,372	4,713
7	2,965	3,283	3,609	3,941	4,279	4,622	4,968
8	3,199	3,520	3,849	4,186	4,528	4,875	5,227

Using the above data in Table 11.2, Matlab program plotted a graph as shown in Figure 11.1.

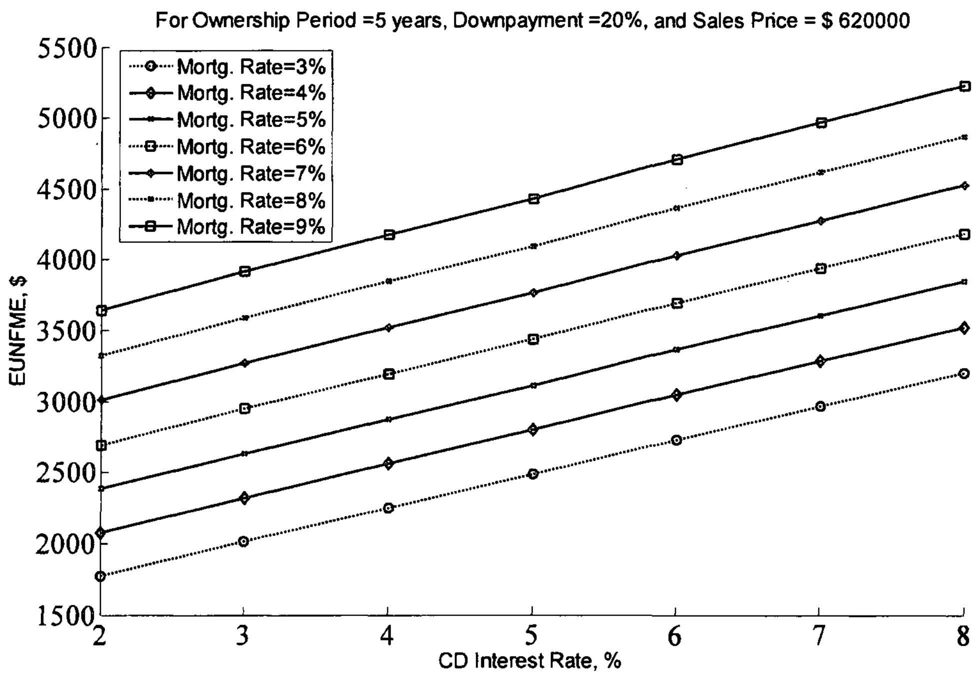

Figure 11.1: EUNFME vs. CD rates for various mortgage rates with 20% down payment, and 5 years of ownership period

Table 11.3: EUNFME vs. CD rates for various mortgage rates with 50% down payment, and 5 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,814	2,004	2,197	2,391	2,588	2,786	2,985
3	2,259	2,451	2,646	2,844	3,043	3,245	3,448
4	2,705	2,898	3,095	3,295	3,498	3,703	3,909
5	3,144	3,339	3,538	3,741	3,946	4,153	4,362
6	3,600	3,797	3,999	4,205	4,413	4,625	4,838
7	4,039	4,238	4,442	4,650	4,861	5,075	5,291
8	4,480	4,680	4,886	5,096	5,310	5,527	5,747

Using the above data Matlab program plotted a graph as shown in Figure 11.2.

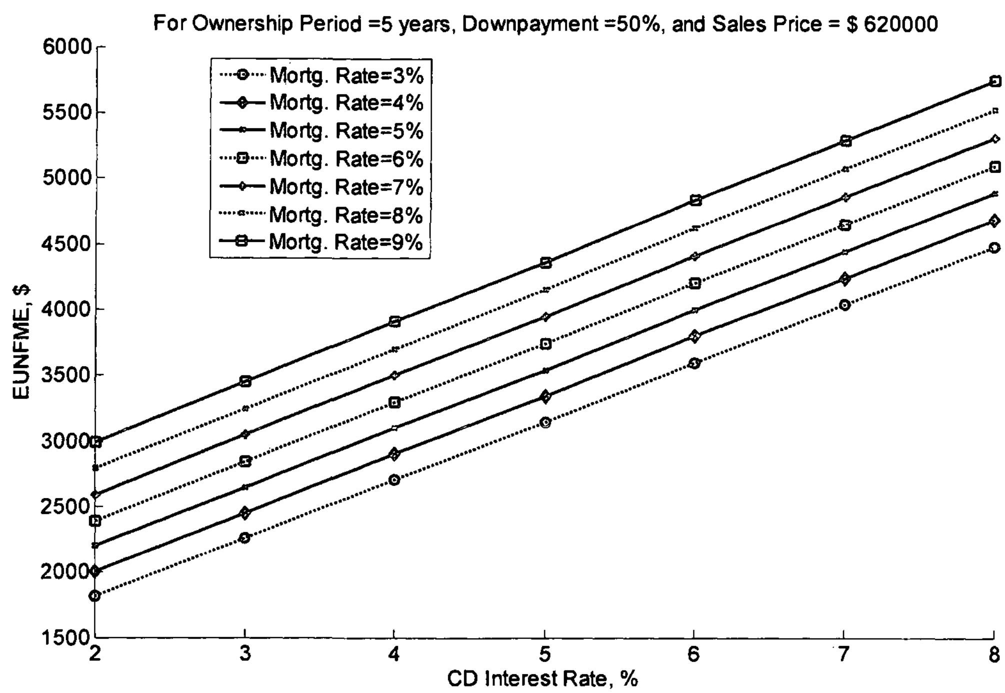

Figure 11.2: EUNFME vs. CD rates for various mortgage rates with 50% down payment, and 5 years of ownership period

Table 11.4: EUNFME vs. CD rates for various mortgage rates with 100% down payment, and 5 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,884	1,884	1,884	1,884	1,884	1,884	1,884
3	2,666	2,666	2,666	2,666	2,666	2,666	2,666
4	3,461	3,461	3,461	3,461	3,461	3,461	3,461
5	4,245	4,245	4,245	4,245	4,245	4,245	4,245
6	5,046	5,046	5,046	5,046	5,046	5,046	5,046
7	5,830	5,830	5,830	5,830	5,830	5,830	5,830
8	6,614	6,614	6,614	6,614	6,614	6,614	6,614

Using the above data Matlab program plotted a graph as shown in Figure 11.3.

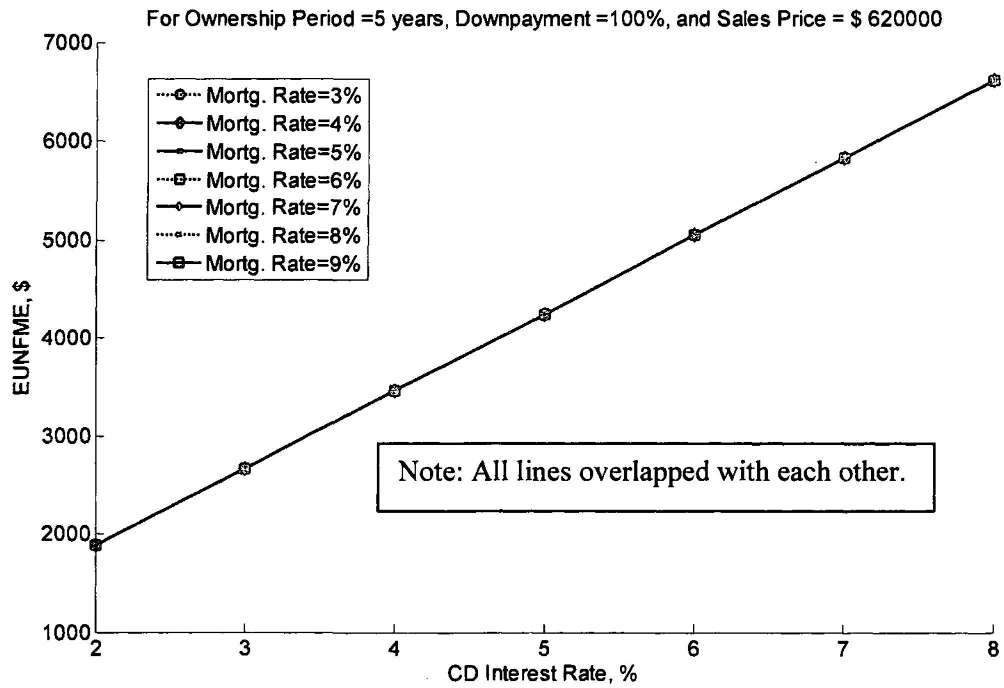

Figure 11.3: EUNFME vs. CD rates for various mortgage rates with 100% down payment, and 5 years of ownership period

Table 11.5: EUNFME vs. CD rates for various mortgage rates with 20% down payment, and 15 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,450	1,720	2,001	2,293	2,593	2,901	3,214
3	1,776	2,053	2,344	2,645	2,956	3,275	3,600
4	2,162	2,451	2,755	3,070	3,396	3,732	4,075
5	2,484	2,781	3,093	3,418	3,754	4,101	4,456
6	2,821	3,126	3,446	3,781	4,129	4,487	4,854
7	3,159	3,473	3,804	4,150	4,509	4,880	5,262
8	3,485	3,807	4,147	4,503	4,873	5,256	5,649

Using the above data Matlab program plotted a graph as shown in Figure 11.4.

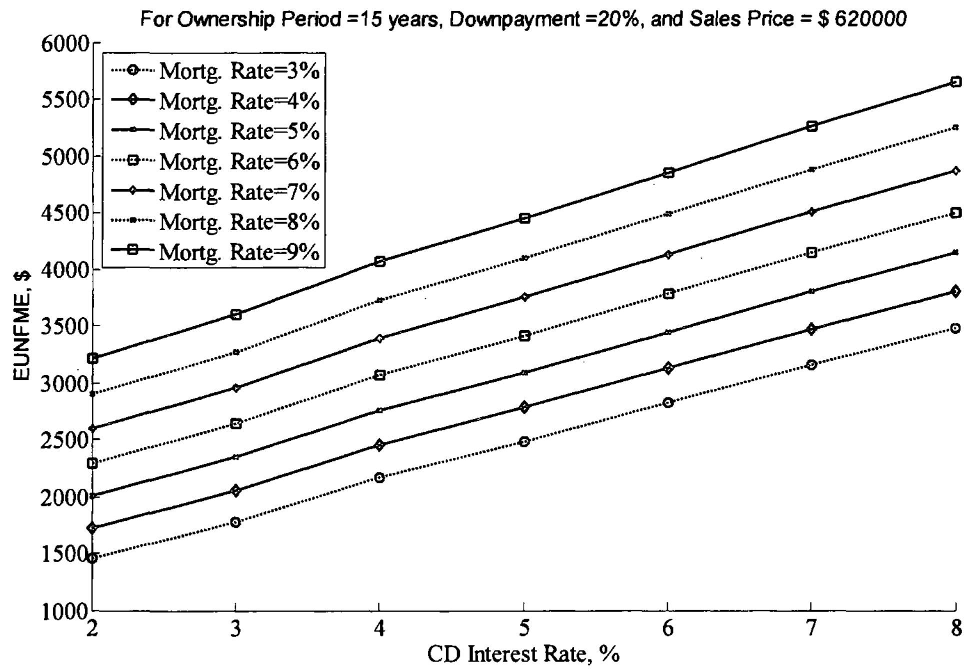

Figure 11.4: EUNFME vs. CD rates for various mortgage rates with 20% down payment, and 15 years of ownership period

Table 11.6: EUNFME vs. CD rates for various mortgage rates with 50% down payment, and 15 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,472	1,641	1,817	1,999	2,187	2,379	2,575
3	1,960	2,133	2,315	2,503	2,697	2,897	3,100
4	2,489	2,670	2,859	3,056	3,260	3,470	3,684
5	2,980	3,165	3,360	3,563	3,774	3,990	4,212
6	3,473	3,664	3,864	4,074	4,291	4,515	4,744
7	3,981	4,177	4,384	4,600	4,825	5,057	5,295
8	4,468	4,669	4,881	5,104	5,335	5,574	5,820

Using the above data Matlab program plotted a graph as shown in Figure 11.5.

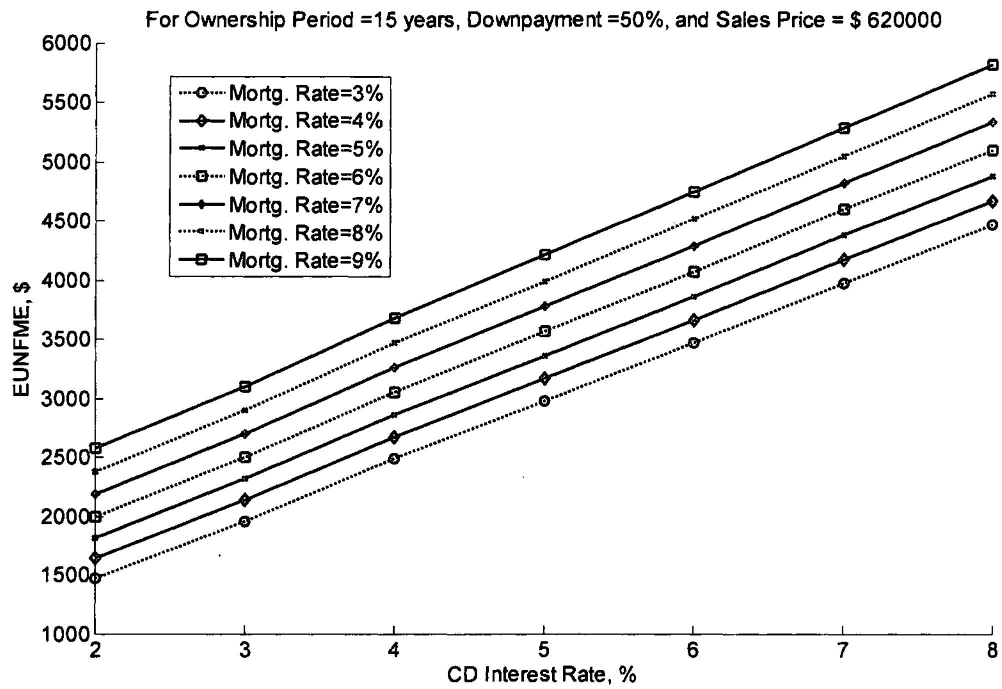

Figure 11.5: EUNFME vs. CD rates for various mortgage rates with 50% down payment, and 15 years of ownership period

Table 11.7: EUNFME vs. CD rates for various mortgage rates with 100% down payment, and 15 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,510	1,510	1,510	1,510	1,510	1,510	1,510
3	2,267	2,267	2,267	2,267	2,267	2,267	2,267
4	3,033	3,033	3,033	3,033	3,033	3,033	3,033
5	3,806	3,806	3,806	3,806	3,806	3,806	3,806
6	4,561	4,561	4,561	4,561	4,561	4,561	4,561
7	5,351	5,351	5,351	5,351	5,351	5,351	5,351
8	6,105	6,105	6,105	6,105	6,105	6,105	6,105

Using the above data Matlab program plotted a graph as shown in Figure 11.6.

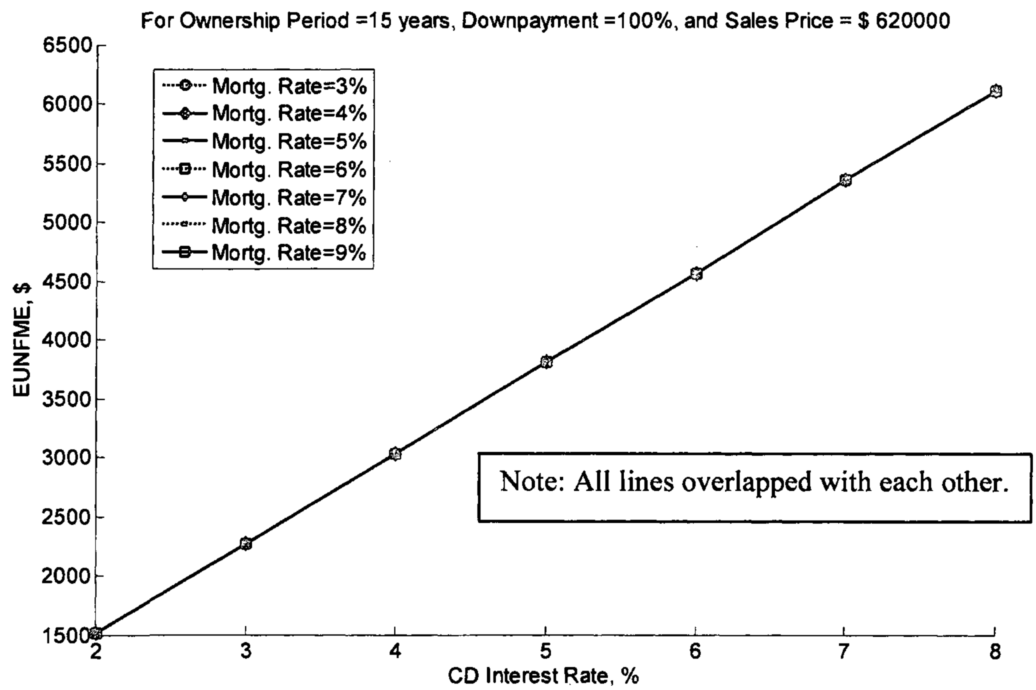

Figure 11.6: EUNFME vs. CD rates for various mortgage rates with 100% down payment, and 15 years of ownership period

Table 11.8: EUNFME vs. CD rates for various mortgage rates with 20% down payment, and 30 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,491	1,702	1,928	2,166	2,417	2,677	2,947
3	2,015	2,253	2,506	2,773	3,054	3,346	3,650
4	2,537	2,799	3,078	3,373	3,683	4,006	4,341
5	2,958	3,235	3,531	3,844	4,173	4,516	4,872
6	3,392	3,688	4,004	4,338	4,689	5,056	5,436
7	3,761	4,069	4,399	4,748	5,115	5,498	5,895
8	4,213	4,543	4,896	5,270	5,662	6,072	6,498

Using the above data Matlab program plotted a graph as shown in Figure 11.7.

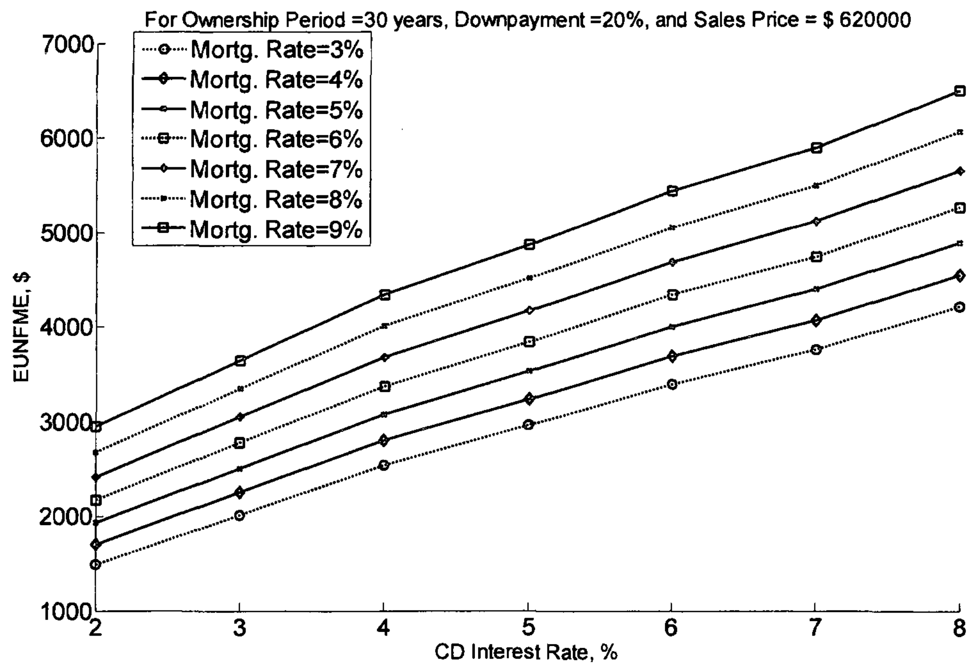

Figure 11.7: EUNFME vs. CD rates for various mortgage rates with 20% down payment, and 30 years of ownership period

Table 11.9: EUNFME vs. CD rates for various mortgage rates with 50% down payment, and 30 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,482	1,614	1,755	1,904	2,061	2,224	2,393
3	2,094	2,243	2,401	2,568	2,743	2,926	3,116
4	2,698	2,862	3,036	3,221	3,415	3,617	3,826
5	3,232	3,406	3,591	3,786	3,992	4,207	4,429
6	3,797	3,982	4,179	4,388	4,608	4,837	5,074
7	4,298	4,491	4,697	4,915	5,144	5,384	5,632
8	4,884	5,090	5,311	5,544	5,790	6,046	6,312

Using the above data Matlab program plotted a graph as shown in Figure 11.8.

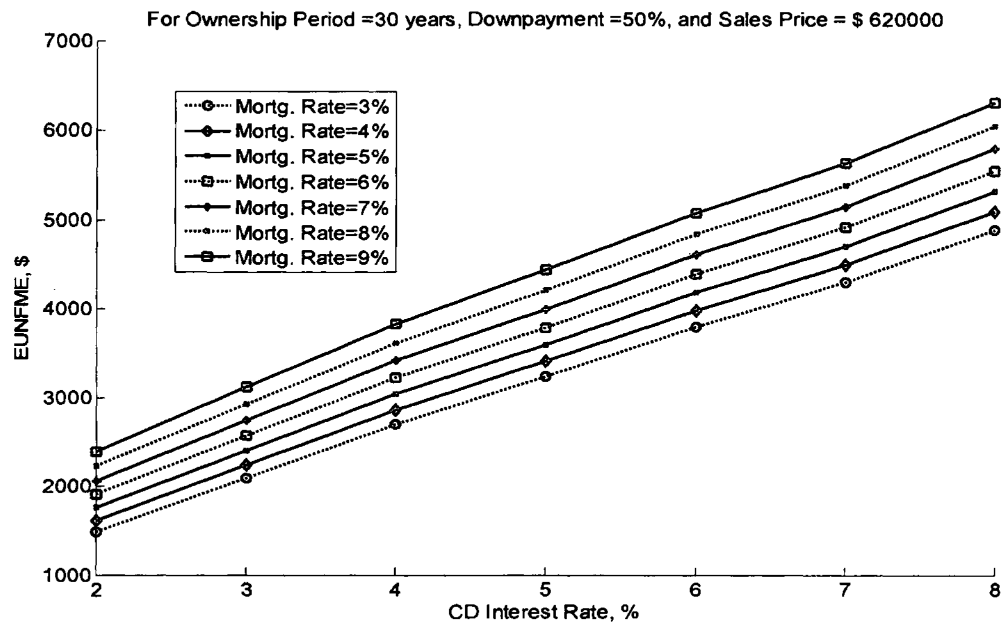

Figure 11.8: EUNFME vs. CD rates for various mortgage rates with 50% down payment, and 30 years of ownership period

Table 11.10: EUNFME vs. CD rates for various mortgage rates with 100% down payment, and 30 years of ownership period

CD interest rate, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,468	1,468	1,468	1,468	1,468	1,468	1,468
3	2,226	2,226	2,226	2,226	2,226	2,226	2,226
4	2,967	2,967	2,967	2,967	2,967	2,967	2,967
5	3,690	3,690	3,690	3,690	3,690	3,690	3,690
6	4,472	4,472	4,472	4,472	4,472	4,472	4,472
7	5,193	5,193	5,193	5,193	5,193	5,193	5,193
8	6,002	6,002	6,002	6,002	6,002	6,002	6,002

The data from Table 11.10 were plotted as shown in Figure 11.8. In this manner, a total of nine different sets of results were acquired to analyze as to how CD rates and mortgage rates influence EUNFME.

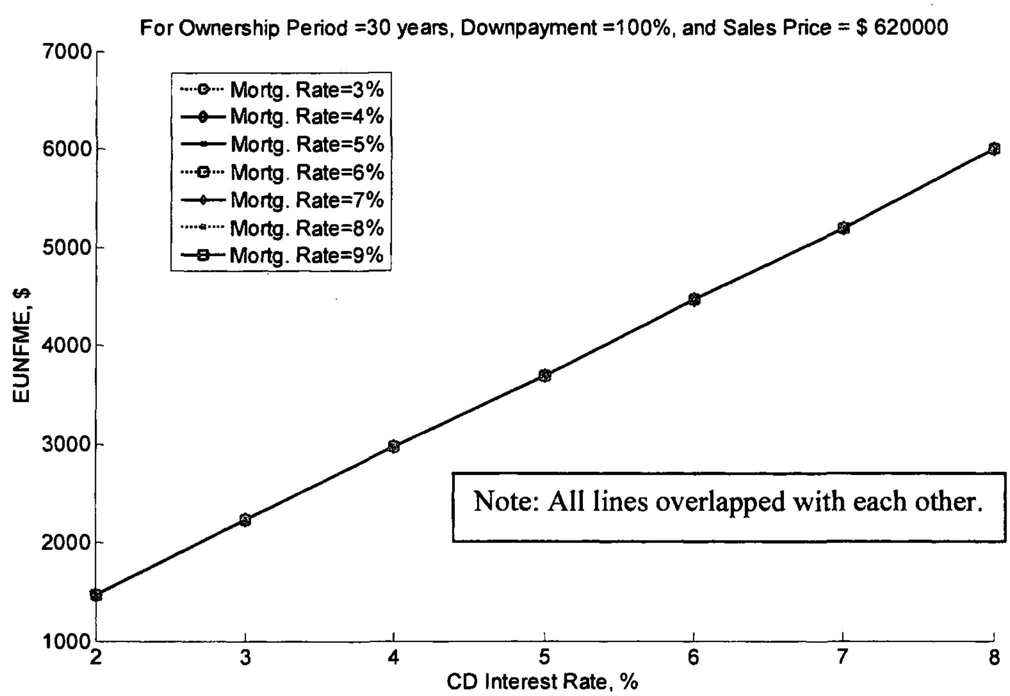

Figure 11.9: EUNFME vs. CD rates for various mortgage rates with 20% down payment, and 15 years of ownership period

11.3.2 Results of EUNFME versus Down Payment

For these results, down payment size and mortgage rates were considered as a major variable while CD rates and the ownership periods are taken fixed at a time. The results for EUNFME are obtained for down payment size ranging between 10% and 100% at the interval of 10%. The CD rates considered in these calculations are 2%, 4%, and 6%, in combination with the ownership period of 5 years, 15 years and 30 years. The results are presented in Table 11.11 to Table 11.20 and in Figure 11.10 to Figure 11.19.

Table 11.11: EUNFME vs. down payment for various mortgage rates with 2% CD rate, and 5 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	1,759	2,100	2,447	2,797	3,151	3,508	3,866
20%	1,773	2,076	2,384	2,696	3,010	3,327	3,646
30%	1,787	2,052	2,322	2,594	2,870	3,147	3,426
40%	1,801	2,028	2,259	2,493	2,729	2,967	3,206
50%	1,814	2,004	2,197	2,391	2,588	2,786	2,985
60%	1,828	1,980	2,134	2,290	2,447	2,606	2,765
70%	1,842	1,956	2,072	2,188	2,306	2,425	2,545
80%	1,856	1,932	2,009	2,087	2,166	2,245	2,325
90%	1,870	1,908	1,947	1,986	2,025	2,065	2,104
100%	1,884	1,884	1,884	1,884	1,884	1,884	1,884

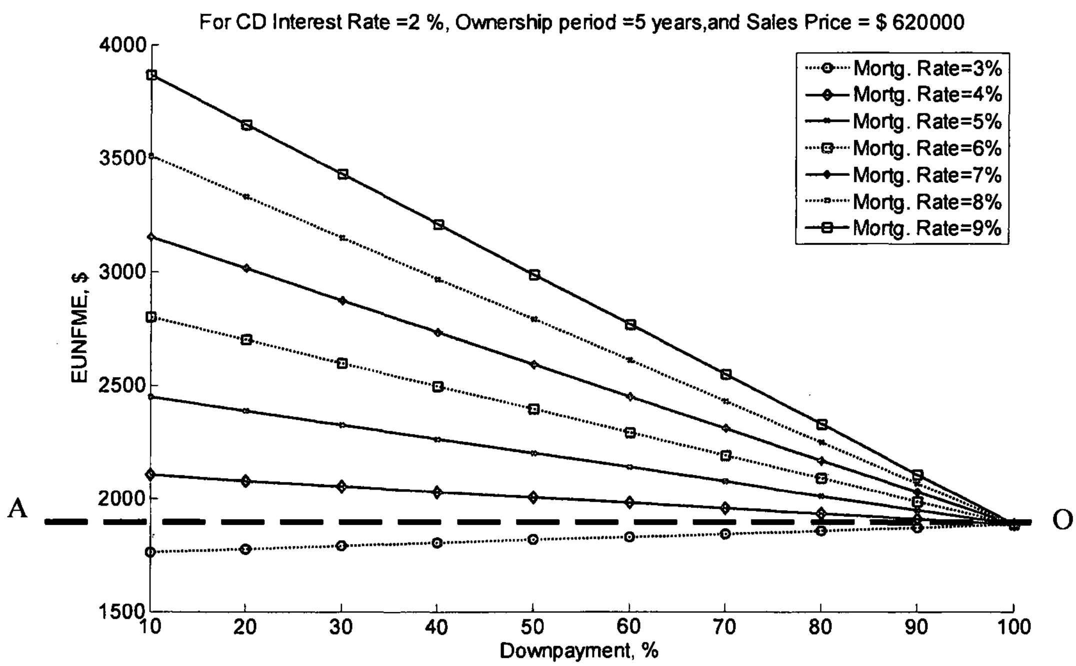

Figure 11.10: EUNFME vs. down payment for various mortgage rates with 2% CD rate, and 5 years of ownership period

Table 11.12: EUNFME vs. down payment for various mortgage rates with 4% CD rate, and 5 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	2,099	2,448	2,802	3,163	3,527	3,896	4,267
20%	2,251	2,560	2,876	3,196	3,520	3,847	4,177
30%	2,402	2,673	2,949	3,229	3,513	3,799	4,088
40%	2,553	2,786	3,022	3,262	3,505	3,751	3,998
50%	2,705	2,898	3,095	3,295	3,498	3,703	3,909
60%	2,856	3,011	3,168	3,328	3,491	3,654	3,819
70%	3,007	3,123	3,242	3,362	3,483	3,606	3,730
80%	3,159	3,236	3,315	3,395	3,476	3,558	3,640
90%	3,310	3,349	3,388	3,428	3,469	3,509	3,551
100%	3,461	3,461	3,461	3,461	3,461	3,461	3,461

Using the above data Matlab program plotted a graph as shown in Figure 11.11.

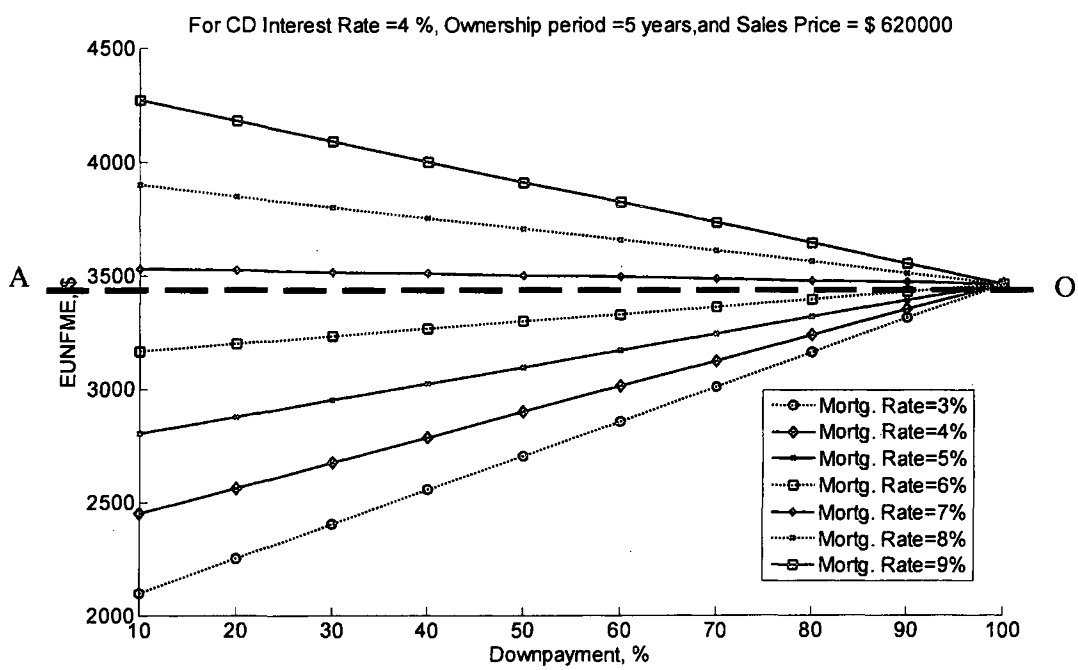

Figure 11.11: EUNFME vs. down payment for various mortgage rates with 4% CD rate, and 5 years of ownership period

Table 11.13: EUNFME vs. down payment for various mortgage rates with 6% CD rate, and 5 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	2,443	2,798	3,161	3,531	3,907	4,287	4,672
20%	2,732	3,048	3,371	3,700	4,034	4,372	4,713
30%	3,021	3,298	3,580	3,868	4,160	4,456	4,755
40%	3,310	3,547	3,790	4,036	4,287	4,540	4,796
50%	3,600	3,797	3,999	4,205	4,413	4,625	4,838
60%	3,889	4,047	4,208	4,373	4,540	4,709	4,880
70%	4,178	4,297	4,418	4,541	4,666	4,793	4,921
80%	4,467	4,546	4,627	4,709	4,793	4,877	4,963
90%	4,757	4,796	4,837	4,878	4,919	4,962	5,004
100%	5,046	5,046	5,046	5,046	5,046	5,046	5,046

Using the above data Matlab program plotted a graph as shown in Figure 11.12.

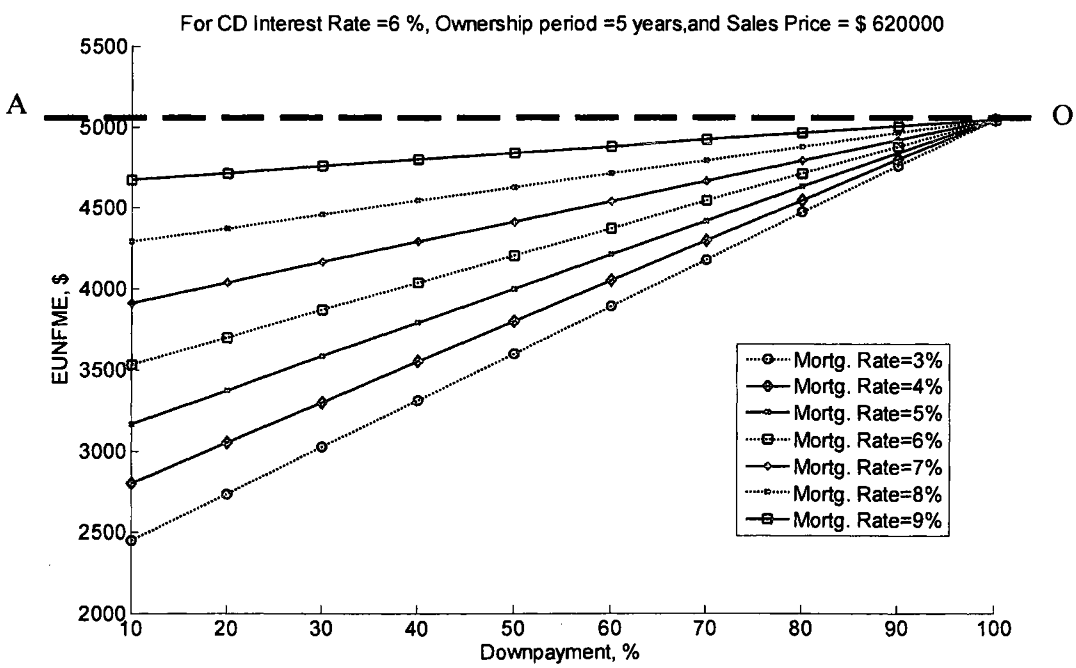

Figure 11.12: EUNFME vs. down payment for various mortgage rates with 6% CD rate, and 5 years of ownership period

Table 11.14: EUNFME vs. down payment for various mortgage rates with 2% CD rate, and 15 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	1,442	1,746	2,063	2,391	2,729	3,075	3,427
20%	1,450	1,720	2,001	2,293	2,593	2,901	3,214
30%	1,457	1,694	1,940	2,195	2,458	2,727	3,001
40%	1,465	1,667	1,878	2,097	2,322	2,553	2,788
50%	1,472	1,641	1,817	1,999	2,187	2,379	2,575
60%	1,480	1,615	1,756	1,901	2,052	2,205	2,362
70%	1,487	1,588	1,694	1,803	1,916	2,031	2,149
80%	1,495	1,562	1,633	1,706	1,781	1,858	1,936
90%	1,502	1,536	1,571	1,608	1,645	1,684	1,723
100%	1,510	1,510	1,510	1,510	1,510	1,510	1,510

Using the above data Matlab program plotted a graph as shown in Figure 11.13.

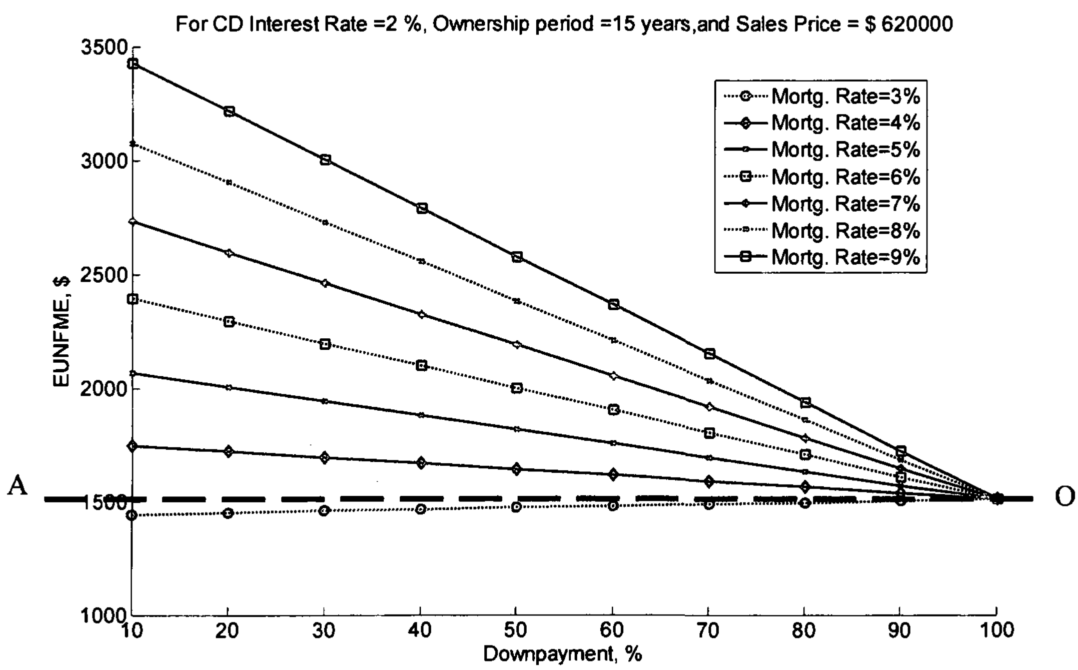

Figure 11.13: EUNFME vs. down payment for various mortgage rates with 2% CD rate, and 15 years of ownership period

Table 11.15: EUNFME vs. down payment for various mortgage rates with 4% CD rate, and 15 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	2,053	2,379	2,720	3,075	3,442	3,819	4,205
20%	2,162	2,451	2,755	3,070	3,396	3,732	4,075
30%	2,271	2,524	2,789	3,065	3,351	3,644	3,945
40%	2,380	2,597	2,824	3,061	3,306	3,557	3,814
50%	2,489	2,670	2,859	3,056	3,260	3,470	3,684
60%	2,598	2,742	2,894	3,052	3,215	3,382	3,554
70%	2,706	2,815	2,929	3,047	3,169	3,295	3,424
80%	2,815	2,888	2,964	3,042	3,124	3,208	3,294
90%	2,924	2,960	2,998	3,038	3,079	3,120	3,163
100%	3,033	3,033	3,033	3,033	3,033	3,033	3,033

Using the above data Matlab program plotted a graph as shown in Figure 11.14.

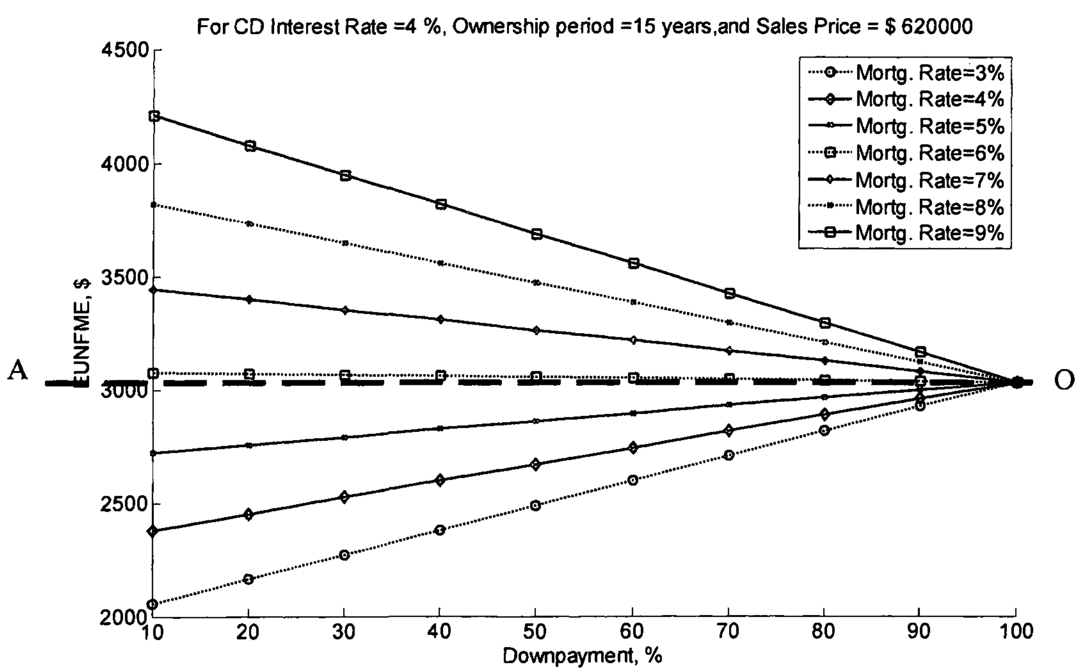

Figure 11.14: EUNFME vs. down payment for various mortgage rates with 4% CD rate, and 15 years of ownership period

Table 11.16: EUNFME vs. down payment for various mortgage rates with 6% CD rate, and 15 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	2,603	2,946	3,307	3,684	4,075	4,478	4,891
20%	2,821	3,126	3,446	3,781	4,129	4,487	4,854
30%	3,038	3,305	3,586	3,879	4,183	4,496	4,818
40%	3,256	3,485	3,725	3,976	4,237	4,505	4,781
50%	3,473	3,664	3,864	4,074	4,291	4,515	4,744
60%	3,691	3,843	4,004	4,171	4,345	4,524	4,708
70%	3,908	4,023	4,143	4,269	4,399	4,533	4,671
80%	4,126	4,202	4,282	4,366	4,453	4,543	4,634
90%	4,344	4,382	4,422	4,464	4,507	4,552	4,598
100%	4,561	4,561	4,561	4,561	4,561	4,561	4,561

Using the above data Matlab program plotted a graph as shown in Figure 11.15.

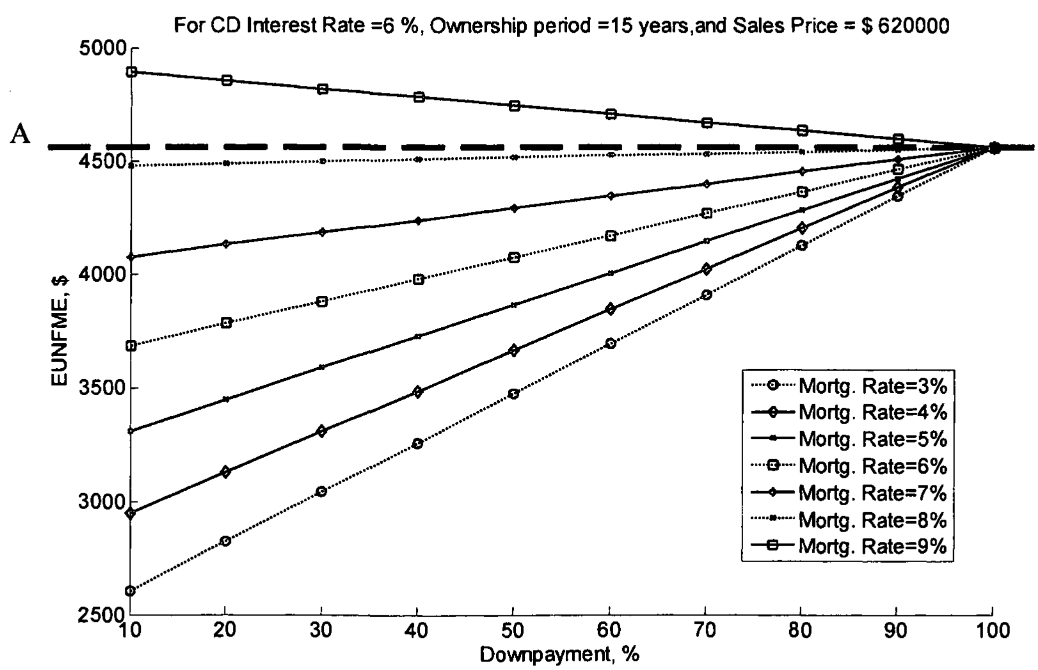

Figure 11.15: EUNFME vs. down payment for various mortgage rates with 6% CD rate, and 15 years of ownership period

Table 11.17: EUNFME vs. down payment for various mortgage rates with 2% CD rate, and 30 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	1,493	1,732	1,985	2,254	2,535	2,828	3,132
20%	1,491	1,702	1,928	2,166	2,417	2,677	2,947
30%	1,488	1,673	1,870	2,079	2,298	2,526	2,762
40%	1,485	1,644	1,813	1,992	2,179	2,375	2,577
50%	1,482	1,614	1,755	1,904	2,061	2,224	2,393
60%	1,479	1,585	1,698	1,817	1,942	2,073	2,208
70%	1,476	1,556	1,640	1,730	1,824	1,921	2,023
80%	1,474	1,527	1,583	1,643	1,705	1,770	1,838
90%	1,471	1,497	1,525	1,555	1,587	1,619	1,653
100%	1,468	1,468	1,468	1,468	1,468	1,468	1,468

Using the above data Matlab program plotted a graph as shown in Figure 11.16.

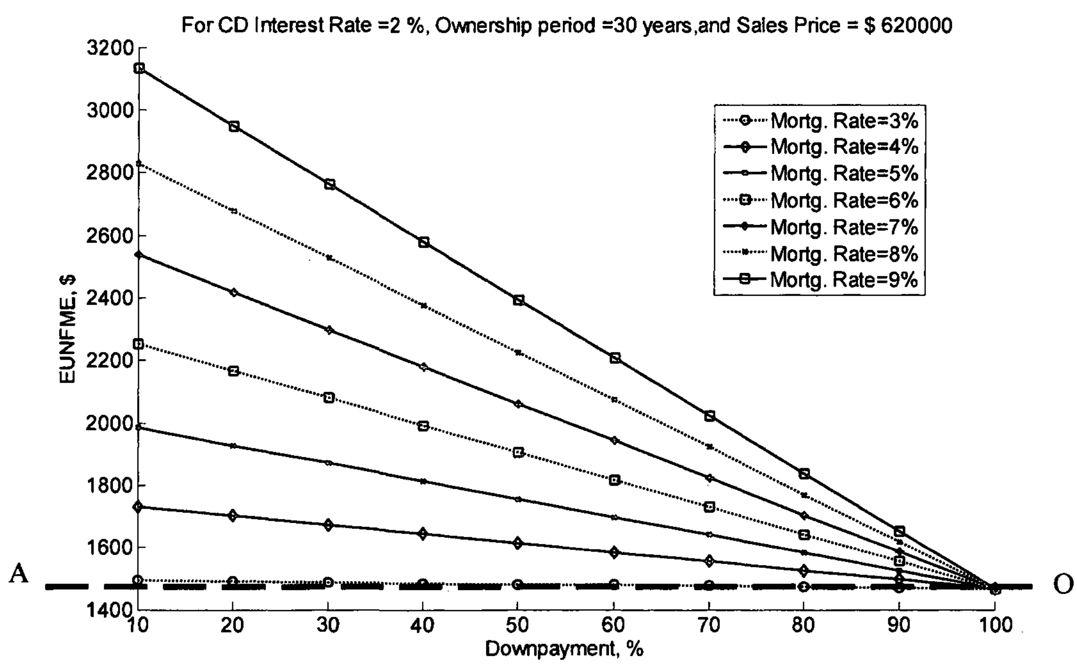

Figure 11.16: EUNFME vs. down payment for various mortgage rates with 2% CD rate, and 30 years of ownership period

Table 11.18: EUNFME vs. down payment for various mortgage rates with 4% CD rate, and 30 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	2,483	2,778	3,092	3,424	3,772	4,136	4,513
20%	2,537	2,799	3,078	3,373	3,683	4,006	4,341
30%	2,591	2,820	3,064	3,322	3,593	3,876	4,169
40%	2,645	2,841	3,050	3,272	3,504	3,746	3,998
50%	2,698	2,862	3,036	3,221	3,415	3,617	3,826
60%	2,752	2,883	3,022	3,170	3,325	3,487	3,654
70%	2,806	2,904	3,009	3,119	3,236	3,357	3,482
80%	2,860	2,925	2,995	3,069	3,146	3,227	3,311
90%	2,913	2,946	2,981	3,018	3,057	3,097	3,139
100%	2,967	2,967	2,967	2,967	2,967	2,967	2,967

Using the above data Matlab program plotted a graph as shown in Figure 11.17.

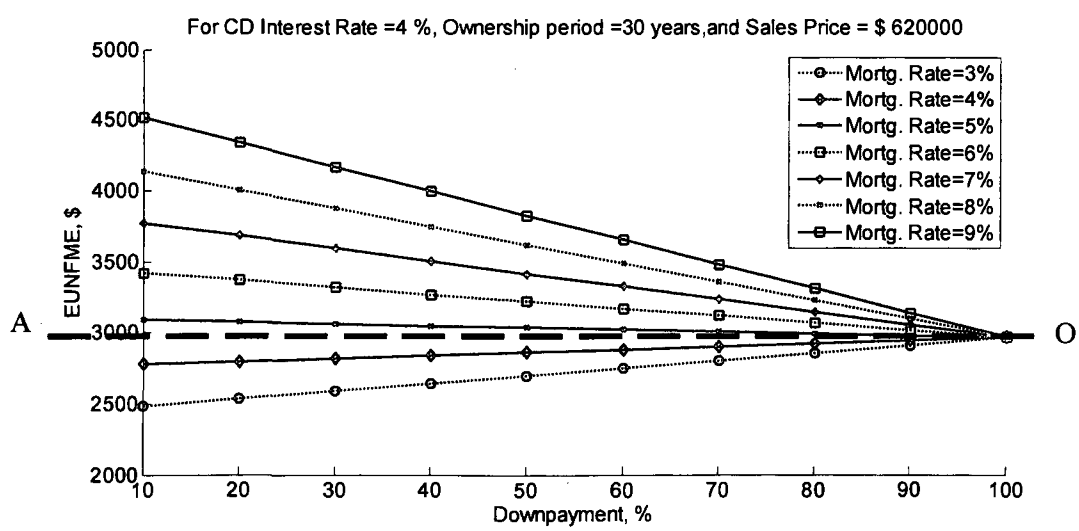

Figure 11.17: EUNFME vs. down payment for various mortgage rates with 4% CD rate, and 30 years of ownership period

Table 11.19: EUNFME vs. down payment for various mortgage rates with 6% CD rate, and 30 years of ownership period

Down payment, %	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
10%	3,257	3,590	3,945	4,321	4,717	5,129	5,556
20%	3,392	3,688	4,004	4,338	4,689	5,056	5,436
30%	3,527	3,786	4,062	4,355	4,662	4,983	5,315
40%	3,662	3,884	4,121	4,372	4,635	4,910	5,195
50%	3,797	3,982	4,179	4,388	4,608	4,837	5,074
60%	3,932	4,080	4,238	4,405	4,581	4,764	4,954
70%	4,067	4,178	4,297	4,422	4,554	4,691	4,833
80%	4,202	4,276	4,355	4,439	4,526	4,618	4,713
90%	4,337	4,374	4,414	4,455	4,499	4,545	4,593
100%	4,472	4,472	4,472	4,472	4,472	4,472	4,472

Using the above data Matlab program plotted a graph as shown in Figure 11.18.

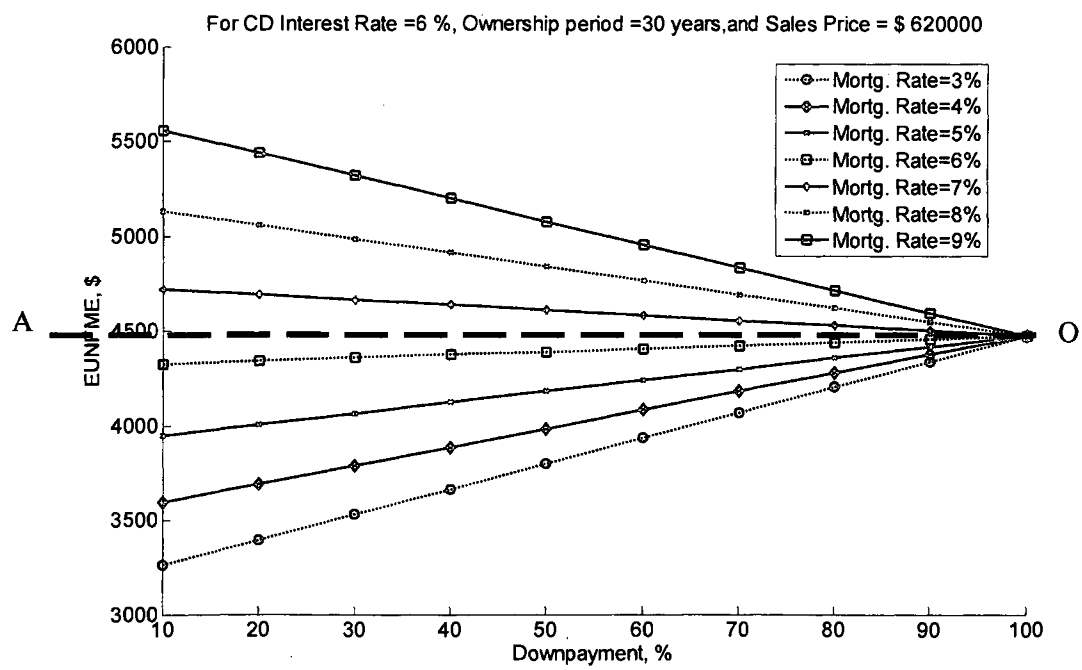

Figure 11.18: EUNFME vs. down payment for various mortgage rates with 6% CD rate, and 30 years of ownership period

11.3.3 Results of EUNFME versus Ownership Period

In this category of the results, ownership periods and mortgage rates are considered as main variables while CD rates and the down payment size are taken fixed at a time. The results for EUNFME are obtained for ownership periods ranging between 5 years and 30 years at the interval of 5 years. The CD rates considered in these calculations are 2%, 4%, and 6%, in combination with the down payment size of 20%, 50%, and 100%. The results are presented as shown in Table 11.20 to Table 11.28 and in Figure 11.19 to Figure 11.27. The intention of this analysis is to observe and analyze the relationship between the ownership period and the EUNFME while all other factors are kept constant.

Table 11.20: EUNFME vs. ownership periods for various mortgage rates with 2% CD rate, and 20% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	1,773	2,076	2,384	2,696	3,010	3,327	3,646
10	1,433	1,720	2,016	2,318	2,627	2,941	3,258
15	1,450	1,720	2,001	2,293	2,593	2,901	3,214
20	1,424	1,675	1,940	2,217	2,504	2,801	3,106
25	1,450	1,684	1,932	2,194	2,468	2,752	3,046
30	1,491	1,702	1,928	2,166	2,417	2,677	2,947

Using the above data Matlab program plotted a graph as shown in Figure 11.19.

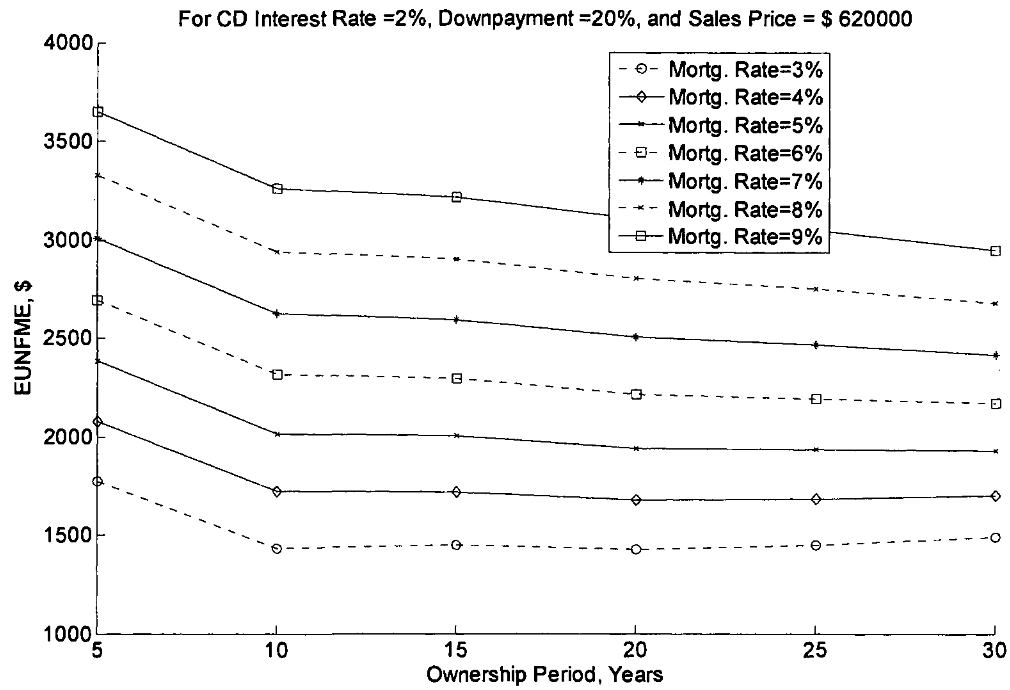

Figure 11.19: EUNFME vs. ownership periods for various mortgage rates with 2% CD rate, and 20% down payment

Table 11.21: EUNFME vs. ownership periods for various mortgage rates with 4% CD rate, and 20% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	2,251	2,560	2,876	3,196	3,520	3,847	4,177
10	2,038	2,337	2,647	2,966	3,292	3,625	3,963
15	2,162	2,451	2,755	3,070	3,396	3,732	4,075
20	2,243	2,521	2,815	3,124	3,446	3,779	4,121
25	2,372	2,642	2,928	3,231	3,548	3,878	4,220
30	2,537	2,799	3,078	3,373	3,683	4,006	4,341

Using the above data Matlab program plotted a graph as shown in Figure 11.20.

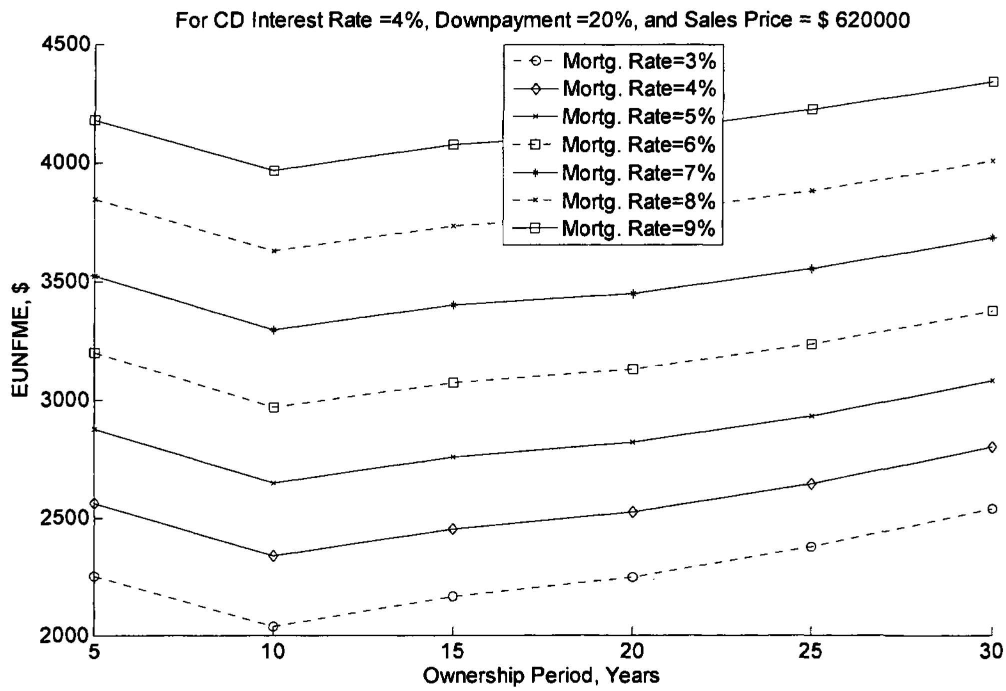

Figure 11.20: EUNFME vs. ownership periods for various mortgage rates with 4% CD rate and 20% down payment

Table11.22: EUNFME vs. ownership periods for various mortgage rates with 6% CD rate and 20% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	2,732	3,048	3,371	3,700	4,034	4,372	4,713
10	2,634	2,945	3,267	3,601	3,944	4,294	4,651
15	2,821	3,126	3,446	3,781	4,129	4,487	4,854
20	3,015	3,317	3,638	3,975	4,326	4,692	5,068
25	3,217	3,517	3,837	4,176	4,530	4,900	5,283
30	3,392	3,688	4,004	4,338	4,689	5,056	5,436

Using the above data Matlab program plotted a graph as shown in Figure 11.21.

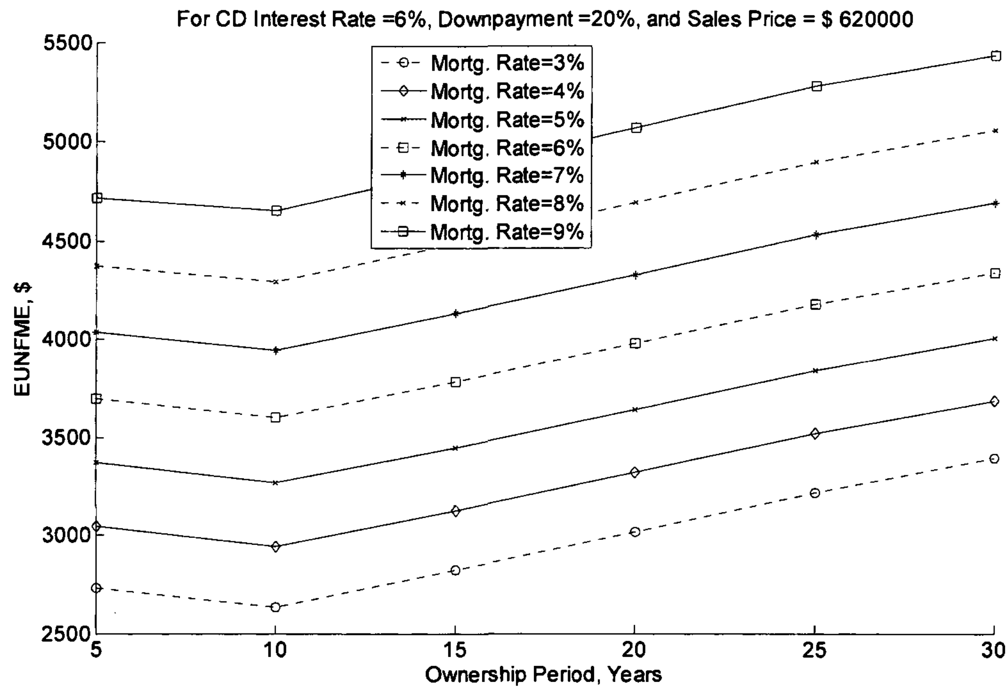

Figure 11.21: EUNFME vs. ownership periods for various mortgage rates with 6% CD rate, and 20% down payment

Table11.23: EUNFME vs. ownership periods for various mortgage rates with 2% CD rate and 50% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	1,814	2,004	2,197	2,391	2,588	2,786	2,985
10	1,474	1,654	1,838	2,027	2,220	2,416	2,614
15	1,472	1,641	1,817	1,999	2,187	2,379	2,575
20	1,439	1,596	1,762	1,935	2,115	2,300	2,490
25	1,453	1,599	1,754	1,918	2,089	2,267	2,450
30	1,482	1,614	1,755	1,904	2,061	2,224	2,393

Using the above data Matlab program plotted a graph as shown in Figure 11.22.

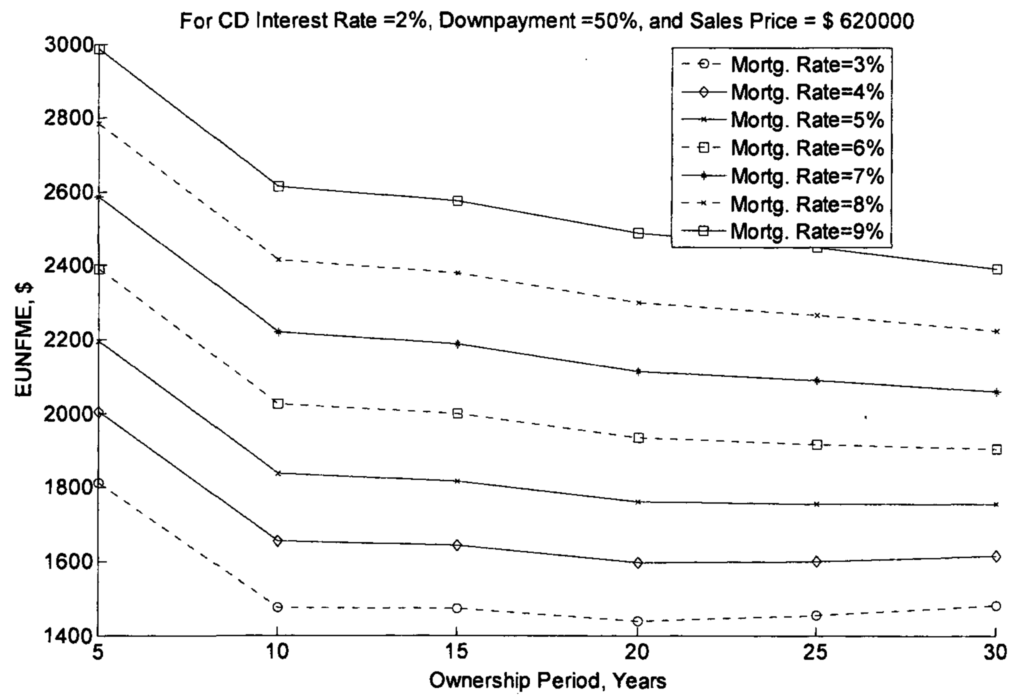

Figure 11.22: EUNFME vs. ownership periods for various mortgage rates with 2% CD rate, and 50% down payment

Table11.24: EUNFME vs. ownership periods for various mortgage rates with 4% CD rate and 50% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	2,705	2,898	3,095	3,295	3,498	3,703	3,909
10	2,435	2,622	2,816	3,015	3,219	3,427	3,638
15	2,489	2,670	2,859	3,056	3,260	3,470	3,684
20	2,520	2,694	2,877	3,070	3,271	3,479	3,694
25	2,597	2,766	2,945	3,134	3,332	3,539	3,752
30	2,698	2,862	3,036	3,221	3,415	3,617	3,826

Using the above data Matlab program plotted a graph as shown in Figure 11.23.

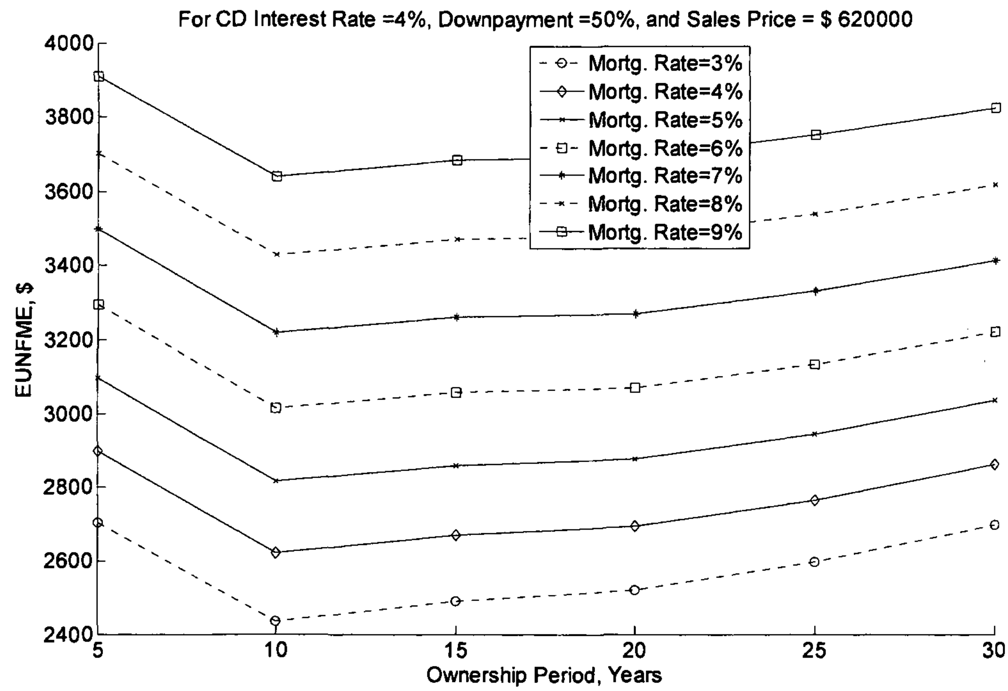

Figure 11.23: EUNFME vs. ownership periods for various mortgage rates with 4% CD rate and 50% down payment

Table 11.25: EUNFME vs. ownership periods for various mortgage rates with 6% CD rate and 50% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	3,600	3,797	3,999	4,205	4,413	4,625	4,838
10	3,386	3,580	3,782	3,990	4,205	4,424	4,647
15	3,473	3,664	3,864	4,074	4,291	4,515	4,744
20	3,576	3765	3,965	4,176	4,396	4,624	4,860
25	3,680	3,868	4,068	4,279	4,501	4,732	4,971
30	3,797	3,982	4,179	4,388	4608	4,837	5,074

Using the above data Matlab program plotted a graph as shown in Figure 11.24.

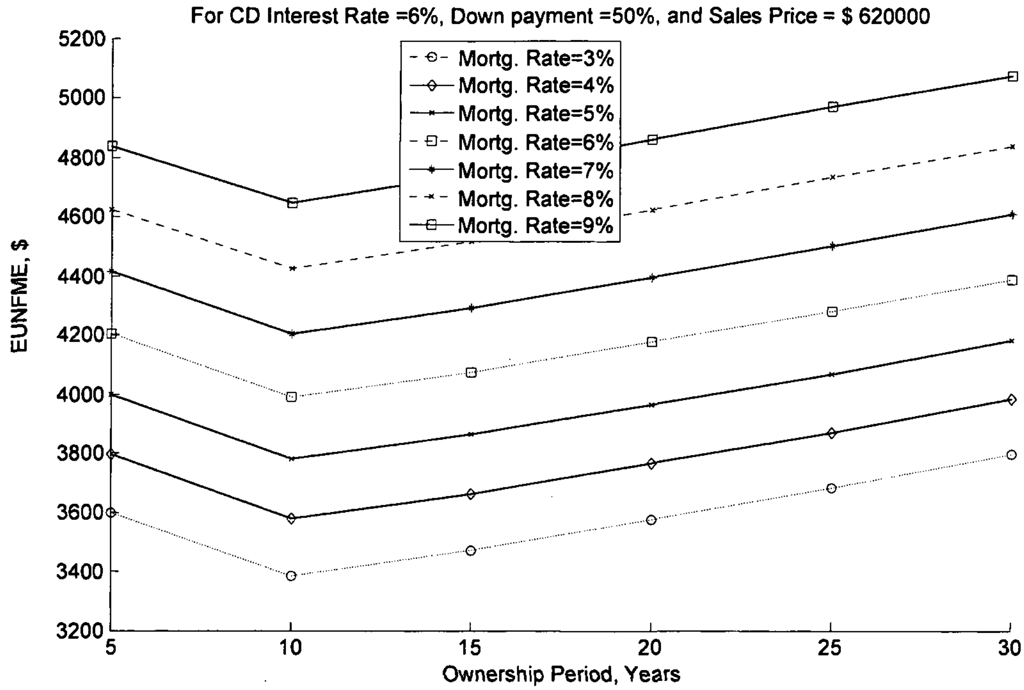

Figure 11.24: EUNFME vs. ownership periods for various mortgage rates with 6% CD rate and 50% down payment

Table 11.26: EUNFME vs. ownership periods for various mortgage rates with 2% CD rate and 100% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	1,884	1,884	1,884	1,884	1,884	1,884	1,884
10	1,542	1,542	1,542	1,542	1,542	1,542	1,542
15	1,510	1,510	1,510	1,510	1,510	1,510	1,510
20	1,465	1,465	1,465	1,465	1,465	1,465	1,465
25	1,458	1,458	1,458	1,458	1,458	1,458	1,458
30	1,468	1,468	1,468	1,468	1,468	1,468	1,468

Using the above data Matlab program plotted a graph as shown in Figure 11.25.

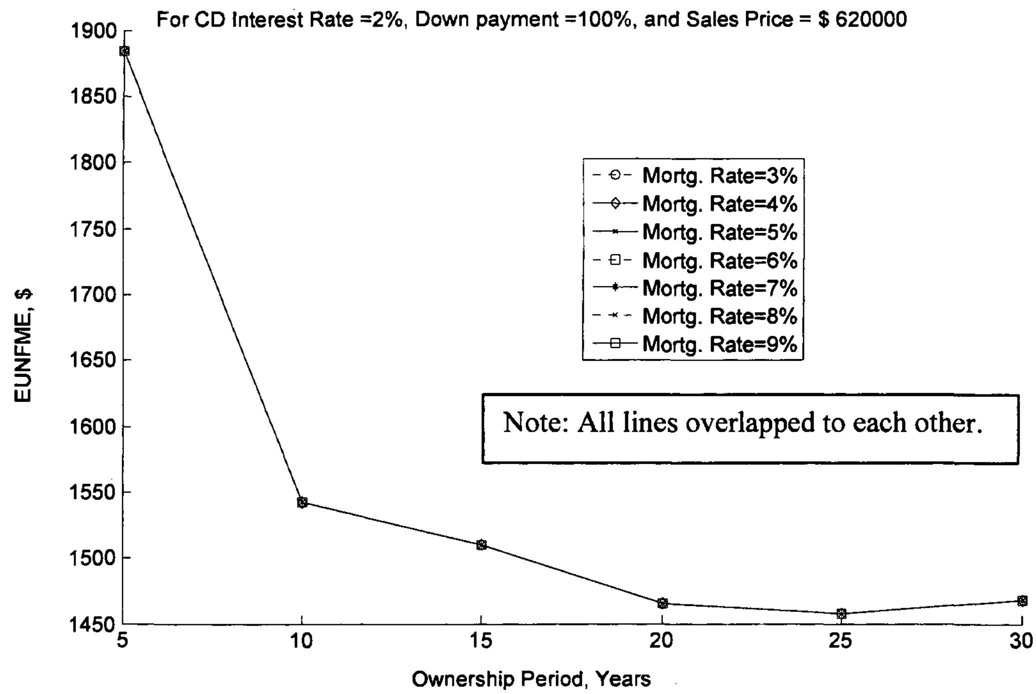

Figure 11.25: EUNFME vs. ownership periods for various mortgage rates with 2% CD rate and 100% down payment

Table 11.27: EUNFME vs. ownership periods for various mortgage rates with 4% CD rate and 100% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	3,461	3,461	3,461	3,461	3,461	3,461	3,461
10	3,097	3,097	3,097	3,097	3,097	3,097	3,097
15	3,033	3,033	3,033	3,033	3,033	3,033	3,033
20	2,981	2,981	2,981	2,981	2,981	2,981	2,981
25	2,972	2,972	2,972	2,972	2,972	2,972	2,972
30	2,967	2,967	2,967	2,967	2,967	2,967	2,967

Using the above data Matlab program plotted a graph as shown in Figure 11.26.

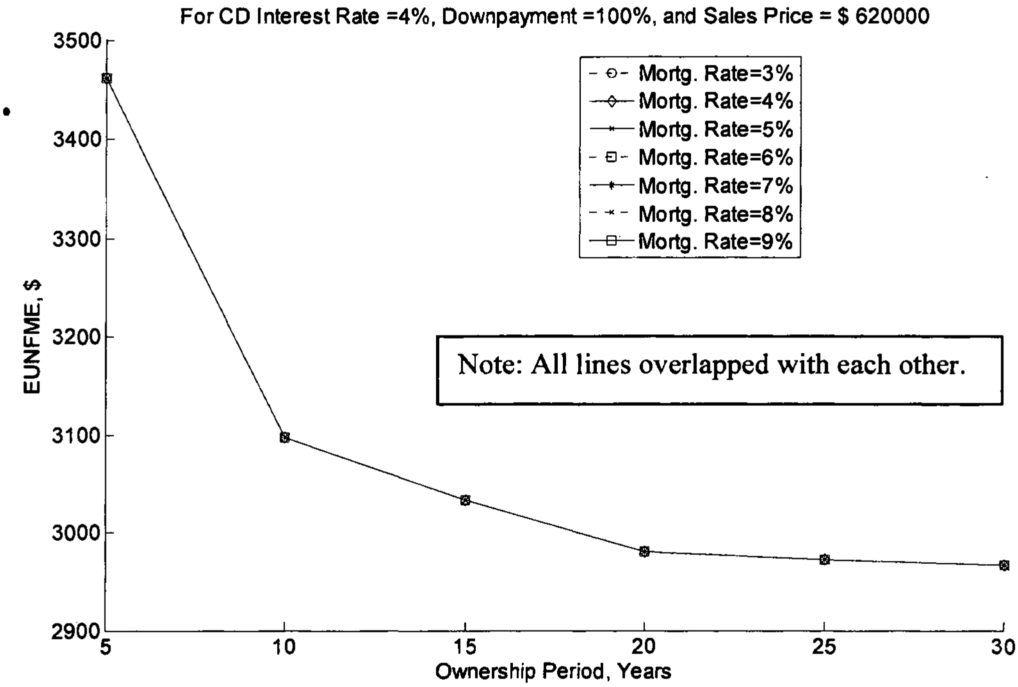

Figure 11.26: EUNFME vs. ownership periods for various mortgage rates with 4% CD rate, and 100% down payment

Table 11.28: EUNFME vs. ownership periods for various mortgage rates with 6% CD rate, and 100% down payment

Ownership period, years	Mortgage interest rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
5	5,046	5,046	5,046	5,046	5,046	5,046	5,046
10	4,640	4,640	4,640	4,640	4,640	4,640	4,640
15	4,561	4,561	4,561	4,561	4,561	4,561	4,561
20	4,512	4,512	4,512	4,512	4,512	4,512	4,512
25	4,451	4,451	4,451	4,451	4,451	4,451	4,451
30	4,472	4,472	4,472	4,472	4,472	4,472	4,472

Using the above data Matlab program plotted a graph as shown in Figure 11.27.

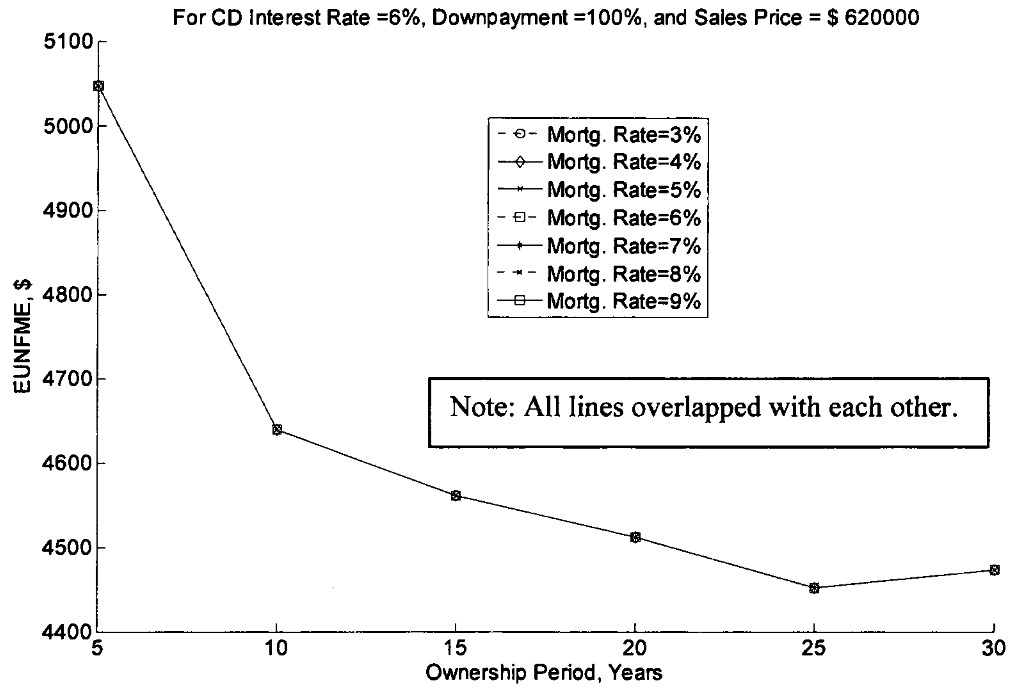

Figure 11.27: EUNFME vs. ownership periods for various mortgage rates with 6% CD rate and 100% down payment

11.3.4 Mortgage Severity Indices (MSI)

Mortgage severity indices were calculated based on the CD interest rate, mortgage rate, down payment size, and the home ownership period as main variables, while assuming all other input parameters as fixed. As discussed in Chapter 9, following indices were calculated to analyze the affordability of the purchase example:

a) Ownership MSI, and
b) Operational MSI.

Ownership MSI accounts for all cradle-to-grave expenses and revenues of the entire life-cycle period of home-ownership, starting from the acquisition of the property until the ownership termination. Operational MSI indicates the economic burden of occupying the facility and maintaining the ownership rights over the property. The operational expenses included in the occupancy costs are items such as utilities, home insurance, minor repairs, and maintenance that that are directly related to occupancy and the up-keeping of the facility. Furthermore the operational expenses should include the costs that are necessary to maintain the ownership rights on the property, such as monthly mortgage, property tax, and taxes on incomes from the property. However, operational MSI excludes the expenses and revenues that occur during the acquisition and termination phases.

Table 11.29: EUNFME ($) for 81 different combinations of ownership period, CD rate, mortgage rate, and down payment size.

Mortgage rate, %	Down-payment, %	Ownership period, years								
		5			15			30		
		CD interest rate, %								
		2	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**
5	**20**	2,384	2,876	3,371	2,001	2,755	3,446	1,928	3,078	4,004
	50	2,197	3,095	3,999	1,817	2,859	3,864	1,755	3,036	4,179
	100	1,884	3,461	5,046	1,510	3,033	4,561	1,468	2,967	4,472
6	**20**	2,696	3,196	3,700	2,293	3,070	3,781	2,166	3,373	4,338
	50	2,391	3,295	4,205	1,999	3,056	4,074	1,904	3,221	4,388
	100	1,884	3,461	5,046	1,510	3,033	4,561	1,468	2,967	4,472
7	**20**	3,010	3,520	4,034	2,593	3,396	4,129	2,417	3,683	4,689
	50	2,588	3,498	4,413	2,187	3,260	4,291	2,061	3,415	4,608
	100	1,884	3,461	5,046	1,510	3,030	4,561	1,468	2,967	4,472

The MSI indices were obtained for 81 different combinations of the four major variables, i.e. mortgage rate, down payment size, ownership period and the CD rate for the given purchase example. The ownership MSI and operational MSI results are summarized in Table 11.29 through Table 11.31.

Table 11.30: Ownership mortgage severity index (ownership MSI) for 81 different combinations of ownership period, CD rate, mortgage rate, and down payment size

Mortgage rate, %	Down-payment, %	Ownership period, years								
		5			15			30		
		CD interest rate, %								
		2	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**
5	**20**	0.390	0.470	0.551	0.324	0.446	0.558	0.309	0.493	0.641
	50	0.359	0.506	0.654	0.294	0.463	0.626	0.281	0.486	0.669
	100	0.308	0.566	0.825	0.244	0.491	0.739	0.235	0.475	0.716
6	**20**	0.441	0.523	0.605	0.371	0.497	0.612	0.347	0.540	0.694
	50	0.391	0.539	0.688	0.324	0.495	0.660	0.305	0.515	0.702
	100	0.308	0.566	0.825	0.244	0.491	0.739	0.235	0.475	0.716
7	**20**	0.492	0.576	0.660	0.420	0.550	0.668	0.387	0.589	0.750
	50	0.423	0.572	0.722	0.354	0.528	0.695	0.330	0.546	0.737
	100	0.308	0.566	0.825	0.244	0.491	0.739	0.235	0.475	0.716

Table 11.31: Operational mortgage severity index (operational MSI) for 81 different combinations of ownership period, CD rate, mortgage rate, and down payment size

Mortgage rate, %	Down-payment, %	Ownership period, years								
		5			15			30		
		CD interest rate, %								
		2	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**
5	**20**	0.494	0.510	0.527	0.511	0.553	0.587	0.514	0.595	0.647
	50	0.361	0.371	0.381	0.375	0.401	0.422	0.377	0.428	0.460
	100	0.140	0.139	0.139	0.150	0.149	0.146	0.149	0.150	0.147
6	**20**	0.530	0.548	0.566	0.547	0.594	0.632	0.552	0.642	0.701
	50	0.383	0.395	0.406	0.398	0.427	0.450	0.401	0.458	0.493
	100	0.140	0.139	0.139	0.150	0.149	0.146	0.149	0.150	0.147
7	**20**	0.568	0.588	0.609	0.585	0.638	0.681	0.592	0.692	0.757
	50	0.407	0.420	0.432	0.422	0.455	0.480	0.426	0.489	0.528
	100	0.140	0.139	0.139	0.150	0.149	0.146	0.149	0.150	0.147

11.3.5 Renting Severity Index (RSI)

The RSI was calculated for three different baseline monthly rental rates of $1,500, $1,800, and $2,100 while taking the baseline annual median family income of $93,600 as its constant. Three different renting periods of 5 years, 15 years, and 30 years, along with varying CD interest rates of 2%, 4%, and 6% were considered in the analysis. The results of RSI for each of the monthly rental categories are shown separately in Table 11.32, Table 11.33, and Table 11.34.

Table 11.32: Renting severity index (RSI) for a baseline monthly rental of $1500

Renting period, years	CD interest rate, %		
	2	4	6
5	0.2865	0.2873	0.2885
15	0.2853	0.2859	0.2864
30	0.2785	0.2882	0.2860

Table 11.33: Renting severity index (RSI) for a baseline monthly rental of $1,800

Renting period, years	CD interest rate, %		
	2	4	6
5	0.3364	0.3374	0.3388
15	0.3349	0.3356	0.3362
30	0.3268	0.3382	0.3356

Table 11.34: Renting severity index for a baseline monthly rental of $2,100

Renting period, years	CD interest rate, %		
	2	4	6
5	0.3862	0.3874	0.3890
15	0.3845	0.3852	0.3860
30	0.3752	0.3882	0.3853

These results are analyzed in the next chapter.

11.3.6 Buying versus Renting Ratio (BRR)

In order to compare the buying versus renting alternatives, 81 different purchase conditions were compared against three different baseline monthly rental rates of $1,500, $ 1,800, and $2,100. These three rental alternatives were compared discretely with 81 different combinations of the purchase conditions. The results for BRR for a baseline monthly rental of $1,500 are shown in Table 11.35. Similarly, BRR for other two renting alternatives $1,800 and $ 2,100 are shown in Table 11.36 and Table 11.37 respectively.

When, the BRR is less than 1, buying a house is more economically rewarding than renting, and these values are shown as bold in the tabulation. Similarly, when the BRR is greater than 1, the renting is economically more attractive than home-ownership.

Table 11.35: Buying versus renting ratio with baseline monthly rent of $1500

Mortgage rate, %	Down-payment, %	Ownership period, years								
		5			**15**			**30**		
		CD interest rate, %								
		2	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**
		BRR								
5	**20**	1.361	1.637	1.911	1.136	1.560	1.948	1.108	1.709	2.241
	50	1.254	1.762	2.267	1.031	1.619	2.185	1.009	1.686	2.339
	100	1.076	1.970	2.860	**0.857**	1.718	2.579	**0.843**	1.648	2.503
6	**20**	1.539	1.819	2.097	1.301	1.739	2.138	1.245	1.873	2.428
	50	1.365	1.876	2.383	1.134	1.731	2.303	1.094	1.788	2.456
	100	1.076	1.970	2.860	**0.857**	1.718	2.579	**0.843**	1.648	2.503
7	**20**	1.719	2.004	2.286	1.472	1.923	2.334	1.388	2.045	2.624
	50	1.478	1.991	2.502	1.241	1.846	2.426	1.184	1.896	2.579
	100	1.076	1.970	2.860	**0.857**	1.718	2.579	**0.843**	1.648	2.503

Table 11.36: Buying versus renting ratio with baseline monthly rent of $1800

Mortgage rate, %	Down-payment, %	Ownership period, years								
		5			15			30		
		CD interest rate, %								
		2	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**
		BRR								
5	**20**	1.159	1.394	1.627	**0.967**	1.329	1.66	**0.944**	1.456	1.909
	50	1.068	1.501	1.931	**0.878**	1.38	1.861	**0.859**	1.437	1.993
	100	**0.916**	1.678	2.436	**0.730**	1.464	2.197	**0.719**	1.404	3.132
6	**20**	1.311	1.549	1.786	1.108	1.481	1.821	1.061	1.596	2.068
	50	1.163	1.598	2.03	**0.966**	1.475	1.962	**0.932**	1.524	2.092
	100	**0.916**	1.678	2.436	**0.73**	1.464	2.197	**0.719**	1.404	2.132
7	**20**	1.464	1.707	1.948	1.254	1.639	1.988	1.183	1.743	2.236
	50	1.259	1.696	2.131	1.057	1.573	2.066	1.009	1.616	2.197
	100	**0.916**	1.678	2.436	**0.730**	1.464	2.197	0.719	1.404	2.132

Table 11.37: Buying versus renting ratio with baseline monthly rent of $2100

Mortgage rate, %	Down-payment, %	Ownership period, years								
		5			15			30		
		CD interest rate, %								
		2	**4**	**6**	**2**	**4**	**6**	**2**	**4**	**6**
		BRR*								
5	**20**	1.009	1.214	1.417	**0.843**	1.158	1.446	**0.822**	1.269	1.663
	50	**0.930**	1.307	1.681	**0.765**	1.202	1.621	**0.749**	1.251	1.736
	100	**0.798**	1.461	2.121	**0.636**	1.275	1.913	**0.626**	1.223	1.857
6	**20**	1.142	1.349	1.555	**0.966**	1.29	1.586	**0.924**	1.39	1.802
	50	1.013	1.391	1.768	**0.842**	1.285	1.709	**0.812**	1.328	1.823
	100	**0.798**	1.461	2.121	**0.636**	1.275	1.913	**0.626**	1.223	1.857
7	**20**	1.275	1.486	1.696	1.092	1.427	1.732	1.031	1.518	1.948
	50	1.096	1.477	1.855	**0.921**	1.37	1.8	**0.879**	1.407	1.914
	100	**0.798**	1.461	2.121	**0.636**	1.275	1.913	**0.626**	1.223	1.857

These results are analyzed in the next Chapter.

CHAPTER 12: ANALYSIS AND DISCUSSION

12.1 General

This chapter analyzes the results for the purchase example presented in Chapter 11. The major observations, trends and analysis of the results are discussed in this chapter. The objective of the life-cycle cost analysis, in the context of this study is to minimize the net expenses of the home-ownership, which is the equal uniform net final monthly expenses (EUNFME). The main purpose of the analysis was to evaluate the various parameters in such a way that all possible combinations of purchase conditions are explored in order to find the best possible EUNFME.

12.2 Minimize the EUNFME

As demonstrated in the methodology, EUNFME is calculated by identifying all expenses and revenues in each phase of home-ownership, either on a year-to-year or on a month-to-month basis, as appropriate, for the entire span of the life-cycle and presented as annualized monthly costs. EUNFME serves as a universal indicator of life-cycle cost in the present worth term, and indicates the magnitude of costs committed by the homebuyer at the time of the home purchase. Therefore, this model of life-cycle cost analysis for home-buying considers EUNFME as one of the key indicators.

The lowest possible EUNFME will be the most beneficial options from the point of view of affordability as well as maximization of economic returns. A homebuyer should optimize the purchase conditions by juggling various parameters in such a way so that the best EUNFME is sought from among the possible combinations of purchase conditions, and all possible purchase conditions must be explored. This is one of the fundamental concepts of this research.

For this study, a total of 81 various combinations of purchase conditions were analyzed as shown in Table 11.29. Among those alternatives, the lowest EUNFME of $1,468 was found when the down payment was 100%, the CD rate was 2%, and the ownership period was 30 years. However, 100% down payment is not common in the US market.

12.3 Influence of Mortgage Rates

Mortgage interest rates linearly influence the EUNFME. Keeping all other factors as given and increasing the mortgage rate increases the EUNFME and vice versa. The results obtained in Chapter 11, indicated that EUNFME increased as the mortgage rate increased while keeping all other parameters constant. This can be seen in the Figures 11.1 to 11.9. In these figures, it was consistently observed that the higher the mortgage rates for a constant CD interest rate and down payment, the larger were the EUNFME. For example, in Table 11.2, when the mortgage rate is 3% and the CD rate is 2%, the EUNFME is $1,773. By keeping the CD interest rate at 2% and increasing the mortgage rate to 4%, the EUNFME increases to $2,076, a 17% increase in cost. EUNFME increased linearly as the mortgage rates were increased. This trend was uniformly prevalent for all conditions, considered in this example of purchase analysis as evidenced in Figures 11.1 to 11.9. This was because of the higher borrowing costs of the mortgage loan directly contributing to the life-cycle costs.

The 100% down payment neutralizes the effect of mortgage rates. From the results of the purchase example, it was observed that a 100% down payment yields a constant EUNFME for any mortgage rates when all other parameters are fixed, as seen in Figure 11.3, 11.6, and 11.9. In these figures, all lines representing various mortgage interest rates overlapped with each other, indicating that down payment has no influence on the EUNFME. This is obvious because the mortgage interest rate has no role to play in EUNFME when there was no loan borrowed. Therefore, all the lines representing the various mortgage rates were overlapped with each other when down payment paid was 100% as indicated by the data shown in Tables 11.4, 11.7, and 11.10.

12.4 Influence of CD Interest Rates

The results indicated that the CD interest rates also proportionally contribute to the magnitude of EUNFME. The results of the purchase analysis as shown in Figures 11.1 to 11.9 showed that the net ownership expenses EUNFME increased as the CD rates were increased while all other parameters were fixed. For example, in Figure 11.1, for a home purchase with 20% down payment and for an ownership period of 5 years, EUNFME increased gradually as the CD rates increased irrespective of the mortgage rates. This is mainly due to the fact that higher CD rates yield greater opportunity costs. Such a tendency was observed consistently in all other purchase conditions as shown in Figures 11.2 to 11.9. From these figures it became clear that CD interest rates linearly and directly influence the EUNFME. This suggests that when the return on investment is higher elsewhere, it would not be economically attractive to invest in home-buying. However, it has to be noted that CD rate alone is not the only factor to influence the opportunity loss or gain. Other items such as amount of down payment, discount points, closing costs, and all other periodic costs will influence the magnitude of EUNFME.

12.5 Influence of CD and Mortgage Rates Together

The magnitude of opportunity costs is greatly influenced by both CD and mortgage rates. In previous sections we have seen that both CD and mortgage rates directly influence EUNFME. It was also noticed that the lowest possible EUNFME was obtained when both CD and mortgage rates were at the lowest possible level. If only one of these rates is increased, the EUNFME also increases. For example, from Table 11.2, when both CD and mortgage rates are at 3% the EUNFME is $2,015. While keeping all other parameters fixed, and by increasing both of these rates by one percentage point to 4%, the EUNFME increased by 27%, reaching $2,560. Such a sharp rise in EUNFME prevailed in all situations considered in the purchase example of this study. The lines representing the various mortgage rates were stretched parallel to each other with a progressively increasing trend of EUNFME as the CD rate and mortgage rates were increased. This indicated that the stake of opportunity loss is greatly enhanced when both of the rates were increased simultaneously.

From the above analysis, it must be noted that in order to offset the opportunity loss and to maximize the attractiveness of home-buying, one must seek a situation when both CD interest rate (i.e. alternative investment rate of return) and mortgage interest rate are at the lowest possible level in the market.

12.6 Influence of Down Payment

Larger down payments were observed to be more attractive when mortgage rates were higher than CD interest rates. For a fixed CD rate of 2% and for a 5 years ownership period, the greater the size of the down payment the smaller was the EUNFME when mortgage rates were higher than 4% (see Figure 11.10 and Table 11.11). Likewise, higher down payments were better with 2% CD rates for 15 years and 30 years of ownership periods, when mortgage rates were higher than 4% and 3%, respectively, as seen in Figure 11.13 and 11.16 (Table 11.14 and 11.17). Larger down payments with 4% CD rates were observed to yield smaller EUNFME for 5 years, 15 years, and 30 years of ownership periods, when mortgage rates were higher than 7%, 6%, and 5%, respectively, as seen in Figure 11.11, Figure 11.14, and Figure 11.17. Such a trend also prevailed for a fixed CD rate of 6%, for 5 years, 15 years, and 30 years of ownership periods respectively. The only exceptional condition when mortgage rates had no influence on the magnitude of EUNFME was with a 100% down payment.

EUNFME converged at 100% down payment regardless of mortgage and CD rates as observed in Figure 11.10 through Figure 11.18. When CD rates were fixed and mortgage rates were gradually increased from 3% to 9%, EUNFME inclined to converge gradually with the increase of down payment size from 10% to 100%, and the point of locus was at the 100% down payment. It was interesting to note that for a fixed CD rate, the

EUNFME was constant for any mortgage rates when down payment was 100%. For example, in Figure 11.10, the EUNFME was constant at $1,884 when down payment was 100%, for any mortgage rates. This finding is rather trivial because mortgage rates had no influence on EUNFME when home purchase was realized with 100% down payment.

The opportunity cost increased along with increasing trends of both down payment size and CD interest rates. The point of convergence gradually moved upwards, and thus increased the value of EUNFME, as the CD interest rates were gradually increased from 2% to 6% regardless of mortgage rates. This movement was noticed by comparing the location of convergence points in Figures 11.10 to 11.12. For example, in Figure 11.10, it was noticed that with 2% CD interest rate, and for 100% down payment size, the EUNFME was $1,884. When all other variables were kept constant, and CD interest was increased to 4%, the EUNFME for 100% down payment was increased to $3,461 (Figure 11.11). Similarly, for a CD interest rate of 6%, and for 100% down payment, the EUNFME was further increased to $5,046 as observed in Figure 11.12. The increase in EUNFME along with the increase of CD rate and down payment size is because of the opportunity loss caused by high down payment and high CD interest rates.

Minimum down payment will make home-buying economically more attractive when CD rates are higher and mortgage rates are at the lower range. The results indicated that for a fixed mortgage, the EUNFME increases as the CD rate increases as noticed in previous sections. For example, from Table 11.11, it was obvious that the lowest possible EUNFME of $1,759 was achieved when the CD rate was 2%, the mortgage rate 3%, and the down payment 10%. In these purchase analyses, a down payment size smaller than 10% was not considered, because a minimum of 20% of down payment is a normal purchase condition.

12.7 Optimum Down Payment

From the discussions in the previous section it was clear as to when the maximum and minimum down payments are attractive. However, it was not apparent as to what combination of CD and mortgage rates will yield the optimum down payment size. Therefore, it was interesting to find out a pair of CD and mortgage rates that optimizes the down payment for a given set of purchase conditions.

A critical set of CD and mortgage rates that breakeven EUNFME irrespective of down payment size will be the optimal condition. Such a condition will reverse the attractiveness of down payment size. To find out the breakeven EUNFME, let's consider Figure 11.10. This figure represents a constant CD rate of 2%. In this figure, a horizontal line (OA) was drawn through the point of convergence and perpendicular to Y-axis as shown in the Figure 11.10. In this particular case, the horizontal line OA passes between the lines of 3% and 4% mortgage rates. Graphically, it was estimated that the OA is the critical line which represents approximately 3.5% mortgage rate. Therefore, in this particular condition, 2% CD rate and 3.5% mortgage rate were considered as a critical pair that yields the breakeven EUNFME for any size of down payment ranging from 0% to 100%. A similar exercise was repeated in Figure 11.11 through 11.19, to establish the critical CD and mortgage rates for each purchase conditions. The results of such an exercise were summarized in Tables 12.1 to 12.3. Using these data, a graph was drawn as shown in Figure 12.1.

Table 12.1: Breakeven CD and mortgage rates for all sizes of down payment for 5 years ownership period

CD interest rate, %	Mortgage rate, % (± 0.25% accuracy)	Breakeven EUNFME, $
2	3.40	1,884
4	6.75	3,461
6	10.00	5,046

Table 12.2: Breakeven CD and mortgage rates for all sizes of down payment for 15 years ownership period

CD interest rate, %	Mortgage rate, % (± 0.25% accuracy)	Breakeven EUNFME, $
2	3.25	1,510
4	5.80	3,030
6	8.25	4,561

Table 12.3: Breakeven CD and mortgage rates for all sizes of down payment for 30 years ownership period

CD interest rate, %	Mortgage rate, % (± 0.25% accuracy)	Breakeven EUNFME, $
2	2.80	1,468
4	4.60	2,967
6	6.40	4,472

Figure 12.1 shows that for the purchase conditions considered in this analysis, the breakeven mortgage rates for any size of down payment would gradually increase as the ownership period increases. As can be seen from the figure, the CD and the mortgage rates tend to converge as they become smaller, in order to yield a breakeven EUNFME

for any size of down payment. It is also noticed that at breakeven EUNFME, the mortgage rate is always greater than the CD rate for any size of down payment, and for a given set of purchase conditions.

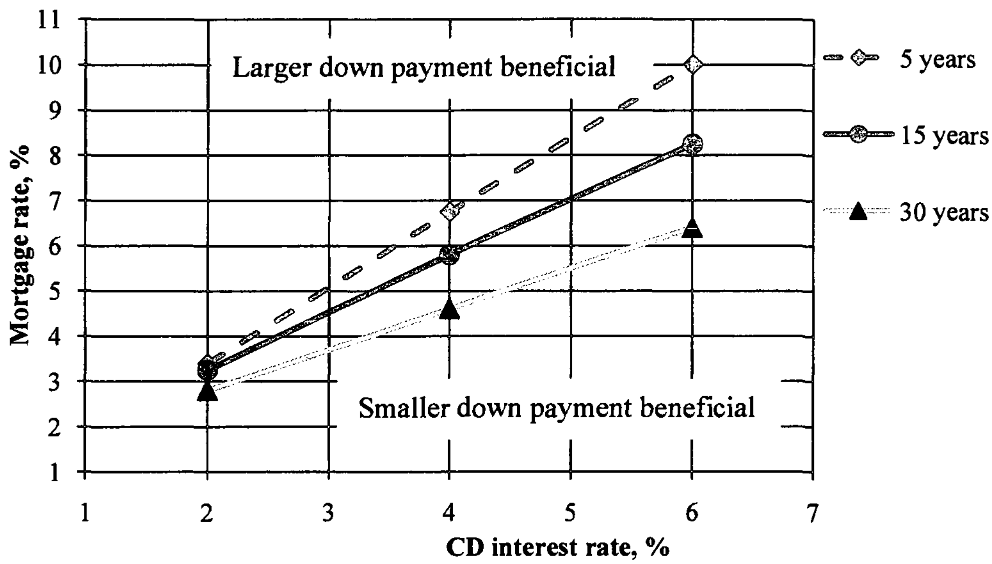

Figure 12.1: Breakeven CD and mortgage rates for all sizes of down payment for 5, 15 and 30 years of ownership period.

As depicted in Figure 12.1, a larger down payment will be economically advantageous when mortgage rates are located on the upper half of the graph separated by the lines representing a particular ownership period. Otherwise, a minimal down payment will be economically more rewarding. For example, if the CD rate is 4% and mortgage rate is 6%, it would be beneficial to pay a down payment that is as large as possible if the buyer is planning to retain the home-ownership for at least 15 years. However, if the buyer is considering the ownership period of 5 years or less, with the same set of mortgage and CD rates, the down payment size must be kept as small as possible. Any size of down payment will yield the optimum EUNFME along the line for the selected ownership period.

12.8 Influence of Duration of Ownership Period

With reference to Figures 11.19 to 11.27, it is observed that the longer ownership periods are more attractive when CD rates are low. With a normal down payment size of 20% and CD rates as low as 2%, ownership periods longer than 10 years were economically rewarding. When CD rates were increased from 2% to 6%, the most optimal ownership period appeared to be a 10 years. Beyond 10 years, EUNFME increases linearly with ownership period for higher CD and mortgage rates. This is due to the fact that capital is occupied in home ownership and thus losing the opportunities from alternative investment returns.

When CD rates are low and down payments are high, EUNFME are smaller for extended ownership periods. For example, with 2% CD rates and 50% down payment, EUNFME were at the highest when ownership period was shorter than 10 years in this case for any mortgage rates as seen in Figure 11.22. For these conditions, generally longer ownership period was seen to be better, as the EUNFME were at the same level or decreased slowly when the ownership period was 10 years or longer.

However, for CD rates of 4% and 50% down payment, the most optimal period was clearly seen to be around 10 years, for any mortgage rates (Figure 11.23). Likewise, 10 years was the optimal of ownership period, when CD rate was 6% and down payment was 50% as seen in Figures 11.23 and 11.24. The optimal ownership period was observed to be about 25 years when 100% down payment was combined with CD rate of 2% or 6% as seen in Figure 11.25 and 11.27. Whereas, 30 years was observed to be the best ownership period in the case of 4% CD rate, as depicted in Figure 11.26. This implies that when CD rates are at the lowest level, it is more economically rewarding to pay 100% down payment and retain the ownership period as long as 25 years.

Table 12.4: Optimal ownership period, years (see Figures 11.19 to 11.27)

CD Rate	Down payment		
	20%	50%	100%
2%	10	20	25
4%	10	10	30
6%	10	10	25

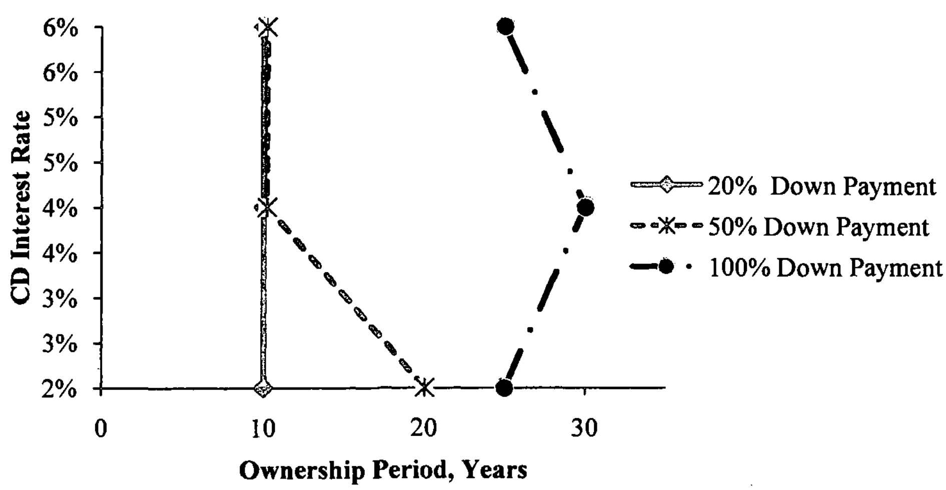

Figure 12.2: Optimal Ownership Periods

Based on the observation of the trends, noticed in Figures 11.19 to 11.27, optimal ownership period for given down payment and CD interest rates was summarized as shown in Table 12.4. In these conditions, the influence of mortgage rate was ignored, because, as noticed in these figures, the nature of the trends lines was not affected by mortgage rates. Using the data from Table 12.4, a graph was drawn as shown in Figure 12.2. The graph indicated that increased down payment combined with smaller CD interest rates tends to yield extended optimal ownership period.

12.9 Sensitivity Analysis for Inflation Rates (CPI index)

A sensitivity analysis was also performed to analyze the influence of inflation rates (CPI index) on EUNFME. According to the analysis presented in Chapter 8, the average annual inflation rates are forecast at 1.66%, 1.87%, and 2.06% for the ownership periods of 5 years, 15 years, and 30 years, respectively (see Table 8.4). These inflation rates were used as baseline scenario to calculate the EUNFME in all previous analysis. To examine the sensitivities of EUNFME to inflation, three different inflation rates of 1%, 2%, and 3% are considered so as to keep the baseline condition in the middle point. The values of EUNFME for these three different CPI rates were obtained for 20% down payment and 5 years of ownership period. These results are shown in Tables 12.5, 12.6 and 12.7, and in Figures 12.3, 12.4 and 12.5.

From Figures 12.3, 12.4 and 12.5, it was noticed that the slopes of the lines were consistent and the trend lines of EUNFME as a function of mortgage rates and CD rates were not altered by changing the CPI (inflation) rates from 1% to 2% and from 2% to

3%. The trend of the larger EUNFME values for higher mortgage rate was consistent for any CD interest rate regardless of the inflation rate. Furthermore consistent with previous observation (Figures 11.1 to 11.8) these lines were parallel to each other.

Table 12.5: Results of EUNFME for 1% CPI index

CD Interest Rate, %	Mortgage Interest Rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,862	2,179	2,501	2,827	3,157	3,489	3,823
3	2,102	2,421	2,746	3,076	3,409	3,746	4,085
4	2,341	2,662	2,990	3,323	3,660	4,001	4,345
5	2,580	2,904	3,235	3,571	3,912	4,258	4,606
6	2,818	3,144	3,477	3,817	4,162	4,511	4,864
7	3,060	3,389	3,726	4,070	4,420	4,774	5,132
8	3,300	3,632	3,972	4,320	4,674	5,033	5,396

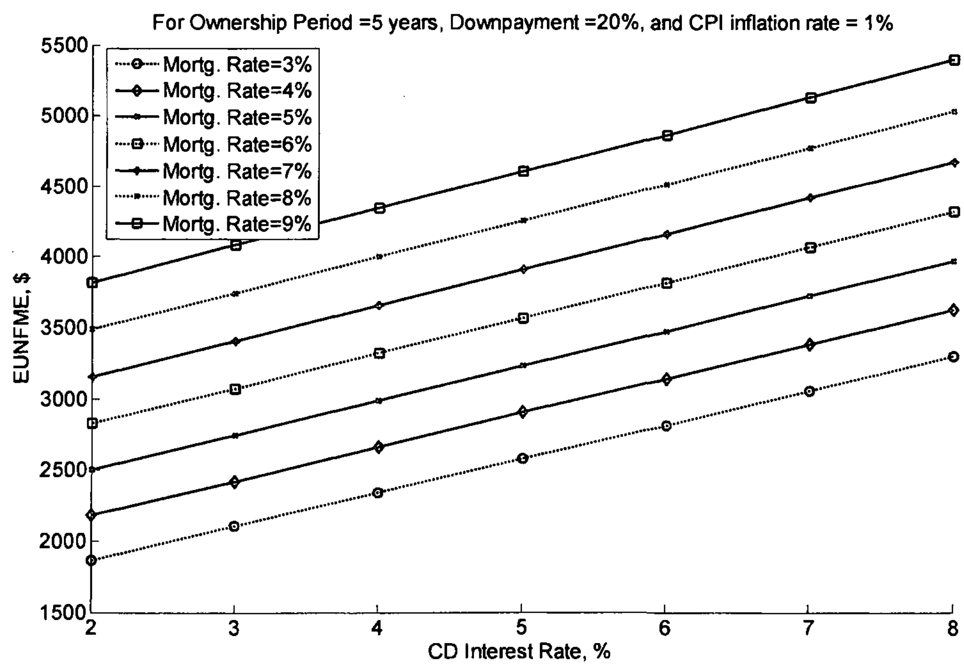

Figure 12.3: Results of EUNFME for 1% CPI index

Table 12.6: Results of EUNFME for 2% CPI index

CD Interest Rate, %	Mortgage Interest Rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,817	2,126	2,440	2,758	3,079	3,403	3,729
3	2,045	2,356	2,673	2,994	3,319	3,646	3,977
4	2,283	2,597	2,916	3,241	3,570	3,903	4,238
5	2,518	2,834	3,157	3,486	3,819	4,156	4,496
6	2,750	3,069	3,394	3,726	4,062	4,403	4,748
7	2,981	3,301	3,629	3,964	4,304	4648	4,997
8	3,215	3,538	3,869	4,207	4,551	4,901	5,255

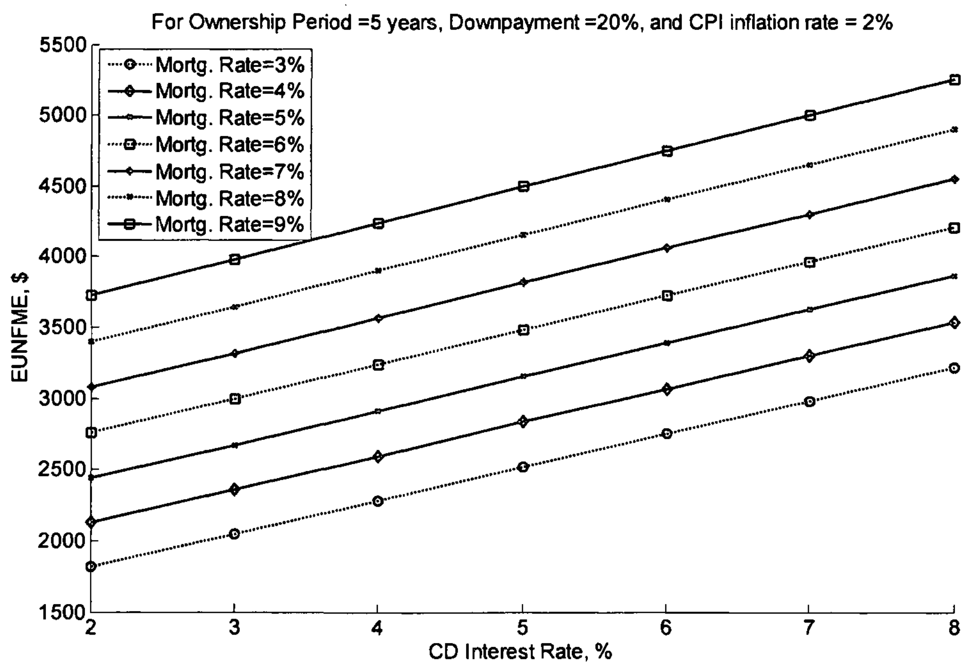

Figure 12.4: Results of EUNFME for 2% CPI index

In order to evaluate the sensitivity of EUNFME to the CPI index, two mortgage rates, 3% and 6% were selected and a new graph was drawn using results of EUNFME for the 1%, 2%, and 3% CPI index for each of these mortgage rates as shown in Figure 12.6.

Table 12.7: Results of EUNFME for 3% CPI index

CD Interest Rate, %	Mortgage Interest Rate, %						
	3	4	5	6	7	8	9
	EUNFME, $						
2	1,771	2,073	2,379	2,689	3,002	3,318	3,636
3	1,993	2,297	2,605	2,919	3,236	3,555	3,877
4	2,221	2,526	2,837	3,153	3,473	3,797	4,123
5	2,456	2,765	3,080	3,400	3,725	4,054	4,386
6	2,684	2,995	3,313	3,636	3,965	4,298	4,635
7	2,909	3,222	3,543	3,869	4,202	4,539	4,880
8	3,138	3,454	3,777	4,107	4,444	4,785	5,131

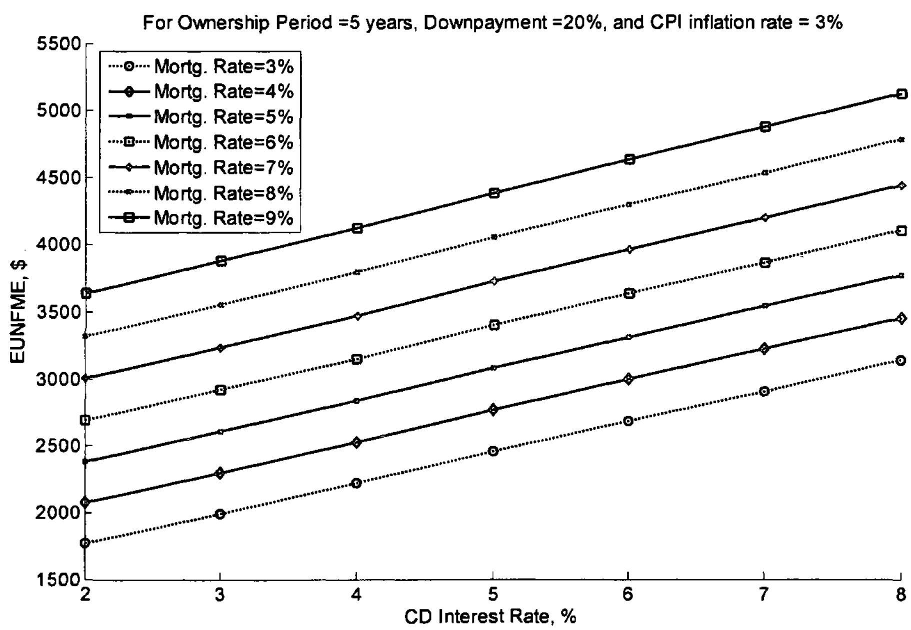

Figure 12.5: Results of EUNFME for 3% CPI index

The sensitivity analysis results indicated that although the EUNFME is sensitive to the CPI index, the change in the CPI index alone would not reverse the decision. Figure 12.6 showed that with the increase of inflation rate, for a given set of mortgage and CD rates,

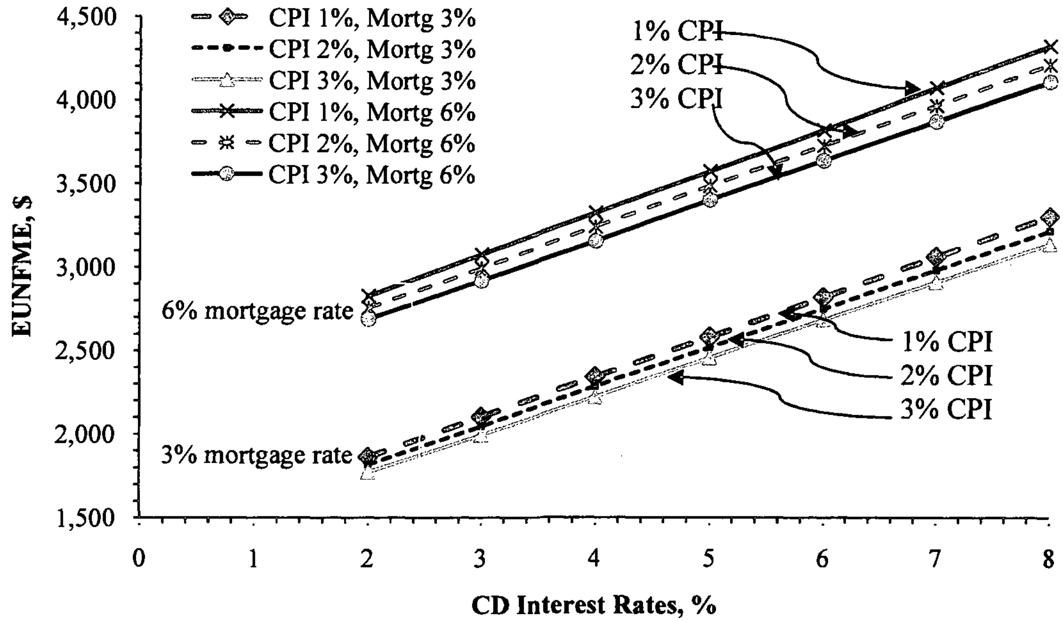

Figure 12.6: Sensitivity analysis EUNFME results for CPI Index of 1%, 2% and 3 % for mortgage rates of 3% and 6% for 5 years ownership period.

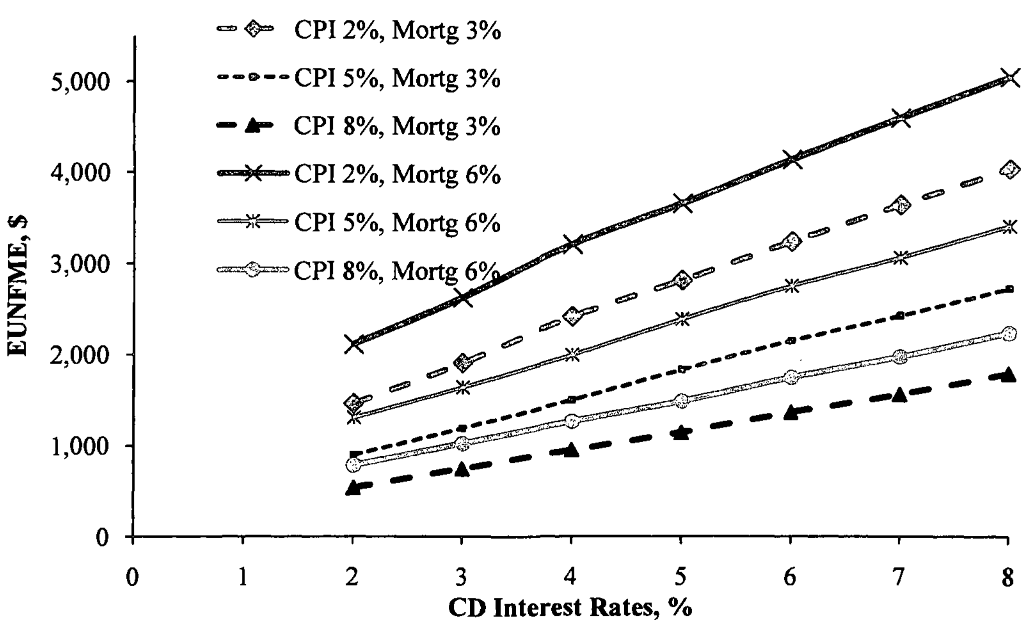

Figure 12.7: Sensitivity analysis of CPI index showing EUNFME results for CPI Index of 2%, 5% and 8% for mortgage rates of 3% and 6% for 30 years ownership period.

the EUNFME decreases. For example, in Figure 12.6, the lower group of lines represents the 3% mortgage rates and the upper group is for 6% mortgage rates. In each group, the top most line represents 1% CPI inflation rate. Whereas, the middle and the bottom lines represent 2% and 3% CPI inflation rates, respectively.

Sensitivity analysis was done in the same manner for 30 years of ownership period to confirm whether such a trend is consistent for short term as well as long-term ownership periods. Furthermore, a different set of CPI forecast of 2%, 5%, and 8% were used to verify that the sensitivity of the EUNFME would not be reversed when CPI inflation is as high as 8%. These results are shown in Figure 12.7.

No new trends observed when a longer life-cycle period along with higher inflation rates was considered. In Figure 12.7, the set of continuous lines represent 6% mortgage rate whereas the broken lines indicate 3% mortgage rate. For a given mortgage rate, EUNFME was lower when higher inflation rates were used. This is consistent to previous observations.

The results suggest that increasing or decreasing inflation rates, while keeping the CD and mortgage as fixed will not reverse the home-buying decision. As observed from the sensitivity analysis results, for various purchase conditions, increasing the inflation rate will reduce the EUNFME and vice versa. Any such increase or decrease in EUNFME was consistent and linear in nature. However, it may seem beneficial to experience higher inflation rates for a homebuyer who has a fixed mortgage rate and CD interest rates because of a reduced EUNFME in present worth term, but this will consistently reduce the equivalent present worth of the buyer's income as well, thus offsetting decision reversal.

12.10 Sensitivity Analysis for Discount Points Paired with Mortgage Rates

The previous analyses were based on two points (2) for all mortgage rates as baseline scenario. Several sensitivity analyses were performed to find out how the mortgage rates will influence the EUNFME when combined with different discount points. The combination of different mortgage rates and discount points analyzed are shown in Table 12.8. These are typical mortgage rates and discount points used in practice as shown in Table 5.2 (Chapter 5), as guidelines for 30-year fixed rate mortgage terms.

Table 12.8: Pairs of mortgage rates and discount points

Discount points	Mortgage rate, %				
	4	**5**	**6**	**7**	**8**
Baseline	2	2	2	2	2
Combination A	+5.0	+3.5	0	-3.5	-5.0

The positive discount points represent the expense and the negative points are the income of the homebuyer. In the case of negative points, the lender (seller) pays the equivalent cash to the borrower at the expenses of higher mortgage rates. Initially, the sensitivity analysis was performed for a 5-year ownership period and 20% down payment. These results of EUNFME are presented in Table 12.9 and in Figure 12.8.

The trend lines indicated that the EUNFME is sensitive to mortgage rates in combination with discount points. From Figure 12.8, it was noticed that the lines representing 5% (with 3.5 points), 6% (with 0 points), and 7% (with -3.5 points) mortgage rates converged

Table 12.9: EUNFME for combination A of mortgage rate and point for 20% down payment and 5 years of ownership period

CD interest rate, %	Mortgage interest rate (%), (Points)				
	4 (+5.0)	**5 (+3.5)**	**6 (0)**	**7(-3.5)**	**8(-5.0)**
	EUNFME, $				
2	2,285	2,489	2,556	2,627	2,839
3	2,544	2,745	2,802	2,863	3,075
4	2,796	2,993	3,039	3,088	3,298
5	3,044	3,238	3,272	3,310	3,518
6	3,310	3,502	3,525	3,553	3,760
7	3,558	3,747	3,758	3,775	3,980
8	3,808	3,994	3,993	3,999	4,202
9	4,063	4,244	4,232	4,226	4,427

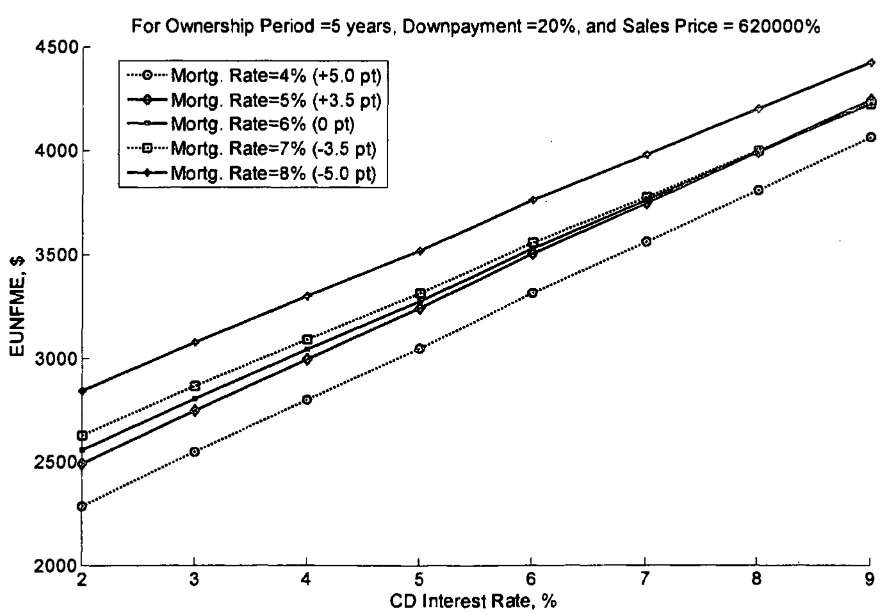

Figure 12.8: EUNFME for pair set A of mortgage rate and point for 20% down payment and 5 years of ownership period

at the point when the CD interest rate was about 8%. As the CD interest was increased from 8% to 9%, the trend lines representing these mortgage rates were reversed. Such a reversal in the trend of EUNFME is influenced by the opportunity cost associated with points, and the amount of interest paid.

These results were compared further with the results of the baseline alternative of two discount points (2) were used with all mortgage rates. The results of the base line alternative are shown in Figure 11.1 (Chapter 11). Figure 11.1 and Figure 12.8 were merged and a new graph was drawn as shown in Figure 12.9. In Figure 12.9, broken lines represent the baseline with 2 discount points and continued lines represent the variable discount points (combination *A*).

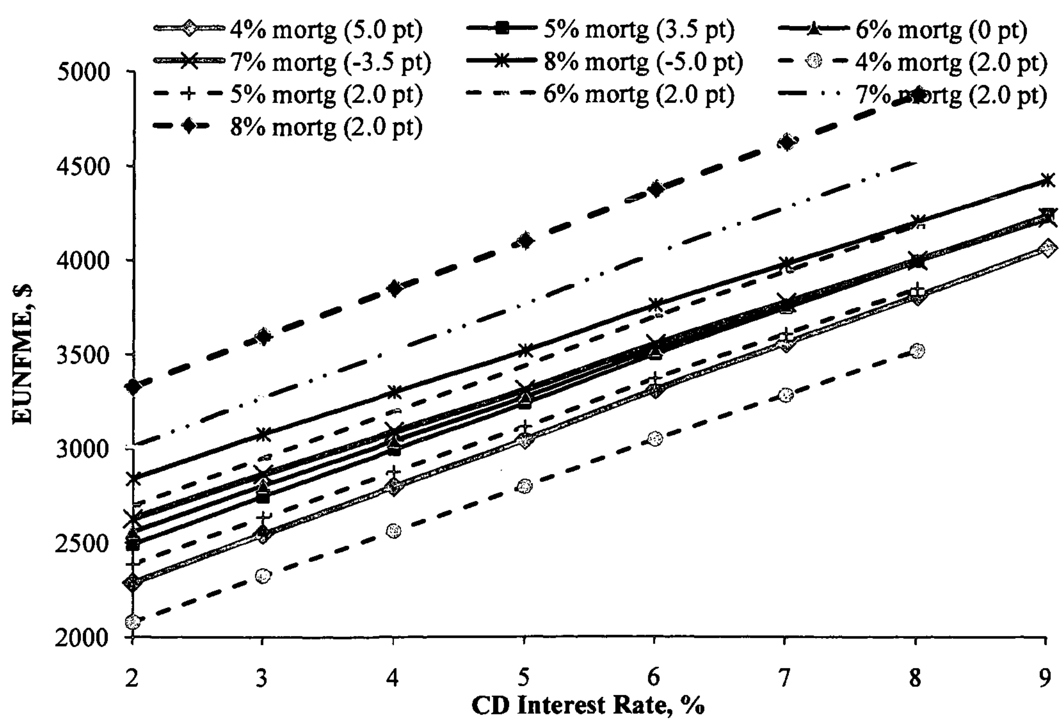

Figure 12.9: Comparison of sensitivity analysis results for baseline and pair set 1 for 20% down payment and 5 years ownership period

Among the compared alternatives, the EUNFME was at the lowest range when mortgage rate of 4% was paired with 2 discount points, represented by the bottom line. Similarly, EUNFME was at the highest level when mortgage rate of 8% was combined with 2 discount points, represented by the top most line.

However, as shown in Figure 12.9, some of the lines in the middle part of the graph produced by combination *A* were gradually converging with the increasing trend of CD rates. This has yielded crossings of some of the lines representing the baseline scenario and the combination *A*. For example the line representing 7% (2 pt) mortgage rate of base line case meets the line representing 8% (-5 pt) when CD rate is 8%. This confirmed that EUNFME is sensitive to discount points, and changing the magnitude of points may reverse the optimality condition. These alternatives were ranked based on their attractiveness in decreasing order of the values of EUNFME as follows:

1) 4% mortgage rate paired with +2 discount points - best alternative
2) 4% mortgage rate paired with +5 discount points - second best
3) 5% mortgage rate paired with +2 discount points - third best
4) 5% mortgage rate paired with +3.5 discount points
5) 6% mortgage rate paired with 0 discount point
6) 7 % mortgage rate paired with -3.5 discount points
7) 6% mortgage rate paired with +2 discount points
8) 8% mortgage rate paired with -5.0 discount points
9) 7% mortgage rate paired with +2.0 discount points - second least desired
10) 8% mortgage rate paired with +2.0 discount points - least desired

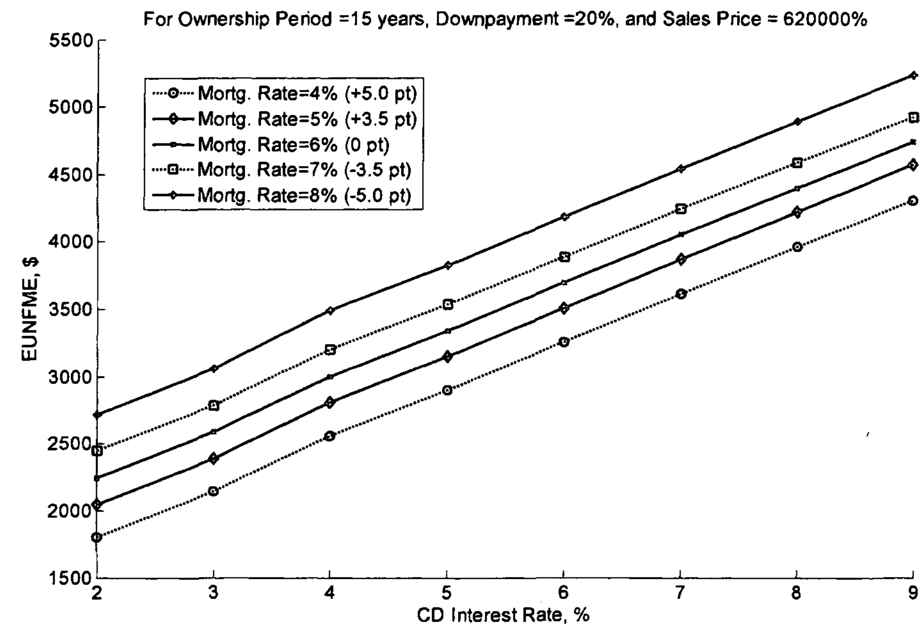

Figure 12.10: EUNFME for pair set A of mortgage rate and point for 20% down payment and 15 years of ownership period

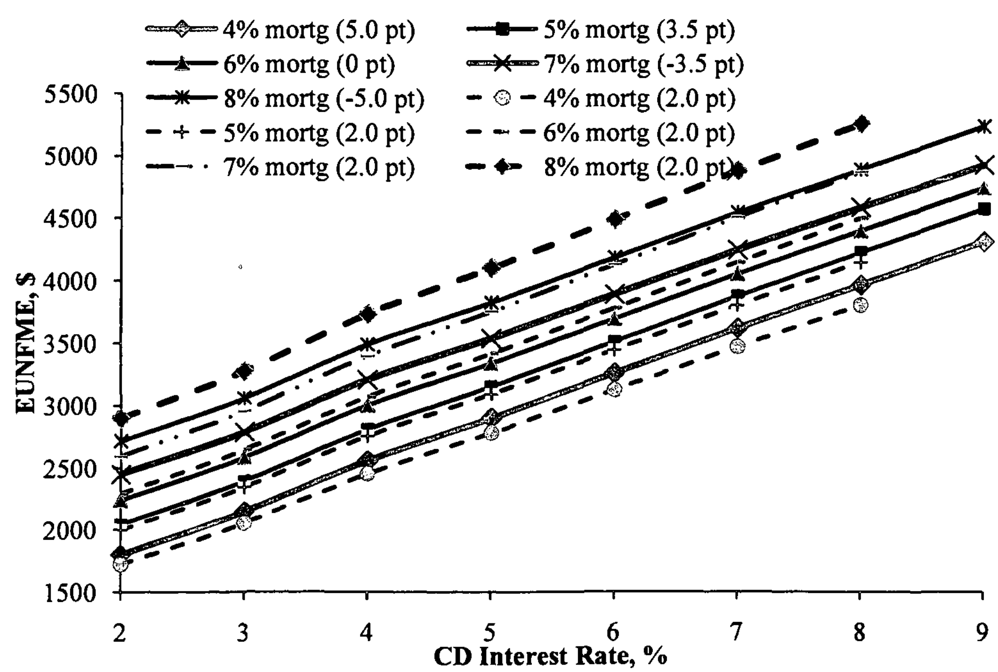

Figure 12.11: Comparison of sensitivity analysis results for baseline and combination A for 20% down payment and 15 years ownership period

In order to examine the sensitivity of EUNFME to discount points combined with a change in ownership periods, the results of EUNFME for set A of mortgage rate and discount points for an ownership period of 15 years are plotted in Figure 12.10.

To compare these results with the baseline scenario, Figure 12.10 was superimposed on Figure 11.4 (Chapter 11) resulting in a new graph as shown in Figure 12.11 for an ownership period of 15 years. As can be seen in Figure 12.11, the converging nature of the lines became less pronounced except for two lines for representing a baseline case of 7% (2 point) and combination *A* for 8% (-5.0 point) case. These two lines appeared to merge when CD rate was approximately 8%. These alternatives were ranked in decreasing order for their attractiveness based on their respective yield of EUNFME:

1) 4% mortgage rate paired with +2 discount points - best alternative
2) 4% mortgage rate paired with +5 discount points - second best
3) 5% mortgage rate paired with +2 discount points - third best
4) 5% mortgage rate paired with +3.5 discount points
5) 6% mortgage rate paired with 0 discount point
6) 6% mortgage rate paired with +2 discount points
7) 7 % mortgage rate paired with -3.5 discount points
8) 7% mortgage rate paired with +2.0 discount points
9) 8% mortgage rate paired with -5.0 discount points - second least desired
10) 8% mortgage rate paired with +2.0 discount points - least desired

When compared with the 5-year ownership scenario, the sequence of attractiveness was switched between rank 6 and 7, and 8 and 9 in the case of 15 years of ownership period. For example, 6% mortgage (2 points) became more attractive than 7% (-3.5 points) in 15 years compared to 5 years of ownership period. Similarly, 7% mortgage (2 points) became more attractive than 8% (-5.0 points) in 15 years than in 5 years of ownership period.

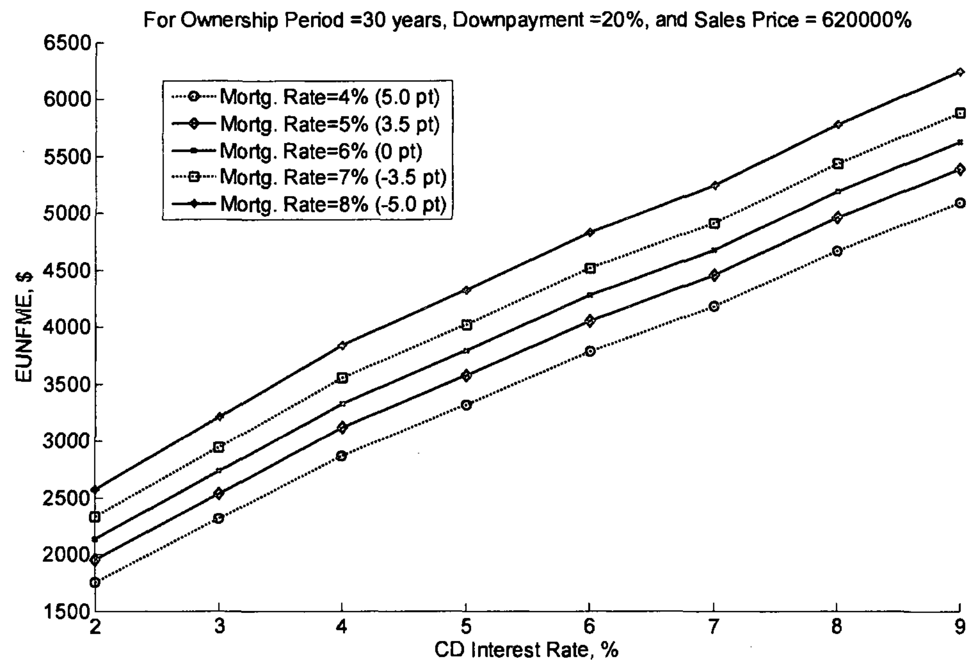

Figure 12.12: EUNFME for pair set A of mortgage rate and point for 20% down payment and 30 years of ownership period

In another similar sensitivity analysis, two figures, the baseline scenario in Figure 11.7 (Chapter 11) and the EUNFME results of combination set *A* (Figure 12.12), were merged, yielding Figure 12.13.

Figure 12.13 indicated that the EUNFME is highly sensitive to the combination of mortgage rates with changes in discount points. When the ownership period is 30 years, some of the trend lines crossed each other at the point when CD rate was as low as 3%.

In general, the slope of the baseline case appeared to be steeper than the combination *A*. Therefore, combination *A* became gradually more attractive with the increase of CD interest rates.

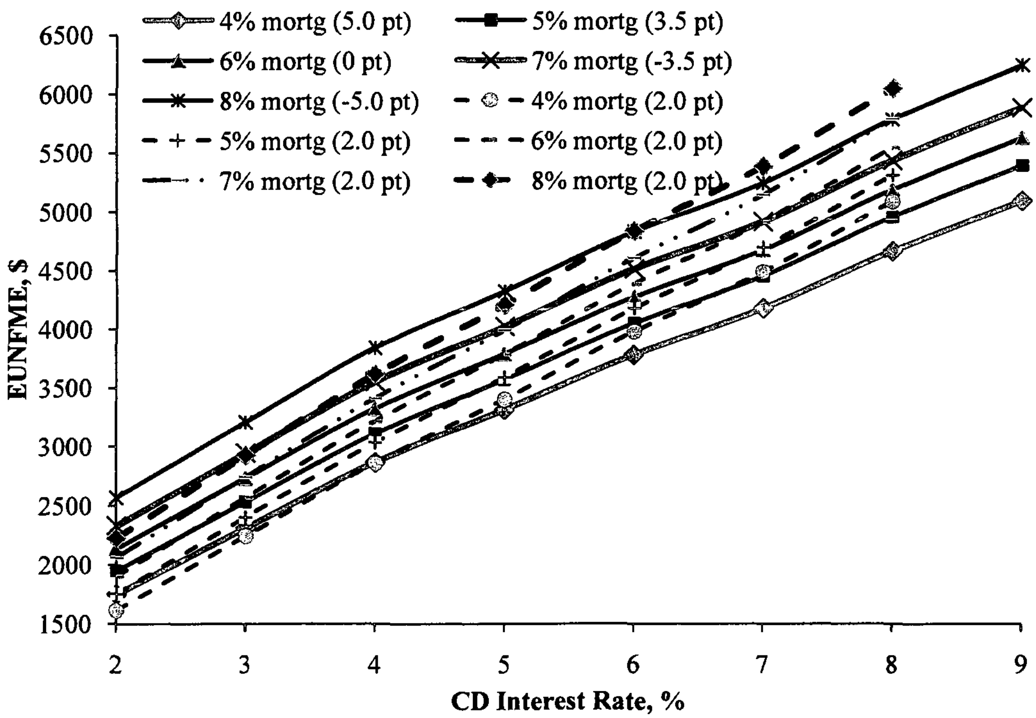

Figure 12.13: Comparison of sensitivity analysis results for baseline and combination A for 20% down payment and 30 years ownership period

For example, 4% mortgage rate combined with two (2) discount points was the most attractive among the alternatives until the CD rate was less than 4%. When the CD became higher than 4%, then the 4% mortgage rate combined with 5 points became more attractive. For a condition of CD rate being 4%, and 30 years of ownership period, attractiveness of various alternatives were ranked in decreasing order based on their yield of EUNFME as follows:

1) 4% mortgage rate paired with +2 discount points - best alternative
2) 4% mortgage rate paired with +5 discount points - second best
3) 5% mortgage rate paired with +2 discount points - third best
4) 5% mortgage rate paired with +3.5 discount points
5) 7% mortgage rate paired with 2 discount point
6) 6% mortgage rate paired with +0 discount points
7) 7 % mortgage rate paired with -3.5 discount points
8) 8% mortgage rate paired with +2.0 discount points
9) 8% mortgage rate paired with -5.0 discount points - second least desired
10) 8% mortgage rate paired with +2.0 discount points - least desired

These sensitivity analyses for discount points indicated that the rank of attractiveness of any mortgage rate may be changed when combined with a different set of discount points. Paying more discount points with smaller mortgage rate appears to be financially more rewarding for mortgage borrower rather than paying higher mortgage rates and smaller discount points, except for when CD interest rate is very high, such as 8%. Paying higher mortgage rate and receiving cash as negative discount points was a the most beneficial choice in the given analysis.

12.11 Analysis of Mortgage Severity (MSI) Indices

The results of EUNFME (Table 11.29), the ownership MSI (Table 11.30) and operational MSI (Table 11.31) were merged into one single table showing varying levels of mortgage rate, down payment, CD interest rate and ownership period. Then the data were ranked for EUNFME in increasing order as shown in Table C-1 (Appendix C). Sorting the

EUNFME in this way will help in visualizing as to how the ownership and operational MSI related to EUNFME. A graph was drawn utilizing the EUNFME, ownership MSI and operational MSI as shown in Figure 12.14.

The analysis indicated that the ownership MSI was directly proportional to EUNFME. From Figure 12.14 it was seen that MSI increased linearly along with the increase of EUNFME. The highest ownership MSI was observed when EUNFME was highest, and vice-versa.

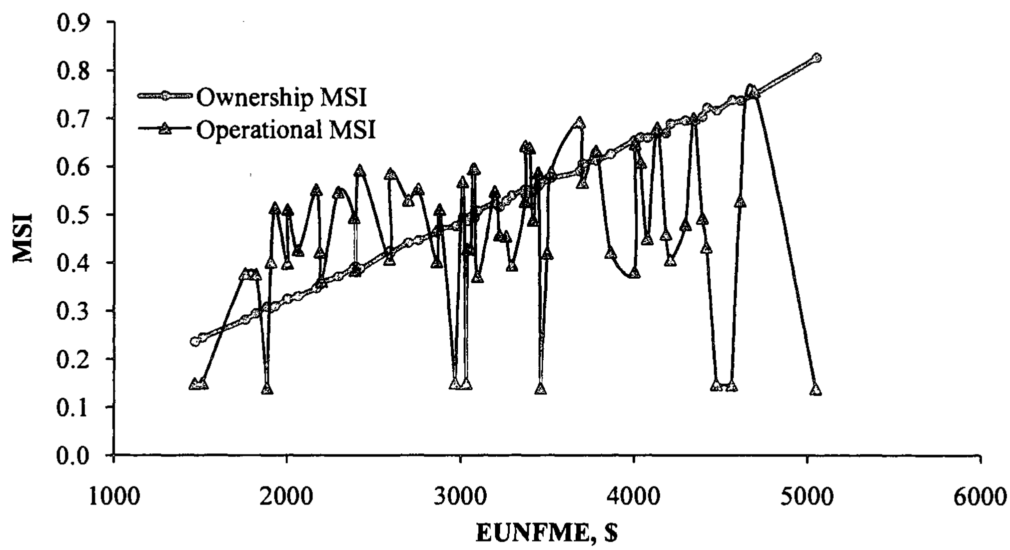

Figure 12.14: Graph of mortgage severity indices versus EUNFME

From Figure 12.14 alone, the relationship between operational MSI with EUNFME was not clear, because the trend of operational MSI appeared to be independent of EUNFME. In order to find out the trend of operational MSI, the data were sorted in an ascending order as shown in Table C-2 (Appendix C). The sorted data showed that the operational MSI had a similar trend as the down payment size. The relationship between operational

MSI and down payment size is shown in Figure 12.15. For comparison, the relationship between ownership MSI and down payment is depicted in Figure 12.16.

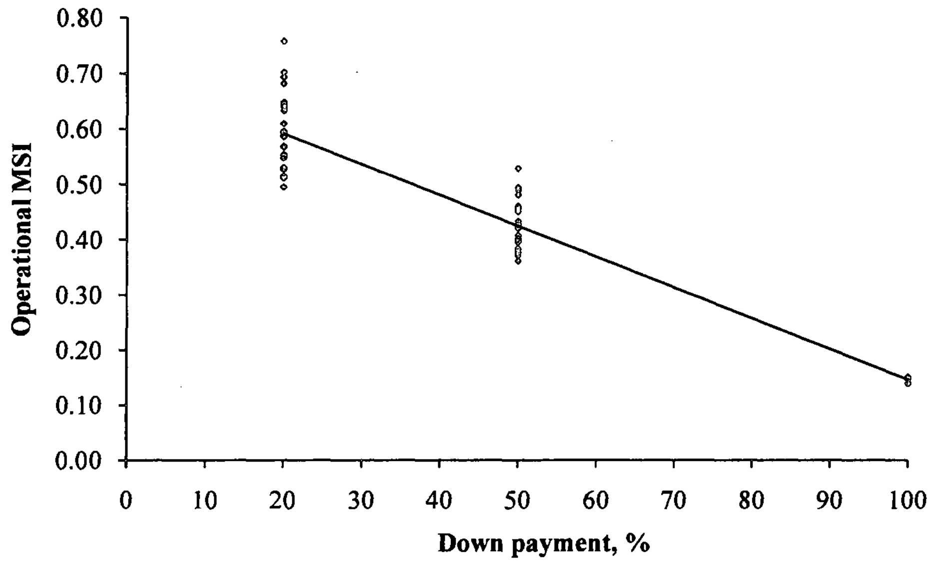

Figure 12.15: Relationship of operational MSI and down payment size

Figure 12.15 indicated that higher the down payment size the more affordable was the home-ownership in terms of operational MSI. The values of operational MSI ranged from 0.494 to 0.757 when down payment was only 20%. The severity index gradually decreased with the increased size of down payment. For 50% down payment, the operational MSI ranged from 0.361 to 0.525, averaging at 0.424. With a very narrow range of 0.139 to 0.150, the average operational MSI was the lowest at 0.145, for 100% down payment. This was mainly because the monthly mortgage payment, the expense of home-ownership was avoided by purchasing the house without any loans.

However, it should be noted that 100% down payment is not always the best scenario. As has been demonstrated in previous sections, the impact of down payment size on affordability of home-ownership has to be evaluated on a case-by-case basis. The evaluation of operational MSI should be used as only one of the several factors for deciding the down payment size. Obviously, for homebuyers who have a risky job and enough cash balances, paying a larger amount of down payment could be an option if other investment opportunities are not as attractive as investing in a home purchase.

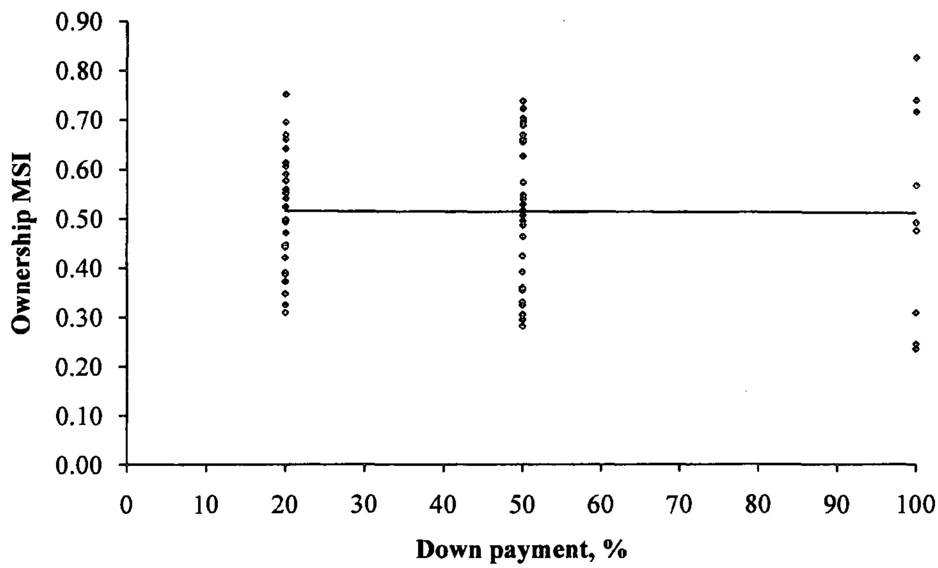

Figure 12.16: Relationship of ownership MSI and down payment size

For further analysis of relationship between ownership and operational MSI, the results from six randomly selected purchase conditions were plotted in Figures 12.17 to Figure 12.22. It was clear from these figures that ownership MSI and operational MSI had no similarity in their trend with respect to magnitude of down payment. Operational MSI decreased with the increased amount of down payment while it was opposite for ownership MSI, except for a condition when CD rate was significantly lower than mortgage interest rate.

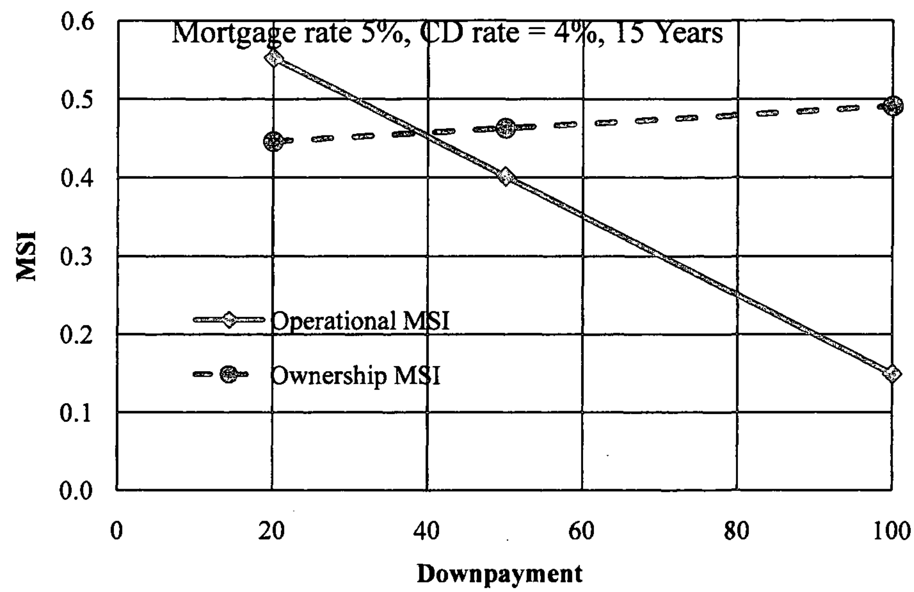

Figure 12.17: Ownership and operational MSI for 5% mortgage rate, 4% CD rate and 15 years of ownership period

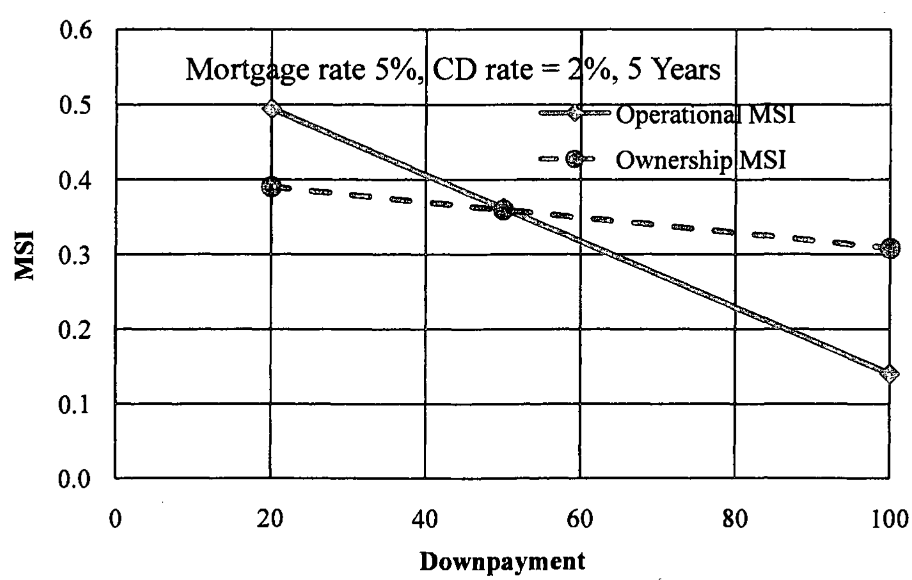

Figure 12.18: Ownership and operational MSI for 5% mortgage rate, 2% CD rate and 5 years of ownership period

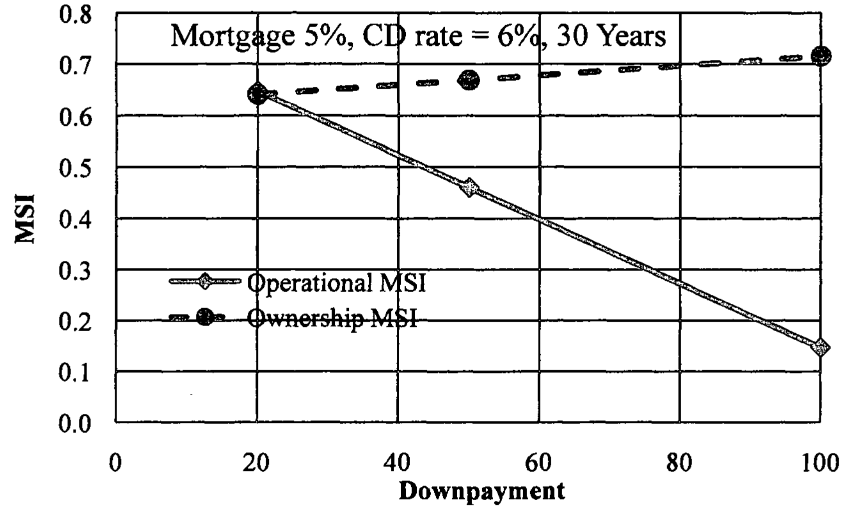

Figure 12.19: Ownership and operational MSI for 5% mortgage rate, 6% CD rate and 30 years of ownership period

From these figures, it can be inferred that ownership MSI and operational MSI have their own roles in the life-cycle cost of home-ownership and therefore they should be considered in the analysis separately.

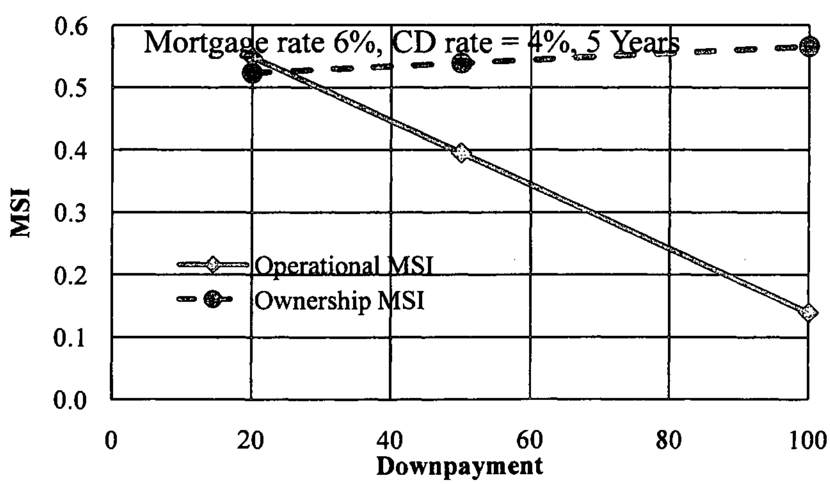

Figure 12.20: Ownership and operational MSI for 6% mortgage rate, 4% CD rate and 5 years of ownership period

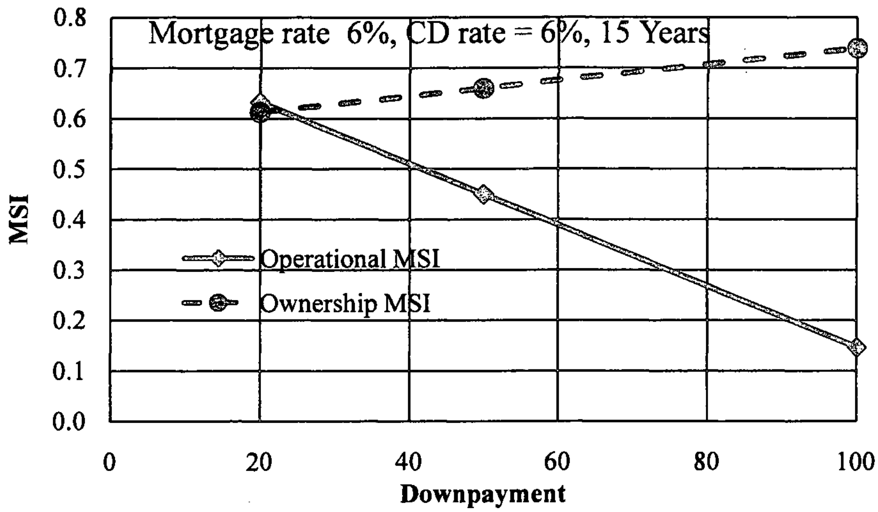

Figure 12.21: Ownership and operational MSI for 6% mortgage rate, 6% CD rate and 15 years of ownership period

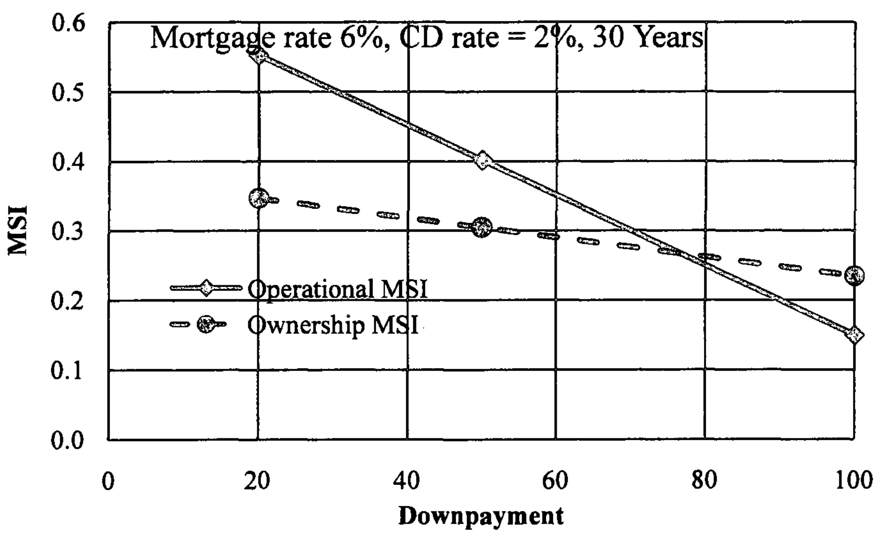

Figure 12.22: Ownership and operational MSI for 6% mortgage rate, 2% CD rate and 30 years of ownership period

From these figures, it can be inferred that ownership MSI and operational MSI have their own roles in the life-cycle cost of home-ownership, and therefore they should be considered in the analysis separately.

12.12 Comparing Mortgage Severity Indices and Housing Affordability

A common method of affordability measure used in the real estate industry is HAI index developed by the National Association of Realtors (NAR, 2008). Another method of measuring the affordability is median multiples. These methods were discussed in Chapter 6. In this section the results of HAI index, multiple median, and the MSI indices of the purchase example are compared.

Using equation 6.1 (Chapter 6), HAI indices were calculated for the purchase example (sales price of house $620,000 with 20% down payment) for three different mortgage rates, i.e., 5%, 6%, and 7%. The median annual income of the home buyer was assumed $93,600. The calculated HAI indices were 0.73, 0.66, and 0.59 for mortgage rates 5%, 6% and 7%, respectively, as shown in Table 12.11.

The comparable Ownership and operational MSI indices for 20% down payment and mortgage rates 5%, 6%, and 7% were selected from Table 11.30 and Table 11.31, and these values have been tabulated against the HAI indices as shown in Table 12.10. Using these results a graph was drawn for better comprehension of the comparison between HAI and MSI indices as shown in Figure 12.23.

There are some fundamental differences between HAI and ownership MSI and operational MSI. The HAI does not consider any other life-cycle costs other than the mortgage payment. Whereas, ownership MSI is calculated taking into account cradle-to-

Table 12.10: Comparison of HAI against ownership and operational MSI at 2%, 4% and 6% CD interest rates

		CD interest rate = 2%	
Mortgage Rate, %	HAI, Equation (6.1)	Ownership MSI (Table 11.30)	Operational MSI Table 11.31
5	0.73	0.309	0.514
6	0.66	0.347	0.552
7	0.59	0.387	0.592

		CD interest rate = 4%	
Mortgage Rate, %	HAI, Equation (6.1)	Ownership MSI (Table 11.30)	Operational MSI Table 11.31
5	0.73	0.493	0.595
6	0.66	0.540	0.642
7	0.59	0.589	0.692

		CD interest rate = 6%	
Mortgage Rate, %	HAI, Equation (6.1)	Ownership MSI (Table 11.30)	Operational MSI Table 11.31
5	0.73	0.641	0.647
6	0.66	0.694	0.701
7	0.59	0.750	0.757

grave life-cycle expenses including the mortgage payment. The operational MSI is the index calculated taking into account of all expenses and revenues that may occur only during the occupancy and ownership phase. These are the expenses shown in the middle column of Table 9.1 in Chapter 9. This index excludes all expenses occurred during the acquisition and the termination phases. Whereas, HAI does not consider time-value of money, ownership and operation MSI are calculated with due consideration of time value of money. Therefore, it is the opinion of this author that ownership and operational MSI represent more comprehensive and actual affordability indices rather than HAI.

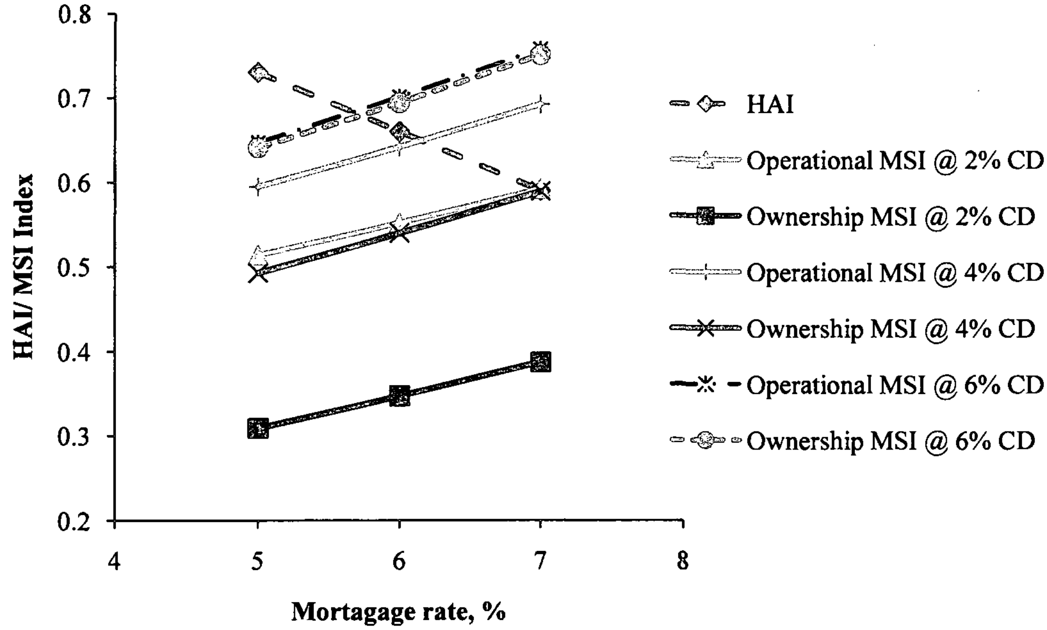

Figure 12.23: Comparison of HAI and ownership and operational MSI

The comparative chart of HAI, ownership and operation MSI as shown in Figure 12.23, indicated that HAI has a negative correlation with both types of MSI indices. The HAI index keeps decreasing in a liner manner with the increase of mortgage interest rate, because mortgage payment is the single cost variable in this index, when home sales price, down payment and buyer's income are constant. MSI indices incorporate many more cost items (utilities, insurance, operation maintenance, major repair, and tax implications) other than the mortgage payment, considers time-value of money and opportunity loss or gain. Therefore the trend lines of the MSI indices are different that the HAI index.

From the Figure 12.23, it has become clear that most of the time HAI indices are liberal due to omission of essential expenses items, opportunity loss or gain and other implications such as tax returns. Thirteen out of eighteen MSI indices were observed to be significantly lower than the HAI indices. Such liberal HAI is misleading, because it may lead the homebuyers to loan delinquencies and unanticipated foreclosures.

On the similar account, a quick evaluation of affordability was assessed based on the median multiple (see section 6.3). Using the home sales price of $620,000 and buyer's income of $93,600, the calculated median multiple index was 6.6. Based on the guidelines developed by Demographia (2008), this is severely unaffordable purchase situation. Similar to HAI, the median multiple method does not consider any other life-cycle costs other than the income and the house price.

12.13 Benefits of Tax Return for Mortgage Interest

It is often over-emphasized by lenders and real estate brokers that the primary reason for buying a home is the hidden benefits from deduction of mortgage interest from taxes. They argue that buying a home will save money in tax because homebuyers receive tax return on the mortgage interest and thus save thousands of dollars in tax payments (Garton-Good, 2004; Summers, 2005). In order to evaluate these claims, an analysis was also performed based on the results of the purchase example considered.

First of all, an analysis was carried out to determine the benefits of tax return on the interest paid for home loans. Based on the purchased conditions mentioned in previous sections, and the amount of loan borrowed in the purchase example, the actual amount of interest paid and the subsequent amount of tax benefits received in actual dollars for each year were calculated. These results are shown as shown in Figure 12.23 while detailed calculations are presented in an Excel spreadsheet – Sheet K1 (Appendix A).

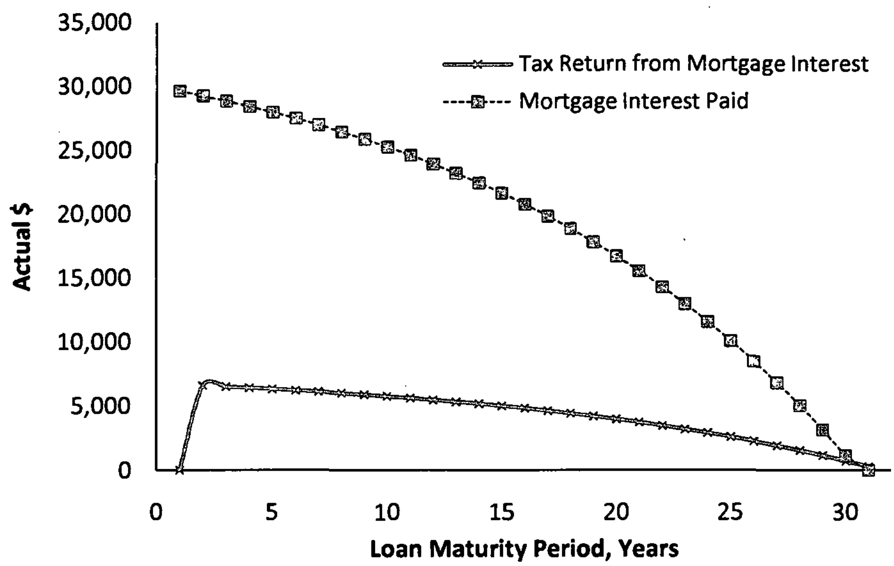

Figure 12.24: Tax return received for mortgage interest paid each year.

In the purchase example analyzed, down payment was 20% and the amount of loan borrowed was $496,000. With a 30-year fixed mortgage interest rate of 6% (with 2 discount points) monthly mortgage was $2,974. The analysis assumes a fixed 22.25% of income tax rate. Therefore, the amount of tax return is always 22.25% of the mortgage interest paid. It is obvious that as the maturity of loan grows, the net amount of tax return from mortgage interest decreases because the amount of mortgage interest paid also decreases with the duration of loan, while the amount of monthly mortgage to be paid remains constant until the loan is fully paid back.

12.14 Building Equity and Earning Money on Homes

Another argument often heard from lenders and real estate brokers is that one of the primary reasons to buy and own a family home is equity building because of appreciation in home values and thus earning money as an investment. They argue that buying a home will build equity and the buyer will earn money when the home is resold (Summers, 2005; Garton-Good, 2004). On the other hand, investment gurus like Hough (2008) and Goodman (2003) argue that investment on owner occupied homes have never been attractive enough, because the rates in which house prices increase are less than that of other investment opportunities. The vast majority of homebuyers finance the purchase with an average loan of 75% of the sales price, and the cost of a home loan normally offsets the market CD interest rate. In order to assess whether homebuyers would benefit from equity investment and make money when the property is resold, some analysis was undertaken as discussed next.

As discussed in Chapter 8, forecasts were made for CPI inflation as well as for property appreciation rates as summarized in Table 8.2. Using the data from Table 8.4 for CPI inflation and property appreciation rates, a graph was drawn to visualize the trend and to compare these two rates as shown in Figure 12.25. Then, real rate of return on investment was calculated using equation (7.10), i.e., $r = (i-f)/(1+f)$. In this equation, (f) is the CPI inflation, and (i) is the property appreciation rate. The results of the real rate of return are shown in Table 12.11. The trend of real rate of return is shown as dashed line in Figure 12.25.

Table 12.11: Real rate of return on investment

Ownership period, years	5	15	30
CPI inflation rate	2.06%	1.87%	1.66%
Property appreciation rate	2.48%	2.22%	1.93%
Real rate of return on investment	0.41%	0.34%	0.27%

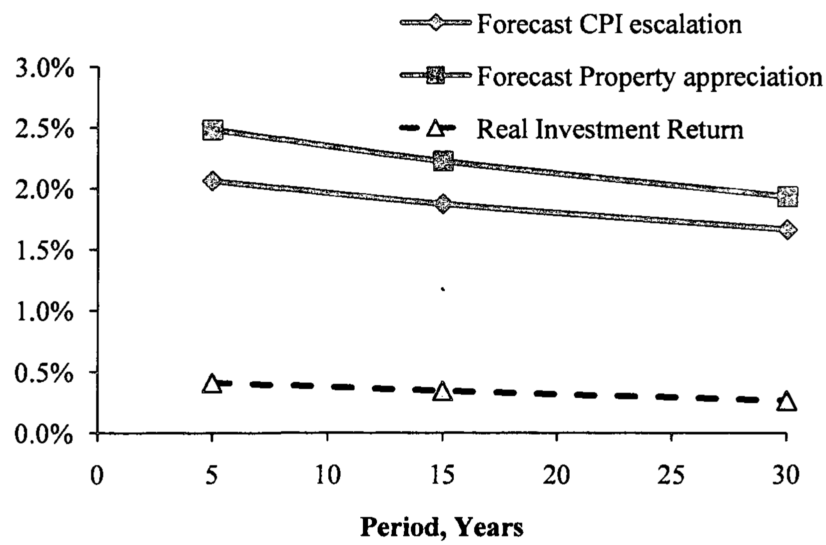

Figure 12.25: Real rate of return on investment

From the forecasting analysis, we have seen that the net return from the investment made on owner-occupied homes is less than 0.5 % per annum, which agrees with the arguments made by Hough (2008). The return on investment less than 1% point per year is considered to be rather unattractive compared to 7% or more net return from stock and other businesses in average, not withstanding capital gains tax. On the other hand, one may argue about the pride of ownership, comfort, and other social and psychological benefits of buying a house.

Buying a house is not only a search for comfort, but it is a marriage between a comfort of facility and financing a property. Therefore, an optimal solution must be sought to maximize benefits. Factors such as pride of ownership, comfort, and other social and psychological benefits cannot be directly converted into monetary terms. For some homebuyers, a house is just an ordinary good rather than an item for pride and luxury, and therefore they may not care about these parameters.

From a different perspective, one may argue that the forecast made in Chapter 8 with respect to property appreciation may not be accurate enough. Historically, an annual real rate of return on typical homes was roughly 0.75% or less, according to research by Harding el al. (2007). The same research found out that during the period of 1983 to 2001, the real price escalation averaged roughly 2.68 % per year. This considered age related depreciation of 2.5% to 3.0% per year. From this analysis, it is clear that return on investment on owner-occupied homes is not as attractive as other investment opportunities. Furthermore, the real rate of return decreases with the increased life-cycle period, as noticed in Figure 12.25.

In order to further comprehend the return on investment another purchase example was briefly analyzed, by taking a different purchase and resale case. It was assumed that a single family house was purchase in 1993 with median price of $358,000, and then sold in 2008 with median price of $620,000. It was assumed that there was no any major repair and capital improvements were implemented other than routine monthly repair and maintenance. The calculated CPI inflation for the given period was approximately 2.65%

per year. Alternative rate of investment return (CD interest) was assumed to be a moderate rate of 4%. Based on historical data, other purchase conditions were taken as shown in Table 12.12.

Table 12.12: Purchase conditions for a single-family house bought in year 1993.

S.No	Cost item	Unit	Quantity
4	Down payment (as % of sales price)	%	20
5	Nominal mortgage interest rate	%	6
6	Discount points (as % of loan amount)	%	2
7	Nominal market interest rate (CD rate)	%	4
8	Buyer's closing costs (% of sales price)	%	1.5
9	Realtor's fee (%of sales price)	%	6
11	Baseline utilities costs	$/month	152
12	Baseline maintenance & repair costs	$/month	132
14	Baseline home insurance	$/year	500
15	Annual property tax (as % of property value)	%	0.555
16	Income tax rate (as % of income)	%	22.25
19	Capital gain tax (as % of capital gain)	%	22.25

Using the computational program, the life-cycle cost EUNFME was calculated to analyze if the home-ownership was a significant return on investment. The calculated EUNFME was found to be $1,520. That means that the equal uniform net final monthly burden of home-ownership was $1,274 at the price level of 1993. At the price level of 1993 the median gross rent for single family size house was only around $700 per month. With that rental, for the same tenancy period, the equal uniform net final monthly rental expense (EUNFMR) would have been around $890.

Obviously, instead of buying a house, in this case, renting could have been economically more attractive. Furthermore, consideration of reroofing and any other capital improvement would have increased the EUNFME, making the deal even more unattractive.

12.15 Distribution of Home-ownership Major Expenses

EUNFME is made up of direct expenses/revenues and opportunity loss/gain. In the given purchase example scenario, assuming an average mortgage interest rate 6% with 2 discount points, CD interest rate of 4%, and 20% down payment, contribution of direct expenses and opportunity losses were analyzed with reference to EUNFME. The contribution was calculated by assuming EUNFME makes the 100%. This has been tabulated for 5-year, 15-year and 30-year scenarios as shown in Table 12.13.

Table 12.13: Distribution of direct and opportunity costs

Expense items	5-year ownership	15-year ownership	30-year ownership
EUNFME, (100% basis), $	3,196	3,070	3,373
Direct expenses – contribution %	82%	68%	57%
Opportunity cost - contribution %	18%	32%	43%

This analysis indicated that longer the period of home-ownership greater the contribution of opportunity costs. This is because the capital has been occupied in the home-ownership, which otherwise could have earned returns.

Similarly, another analysis was performed for the same conditions, to identify and rank the costs contributions in each phase of the home-ownership life cycle phase, i.e., acquisition phase, occupancy and ownership phase, and termination phase. The contribution was calculated by assuming EUNFME makes the 100%. Distribution of all expenses was calculated for the purchase example for 5-year, 15-year, and 30-year ownership period and tabulated as shown in Table 12.14.

Table 12.14: Distribution cost by life-cycle phase

Expense items	5-year ownership	15-year ownership	30-year ownership
EUNFME, (100% basis), $	3,196	3,070	3,373
Acquisition phase - contribution, %	+89%	+40%	+24%
Occupancy phase - contribution, %	+105%	+121%	+120%
Termination phase - contribution, %	-94%	-61%	- 44%

In Table 12.14, negative contribution during termination phase indicates revenue generated. This analysis shows that as the ownership period is kept longer, the revenue after resale becomes thinner, mainly because of the constant inflation due to time value of money, and thus present work becoming smaller. Similarly, the present worth of acquisition phase expenses keep dwindling as the ownership period is extended, mainly due to the same reason.

Table 12.14 indicated that the heavy weight of expenses is located in the occupancy phase; this is mainly because of the monthly mortgage, and many other expenses such as utilities, repair and maintenance, home insurance and property tax falling under this category. When loan is a significant portion of the home-purchase price, the occupancy phase expenses will become a significant burden to homeowner, especially when down payment paid is a least amount such as 20% or below. This is often undermined and could cause payment defaults and foreclosures in time of economic distress. From Table 12.14, it is clear that although mortgage payment is the largest contributor in the occupancy cost, the burden of other items is not negligible.

12.16 Renting Severity Index (RSI)

The RSI indicates the fraction of income to be dedicated for rental expenses. For example if RSI is 0.25, only 25% of the income has to be allocated for rental expenses. Results of RSI were obtained in Chapter 11 (see Table 11.35, 11.36, and 11.37). Those results are shown graphically in Figures 12.26, 12.27, and 12.28 below. The smaller the RSI index, the better is the deal for renters. The data indicated that the rental severity index for a baseline monthly rental of $1,500 was in the range of 0.27 to 0.28, with the average RSI of 0.2857. Similarly, the RSI for a baseline monthly rental of $1,800 was in the range of 0.33 to 0.34 averaging at 0.3356.

For a baseline monthly rental of $2,100 the RSI ranged between 0.38 and 0.39, with the average of 0.3852. Using the average RSI of three different baseline monthly rentals of $1,500, $1,800, and $2,100 a histogram was drawn as shown in Figure 12.29.

Table 12.15: Percentage distribution of all expenses

Expense items	5-year ownership	15-year ownership	30-year ownership
EUNFME, $	3,196	3,070	3,373
Acquisition Phase			
Down payment	76%	34%	20%
Closing Costs	6%	3%	2%
Points	6%	3%	2%
Subtotal: Acquisition Phase	88%	39%	24%
Occupancy Phase			
Mortgage Expenses	95%	104%	101%
Utilities	7%	8%	7%
R&M	5%	5%	4%
Excess gasoline	2%	2%	2%
Home insurance	4%	4%	4%
Property tax	9%	10%	9%
Tax return from discount points	-1%	0%	0%
Tax return from mortgage interest	-16%	-14%	-10%
Tax return from property tax	-2%	-2%	-2%
Reroofing	0%	2%	1%
Repainting	2%	2%	2%
Subtotal: Occupancy Phase	105%	120%	119%
Termination phase			
Salvage Value (Resale Price)	-323%	-109%	-46%
Seller's Closing Costs (1%)	19%	7%	3%
Capital Gain Tax	0%	0%	0%
Remaining loan to be paid	211%	44%	0%
Subtotal: Termination Phase	-92%	-58%	-43%
Grand total	100%	100%	100%

This analysis indicated that the higher the rental period, the more attractive was rental option. For example, when CD rate was 2% and the rental period was considered 30 years, in Figure 12.26, only 37.5% of the income had to be allocated for rental expenses. The histogram indicated that higher the rentals, the greater are the RSI, which means larger fraction of income had to be allocated to cover the rental expenses.

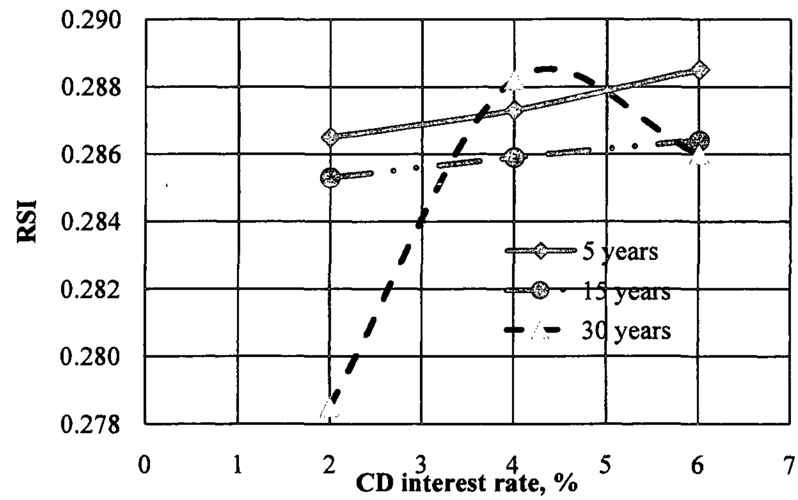

Figure 12.26: Rental severity index for baseline monthly rental $1,500.

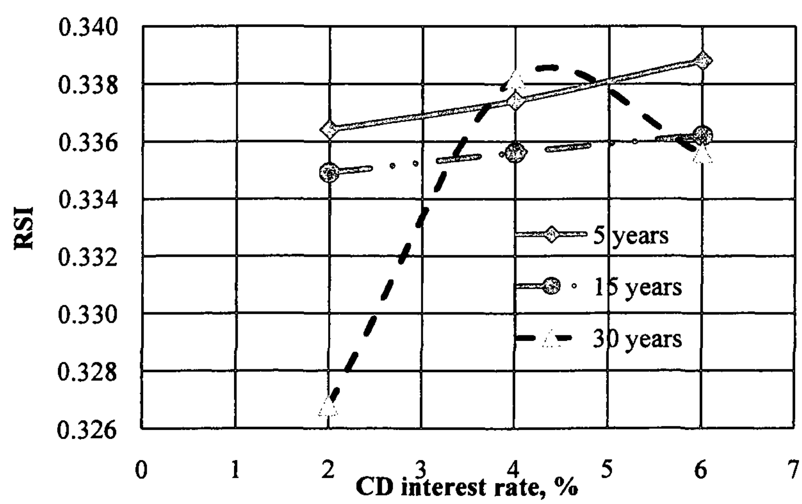

Figure 12.27: Rental severity index for baseline monthly rental $1,800.

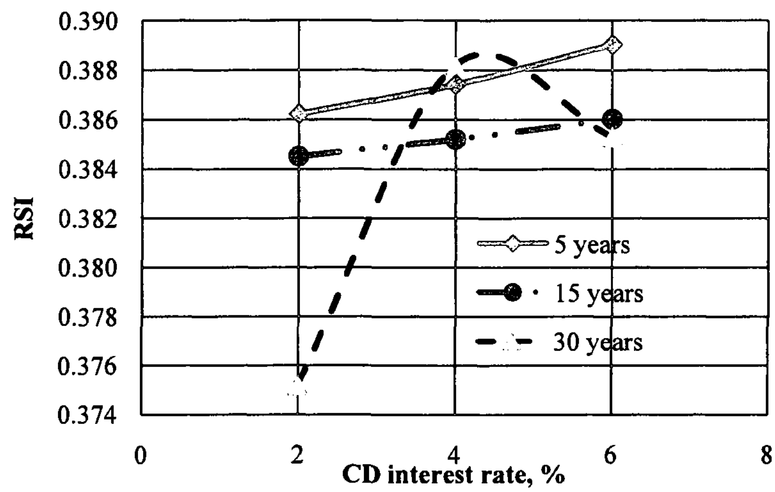

Figure 12.28: Rental severity index for baseline monthly rental $2,100.

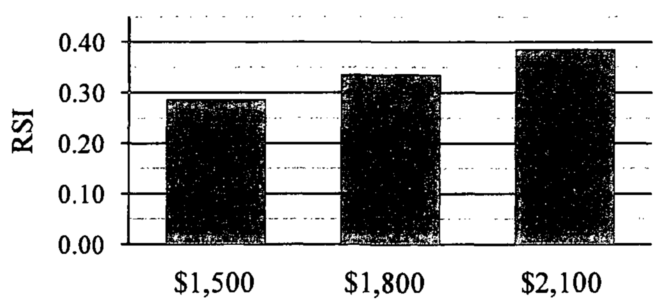

Figure 12.29: Average rental severity index for median family income of $93,600

12.17 Buying versus Renting

In order to compare between the benefits of buying and renting, an analysis was performed comparing buying versus renting ratio (BRR). In Chapter 11, BRR was calculated for 81 different buying options comparing with three different rental options (see Tables 11.35, 11.36 and 11.37). In these tables, when the BRR index is less than 1.00, it was economical to buy a property with the given conditions as shown in the left hand side and in the header of the table. When the index is 1, both options are equally attractive. Similarly, when the index is greater than 1, renting is a better option.

For example, under baseline monthly rental cost of $1,500, there were only six out of eighty one scenarios in which buying outweighed the renting option, all with 100% down payment, 2% CD rate and for 15 and 30 years of ownership period. However, the buying option became more attractive as the baseline renting was increased to $1,800. In this case, in 14 out of 81 scenarios analyzed, buying outweighed the renting option, again all with 2% CD rate. In the similar manner when baseline monthly rental rate was further increased to $2,100 the buying alternative became even more attractive; with buying outweighing the renting option in 21 of 84 purchase scenarios.

Life-cycle cost analysis of the purchase example indicated that under most cases analyzed renting a house could be economically more rewarding than buying a house. Therefore, there is no universal answer to the question of choice between buying versus renting. Options must be evaluated on a case-by-case basis.

12.18 Application of the Model for Refinancing and Reverse Mortgage

Although the analysis of refinancing and reverse mortgage aspects of the home-ownership was beyond the scope and objective of the current research, the homeownership life-cycle cost analysis model developed in this research could be a useful tool in analyzing refinancing and reverse mortgages as well. In the case of the refinancing, it has to be assumed that the home ownership life cycle be terminated at the time of refinance, and reinstate the ownership upon refinancing. Therefore analysis must be done in the basis that a new life-cycle of home ownership starts at the point in time of refinancing. All the expenses incurred during the refinancing process could be considered as purchasing costs. Then operation and maintenance, and termination costs/revenues should be considered as usual.

In the case of the reverse mortgage, the direction of mortgage payment is reversed. Therefore cost accounting has to be done accordingly to reflect the incoming and outgoing funds in the cash flow analysis. It has to be noted that in the reverse mortgage the equity on house will be keep reducing as the maturity of reverse mortgage grows. Therefore these aspects could easily be adjusted and in the proposed model. However, it is very important that all the cash flows are correctly represented while using the model in analyzing these aspects.

CHAPTER 13: CONCLUSIONS

This research presented a new methodology for analyzing life-cycle cost of home-buying, a model that was not developed elsewhere, in its entirety. This methodology analyzes the committed life-cycle cost of home-ownership considering present and future expenses and evaluating the various influential parameters. The proposed model is built upon well-established fundamentals of engineering economics, cost engineering, cost forecasting, cost accounting, and the underlying basic concepts of life-cycle cost analysis. So, what makes this methodology different from other models of life-cycle cost analysis?

First of all, the current model has itemized and estimated what are the possible cradle-to-grave expense and revenue items in the case of a home purchase. It has shown how these costs and revenues may occur within the life-cycle period of home-ownership.

Second, this model has integrated cost forecasting as an important step in the life-cycle cost analysis process. This is very important because life-cycle costs involve future expenses/revenues and forecasting is the only way to identify and quantify any such costs in real-time. Life-cycle costs analysis done without forecasting the future activities will be far from the reality. The life-cycle cost analysis model developed in this research has demonstrated how cost forecasting can practically be integrated into the life-cycle analysis process. No other models have shown such process with application in home-ownership life-cycle cost analysis.

Third, this model takes into account the opportunity gain and loss, considering time value of money. The life-cycle costs involves the future expenses that their opportunity loss or gain must be accounted for as they happened in real time.

Fourth, the illustration of the purchase example with the application of Excel and Matlab program has demonstrated that life-cycle cost analysis can be performed efficiently to evaluate each and every home-buying case if there were reliable computer programs. The computer programs developed as part of this research may be further improved to be made more efficient, but the results obtained thus far were reliable enough and it is an added benefit for common homebuyers.

Finally, buying a house is a marriage between comfort of facility and financing in a property, and optimal solution must be researched between the facility and the financing. This life-cycle cost analysis model shows that a homebuyer would be able to explore conditions that can be optimized to maximize economic benefits of home-ownership without compromising the comfort of home-ownership. For example, even if a buyer has enough cash to pay 100% down payment, he or she may not opt to do so if it is economically more rewarding otherwise. Therefore this model can serve as a comprehensive economic decision making tool for prospective homebuyers.

From the analysis of the purchase example, involving median price and other conditions, the following conclusions can be drawn as findings of this research:

1. Buying a home is a marriage between comfort of a facility and investment. To optimize the economic benefits, homebuyers should explore the purchase conditions and find the one that minimizes the life-cycle cost, namely the equal uniform net final monthly expenses (EUNFME).
2. Mortgage and CD interest rates proportionally and linearly contribute to the home-ownership life-cycle costs. Therefore, in order to offset the opportunity loss and to maximize the attractiveness of home buying, one must seek purchase conditions such that when both CD interest rate (i.e. alternative investment rate of return) and mortgage interest rate are at the lowest possible level in the market. The low CD rates reduce the cost of lost opportunity, while the low mortgage rates reduce the mortgage payments. Both of these are large components.
3. When a homebuyer, as a mortgage borrower is able to select from various combinations of mortgage rate and discount points, optimization analysis must be done on a case-by-case basis to decide what combination makes the best deal. Obviously, the lowest possible mortgage rate, combined with lowest possible points would minimize the cost of the borrowing. Analysis of the purchase example demonstrated that the lowest possible mortgage rates combined with the larger discount point were found to be economically more attractive than higher mortgage rates combined with negative discount points within a normal range of mortgage rates, i.e., 3% to 8%.
4. The sensitivity analysis showed that the CPI inflation rate influences the EUNFME linearly. The higher the inflation rate, the lower the amount of EUNFME, and vice

versa. This is because the present value of future costs is minimized when inflation rate is high, and vice versa. On the other hand, inflation, whether high or low, has consistently same effect on all expenses regardless of the type and nature of cost items. Therefore, change in inflation rates, will not reverse decisions based on minimized EUNFME.

5. Although paying maximum down payment might appear to be less burdensome to a homebuyer, it may not always be the best investment option from an economic perspective when the time value of money is considered. It would be economically more rewarding to pay the least possible down payment when CD interest rates are at the highest end and the mortgage interest rates are at the lowest range. Thus, opportunity losses are minimized. Contrary to this, it would be more attractive to pay the highest possible down payment when mortgage rates are at the highest range, whereas CD rates are at the lowest end and lesser than mortgage rates.
6. Optimal down payment size may vary depending upon ownership period, mortgage, and CD interest rates. There exists a breakeven EUNFME at certain combinations of mortgage and CD rates and ownership period when any size of down payment would be equally worthwhile.
7. One of the obvious attractions of paying the maximum possible down payment was the reduction in operational MSI. Paying maximum down payment reduces the operational MSI substantially, because the burden of mortgage reduces proportionally to the size of down payment. Thus paying maximum down payment makes more affordable even when there are reductions in anticipated income.

8. There exists a set of conditions that yields optimal duration of ownership period when EUNFME is at the lowest. In the given purchase example, for median prices, optimal ownership period was observed to be 10 years when 20% was the down payment, 4% was the CD interest rate, irrespective of mortgage rates. Whereas for other conditions, longer periods such as 25 years or more was found to be economically attractive. However, analysis must be done on a case-by-case basis to find out the optimal ownership period. In most situations, the longer the ownership period, the more attractive was the life-cycle cost of home ownership.
9. Sensitivity analysis of the example indicated that the lowest possible mortgage rate when combined with reasonable discount points would always be economically attractive than high mortgage rates or even negative discount points. Since, variety of combination would be possible in the market, a quick sensitivity analysis or optimization would always be helpful in deciding the set of best mortgage rate and discount points. In the purchase example 4% mortgage rate in combination with 5.0 discount points was more attractive than that of 5% combined with 3.5 discount points from a borrower's perspective. However, the decision could be reversed if the CD interest rate is very high, 8% or above.
10. Mortgage severity analysis indicated that ownership MSI and EUNFME are directly proportional, and therefore minimizing the EUNFME will obviously lower the severity of ownership obligations. Out of 81 different buying options, only six options were found to be within the recommended range of affordability when it was evaluated based on the ownership MSI.

11. The lenders and real estate brokers may over-emphasize the tax benefits that one may receive on mortgage interest paid to attract homebuyers. It is often said that what is paid in mortgage interest is returned as tax benefit. The purchase example analysis indicated that the tax return is only about 1/5 of the mortgage interest paid based on the prevailing income tax rates in the case of Hawai'i, i.e., 22.25%. The amount of tax return keeps dwindling as the loan maturity increases. Therefore, the return benefits are small; that the tax benefit is consequential for homebuyers is overstated.
12. Another argument often heard from lenders and real estate brokers is that no matter what the economic situation, buying a house is a good, safe investment with returns. The analysis of the purchase example indicated that from a purely economic point of view, the real return from owner-occupied homes are less than 0.5 % points annual after discounting for inflation. This is significantly lower than many other investment alternatives.
13. Life-cycle cost analysis indicated that, in many situations, renting a house proved to be economically more rewarding than buying a house, provided that access funds are invested at CD rates. Therefore, there is no universal answer to the question of buying versus renting. Options must be evaluated on a case-to-case basis. Normally, buying a house becomes attractive as long as the mortgage rate and alternative investment rate (CD rate) are low in the market. In contrast, when these rates are at the higher end, it was noticed to be more economical to rent a house.

These conclusions convey that the economics of home buying is more complex than hitherto known to the majority of homebuyers. The ability of lenders real estate brokers to easily convince homebuyers has been another source of disappointment to many homebuyers. It was seen that the HAI adopted by realtors is far more liberal than reality. This translates to payment defaults and foreclosures in time of economic distress.

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APPENDIX A: EXCEL PROGRAM

Appendix A: Worksheet Table of Content

SUMMARY SHEET: Ownership Period 15 Years

INPUT DATA

Purchase Condition		
Items	Unit	Amount
Sale Price	$	620,000
Down Payment		
% of Sales Price	%	20%
Down Payment	$	124,000
Loan		
Loan Amount	$	496,000
Annual Mortgage Interest Rate	%	6.00%
Payback period (n_1)	Year	30
Points		
% of Loan Amount	%	2.00%
Points Amount	$	9,920
Buyer's Closing Costs		
% of Sales Price	%	1.50%
Closing Costs, amount	$	9,300
Ownership starting year		2009
Ownership period (n_2)	year	15
Seller's Closing Costs		
Advertisement Cost	$	0
Realtor's Fee as % of Sales Price	%	5%
Other closing cost if any as % of SP	%	1%
Income Tax Rates		22.25%
Federal	%	15%
State of Hawaii	%	7.25%
Capital Gain Tax Rates		22.25%
Federal	%	15%
State of Hawaii	%	7.25%

Economic Variables			
Items	Unit	Amount	Recommended values
Annual CPI Inflation Rate	%	1.87%	1.870%
Market Interest Rate (CD rate)	%	4.00%	10.000%
Cost Escalation Rates:			
Property Tax	%	0.00%	0.000%
Maintenance Costs and Fees	%	1.52%	1.523%
Utilities (electricity, water, gas)	%	2.22%	2.215%
House Insurance	%	3.90%	3.899%
Gasoline	%	3.39%	3.391%
Property Value Appreciation Rate	%	2.3400%	2.342%
Baseline Monthly Expenses:			
Maintenance Fee (Condo only)	$	0	0
Repair and Maintenance Cost	$	150	
Utilities (electricity, water, gas)	$	220	
Gasoline	$	50	
Baseline Annual Expenses			
Property Tax Rate, Honolulu County	$	0.555%	
Home Insurance	$	1337	
Reroofing - Baseline Cost	$/sft	10,000	
Repainting - Baseline Cost	$/sft	4,500	
Rental Option			
Monthly Rental Expense	$	2500	
Annual Rental Escalation Rate	%	1.89%	1.89%
Utilities (electricity, water gas)	$	220	
Median Family Income			
Median Family Income	$	83,413	83413
Annual Increment of Income	%	1.99%	1.99%

Output Data		
Equal Uniform Ownership Monthly Expenses:		
Monthly Mortgage (Actual $):	$	2,974
Other expenses	$	481
Monthly Operational Expenses (EUNFMOE)		3,670
Revenue on Resale after 30 years		
PV of Total Incoming Funds (After Resale)	$	(549,252)
Equal Uniform Monthly Net Return	$	(1,795)
Upon Resale		
Equal Uniform Total Monthly Expenses	$	6,921
Equal Unifiorm Total Monthly Return	$	(3,851)
Equal Uniform Net Final Monthly Expenses (EUNFME)	$	3,070
Buying Vs Renting		
Buying: Eual Uniform Net Final Monthly Expenses (EUNFME)	$	3,070
Renting: Equal Uniform Monthly Rental Expenses (EUMRE)	$	2,795
Buying/Renting Ratio : EUNFME/EUMRE		1.10
Equal Uniform Monthly Income (EUMI)	$	5,504
Mortgage Severity Index (MSI)		
Ownership MSI: EUNFME / EUMI		0.56
Operational MSI: EUNFMOE / EUMI		0.67

Summary Sheet: Homebuying Expenses

Ownership period: 15 years

(F/P, e%, n) → [4]; (P/F, i'_a%, n) → [5]; (A/P, i'_a%, n) → [7]; (A/P, i'_a%, n) → [8]; EUME

	Cash Flow Items	Occurance	Baseline Expenses, $	Cost Escalation (e%)	Future Worth, Actual $	Equivalent PW, $	Opportunity Loss (Gain), PW $	Expenses (Revenues)	Opportunity Loss (Gain)	Total
	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
	Acquisition Phase					FW (F/P, i_a%, n)				
A	Down payment	Once	124,000		73,959	124,000	46,312	753	281	1,034
B	Closing Costs	Once	9,300		5,547	9,300	3,473	56	21	78
C	Points	Once	9,920		5,917	9,920	3,705	60	23	83
	Acquisition Phase Subtotal		143,220		85,423	143,220	53,490	870	325	1,195
	Occupancy & Ownership Phase									
D	Mortgage Expenses	Monthly	2,974		683,382	535,279	92,807	2,625	564	3,189
E	Utilities	Monthly	220	2.22%	47,943	30,328	7,728	184	47	231
F	R&M	Monthly	150	1.52%	30,760	19,458	5,055	118	31	149
T	Maintenance fee (condo only)	Monthly	0	1.52%	0	0	0	0	0	0
G	Excess gasoline	Monthly	60	3.39%	14,489	9,166	2,260	56	14	69
H	Home insurance	Six-Monthly	695	3.90%	27,610	17,466	4,442	106	27	133
I	Property tax	Yearly	3,441	0.00%	62,417	38,914	9,329	238	57	296
J	Tax return from discount points	Once	(2,207)		(3,487)	(1,396)	(802)	(8)	(5)	(13)
K	Tax return from mortgage interest	Yearly	(6,585)		(113,084)	(55,129)	(16,406)	(335)	(100)	(434)
L	Tax return from property tax	Yearly	0		(17,561)	(8,785)	(2,302)	(53)	(14)	(67)
M	Reroofing	Every 15 years	10,000	1.5%	12,539	7,932	0	48	0	48
N	Repainting	Every 5 years	4,500	1.5%	15,728	9,806	1,666	60	10	70
	Occupancy Phase Subtotal		13,247		760,737	603,038	103,777	3,040	631	3,670
	Termination phase									
O1	Salvage Value (Resale Price)	Once	(620,000)	2.34%	(877,148)	(549,252)	0	(3,336)	0	(3,336)
O2	Seller's Closing Costs	Once	6,200	1.00%	52,629	32,955	0	200	0	200
O3	Capital Gain Tax	Once	0	22.25%	0	0	0	0	0	0
O4	Remaining loan to be paid	Once			352,402	220,667	0	1,340	0	1,340
	Termination Phase Subtotal		(613,800)		(472,117)	(295,630)	0	(1,795)	0	(1,795)
	Grand total					**450,629**	**157,267**	**2,114**	**956**	**3,070**

Equal Uniform Total Monthly Expenses	**5,846**	**1,074**	**6,921**
Equal Uniform Total Monthly Return	**(3,732)**	**(118)**	**(3,851)**
Equal Uniform Net Final Monthly Expenses	**2,114**	**956**	**3,070**

Summary Sheet: Rental Expenses

(F/P, e%, n) (P/F, i_a%, n) (A/P, i'_a%, n) (A/P, i'_a%, n) EUME

	Cash Flow Items	Occurance	Baseline Expenses, $	Cost Escalation (e%)	Future Worth, Actual $	Equivalent PW, $	Opportunity Loss (Gain), PW $	Expenses	Opportunity Loss (Gain)	Total
	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
Q	Monthly Rental	Monthly	2,500	1.89%	529,383	334,881	87,201	2,034	530	2,563
R	Utilities	Monthly	220	2.22%	47,943	30,328	7,728	184	47	231
	Grand total				577,326	365,209	94,929	2,218	577	2,795

Equal Uniform Net Final Monthly Rental Expenses	**2,218**	**577**	**2,795**

Summary Sheet: Family Income

$(F/P, e\%, n)$ $(P/F, i_a\%, n)$ $(A/P, i'_a\%, n)$ $(A/P, i'_a\%, n)$ EUMI

	Cash Flow Items	Occurance	First Year, Annual Income, $	Increase in income (e%)	Last Year, Annual Income, $	Equivalent PW, of all years, $	Opportunity Loss (Gain), PW $	Income	Opportunity Loss (Gain)	Total
	[0]	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]
S	Monthly Rental	Monthly	83,413	1.99%	112,098	982,022	0	5,504	0	5,504
	Grand total				112,098	982,022	0	5,504	0	5,504

Equal Uniform Monthly Income (EUMI)	**5,504**	**0**	**5,504**

Sheet A: Opportunity Loss for Down Payment

Original Down Payment (DP) Amount	124,000
EUME of Down Payment [PW(A/P, i'a%, n)]	753

Opportunity Loss		
FW, Actual $, Last Row of [7]	**PW**	**EUME**
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
73,959	**46,312**	**281**

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.16%
Nominal CD Interest Rate (i)	4.00%	0.33%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.17%	3.12%	0.26%
Real Interest Rate (i'_a)	-	1.23%	0.10%

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Year	BOY Running Capital	FVn of Running Capital for Year n	Taxable Interest from Running Capital	Income Tax	Interest Lost	Cumulative Lost Interst	EOY Running Capital	EOY Running Capital	After Tax "Adjusted" Effective Annual Rate of Return
	$[8]_{n-1}$	[2] x (F/P, i%, n)	[3]-[2]	[ITX] x [4]	[4]-[5]		[2]+[6]	[3]-[5]	{[9]-[2]}/[2]
0							0	0	
1	124,000	129,052	5,052	1,124	3,928	3,928	127,928	127,928	3.17%
2	127,928	133,140	5,212	1,160	4,052	7,980	131,980	131,980	3.17%
3	131,980	137,357	5,377	1,196	4,181	12,161	136,161	136,161	3.17%
4	136,161	141,708	5,547	1,234	4,313	16,474	140,474	140,474	3.17%
5	140,474	146,197	5,723	1,273	4,450	20,924	144,924	144,924	3.17%
6	144,924	150,828	5,904	1,314	4,591	25,514	149,514	149,514	3.17%
7	149,514	155,606	6,091	1,355	4,736	30,251	154,251	154,251	3.17%
8	154,251	160,535	6,284	1,398	4,886	35,137	159,137	159,137	3.17%
9	159,137	165,620	6,483	1,443	5,041	40,178	164,178	164,178	3.17%
10	164,178	170,866	6,689	1,488	5,201	45,378	169,378	169,378	3.17%
11	169,378	176,279	6,901	1,535	5,365	50,743	174,743	174,743	3.17%
12	174,743	181,863	7,119	1,584	5,535	56,279	180,279	180,279	3.17%
13	180,279	187,624	7,345	1,634	5,711	61,989	185,989	185,989	3.17%
14	185,989	193,567	7,577	1,686	5,891	67,881	191,881	191,881	3.17%
15	191,881	199,698	7,818	1,739	6,078	73,959	197,959	197,959	3.17%

Sheet B: Opportunity Loss for Closing Costs

Original Closing Costs (DP) Amount	9,300
EUME of Clsoing Costs [PW(A/P, i'a%, n)]	56

Opportunity Loss		
FW, Actual $, Last Row of [7]	**PW**	**EUME**
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
5,547	**3,473**	**21**

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.16%
Nominal CD Interest Rate (i)	4.00%	0.33%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.17%	3.12%	0.26%
Real Interest Rate (i'_a)	-	1.23%	0.10%

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Year	BOY Running Capital	FVn of Running Capital for Year n	Taxable Interest from Running Capital	Income Tax	Interest Lost	Cumulative Lost Interst	EOY Running Capital	EOY Running Capital	After Tax "Adjusted" Effective Annual Rate of Return
		[2] x (F/P, i%, n)	[3]-[2]	[ITX] x [4]	[4]-[5]		[2]+[6]	[3]-[5]	{[9]-[2]}/[2]
0							0	0	
1	9,300	9,679	379	84	295	295	9,595	9,595	3.17%
2	9,595	9,985	391	87	304	599	9,899	9,899	3.17%
3	9,899	10,302	403	90	314	912	10,212	10,212	3.17%
4	10,212	10,628	416	93	323	1,236	10,536	10,536	3.17%
5	10,536	10,965	429	96	334	1,569	10,869	10,869	3.17%
6	10,869	11,312	443	99	344	1,914	11,214	11,214	3.17%
7	11,214	11,670	457	102	355	2,269	11,569	11,569	3.17%
8	11,569	12,040	471	105	366	2,635	11,935	11,935	3.17%
9	11,935	12,422	486	108	378	3,013	12,313	12,313	3.17%
10	12,313	12,815	502	112	390	3,403	12,703	12,703	3.17%
11	12,703	13,221	518	115	402	3,806	13,106	13,106	3.17%
12	13,106	13,640	534	119	415	4,221	13,521	13,521	3.17%
13	13,521	14,072	551	123	428	4,649	13,949	13,949	3.17%
14	13,949	14,518	568	126	442	5,091	14,391	14,391	3.17%
15	14,391	14,977	586	130	456	5,547	14,847	14,847	3.17%

Sheet C: Opportunity Loss for Discount Points

Original Discount Points (DPts) Amount	9,920
EUME of Discount Points [PW(A/P, i'a%, n)]	60

Opportunity Loss		
FW, Actual $, Last Row of [7]	**PW**	**EUME**
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
5,917	**3,705**	**23**

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.16%
Nominal CD Interest Rate (i)	4.00%	0.33%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.17%	3.12%	0.26%
Real Interest Rate (i'_a)	-	1.23%	0.10%

[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Year	BOY Running Capital	FVn of Running Capital for Year n	Taxable Interest from Running Capital	Income Tax	Interest Lost	Cumulative Lost Interst	EOY Running Capital	EOY Running Capital	After Tax "Adjusted" Effective Annual Rate of Return
		[2] x (F/P, i%, n)	[3]-[2]	[ITX] x [4]	[4]-[5]		[2]+[6]	[3]-[5]	{[9]-[2]}/[2]
0							0	0	
1	9,920	10,324	404	90	314	314	10,234	10,234	3.17%
2	10,234	10,651	417	93	324	638	10,558	10,558	3.17%
3	10,558	10,989	430	96	334	973	10,893	10,893	3.17%
4	10,893	11,337	444	99	345	1,318	11,238	11,238	3.17%
5	11,238	11,696	458	102	356	1,674	11,594	11,594	3.17%
6	11,594	12,066	472	105	367	2,041	11,961	11,961	3.17%
7	11,961	12,448	487	108	379	2,420	12,340	12,340	3.17%
8	12,340	12,843	503	112	391	2,811	12,731	12,731	3.17%
9	12,731	13,250	519	115	403	3,214	13,134	13,134	3.17%
10	13,134	13,669	535	119	416	3,630	13,550	13,550	3.17%
11	13,550	14,102	552	123	429	4,059	13,979	13,979	3.17%
12	13,979	14,549	570	127	443	4,502	14,422	14,422	3.17%
13	14,422	15,010	588	131	457	4,959	14,879	14,879	3.17%
14	14,879	15,485	606	135	471	5,430	15,350	15,350	3.17%
15	15,350	15,976	625	139	486	5,917	15,837	15,837	3.17%

Sheet D: Opportunity Loss for Mortgage

Original Loan Amount (P)	496,000
Monthly Mortgage	2,974
Equivalent Present Worth	432,298
EUME	2,625

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
148,103	92,807	564

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rat	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.17%	0.10%

[1]	[2]
Year	Monthly Mortgage Payment, Actual $
0	NA
1	2,974
2	2,974
3	2,974
4	2,974
5	2,974
6	2,974
7	2,974
8	2,974
9	2,974
10	2,974
11	2,974
12	2,974
13	2,974
14	2,974
15	2,974

[3]	[4]	[5]
Without Opportunity Loss, Actual $		
BOY	During the Year	Future Worth, EOY
$[5]_{n-1}$	12 x [2]	[3]+[4]
0		0
0	35,685	35,685
35685	35,685	71,370
71370	35,685	107,056
107056	35,685	142,741
142741	35,685	178,426
178426	35,685	214,111
214111	35,685	249,797
249797	35,685	285,482
285482	35,685	321,167
321167	35,685	356,852
356852	35,685	392,538
392538	35,685	428,223
428223	35,685	463,908
463908	35,685	499,593
499593	35,685	535,279

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Year	With Opportunity Loss at CD Interest Rate, Actual $													
	BOY Running Capital	Mortgage	FVn of Monthly Mortgage for Year n	FVn of Running Capital for Year n	Mortgage w/o Interest	Running Capital w/o Interest	Interest from Current Year's Mortgage	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	2,974	36,468	0	35,685	0	783	0	783	174	609	609	36,294	36,294
2	36,294	2,974	36,468	37,772	35,685	36,294	783	1,479	2,261	503	1,758	2,367	73,737	73,737
3	73,737	2,974	36,468	76,741	35,685	73,737	783	3,004	3,787	843	2,944	5,311	112,367	112,367
4	112,367	2,974	36,468	116,945	35,685	112,367	783	4,578	5,361	1,193	4,168	9,479	152,220	152,220
5	152,220	2,974	36,468	158,422	35,685	152,220	783	6,202	6,984	1,554	5,430	14,909	193,336	193,336
6	193,336	2,974	36,468	201,212	35,685	193,336	783	7,877	8,660	1,927	6,733	21,642	235,754	235,754
7	235,754	2,974	36,468	245,359	35,685	235,754	783	9,605	10,388	2,311	8,076	29,719	279,515	279,515
8	279,515	2,974	36,468	290,903	35,685	279,515	783	11,388	12,171	2,708	9,463	39,181	324,663	324,663
9	324,663	2,974	36,468	337,890	35,685	324,663	783	13,227	14,010	3,117	10,893	50,074	371,241	371,241
10	371,241	2,974	36,468	386,366	35,685	371,241	783	15,125	15,908	3,539	12,368	62,442	419,295	419,295
11	419,295	2,974	36,468	436,377	35,685	419,295	783	17,083	17,865	3,975	13,890	76,333	468,870	468,870
12	468,870	2,974	36,468	487,973	35,685	468,870	783	19,102	19,885	4,424	15,461	91,793	520,016	520,016
13	520,016	2,974	36,468	541,203	35,685	520,016	783	21,186	21,969	4,888	17,081	108,874	572,782	572,782
14	572,782	2,974	36,468	596,118	35,685	572,782	783	23,336	24,119	5,366	18,752	127,626	627,220	627,220
15	627,220	2,974	36,468	652,774	35,685	627,220	783	25,554	26,337	5,860	20,477	148,103	683,382	683,382

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [23] = [24]			3.122452%
[7]x(F/P, i_t%, n)	[8]x(F/A, i_t%, n)	[21]+[22]	[20]
-	36,295	36,295	36,294
37,443	36,295	73,738	73,737
76,073	36,295	112,368	112,367
115,928	36,295	152,221	152,220
157,042	36,295	193,338	193,336
199,460	36,295	235,754	235,754
243,221	36,295	279,516	279,515
288,369	36,295	324,664	324,663
334,947	36,295	371,242	371,241
383,000	36,295	419,295	419,295
432,576	36,295	468,871	468,870
483,722	36,295	520,016	520,016
536,488	36,295	572,783	572,782
590,925	36,295	627,220	627,220
647,087	36,295	683,382	683,382

Sheet E: Opportunity Loss for Utility Expenses

Baseline Monthly Utility Expenses	220
Annual Cost Escalation Rate	2.2200000%
Equivalent Present Worth	30,328
EUME	184

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
12,332	7,728	47

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.17%	0.10%

[1]	[2]
Year	Monthly Utility Expenses, Actual $
0	220
1	227
2	232
3	238
4	243
5	248
6	254
7	259
8	265
9	271
10	277
11	283
12	289
13	296
14	302
15	309
16	

[3]	[4]	[5]
Without Opportunity Loss, Actual $		
BOY	During the Year	Future Worth, EOY
$[5]_{n-1}$	12 x [2]	[3]+[4]
0		0
0	2,729	2,729
2729	2,789	5,518
5518	2,851	8,369
8369	2,914	11,283
11283	2,979	14,262
14262	3,045	17,307
17307	3,113	20,420
20420	3,182	23,602
23602	3,253	26,855
26855	3,325	30,179
30179	3,399	33,578
33578	3,474	37,052
37052	3,551	40,603
40603	3,630	44,233
44233	3,711	47,943

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Year	With Opportunity Loss at CD Interest Rate, Actual $													
	BOY Running Capital	Monthly Expenses	FVn of Monthly Expenses for Year n	FVn of Running Capital for Year n	Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	(ITX)x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	227	2,779	0	2,729	0	51	0	51	11	39	39	2,768	2,768
2	2,768	232	2,841	2,881	2,789	2,768	52	113	164	37	128	167	5,685	5,685
3	5,685	238	2,904	5,917	2,851	5,685	53	232	284	63	221	388	8,757	8,757
4	8,757	243	2,968	9,114	2,914	8,757	54	357	411	91	319	708	11,991	11,991
5	11,991	248	3,034	12,479	2,979	11,991	55	489	544	121	423	1,131	15,393	15,393
6	15,393	254	3,102	16,020	3,045	15,393	56	627	684	152	531	1,662	18,969	18,969
7	18,969	259	3,170	19,742	3,113	18,969	58	773	831	185	646	2,308	22,728	22,728
8	22,728	265	3,241	23,654	3,182	22,728	59	926	985	219	766	3,074	26,676	26,676
9	26,676	271	3,313	27,762	3,253	26,676	60	1,087	1,147	255	892	3,965	30,820	30,820
10	30,820	277	3,386	32,076	3,325	30,820	62	1,256	1,317	293	1,024	4,990	35,169	35,169
11	35,169	283	3,462	36,602	3,399	35,169	63	1,433	1,496	333	1,163	6,153	39,730	39,730
12	39,730	289	3,538	41,349	3,474	39,730	64	1,619	1,683	374	1,309	7,461	44,513	44,513
13	44,513	296	3,617	46,327	3,551	44,513	66	1,814	1,878	416	1,461	8,922	49,525	49,525
14	49,525	302	3,697	51,543	3,630	49,525	67	2,018	2,085	464	1,621	10,544	54,776	54,776
15	54,776	309	3,779	57,008	3,711	54,776	69	2,232	2,300	512	1,789	12,332	60,276	60,276

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [23] = [24]			3.12243%
[7]x(F/P, i_t%, n)	[8]x(F/A, i_t%, n)	[21]+[22]	[20]
-	2,768	2,768	2,768
2,856	2,829	5,685	5,685
5,865	2,892	8,757	8,757
9,035	2,956	11,991	11,991
12,371	3,022	15,393	15,393
15,880	3,089	18,969	18,969
19,570	3,158	22,728	22,728
23,448	3,228	26,676	26,676
27,521	3,299	30,820	30,820
31,796	3,373	35,169	35,169
36,283	3,448	39,731	39,730
40,989	3,524	44,513	44,513
45,923	3,602	49,525	49,525
51,094	3,682	54,776	54,776
56,511	3,764	60,276	#

Sheet F: Opportunity Loss for Monthly Repair and Maintenance Expenses

Baseline Monthly R & M Expenses	150
Annual Cost Escalation Rate	1.52%
Equivalent Present Worth	19,458
EUME	118

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_s%, n)	PW (A/P, i'_s%, n)
8,067	5,055	31

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_s)	3.10%	3.06%	0.26%
Real Interest Rate (i'_s)	-	1.17%	0.10%

[1]	[2]
Year	Monthly R & M Expenses, Actual $
0	150
1	153
2	156
3	158
4	161
5	163
6	165
7	168
8	171
9	173
10	176
11	178
12	181
13	184
14	187
15	190
16	

[3]	[4]	[5]
Without Opportunity Loss, Actual $		
BOY	During the Year	Future Worth, EOY
$[5]_{n-1}$	12 x [2]	[3]+[4]
0		0
0	1,841	1,841
1841	1,869	3,710
3710	1,898	5,608
5608	1,926	7,535
7535	1,956	9,490
9490	1,986	11,476
11476	2,016	13,492
13492	2,046	15,538
15538	2,077	17,615
17615	2,109	19,724
19724	2,141	21,865
21865	2,174	24,039
24039	2,207	26,246
26246	2,240	28,486
28486	2,274	30,760

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Year	With Opportunity Loss at CD Interest Rate, Actual $													
	BOY Running Capital	Monthly Expenses	FVn of Monthly R & M for Year n	FVn of Running Capital for Year n	R& M Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	153	1,875	0	1,841	0	34	0	34	8	27	27	1,868	1,868
2	1,868	156	1,904	1,944	1,869	1,868	35	76	111	25	86	113	3,823	3,823
3	3,823	158	1,933	3,979	1,898	3,823	35	156	191	42	148	261	5,869	5,869
4	5,869	161	1,962	6,108	1,926	5,869	36	239	275	61	214	475	8,009	8,009
5	8,009	163	1,992	8,336	1,956	8,009	36	326	363	81	282	757	10,247	10,247
6	10,247	165	2,022	10,665	1,986	10,247	37	417	454	101	353	1,110	12,586	12,586
7	12,586	168	2,053	13,099	2,016	12,586	37	513	550	122	428	1,538	15,029	15,029
8	15,029	171	2,084	15,642	2,046	15,029	38	612	650	145	506	2,043	17,581	17,581
9	17,581	173	2,116	18,297	2,077	17,581	39	716	755	168	587	2,630	20,245	20,245
10	20,245	176	2,148	21,070	2,109	20,245	39	825	864	192	672	3,302	23,026	23,026
11	23,026	178	2,181	23,964	2,141	23,026	40	938	978	218	760	4,062	25,927	25,927
12	25,927	181	2,214	26,984	2,174	25,927	40	1,056	1,097	244	853	4,915	28,954	28,954
13	28,954	184	2,248	30,133	2,207	28,954	41	1,180	1,221	272	949	5,864	32,109	32,109
14	32,109	187	2,282	33,417	2,240	32,109	42	1,308	1,350	300	1,049	6,913	35,399	35,399
15	35,399	190	2,316	36,841	2,274	35,399	42	1,442	1,484	330	1,154	8,067	38,827	38,827

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [23] = [24]			3.12244%
[7]x(F/P, i%, n)	[8]x(F/A, i%, n)	[21]+[22]	[20]
-	1,868	1,868	1,868
1,927	1,896	3,823	3,823
3,944	1,925	5,869	5,869
6,065	1,954	8,009	8,009
8,263	1,984	10,247	10,247
10,572	2,014	12,586	12,586
12,984	2,045	15,029	15,029
15,505	2,076	17,581	17,581
18,138	2,107	20,245	20,245
20,887	2,139	23,026	23,026
23,755	2,172	25,927	25,927
26,749	2,205	28,954	28,954
29,871	2,238	32,109	32,109
33,126	2,273	35,399	35,399
36,520	2,307	38,827	38,827

Sheet G: Opportunity Loss for Excess Gasoline Expenses

Baseline Monthly Gasoline Expenses	60
Annual Cost Escalation Rate	3.39%
Equivalent Present Worth	9,166
EUME	56

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
3,607	2,260	14

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.17%	0.10%

[1]	[2]
Year	Monthly Excess Gasoline Expenses, Actual $
0	60
1	63
2	65
3	67
4	70
5	72
6	75
7	77
8	80
9	82
10	85
11	88
12	91
13	94
14	97
15	101
16	81

[3]	[4]	[5]
Without Opportunity Loss, Actual $		
BOY	During the Year	Future Worth, EOY
$[5]_{n-1}$	12 x [2]	[3]+[4]
0		0
0	757	757
757	783	1,540
1540	809	2,349
2349	837	3,186
3186	865	4,051
4051	894	4,945
4945	925	5,870
5870	956	6,826
6826	988	7,814
7814	1,022	8,836
8836	1,057	9,893
9893	1,092	10,985
10985	1,129	12,114
12114	1,168	13,282
13282	1,207	14,489

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Year	With Opportunity Loss at CD Interest Rate, Actual $													
	BOY Running Capital	Monthly Expenses	FVn of Monthly Expenses for Year n	FVn of Running Capital for Year n	Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	63	771	0	757	0	14	0	14	3	11	11	768	768
2	768	65	797	799	783	768	15	31	46	10	36	47	1,586	1,586
3	1,586	67	824	1,651	809	1,586	15	65	80	18	62	108	2,457	2,457
4	2,457	70	852	2,557	837	2,457	16	100	116	26	90	198	3,384	3,384
5	3,384	72	881	3,522	865	3,384	16	138	154	34	120	318	4,369	4,369
6	4,369	75	911	4,547	894	4,369	17	178	195	43	151	469	5,414	5,414
7	5,414	77	942	5,635	925	5,414	17	221	238	53	185	654	6,524	6,524
8	6,524	80	974	6,789	956	6,524	18	266	284	63	220	875	7,700	7,700
9	7,700	82	1,007	8,014	988	7,700	18	314	332	74	258	1,133	8,947	8,947
10	8,947	85	1,041	9,311	1,022	8,947	19	365	383	85	298	1,431	10,267	10,267
11	10,267	88	1,076	10,685	1,057	10,267	20	418	438	97	340	1,771	11,664	11,664
12	11,664	91	1,113	12,139	1,092	11,664	20	475	495	110	385	2,156	13,141	13,141
13	13,141	94	1,150	13,677	1,129	13,141	21	535	556	124	433	2,589	14,703	14,703
14	14,703	97	1,189	15,302	1,168	14,703	22	599	621	138	483	3,072	16,354	16,354
15	16,354	101	1,230	17,020	1,207	16,354	22	666	689	153	535	3,607	18,096	18,096

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [22] = [23]			3.12225%
[7]x(F/P, i_t%, n)	[8]x(F/A, i_t%, n)	[21]+[22]	[20]
-	768	768	768
792	794	1,586	1,586
1,636	821	2,457	2,457
2,535	849	3,384	3,384
3,491	878	4,369	4,369
4,507	907	5,414	5,414
5,586	938	6,524	6,524
6,730	970	7,700	7,700
7,944	1,003	8,947	8,947
9,230	1,037	10,267	10,267
10,592	1,072	11,664	11,664
12,033	1,108	13,141	13,141
13,558	1,146	14,703	14,703
15,169	1,185	16,354	16,354
16,872	1,225	18,096	18,096

Sheet H: Opportunity Loss for Home Insurance Expenses

Baseline Annual Insurance Expenses	1,337
Annual Cost Escalation Rate	3.900%
Equivalent Present Worth	17,466
EUME	106

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
7,089	4,442	27

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.17%	0.10%

[1]	[2]
Year	Six-monthly Home Insurance Premium, Actual $
0	669
1	695
2	722
3	750
4	779
5	809
6	841
7	874
8	908
9	943
10	980
11	1,018
12	1,056
13	1,099
14	1,142
15	1,187

[3]	[4]	[5]
Without Opportunity Loss, Actual $		
BOY	During the Year	Future Worth, EOY
$[5]_{n-1}$	2 x [2]	[3]+[4]
0		0
0	1,389	1,389
1389	1,443	2,832
2832	1,500	4,332
4332	1,558	5,890
5890	1,619	7,509
7509	1,682	9,191
9191	1,748	10,939
10939	1,816	12,754
12754	1,887	14,641
14641	1,960	16,601
16601	2,037	18,638
18638	2,116	20,754
20754	2,199	22,952
22952	2,284	25,236
25238	2,373	27,610

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
	With Opportunity Loss at CD Interest Rate, Actual $													
Year	BOY Running Capital	Six-Monthly Expenses	FVn of Insurance for Year n	FVn of Running Capital for Year n	Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	695	1,431	0	1,389	0	42	0	42	9	33	33	1,422	1,422
2	1,422	722	1,487	1,480	1,443	1,422	44	58	102	23	79	112	2,945	2,945
3	2,945	750	1,545	3,065	1,500	2,945	46	120	166	37	129	241	4,573	4,573
4	4,573	779	1,606	4,759	1,558	4,573	47	186	234	52	182	423	6,313	6,313
5	6,313	809	1,668	6,570	1,619	6,313	49	257	306	68	238	661	8,170	8,170
6	8,170	841	1,733	8,503	1,682	8,170	51	333	384	85	299	960	10,151	10,151
7	10,151	874	1,801	10,564	1,748	10,151	53	414	467	104	363	1,322	12,261	12,261
8	12,261	908	1,871	12,761	1,816	12,261	55	500	555	123	431	1,754	14,508	14,508
9	14,508	943	1,944	15,099	1,887	14,508	57	591	649	144	504	2,258	16,899	16,899
10	16,899	980	2,020	17,588	1,960	16,899	60	688	748	166	582	2,840	19,441	19,441
11	19,441	1,018	2,099	20,233	2,037	19,441	62	792	854	190	664	3,504	22,142	22,142
12	22,142	1,058	2,180	23,044	2,116	22,142	64	902	967	215	751	4,255	25,009	25,009
13	25,009	1,099	2,265	26,028	2,199	25,009	67	1,019	1,086	242	844	5,100	28,052	28,052
14	28,052	1,142	2,354	29,195	2,284	28,052	70	1,143	1,212	270	943	6,042	31,279	31,279
15	31,279	1,187	2,446	32,553	2,373	31,279	72	1,274	1,347	300	1,047	7,089	34,699	34,699

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [23] = [24]			3.12244%
(7+8)x(F/P, i%, n)	[8]x(F/A, i%, n)	[21]+[22]	[20]
717	705	1,422	1,422
2,212	733	2,945	2,945
3,811	762	4,573	4,573
5,522	791	6,313	6,313
7,348	822	8,170	8,170
9,296	854	10,151	10,151
11,374	888	12,261	12,261
13,586	922	14,508	14,508
15,941	958	16,899	16,899
18,445	995	19,441	19,441
21,107	1,034	22,142	22,142
23,934	1,075	25,009	25,009
26,935	1,117	28,052	28,052
30,119	1,160	31,279	31,279
33,494	1,205	34,699	34,699

Sheet I: Opportunity Loss for Property Taxes

Baseline Property Value	620,000
Baseline Annual Property Tax	0.55500%
Annual Cost Escalation Rate	0.00%
Equivalent Present Worth	38,914
EUME	238

FW, Actual $, Last row of [18]	Opportunity Loss PW	EUME
	FW (P/F, i_s%, n)	PW (A/P, i'_s%, n)
14,888	9,329	57

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_s)	**3.20%**	3.15%	0.26%
Real Interest Rate (i'_s)	-	1.26%	0.11%

[1]	[2]	[3]	[4]	[5]
		Without Opportunity Loss, Actual $		
Year	Annual Property Tax, Actual $	BOY	During the Year	Future Worth, EOY
		$[5]_{n-1}$	2 x [2]	[3]+[4]
0	3,441	0		0
1	3,522	0	3,522	3,522
2	3,604	3522	3,604	7,125
3	3,688	7125	3,688	10,814
4	3,775	10814	3,775	14,588
5	3,863	14588	3,863	18,451
6	3,953	18451	3,953	22,404
7	4,046	22404	4,046	26,450
8	4,140	26450	4,140	30,591
9	4,237	30591	4,237	34,828
10	4,336	34828	4,336	39,164
11	4,438	39164	4,438	43,602
12	4,542	43602	4,542	48,144
13	4,648	48144	4,648	52,792
14	4,757	52792	4,757	57,549
15	4,868	57549	4,868	62,417

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]
	With Opportunity Loss at CD Interest Rate, Actual $														
Year	BOY Running Capital	Annual Expenses	FVn of property tax for Year n	FVn of Running Capital for Year n	Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital	After Tax "Adjusted" Effective Annual Rate
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]	
0													0	0	
1	0	3,522	3,522	0	3,522	0	0	0	0	0	0	0	3,522	3,522	
2	3,522	3,604	3,604	3,665	3,604	3,522	0	143	143	32	112	112	7,237	7,237	3.168%
3	7,237	3,688	3,688	7,532	3,688	7,237	0	295	295	66	229	341	11,154	11,154	3.168%
4	11,154	3,775	3,775	11,609	3,775	11,154	0	454	454	101	353	694	15,282	15,282	3.168%
5	15,282	3,863	3,863	15,905	3,863	15,282	0	623	623	139	484	1,178	19,629	19,629	3.168%
6	19,629	3,953	3,953	20,429	3,953	19,629	0	800	800	178	622	1,800	24,204	24,204	3.168%
7	24,204	4,046	4,046	25,191	4,046	24,204	0	986	986	219	767	2,567	29,017	29,017	3.168%
8	29,017	4,140	4,140	30,199	4,140	29,017	0	1,182	1,182	263	919	3,486	34,077	34,077	3.168%
9	34,077	4,237	4,237	35,465	4,237	34,077	0	1,388	1,388	309	1,079	4,565	39,393	39,393	3.168%
10	39,393	4,336	4,336	40,998	4,336	39,393	0	1,605	1,605	357	1,248	5,813	44,978	44,978	3.168%
11	44,978	4,438	4,438	46,810	4,438	44,978	0	1,832	1,832	408	1,425	7,238	50,840	50,840	3.168%
12	50,840	4,542	4,542	52,912	4,542	50,840	0	2,071	2,071	461	1,610	8,848	56,993	56,993	3.168%
13	56,993	4,648	4,648	59,315	4,648	56,993	0	2,322	2,322	517	1,805	10,654	63,446	63,446	3.168%
14	63,446	4,757	4,757	66,031	4,757	63,446	0	2,585	2,585	575	2,010	12,663	70,213	70,213	3.168%
15	70,213	4,868	4,868	73,073	4,868	70,213	0	2,861	2,861	636	2,224	14,888	77,305	77,305	3.168%

Sheet J: Tax Return from Discount Points

Baseline Tax Return	2,207
Annual Cost Escalation Rate	0.00%
Equivalent Present Worth	(1,396)
EUME	(8)

Assumed tax Return is received by the end of April for each past tax year

(2,207)

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
(1,280)	(802)	(5)

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.16%
Nominal CD Interest Rate (i)	4.00%	0.33%
Real Interest Rate (i')	2.09%	0.18%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.17%	0.10%

[1]	[2]	[3]	[4]	[5]
	Cashflow		Without interest, Actual $	
Year	Year	Annual Tax Return	This year	Cumulative Income
			[3]	
0	2008	0		
1	2009	0	0	0
2	2010	-2.207	(2.207)	(2,207)
3	2011	0	0	(2,207)
4	2012	0	0	(2,207)
5	2013	0	0	(2,207)
6	2014	0	0	(2,207)
7	2015	0	0	(2,207)
8	2016	0	0	(2,207)
9	2017	0	0	(2,207)
10	2018	0	0	(2,207)
11	2019	0	0	(2,207)
12	2020	0	0	(2,207)
13	2021	0	0	(2,207)
14	2022	0	0	(2,207)
15	2023	0	0	(2,207)
16	2024	0	0	(2,207)

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
	With Opportunity of Investment at CD Interest Rate, Actual $													
Year	BOY Running Capital	This Year's Tax Return received on Apr 31	FVn of Tax return for Year n	FVn of Running Capital for Year n	This Year's Income w/o Interest	Running Capital w/o Interest	Interest from Current Year's Income	Interest from Running Capital	Total Taxable Interest	Tax	Net Interest Income	Cumulative Interest	EOY Running Capital	EOY Running Capital
		[3]	[8]x(F/A,i%,n)	[7](F/P,i%,n)	[8]x12	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0	0	0												
1	0	0											0	0
2	0	(2.207)	(2,267)	0	(2,207)	0	(60)	0	(60)	(13)	(46)	(46)	(2.254)	(2.254)
3	(2,254)	0	0	(2,345)	0	(2.254)	0	(92)	(92)	(20)	(71)	(118)	(2,325)	(2,325)
4	(2.325)	0	0	(2.420)	0	(2.325)	0	(95)	(95)	(21)	(74)	(191)	(2.399)	(2.399)
5	(2.399)	0	0	(2.496)	0	(2,399)	0	(98)	(98)	(22)	(76)	(267)	(2,475)	(2.475)
6	(2.475)	0	0	(2,575)	0	(2,475)	0	(101)	(101)	(22)	(78)	(346)	(2.553)	(2.553)
7	(2.553)	0	0	(2.657)	0	(2.553)	0	(104)	(104)	(23)	(81)	(427)	(2,634)	(2.634)
8	(2,634)	0	0	(2.741)	0	(2.634)	0	(107)	(107)	(24)	(83)	(510)	(2,717)	(2.717)
9	(2.717)	0	0	(2.828)	0	(2,717)	0	(111)	(111)	(25)	(86)	(596)	(2,803)	(2.803)
10	(2.803)	0	0	(2,917)	0	(2,803)	0	(114)	(114)	(25)	(89)	(685)	(2.892)	(2,892)
11	(2.892)	0	0	(3.010)	0	(2.892)	0	(118)	(118)	(26)	(92)	(776)	(2,984)	(2,984)
12	(2.984)	0	0	(3.105)	0	(2.984)	0	(122)	(122)	(27)	(95)	(871)	(3,078)	(3.078)
13	(3.078)	0	0	(3.204)	0	(3.078)	0	(125)	(125)	(28)	(98)	(968)	(3,176)	(3.176)
14	(3.176)	0	0	(3,305)	0	(3,176)	0	(129)	(129)	(29)	(101)	(1,069)	(3.276)	(3,276)
15	(3.276)	0	0	(3.410)	0	(3.276)	0	(133)	(133)	(30)	(104)	(1,173)	(3.380)	(3.380)
16	(3,380)	0	0	(3,518)	0	(3,380)	0	(138)	(138)	(31)	(107)	(1.280)	(3,487)	(3,487)

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_a) rate, that makes [23] = [24]			3.12245%
[7]x(F/P, i_a%, n)	[8]x(F/A, i_a%, n)	[21]+[22]	[20]
-	-	-	-
-	2.277	2.277	2.254
2,325	-	2.325	2,325
2,399	-	2.399	2.399
2,475	-	2,475	2.475
2,553	-	2,553	2.553
2,634	-	2.634	2.634
2,717	-	2.717	2.717
2,803	-	2.803	2.803
2,892	-	2.892	2.892
2.984	-	2.984	2,984
3.078	-	3.078	3.078
3,176	-	3,176	3.176
3,276	-	3,276	3.276
3,380	-	3.380	3.380
3,487	-	3.487	3.487

Sheet K: Tax Return from Mortgage Interest

Baseline Tax Return	(6,585)
Annual Cost Escalation Rate	0.00%
Equivalent Present Worth	(55,129)
EUME	(335)

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_s%, n)	PW (A/P, i'_s%, n)
(25,935)	(16,406)	(100)

Assumed tax Return is received by the end of April for each past tax year

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.16%
Nominal CD Interest Rate (i)	4.00%	0.33%
Real Interest Rate (i')	2.09%	0.18%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_s)	3.10%	3.06%	0.26%
Real Interest Rate (i'_s)	-	1.17%	0.10%

[1]	[2]	[3]
Year	Cashflow: Year	Cashflow: Annual Tax Return
0	2008	0
1	2009	0
2	2010	6,585
3	2011	6,501
4	2012	6,412
5	2013	6,318
6	2014	6,218
7	2015	6,112
8	2016	5,999
9	2017	5,880
10	2018	5,752
11	2019	5,616
12	2020	5,474
13	2021	5,322
14	2022	5,161
15	2023	4,989
16	2024	4,807

[4]	[5]
Without interest, Actual $: This year	Without interest, Actual $: Cumulative Income
[3]	
0	0
(6,585)	(6,585)
(6,501)	(13,086)
(6,412)	(19,498)
(6,318)	(25,816)
(6,218)	(32,035)
(6,112)	(38,147)
(5,999)	(44,146)
(5,880)	(50,025)
(5,752)	(55,778)
(5,616)	(61,395)
(5,474)	(66,870)
(5,322)	(72,192)
(5,161)	(77,352)
(4,989)	(82,342)
(4,807)	(87,149)

With Opportunity of Investment at CD Interest Rate, Actual $

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Year	BOY Running Capital	This Year's Tax Return received on Apr 31	FVn of Tax return for Year n	FVn of Running Capital for Year n	This Year's Income w/o Interest	Running Capital w/o Interest	Interest from Current Year's Income	Interest from Running Capital	Total Taxable Interest	Tax	Net Interest Income	Cumulative Interest	EOY Running Capital	EOY Running Capital
		[3]	[8]x(F/A,i%,n)	[7](F/P,i%,n)	[8]x12	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0	0	0												
1	0	0											0	0
2	0	(6,585)	(6,762)	0	(6,585)	0	(178)	0	(178)	(40)	(138)	(138)	(6,723)	(6,723)
3	(6,723)	(6,501)	(6,677)	(6,997)	(6,501)	(6,723)	(175)	(274)	(449)	(100)	(349)	(487)	(13,573)	(13,573)
4	(13,573)	(6,412)	(6,585)	(14,126)	(6,412)	(13,573)	(173)	(553)	(726)	(162)	(564)	(1,052)	(20,550)	(20,550)
5	(20,550)	(6,318)	(6,489)	(21,387)	(6,318)	(20,550)	(170)	(837)	(1,008)	(224)	(783)	(1,835)	(27,652)	(27,652)
6	(27,652)	(6,218)	(6,386)	(28,778)	(6,218)	(27,652)	(168)	(1,127)	(1,294)	(288)	(1,006)	(2,842)	(34,876)	(34,876)
7	(34,876)	(6,112)	(6,277)	(36,297)	(6,112)	(34,876)	(165)	(1,421)	(1,586)	(353)	(1,233)	(4,075)	(42,221)	(42,221)
8	(42,221)	(5,999)	(6,161)	(43,941)	(5,999)	(42,221)	(162)	(1,720)	(1,882)	(419)	(1,463)	(5,538)	(49,684)	(49,684)
9	(49,684)	(5,880)	(6,038)	(51,708)	(5,880)	(49,684)	(159)	(2,024)	(2,183)	(486)	(1,697)	(7,235)	(57,260)	(57,260)
10	(57,260)	(5,752)	(5,908)	(59,593)	(5,752)	(57,260)	(155)	(2,333)	(2,488)	(554)	(1,934)	(9,170)	(64,947)	(64,947)
11	(64,947)	(5,618)	(5,769)	(67,593)	(5,618)	(64,947)	(152)	(2,646)	(2,798)	(622)	(2,175)	(11,345)	(72,740)	(72,740)
12	(72,740)	(5,474)	(5,622)	(75,704)	(5,474)	(72,740)	(148)	(2,964)	(3,111)	(692)	(2,419)	(13,764)	(80,633)	(80,633)
13	(80,633)	(5,322)	(5,466)	(83,918)	(5,322)	(80,633)	(144)	(3,285)	(3,429)	(763)	(2,666)	(16,430)	(88,621)	(88,621)
14	(88,621)	(5,161)	(5,300)	(92,232)	(5,161)	(88,621)	(139)	(3,611)	(3,750)	(834)	(2,915)	(19,345)	(96,697)	(96,697)
15	(96,697)	(4,989)	(5,124)	(100,637)	(4,989)	(96,697)	(135)	(3,940)	(4,074)	(907)	(3,168)	(22,513)	(104,854)	(104,854)
16	(104,854)	(4,807)	(4,937)	(109,126)	(4,807)	(104,854)	(130)	(4,272)	(4,402)	(979)	(3,422)	(25,935)	(113,084)	(113,084)

Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method

[21]	[22]	[23]	[24]
Input a trial interest (i_s) rate, that makes [23] = [24]			3.12238%
[7]x(F/P, i_s%, n)	[8]x(F/A, i_s%, n)	[21]+[22]	[20]
-	-	-	-
-	6,723	6,723	6,723
6,936	6,638	13,574	13,573
14,003	6,547	20,550	20,550
21,201	6,451	27,652	27,652
28,528	6,349	34,877	34,876
35,981	6,240	42,221	42,221
43,559	6,125	49,684	49,684
51,258	6,003	57,261	57,260
59,074	5,873	64,947	64,947
67,005	5,736	72,740	72,740
75,044	5,589	80,633	80,633
83,187	5,434	88,621	88,621
91,428	5,269	96,697	96,697
99,760	5,094	104,854	104,854
108,176	4,908	113,084	113,084

Sheet K1: Loan Repayment Calculation

Loan amount	496000	
Mortgage Interest rate	6.00%	
Loan Payback Period	15	years
Monthly payment	2974	
Annual income tax rate	22.25%	

Year	Monthly Payment	Monthly Interest Payment	Monthly Principal Payment	Total Payment to Date	Total Interest Paid to Date	Total Principal Paid to Date	Principal Remaining	Interest Paid in the Current Year	Tax Return
1	2,974	2,480	494	2,974	2,480	494	495,506		
12	2,974	2,452	522	35,685	29,594	6,091	489,909	29,594	6,585
24	2,974	2,420	554	71,370	58,813	12,558	483,442	29,219	6,501
36	2,974	2,386	588	107,056	87,633	19,423	476,577	28,820	6,412
48	2,974	2,350	624	142,741	116,029	26,712	469,288	28,396	6,318
60	2,974	2,311	663	178,426	143,976	34,450	461,550	27,947	6,218
72	2,974	2,270	704	214,111	171,445	42,666	453,334	27,469	6,112
84	2,974	2,227	747	249,797	198,408	51,389	444,611	26,963	5,999
96	2,974	2,181	793	285,482	224,833	60,649	435,351	26,425	5,880
108	2,974	2,132	842	321,167	250,686	70,481	425,519	25,854	5,752
120	2,974	2,080	894	356,852	275,934	80,919	415,081	25,247	5,618
132	2,974	2,025	949	392,538	300,537	92,001	403,999	24,603	5,474
144	2,974	1,966	1,008	428,223	324,457	103,766	392,234	23,920	5,322
156	2,974	1,904	1,070	463,908	347,651	116,257	379,743	23,194	5,161
168	2,974	1,838	1,136	499,593	370,075	129,518	366,482	22,424	4,989
180	2,974	1,768	1,206	535,279	391,681	143,598	**352,402**	21,606	4,807

Sheet K2: Tax Return on Mortgage Interest Detailed Calculation

Loan amount	496000	
Mortgage Interest rate	6.00%	
Loan Payback Period	15	years
Monthly payment	2974	
Annual income tax rate	22.25%	

Year	Monthly Payment	Monthly Interest Payment	Monthly Principal Payment	Total Payment to Date	Total Interest Paid to Date	Total Principal Paid to Date	Principal Remaining	Interest Paid in the Current Year	Tax Rebate
1	2,974	2,480	494	2,974	2,480	494	495,506		
2	2,974	2,478	496	5,948	4,958	990	495,010		
3	2,974	2,475	499	8,921	7,433	1,489	494,511		
4	2,974	2,473	501	11,895	9,905	1,990	494,010		
5	2,974	2,470	504	14,869	12,375	2,494	493,506		
6	2,974	2,468	506	17,843	14,843	3,000	493,000		
7	2,974	2,465	509	20,816	17,308	3,509	492,491		
8	2,974	2,462	511	23,790	19,770	4,020	491,980		
9	2,974	2,460	514	26,764	22,230	4,534	491,466		
10	2,974	2,457	516	29,738	24,687	5,050	490,950		
11	2,974	2,455	519	32,711	27,142	5,569	490,431		
12	2,974	2,452	522	35,685	29,594	6,091	489,909	29,594	6,585
13	2,974	2,450	524	38,659	32,044	6,615	489,385		
14	2,974	2,447	527	41,633	34,491	7,142	488,858		
15	2,974	2,444	529	44,607	36,935	7,671	488,329		
16	2,974	2,442	532	47,580	39,377	8,204	487,796		
17	2,974	2,439	535	50,554	41,816	8,738	487,262		
18	2,974	2,436	537	53,528	44,252	9,276	486,724		
19	2,974	2,434	540	56,502	46,686	9,816	486,184		
20	2,974	2,431	543	59,475	49,117	10,359	485,641		
21	2,974	2,428	546	62,449	51,545	10,904	485,096		
22	2,974	2,425	548	65,423	53,970	11,453	484,547		
23	2,974	2,423	551	68,397	56,393	12,004	483,996		
24	2,974	2,420	554	71,370	58,813	12,558	483,442	29,219	6,501
25	2,974	2,417	557	74,344	61,230	13,114	482,886		
26	2,974	2,414	559	77,318	63,645	13,673	482,327		
27	2,974	2,412	562	80,292	66,056	14,236	481,764		
28	2,974	2,409	565	83,266	68,465	14,801	481,199		
29	2,974	2,406	568	86,239	70,871	15,368	480,632		
30	2,974	2,403	571	89,213	73,274	15,939	480,061		
31	2,974	2,400	573	92,187	75,675	16,512	479,488		
32	2,974	2,397	576	95,161	78,072	17,089	478,911		
33	2,974	2,395	579	98,134	80,466	17,668	478,332		
34	2,974	2,392	582	101,108	82,858	18,250	477,750		
35	2,974	2,389	585	104,082	85,247	18,835	477,165		
36	2,974	2,386	588	107,056	87,633	19,423	476,577	28,820	6,412
37	2,974	2,383	591	110,030	90,016	20,014	475,986		
38	2,974	2,380	594	113,003	92,396	20,608	475,392		
39	2,974	2,377	597	115,977	94,773	21,205	474,795		
40	2,974	2,374	600	118,951	97,146	21,804	474,196		
41	2,974	2,371	603	121,925	99,517	22,407	473,593		
42	2,974	2,368	606	124,898	101,885	23,013	472,987		
43	2,974	2,365	609	127,872	104,250	23,622	472,378		
44	2,974	2,362	612	130,846	106,612	24,234	471,766		
45	2,974	2,359	615	133,820	108,971	24,849	471,151		
46	2,974	2,356	618	136,793	111,327	25,467	470,533		
47	2,974	2,353	621	139,767	113,680	26,088	469,912		
48	2,974	2,350	624	142,741	116,029	26,712	469,288	28,396	6,318
49	2,974	2,346	627	145,715	118,376	27,339	468,661		
50	2,974	2,343	630	148,689	120,719	27,970	468,030		
51	2,974	2,340	634	151,662	123,059	28,603	467,397		
52	2,974	2,337	637	154,636	125,396	29,240	466,760		
53	2,974	2,334	640	157,610	127,730	29,880	466,120		
54	2,974	2,331	643	160,584	130,060	30,523	465,477		
55	2,974	2,327	646	163,557	132,388	31,170	464,830		
56	2,974	2,324	650	166,531	134,712	31,819	464,181		
57	2,974	2,321	653	169,505	137,033	32,472	463,528		
58	2,974	2,318	656	172,479	139,350	33,128	462,872		
59	2,974	2,314	659	175,452	141,665	33,788	462,212		
60	2,974	2,311	663	178,426	143,976	34,450	461,550	27,947	6,218

Table continued in the next page.

Sheet K2 Continued...

61	2,974	2,308	666	181,400	146,284	35,116	460,884		
62	2,974	2,304	669	184,374	148,588	35,786	460,214		
63	2,974	2,301	673	187,348	150,889	36,458	459,542		
64	2,974	2,298	676	190,321	153,187	37,135	458,865		
65	2,974	2,294	679	193,295	155,481	37,814	458,186		
66	2,974	2,291	683	196,269	157,772	38,497	457,503		
67	2,974	2,288	686	199,243	160,060	39,183	456,817		
68	2,974	2,284	690	202,216	162,344	39,873	456,127		
69	2,974	2,281	693	205,190	164,624	40,566	455,434		
70	2,974	2,277	697	208,164	166,901	41,262	454,738		
71	2,974	2,274	700	211,138	169,175	41,963	454,037		
72	2,974	2,270	704	214,111	171,445	42,666	453,334	27,469	6,112
73	2,974	2,267	707	217,085	173,712	43,373	452,627		
74	2,974	2,263	711	220,059	175,975	44,084	451,916		
75	2,974	2,260	714	223,033	178,235	44,798	451,202		
76	2,974	2,256	718	226,007	180,491	45,516	450,484		
77	2,974	2,252	721	228,980	182,743	46,237	449,763		
78	2,974	2,249	725	231,954	184,992	46,962	449,038		
79	2,974	2,245	729	234,928	187,237	47,691	448,309		
80	2,974	2,242	732	237,902	189,479	48,423	447,577		
81	2,974	2,238	736	240,875	191,717	49,159	446,841		
82	2,974	2,234	740	243,849	193,951	49,898	446,102		
83	2,974	2,231	743	246,823	196,181	50,642	445,358		
84	2,974	2,227	747	249,797	198,408	51,389	444,611	26,963	5,999
85	2,974	2,223	751	252,771	200,631	52,139	443,861		
86	2,974	2,219	754	255,744	202,850	52,894	443,106		
87	2,974	2,216	758	258,718	205,066	53,652	442,348		
88	2,974	2,212	762	261,692	207,278	54,414	441,586		
89	2,974	2,208	766	264,666	209,486	55,180	440,820		
90	2,974	2,204	770	267,639	211,690	55,950	440,050		
91	2,974	2,200	774	270,613	213,890	56,723	439,277		
92	2,974	2,196	777	273,587	216,086	57,501	438,499		
93	2,974	2,192	781	276,561	218,279	58,282	437,718		
94	2,974	2,189	785	279,534	220,467	59,067	436,933		
95	2,974	2,185	789	282,508	222,652	59,856	436,144		
96	2,974	2,181	793	285,482	224,833	60,649	435,351	26,425	5,880
97	2,974	2,177	797	288,456	227,010	61,446	434,554		
98	2,974	2,173	801	291,430	229,182	62,247	433,753		
99	2,974	2,169	805	294,403	231,351	63,052	432,948		
100	2,974	2,165	809	297,377	233,516	63,861	432,139		
101	2,974	2,161	813	300,351	235,677	64,674	431,326		
102	2,974	2,157	817	303,325	237,833	65,491	430,509		
103	2,974	2,153	821	306,298	239,986	66,313	429,687		
104	2,974	2,148	825	309,272	242,134	67,138	428,862		
105	2,974	2,144	829	312,246	244,278	67,967	428,033		
106	2,974	2,140	834	315,220	246,419	68,801	427,199		
107	2,974	2,136	838	318,193	248,555	69,639	426,361		
108	2,974	2,132	842	321,167	250,686	70,481	425,519	25,854	5,752
109	2,974	2,128	846	324,141	252,814	71,327	424,673		
110	2,974	2,123	850	327,115	254,937	72,177	423,823		
111	2,974	2,119	855	330,089	257,057	73,032	422,968		
112	2,974	2,115	859	333,062	259,171	73,891	422,109		
113	2,974	2,111	863	336,036	261,282	74,754	421,246		
114	2,974	2,106	868	339,010	263,388	75,622	420,378		
115	2,974	2,102	872	341,984	265,490	76,494	419,506		
116	2,974	2,098	876	344,957	267,588	77,370	418,630		
117	2,974	2,093	881	347,931	269,681	78,250	417,750		
118	2,974	2,089	885	350,905	271,769	79,135	416,865		
119	2,974	2,084	889	353,879	273,854	80,025	415,975		
120	2,974	2,080	894	356,852	275,934	80,919	415,081	25,247	5,618
121	2,974	2,075	898	359,826	278,009	81,817	414,183		
122	2,974	2,071	903	362,800	280,080	82,720	413,280		
123	2,974	2,066	907	365,774	282,146	83,627	412,373		
124	2,974	2,062	912	368,748	284,208	84,539	411,461		
125	2,974	2,057	916	371,721	286,266	85,456	410,544		
126	2,974	2,053	921	374,695	288,318	86,377	409,623		
127	2,974	2,048	926	377,669	290,366	87,302	408,698		
128	2,974	2,043	930	380,643	292,410	88,233	407,767		
129	2,974	2,039	935	383,616	294,449	89,168	406,832		
130	2,974	2,034	940	386,590	296,483	90,107	405,893		
131	2,974	2,029	944	389,564	298,512	91,052	404,948		
132	2,974	2,025	949	392,538	300,537	92,001	403,999	24,603	5,474

Table continued in the next page.

Sheet K2 Continued...

133	2,974	2,020	954	395,511	302,557	92,954	403,046		
134	2,974	2,015	959	398,485	304,572	93,913	402,087		
135	2,974	2,010	963	401,459	306,583	94,876	401,124		
136	2,974	2,006	968	404,433	308,588	95,844	400,156		
137	2,974	2,001	973	407,407	310,589	96,817	399,183		
138	2,974	1,996	978	410,380	312,585	97,795	398,205		
139	2,974	1,991	983	413,354	314,576	98,778	397,222		
140	2,974	1,986	988	416,328	316,562	99,766	396,234		
141	2,974	1,981	993	419,302	318,543	100,758	395,242		
142	2,974	1,976	998	422,275	320,520	101,756	394,244		
143	2,974	1,971	1,003	425,249	322,491	102,758	393,242		
144	2,974	1,966	1,008	428,223	324,457	103,766	392,234	23,920	5,322
145	2,974	1,961	1,013	431,197	326,418	104,779	391,221		
146	2,974	1,956	1,018	434,171	328,374	105,796	390,204		
147	2,974	1,951	1,023	437,144	330,325	106,819	389,181		
148	2,974	1,946	1,028	440,118	332,271	107,847	388,153		
149	2,974	1,941	1,033	443,092	334,212	108,880	387,120		
150	2,974	1,936	1,038	446,066	336,148	109,918	386,082		
151	2,974	1,930	1,043	449,039	338,078	110,961	385,039		
152	2,974	1,925	1,049	452,013	340,003	112,010	383,990		
153	2,974	1,920	1,054	454,987	341,923	113,064	382,936		
154	2,974	1,915	1,059	457,961	343,838	114,123	381,877		
155	2,974	1,909	1,064	460,934	345,747	115,187	380,813		
156	2,974	1,904	1,070	463,908	347,651	116,257	379,743	23,194	5,161
157	2,974	1,899	1,075	466,882	349,550	117,332	378,668		
158	2,974	1,893	1,080	469,856	351,443	118,412	377,588		
159	2,974	1,888	1,086	472,830	353,331	119,498	376,502		
160	2,974	1,883	1,091	475,803	355,214	120,590	375,410		
161	2,974	1,877	1,097	478,777	357,091	121,686	374,314		
162	2,974	1,872	1,102	481,751	358,962	122,788	373,212		
163	2,974	1,866	1,108	484,725	360,828	123,896	372,104		
164	2,974	1,861	1,113	487,698	362,689	125,009	370,991		
165	2,974	1,855	1,119	490,672	364,544	126,128	369,872		
166	2,974	1,849	1,124	493,646	366,393	127,253	368,747		
167	2,974	1,844	1,130	496,620	368,237	128,383	367,617		
168	2,974	1,838	1,136	499,593	370,075	129,518	366,482	22,424	4,989
169	2,974	1,832	1,141	502,567	371,907	130,660	365,340		
170	2,974	1,827	1,147	505,541	373,734	131,807	364,193		
171	2,974	1,821	1,153	508,515	375,555	132,960	363,040		
172	2,974	1,815	1,159	511,489	377,370	134,118	361,882		
173	2,974	1,809	1,164	514,462	379,180	135,283	360,717		
174	2,974	1,804	1,170	517,436	380,983	136,453	359,547		
175	2,974	1,798	1,176	520,410	382,781	137,629	358,371		
176	2,974	1,792	1,182	523,384	384,573	138,811	357,189		
177	2,974	1,786	1,188	526,357	386,359	139,999	356,001		
178	2,974	1,780	1,194	529,331	388,139	141,192	354,808		
179	2,974	1,774	1,200	532,305	389,913	142,392	353,608		
180	2,974	1,768	1,206	535,279	391,681	143,598	352,402	21,606	4,807

Sheet L: Tax Return from Property Tax

Baseline Tax Return	784
Annual Cost Escalation Rate	0.00%
Equivalent Present Worth	(8,785)
EUME	(53)

Assumed tax Return is received by the end of April for each past tax year

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i_s%, n)	PW (A/P, i'_s%, n)
(3,673)	(2,302)	(14)

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.16%
Nominal CD Interest Rate (i)	4.00%	0.33%
Real Interest Rate (i')	2.09%	0.18%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_s)	3.10%	############	############
Real Interest Rate (i'_s)	-	############	############

[1]	[2]	[3]
Year	Cashflow	
	Year	Annual Property tax Tax Return
0	2008	0
1	2009	0
2	2010	784
3	2011	802
4	2012	821
5	2013	840
6	2014	859
7	2015	880
8	2016	900
9	2017	921
10	2018	943
11	2019	965
12	2020	987
13	2021	1,011
14	2022	1,034
15	2023	1,058
16	2024	1,083

[4]	[5]
Without interest, Actual $	
This year	Cumulative Income
[3]	
0	0
(784)	(784)
(802)	(1,585)
(821)	(2,406)
(840)	(3,246)
(859)	(4,105)
(880)	(4,985)
(900)	(5,885)
(921)	(6,806)
(943)	(7,749)
(965)	(8,714)
(987)	(9,702)
(1,011)	(10,712)
(1,034)	(11,748)
(1,058)	(12,805)
(1,083)	(13,888)

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Year	With Opportunity of Investment at CD Interest Rate, Actual $													
	BOY Running Capital	This Year's Tax Return received on Apr 31	FVn of Tax return for Year n	FVn of Running Capital for Year n	This Year's Income w/o Interest	Running Capital w/o Interest	Interest from Current Year's Income	Interest from Running Capital	Total Taxable Interest	Tax	Net Interest Income	Cumulative Interest	EOY Running Capital	EOY Running Capital
		[3]	[8]x(F/A,i%,n)	[7](F/P,i%,n)	[8]x12	[7]	[9]-[12]	[10]-[12]	[13]+[14]	(ITX)x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0	0	0												
1	0	0											0	0
2	0	(784)	(805)	0	(784)	0	(21)	0	(21)	(5)	(16)	(16)	(800)	(800)
3	(800)	(802)	(824)	(833)	(802)	(800)	(22)	(33)	(54)	(12)	(42)	(59)	(1,644)	(1,644)
4	(1,644)	(821)	(843)	(1,711)	(821)	(1,644)	(22)	(67)	(89)	(20)	(69)	(128)	(2,534)	(2,534)
5	(2,534)	(840)	(862)	(2,637)	(840)	(2,534)	(23)	(103)	(126)	(28)	(98)	(226)	(3,472)	(3,472)
6	(3,472)	(859)	(883)	(3,613)	(859)	(3,472)	(23)	(141)	(165)	(37)	(128)	(354)	(4,459)	(4,459)
7	(4,459)	(880)	(903)	(4,641)	(880)	(4,459)	(24)	(182)	(205)	(46)	(160)	(513)	(5,498)	(5,498)
8	(5,498)	(900)	(924)	(5,722)	(900)	(5,498)	(24)	(224)	(248)	(55)	(193)	(707)	(6,592)	(6,592)
9	(6,592)	(921)	(946)	(6,860)	(921)	(6,592)	(25)	(269)	(293)	(65)	(228)	(935)	(7,741)	(7,741)
10	(7,741)	(943)	(968)	(8,056)	(943)	(7,741)	(25)	(315)	(341)	(76)	(265)	(1,200)	(8,949)	(8,949)
11	(8,949)	(965)	(991)	(9,313)	(965)	(8,949)	(26)	(365)	(391)	(87)	(304)	(1,503)	(10,217)	(10,217)
12	(10,217)	(987)	(1,014)	(10,634)	(987)	(10,217)	(27)	(416)	(443)	(99)	(344)	(1,848)	(11,549)	(11,549)
13	(11,549)	(1,011)	(1,038)	(12,020)	(1,011)	(11,549)	(27)	(471)	(498)	(111)	(387)	(2,235)	(12,947)	(12,947)
14	(12,947)	(1,034)	(1,062)	(13,474)	(1,034)	(12,947)	(28)	(527)	(555)	(124)	(432)	(2,667)	(14,413)	(14,413)
15	(14,413)	(1,058)	(1,087)	(15,000)	(1,058)	(14,413)	(29)	(587)	(616)	(137)	(478)	(3,145)	(15,950)	(15,950)
16	(15,950)	(1,083)	(1,112)	(16,600)	(1,083)	(15,950)	(29)	(650)	(679)	(151)	(528)	(3,673)	(17,561)	(17,561)

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_s) rate, that makes [23] = [24]			3.12236%
[7]x(F/P, i_s%, n)	[8]x(F/A, i_s%, n)	[21]+[22]	[20]
-	-	-	-
-	800	800	800
825	819	1,644	1,644
1,696	838	2,534	2,534
2,614	857	3,472	3,472
3,582	878	4,459	4,459
4,600	898	5,498	5,498
5,673	919	6,592	6,592
6,800	941	7,741	7,741
7,986	963	8,949	8,949
9,232	985	10,217	10,217
10,541	1,008	11,549	11,549
11,915	1,032	12,947	12,947
13,357	1,056	14,413	14,413
14,869	1,081	15,950	15,950
16,455	1,106	17,561	17,561

Sheet M: Opportunity Loss for Reroofing Costs

Baseline Reroofing Costs	10,000
Annual Cost Escalation Rate	1.52%
Equivalent Present Worth	7,932
EUME	48

FW, Actual $, Last row of [18]	Opportunity Loss PW	EUME
	FW (F/P, i_a%, n)	PW (A/P, i'_a%, n)
0	0	0

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.17%	0.10%

[1]	[2]	[3]	[4]	[5]
		Without Opportunity Loss, Actual $		
Year	Reroofing Cost, Actual $	BOY	During the Year	Future Worth, EOY
		[5]$_{n-1}$	2 x [2]	[3]+[4]
0	NA	0		0
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	0
13	0	0	0	0
14	0	0	0	0
15	12,539	0	12,539	12,539

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]
	With Opportunity Loss at CD Interest Rate, Actual $														
Year	BOY Running Capital	Annual Expenses	FVn of Reroofing for Year n	FVn of Running Capital for Year n	Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital	After Tax "Adjusted" Effective Annual Rate
	[18]$_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]	
0													0	0	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
15	0	12,539	12,539	0	12,539	0	0	0	0	0	0	0	12,539	12,539	0.000%

Sheet N: Opportunity Loss for Repainting Costs

Baseline Repainting Costs	4,500
Annual Cost Escalation Rate	1.52%
Equivalent Present Worth	9,808
EUME	60

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (F/P, i%, n)	PW (A/P, i%, n)
2,659	1,666	10

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.20%	3.15%	0.26%
Real Interest Rate (i'_a)	-	1.25%	0.11%

[1]	[2]	[3]	[4]	[5]
Year	Repainting Cost, Actual $	Without Opportunity Loss, Actual $		
		BOY	During the Year	Future Worth, EOY
		$[5]_{n-1}$	2 x [2]	[3]+[4]
0	NA	0		0
1		0	0	0
2		0	0	0
3		0	0	0
4		0	0	0
5	4,853	0	4,853	4,853
6		4853	0	4,853
7		4853	0	4,853
8		4853	0	4,853
9		4853	0	4,853
10	5,233	4853	5,233	10,085
11		10085	0	10,085
12		10085	0	10,085
13		10085	0	10,085
14		10085	0	10,085
15	5,643	10085	5,643	15,728

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]	[21]
Year	With Opportunity Loss at CD Interest Rate, Actual $														
	BOY Running Capital	Annual Expenses	FVn of Repainting for Year n	FVn of Running Capital for Year n	Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital	After Tax "Adjusted" Effective Annual Rate
	$[18]_{n-1}$	[3]	[4]x(F/A,i%,n)	[7]x(F/P,i%,n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	(ITX)x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]	
0													0	0	
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000%
5	0	4,853	4,853	0	4,853	0	0	0	0	0	0	0	4,853	4,853	0.000%
6	4,853	0	0	5,060	0	4,853	0	198	198	44	154	154	5,006	5,006	3.168%
7	5,006	0	0	5,210	0	5,006	0	204	204	45	159	312	5,165	5,165	3.168%
8	5,165	0	0	5,376	0	5,165	0	210	210	47	164	476	5,328	5,328	3.168%
9	5,328	0	0	5,546	0	5,328	0	217	217	48	169	645	5,497	5,497	3.168%
10	5,497	5,233	5,233	5,721	5,233	5,497	0	224	224	50	174	819	10,904	10,904	3.168%
11	10,904	0	0	11,348	0	10,904	0	444	444	99	345	1,164	11,250	11,250	3.168%
12	11,250	0	0	11,708	0	11,250	0	458	458	102	356	1,521	11,608	11,608	3.168%
13	11,808	0	0	12,079	0	11,808	0	473	473	105	368	1,888	11,973	11,973	3.168%
14	11,973	0	0	12,481	0	11,973	0	488	488	109	379	2,267	12,353	12,353	3.168%
15	12,353	5,643	5,643	12,858	5,643	12,353	0	503	503	112	391	2,659	18,387	18,387	3.168%

Sheet O: Termination of the Poperty - Revenue and Expenses

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Capital Gain Tax Rate (CGT)	22.25%	-

After Tax Adjusted Rates	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	**3.17%**	3.12%	0.26%
Real Interest Rate (i'_a)	-	1.23%	0.10%

O1. Salvage Value (Resale Price)

Baseline Value of the Property	620,000
Property Appreciation Rate	2.34%
Future Worth of the Incoming Funds	877,148

FW, Actual $,	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
(877,148)	**(549,252)**	**(3336)**

O2. Seller's Closing Costs

Baseline Adverstisement Cost	-
Escalated Advertisement Cost	0
Realtor's fee as % of sales Price	43,857
Other closing cost as % of sales price, if any	8,771
Future Worth of Closing Costs	52,629

FW, Actual $,	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
52,629	**32,955**	**200**

O2. Capital Gain Tax

Revenue After Resale	877,148
Deduct Original Purchase Price	620,000
Deduct Buyer's Closing Costs and Discounting	19,220
Deduct Seller's Closing Costs	52,629
Exemption (for couple)	500,000
Taxable capital Gain	0
Capital Gain Tax	0

FW, Actual $,	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
0	**0**	**0**

O4. Remaining Loan to be Paid

Loan to be paid (principal remaining)	352402

FW, Actual $,	PW	EUME
	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
352,402	**220,667**	**1340**

Sheet P: Calculation of Cost Escalation Rates

		Life Cycle Period, Years		
		15		
Economic variables	**Equation**	2009	2024	Rate
CPI Index	9292.76*ln(X) - 70459.37	216	285	1.87%
PPI index	6518.46 *ln(X) - 49384.90	191	239	1.52%
Utilities	164255.2 *ln(X) -1246084.88	3,140	4,362	2.22%
Home insurance	100237.99 *ln(X)-761387.05	962	1,708	3.90%
Property appreciation	30338118.27 *ln(X) - 230189673.21	543,620	769,295	2.34%
Gasoline	22411.30 *ln(X) -170189.90	257	424	3.39%
Rent	60575.91 *ln(X) - 459313.04	1,391	1,841	1.89%
Median family income	3866716.70 *ln(X) -29324484.62	83,413	112,176	1.99%

Sheet Q: Rental Expenses and Opportunity Costs

Baseline Monthly Rental Expenses	2,500
Annual Cost Escalation Rate	1.89000%
Equivalent Present Worth	334,881
EUME	2034

Opportunity Loss		
FW, Actual $,	PW	EUME
Last row of [18]	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
139,158	87,201	530

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87000%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.17%	0.10%

[1]	[2]	[3]	[4]	[5]
		Without Opportunity Loss, Actual $		
Year	Monthly Rental Expenses, Actual $	BOY	During the Year	Future Worth, EOY
		$[5]_{n-1}$	12 x [2]	[3]+[4]
0	2,500	0		0
1	2,571	0	30,856	30,856
2	2,620	30856	31,439	62,295
3	2,669	62295	32,033	94,328
4	2,720	94328	32,639	126,967
5	2,771	126967	33,256	160,222
6	2,824	160222	33,884	194,106
7	2,877	194106	34,524	228,631
8	2,931	228631	35,177	263,808
9	2,987	263808	35,842	299,650
10	3,043	299650	36,519	336,169
11	3,101	336169	37,209	373,378
12	3,159	373378	37,913	411,291
13	3,219	411291	38,629	449,920
14	3,280	449920	39,359	489,280
15	3,342	489280	40,103	529,383
16				

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
	With Opportunity Loss at CD Interest Rate, Actual $													
Year	BOY Running Capital	Monthly Expenses	FVn of Monthly R & M for Year n	FVn of Running Capital for Year n	R& M Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[7]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	2,571	31,533	0	30,856	0	677	0	677	151	526	526	31,382	31,382
2	31,382	2,620	32,129	32,661	31,439	31,382	690	1,279	1,968	438	1,530	2,056	64,351	64,351
3	64,351	2,669	32,736	66,973	32,033	64,351	703	2,622	3,324	740	2,585	4,641	98,969	98,969
4	98,969	2,720	33,355	103,001	32,639	98,969	716	4,032	4,748	1,056	3,692	8,333	135,300	135,300
5	135,300	2,771	33,985	140,812	33,256	135,300	729	5,512	6,242	1,389	4,853	13,186	173,408	173,408
6	173,408	2,824	34,627	180,473	33,884	173,408	743	7,065	7,808	1,737	6,071	19,256	213,363	213,363
7	213,363	2,877	35,282	222,056	34,524	213,363	757	8,693	9,450	2,103	7,347	26,604	255,235	255,235
8	255,235	2,931	35,949	265,633	35,177	255,235	772	10,399	11,170	2,485	8,685	35,289	299,097	299,097
9	299,097	2,987	36,628	311,282	35,842	299,097	786	12,186	12,972	2,886	10,086	45,374	345,024	345,024
10	345,024	3,043	37,320	359,081	36,519	345,024	801	14,057	14,858	3,306	11,552	56,926	393,095	393,095
11	393,095	3,101	38,028	409,110	37,209	393,095	816	16,015	16,831	3,745	13,086	70,013	443,391	443,391
12	443,391	3,159	38,744	461,455	37,913	443,391	832	18,064	18,896	4,204	14,692	84,704	495,995	495,995
13	495,995	3,219	39,477	516,203	38,629	495,995	847	20,208	21,055	4,685	16,370	101,074	550,995	550,995
14	550,995	3,280	40,223	573,443	39,359	550,995	863	22,448	23,312	5,187	18,125	119,199	608,479	608,479
15	608,479	3,342	40,983	633,269	40,103	608,479	880	24,790	25,670	5,712	19,958	139,158	668,541	668,541

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [23] = [24]			3.12243%
[7]x(F/P, i_t%, n)	[8]x(F/A, i_t%, n)	[21]+[22]	[20]
-	31,383	31,383	31,382
32,376	31,976	64,352	64,351
66,390	32,580	98,970	98,969
102,104	33,196	135,300	135,300
139,585	33,823	173,409	173,408
178,901	34,463	213,363	213,363
220,121	35,114	255,235	255,235
263,319	35,778	299,097	299,097
308,570	36,454	345,024	345,024
355,953	37,143	393,095	393,095
405,546	37,845	443,391	443,391
457,435	38,560	495,996	495,995
511,706	39,289	550,995	550,995
568,448	40,031	608,479	608,479
627,753	40,788	668,541	668,541

Sheet R: Rental Utility Expenses and Opportunity Loss

Baseline Monthly Utility Expenses	220
Annual Cost Escalation Rate	2.22000%
Equivalent Present Worth	30,328
EUME	184

Opportunity Loss		
FW, Actual $,	PW	EUME
Last row of [18]	FW (P/F, i_a%, n)	PW (A/P, i'_a%, n)
12,332	7,728	47

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	3.10%	3.06%	0.26%
Real Interest Rate (i'_a)	-	1.20%	0.10%

[1]	[2]
Year	Monthly Utility Expenses, Actual $
0	220
1	227
2	232
3	238
4	243
5	248
6	254
7	259
8	265
9	271
10	277
11	283
12	289
13	296
14	302
15	309
16	266

[3]	[4]	[5]
Without Opportunity Loss, Actual $		
BOY	During the Year	Future Worth, EOY
$[5]_{n-1}$	12 x [2]	[3]+[4]
0		0
0	2,729	2,729
2729	2,789	5,518
5518	2,851	8,369
8369	2,914	11,283
11283	2,979	14,262
14262	3,045	17,307
17307	3,113	20,420
20420	3,182	23,602
23602	3,253	26,855
26855	3,325	30,179
30179	3,399	33,578
33578	3,474	37,052
37052	3,551	40,603
40603	3,630	44,233
44233	3,711	47,943

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
	With Opportunity Loss at CD Interest Rate, Actual $													
Year	BOY Running Capital	Monthly Expenses	FVn of Monthly Expenses for Year n	FVn of Running Capital for Year n	Expenses w/o Interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	227	2,779	0	2,729	0	51	0	51	11	39	39	2,768	2,768
2	2,768	232	2,841	2,881	2,789	2,768	52	113	164	37	128	167	5,685	5,685
3	5,685	238	2,904	5,917	2,851	5,685	53	232	284	63	221	388	8,757	8,757
4	8,757	243	2,968	9,114	2,914	8,757	54	357	411	91	319	708	11,991	11,991
5	11,991	248	3,034	12,479	2,979	11,991	55	489	544	121	423	1,131	15,393	15,393
6	15,393	254	3,102	16,020	3,045	15,393	56	627	684	152	531	1,662	18,969	18,969
7	18,969	259	3,170	19,742	3,113	18,969	58	773	831	185	646	2,308	22,728	22,728
8	22,728	265	3,241	23,654	3,182	22,728	59	926	985	219	766	3,074	26,676	26,676
9	26,676	271	3,313	27,762	3,253	26,676	60	1,087	1,147	255	892	3,965	30,820	30,820
10	30,820	277	3,386	32,076	3,325	30,820	62	1,256	1,317	293	1,024	4,990	35,169	35,169
11	35,169	283	3,462	36,602	3,399	35,169	63	1,433	1,496	333	1,163	6,153	39,730	39,730
12	39,730	289	3,538	41,349	3,474	39,730	64	1,619	1,683	374	1,309	7,461	44,513	44,513
13	44,513	296	3,617	46,327	3,551	44,513	66	1,814	1,879	418	1,461	8,922	49,525	49,525
14	49,525	302	3,697	51,543	3,630	49,525	67	2,018	2,085	464	1,621	10,544	54,776	54,776
15	54,776	309	3,779	57,008	3,711	54,776	69	2,232	2,300	512	1,789	12,332	60,276	60,276

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_i) rate, that makes [23] = [24]			3.10566%
[7]x(F/P, i_i%, n)	[8]x(F/A, i_i%, n)	[21]+[22]	[20]
-	2,775	2,775	2,768
2,855	2,837	5,692	5,685
5,864	2,899	8,763	8,757
9,033	2,964	11,997	11,991
12,369	3,030	15,398	15,393
15,878	3,097	18,975	18,969
19,567	3,166	22,733	22,728
23,444	3,236	26,680	26,676
27,516	3,308	30,824	30,820
31,791	3,381	35,172	35,169
36,277	3,456	39,733	39,730
40,982	3,533	44,515	44,513
45,915	3,611	49,527	49,525
51,086	3,692	54,777	54,776
56,502	3,774	60,276	60,276

Sheet S: Annual Median Family Income

Baseline Annual Median Family Income	83,413
Annual Income Escalation Rate	1.9900%

Equivalent Present Worth of Total Income	982,022
EUMI	5504

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
After Tax adjusted increase	1.99%	0.166%
Real Interest Rate (i')	0.12%	0.01%
Income Tax Rate (ITX)	22.25%	-

[1]	[2]	[3]	[4]	[5]	[6]	[7]
Year	Annual Family Income, Actual $	Annual Income Cashflow, Actual $		After tax adjusted rate of increase	Present Worth	Cumulative Present Worth
		Income Tax	Net After Tax			
		ITX *[2]	[2]-[3]		P=F(P/F,f,n)	
0	83,413	-				
1	85,073	18,929	66,144		64,930	64,930
2	86,766	19,305	67,460	1.99%	65,006	129,936
3	88,493	19,690	68,803	1.99%	65,083	195,020
4	90,254	20,081	70,172	1.99%	65,160	260,179
5	92,050	20,481	71,569	1.99%	65,236	325,416
6	93,881	20,889	72,993	1.99%	65,313	390,729
7	95,750	21,304	74,445	1.99%	65,390	456,119
8	97,655	21,728	75,927	1.99%	65,467	521,587
9	99,598	22,161	77,438	1.99%	65,544	587,131
10	101,580	22,602	78,979	1.99%	65,622	652,753
11	103,602	23,051	80,550	1.99%	65,699	718,452
12	105,663	23,510	82,153	1.99%	65,776	784,228
13	107,766	23,978	83,788	1.99%	65,854	850,082
14	109,911	24,455	85,456	1.99%	65,931	916,013
15	112,098	24,942	87,156	1.99%	66,009	982,022
16	114,329					

Sheet T: Opportunity Loss for Monthly Maintenance Fee

Baseline Monthly Maintenance Fee	-
Annual Cost Escalation Rate	1.52%
Equivalent Present Worth	-
EUME	0

Opportunity Loss		
FW, Actual $, Last row of [18]	PW	EUME
	FW (P/F, i,%, n)	PW (A/P, i'ₐ%, n)
0	0	0

Before Tax Rates	Nominal Annual	Nominal Monthly
CPI Inflation Rate	1.87%	0.156%
Nominal CD Interest Rate (i)	4.00%	0.333%
Real Interest Rate (i')	2.09%	0.17%
Income Tax Rate (ITX)	22.25%	-

After Tax Adjusted Rate	Effective Annual	Nominal Annual	Nominal Monthly
CPI Inflation Rate	-	1.87%	0.16%
CD Interest Rate (i_a)	1.60%	1.59%	0.13%
Real Interest Rate (i'_a)	-	-0.27%	-0.02%

[1]	[2]
Year	Monthly R & M Expenses, Actual $
0	0
1	0
2	0
3	0
4	0
5	0
6	0
7	0
8	0
9	0
10	0
11	0
12	0
13	0
14	0
15	0
16	

[3]	[4]	[5]
Without Opportunity Loss, Actual $		
BOY	During the Year	Future Worth, EOY
$[5]_{n-1}$	12 x [2]	[3]+[4]
0		0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0
0	0	0

[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	[18]	[19]	[20]
Year	With Opportunity Loss at CD Interest Rate, Actual $													
	BOY Running Capital	Monthly Expenses	FVn of Monthly R & M for Year n	FVn of Running Capital for Year n	R& M Expenses w/o interest	Running Capital w/o Interest	Interest from Current Year's Expenses	Interest from Running Capital	Total Taxable Interest	Income Tax	Interest Lost	Cumulative Interest Lost	EOY Running Capital	EOY Running Capital
	$[18]_{n-1}$	[3]	[8]x(F/A, i%, n)	[7]x(F/P, i%, n)	12 x [8]	[7]	[9]-[12]	[10]-[12]	[13]+[14]	[ITX]x[15]	[15]-[16]		[9]+[10]-[16]	[7]+[11]+[17]
0													0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[21]	[22]	[23]	[24]
Calculation of After-Tax Adjusted Rate of Return by Trial and Error Method			
Input a trial interest (i_t) rate, that makes [23] = [24]			1.55812%
[7]x(F/P, i%, n)	[8]x(F/A, i%, n)	[21]+[22]	[20]
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

APPENDIX B: MATLAB CODES

List of Matlab Files

User_Interface_File.m

```
% This is the interface file that has to be executed to run the program
clear all
close all
name = input('\n\n    What is your name?\n\n', 's');
fprintf('\n    Hi %s!', name);
fprintf('\n    WELCOME TO HOMEBUYING ANALYSIS PROGRAM !!!\n');
fprintf('\n\n Please read the instructions, and then enter all requested information.\n');
sss=input('\n    When you are ready, press any key to read further instructions.\n');
fprintf ('\n    This program may produce one of the following analysis results at a time.\n')
fprintf ('\n    Therefore, please Select one of the options from the list below:\n');
fprintf ('\n     1) EUNFME vs CD interest rate graph: -- if this is your choice, please enter [1]
when prompted.\n');
fprintf ('\n     2) EUNFME vs Downpayment size graph: -- if this is your choice, please enter [2]
when prompted.\n');
fprintf ('\n     3) EUNFME vs Ownership period graph: -- if this is your choice, please enter [3]
when prompted.\n');
fprintf ('\n     4) Buying vs Renting and Mortgage Severity Indces: -- if this is your choice,
please enter [4] when prompted.\n');
AAA = input ('\n\n    Now, please enter your choice here:   ');
if AAA ==1
   Main_CDRate  % This will draw EUNFME vs CD Rate graph
   % This code reads data from Input_CDRate
else
    if AAA==2
      Main_Downpayment  % This will draw EUNFME vs Down Payment graph
      %This code reads data from "Input_Downpayment"  and
      %"Forecasting_Coefficients" files
else
      if AAA==3
       Main_Ownership % This will draw EUNFME vs Ownership period graph
       %This code reads data from "Input_Ownership" and
       %"Forecasting_Coefficients" files
      else
         if AAA==4
         Main_Buying_Renting % This will calculate Buying/renting ratio, MSI.
         %This code reads data from "Input_BuyingRenting" and
         %"Forecasting_Coefficients" files
         end
         end
      end
    end
% End of file User_interface_File.m
```

Main_CDRate.m

```
% This program constructs a graph of EUNFME vs CD Rates
clear all;
close all;
Input_CDRate %read input file
D=0.00000001;% This is the increment used for iteration steps
Forecasting_Coefficients % this file contains the forecasting coefficients for price escalation.
    iM1 = MortgageRate;
    X=CDRate;
    n1=MortgagePeriod;
    n2=OwnershipPeriod;
    %DownPayment = DownPay/SP; % This is the downpayment fraction of the sales price
    DPA = SP*DownPayment; % Downpayment in dollar amount
    Pt=Discount_pt/100; % Rate for points
    Loan = SP-DPA; % Loan in dollar amount
    PTA = Pt*Loan; % Discount point in dollar amount
    CCA = BCR/100*SP; % Buyer's closing cost in dollar amount
    SCR=SCR1+SCR2; % This is the clsoing cost rate including realtor fee
% Define matrix to print out EUNFME in a tabular format
EUNFMEmatrix=zeros(length(X),iM1+1);
for i=1:length(X)
  EUNFMEmatrix(i,1)=X(i);
end
 % end of matrix for EUNFME in a tabular format
for jj=1:length(iM1);% this loop is for mortgage interest rate, and this defines the number of curves in the graph
  iM=iM1(jj);
for ii=1:length(X);% this loop is for CD interest rate, and this is the X-axis
    iCD=X(ii);
    Y2 = Y1+n2; % This is the home ownership termination year
    f= calc_escrate(CPI1,CPI2,Y1, n2);  % CPI Index calculation
    emr = calc_escrate(PPI1,PPI2,Y1, n2); % Home maintenance cost escalation rate (PPI)
    eu = calc_escrate(Ku1,Ku2,Y1, n2); % Utilities cost escalation rate
    ei=calc_escrate(Khi1,Khi2,Y1, n2); % Home insurance escalation rate
    pro_app = calc_escrate(Kpap1,Kpap2,Y1, n2);%property appreciation rate
    eg = calc_escrate(Kg1,Kg2,Y1, n2);%Gasoline cost inflation rate
    ept=0; % Property tax escalation is zero in Hawaii
  % This section calculates the Downpayment expenses and associated
  % opportunity loss
   if DPA ==0;
    A2=0;A3=0; A4=0;A5=0;A6=0;A7=0;A8=0;A9=0;
  else
    [CLA,FWA] = calc_fv_woint(DPA,iCD,n1,n2,f,RITX);
    [a1,a2,a3,a4,a5,a6 ] = adj_real_rates( FWA,DPA,n2,f);
    PWA=CLA/((1+a2)^n2);
    if ((1+a6)^(n2*12))==1;
      EUME_OLA = PWA/(n2*12);
```

```
      EUME_expA = DPA/(n2*12);
    else
       EUME_OLA = PWA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
      EUME_expA = DPA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
    end
    A4=CLA;
    A5=DPA;
    A6=PWA;
    A7=EUME_expA;
    A8=EUME_OLA;
    A9=A7+A8;
end
 % End of Downpayment Calculation
 % This section calculates the Closing Costs and associated
% opportunity loss
[CLB,FWB] = calc_fv_woint(CCA,iCD,n1,n2,f,RITX);
[b1,b2,b3,b4,b5,b6 ] = adj_real_rates( FWB,CCA,n2,f);
PWB=CLB/((1+b2)^n2);
    if (((1+b6)^(n2*12)))== 1;
      EUME_OLB =PWB/(n2*12);
      EUME_expB =CCA/(n2*12);
    else
      EUME_OLB = PWB*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
      EUME_expB = CCA*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
    end
B4=CLB;
B5=CCA;
B6=PWB;
B7=EUME_expB;
B8=EUME_OLB;
B9=B7+B8;
% End of Closing Costs Calculation
% This section calculates the Discount Points expenses and associated
% opportunity loss
if PTA ==0;
    C2=0;C3=0; C4=0;C5=0;C6=0;C7=0;C8=0;C9=0;
else
    [CLC,FWC] = calc_fv_woint(PTA,iCD,n1,n2,f,RITX);
    [c1,c2,c3,c4,c5,c6 ] = adj_real_rates( FWC,PTA,n2,f);
    PWC=CLC/((1+c2)^n2);
      if (((1+c6)^(n2*12)))== 1;
        EUME_OLC =PWC/(n2*12);
        EUME_expC =PTA/(n2*12);
      else
        EUME_OLC = PWC*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
        EUME_expC = PTA*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
      end
    C4=CLC;
```

```
  C5=PTA;
  C6=PWC;
  C7=EUME_expC;
  C8=EUME_OLC;
  C9=C7+C8;
end
% End of Discount points calculation
%This section calculates the mortgage expenses and associated opportunity loss
MM= mortgage (Loan, n1, iM);
 [CLD,NetEOYLD,BOYLD,EOYD]= opp_loss_mortgage(MM,iCD,n1,n2,RITX);
  best_iaD = best_adj_rate(f,iCD,D,MM, BOYLD, NetEOYLD);
 fprintf('\nbest_iaD: $ %5.5f\n',best_iaD);
[d1,d2,d3,d4,d5] = adj_real_ratesMortgage( best_iaD,f);
PWD=CLD/((1+d3)^(12*n2));
epwD =NetEOYLD/(1+d1)^n2;
  if ((1+d5)^(n2*12))==1;
    EUME_OLD=PWD/(n2*12);
    EUME_expD =epwD/(n2*12);
  else
    EUME_OLD= PWD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
    EUME_expD= epwD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
  end
D2=MM;
D3=0;
D4=NetEOYLD;
D5=EOYD;
D6=PWD;
D7=EUME_expD;
D8=EUME_OLD;
D9=D7+D8;
% This section calculates the utility expenses and associated opportunity loss

[CLE,NetEOYLE,BOYLE,EOYE,BMavE] = opp_loss_monthlyExp (BMu,eu,iCD,n2,RITX);
 best_iaE = best_adj_rateMonthlyExp(f,iCD,D,BOYLE,BMavE,NetEOYLE);
 [e1,e2,e3,e4,e5] = adj_real_ratesMortgage( best_iaE,f);
 PWE=CLE/((1+e3)^(12*n2));
epwE =EOYE/(1+e1)^n2;
  if ((1+e5)^(n2*12))==1;
    EUME_OLE=PWE/(n2*12);
    EUME_expE=epwE/(n2*12);
  else
    EUME_OLE= PWE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
    EUME_expE= epwE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
  end
E2=BMu;
E3=eu;
E4=EOYE;
E5=epwE;
```

```
E6=PWE;
E7=EUME_expE;
E8=EUME_OLE;
E9=E7+E8;
% End of calculation for utility expenses
% This section calculates the Repair and Maintenance expenses and
% associated opportunity loss
[CLF,NetEOYLF,BOYLF,EOYF,BMavF] = opp_loss_monthlyExp (BMmr,emr,iCD,n2,RITX);
 best_iaF = best_adj_rateMonthlyExp(f,iCD,D,BOYLF,BMavF,NetEOYLF);
 [f1,f2,f3,f4,f5] = adj_real_ratesMortgage( best_iaF,f);
 PWF=CLF/((1+f3)^(12*n2));
epwF =EOYF/(1+f1)^n2;
  if ((1+f5)^(n2*12))==1;
     EUME_OLF=PWF/(n2*12);
     EUME_expF =epwF/(n2*12);
  else
    EUME_OLF= PWF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
    EUME_expF= epwF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
  end
F2=BMmr;
F3=emr;
F4=EOYF;
F5=epwF;
F6=PWF;
F7=EUME_expF;
F8=EUME_OLF;
F9=F7+F8;
%End of calculations for maintenance and repair costs
% This section calculates the monthly maintenance fee and associated
% opportunity loss if the purchase is a condominium

[CLV,NetEOYLV,BOYLV,EOYV,BMavV] = opp_loss_monthlyExp
(BMCF,emr,iCD,n2,RITX);
 best_iaV = best_adj_rateMonthlyExp(f,iCD,D,BOYLV,BMavV,NetEOYLV);
 [v1,v2,v3,v4,v5] = adj_real_ratesMortgage( best_iaV,f);
 PWV=CLV/((1+v3)^(12*n2));
epwV =EOYV/(1+v1)^n2;
  if ((1+v5)^(n2*12))==1;
     EUME_OLV=PWV/(n2*12);
     EUME_expV =epwV/(n2*12);
  else
    EUME_OLV= PWV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
    EUME_expV= epwV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
  end
V2=BMCF;
V3=emr;
V4=EOYV;
V5=epwV;
```

```
  V6=PWV;
  V7=EUME_expV;
  V8=EUME_OLV;
  V9=V7+V8;
   % end of monthly fee calculation
   %This section calculates the excess gasoline expenses and associated opportunity loss
[CLG,NetEOYLG,BOYLG,EOYG,BMavG] = opp_loss_monthlyExp (BMg,eg,iCD,n2,RITX);
   best_iaG = best_adj_rateMonthlyExp(f,iCD,D,BOYLG,BMavG,NetEOYLG);
   [g1,g2,g3,g4,g5] = adj_real_ratesMortgage( best_iaG,f);
   PWG=CLG/((1+g3)^(12*n2));
  epwG =EOYG/(1+g1)^n2;
       if ((1+g5)^(n2*12))==1;
       EUME_OLG=PWG/(n2*12);
       EUME_expG=epwG/(n2*12);
    else
       EUME_OLG= PWG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
       EUME_expG= epwG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
    end
  G2=BMg;
  G3=eg;
  G4=EOYG;
  G5=epwG;
  G6=PWG;
  G7=EUME_expG;
  G8=EUME_OLG;
  G9=G7+G8;
  % End of calculations for excess gasoline expenses
  % This section calculates home insurance expenses and and associated
  % opportunity loss
NP=2; % this means insurance is paid twice a year (six monthly)
[CLH,NetEOYLH,BOYLH,EOYH,BSMH,BCavH] = opp_loss_ins (BAi,ei,iCD,n2,RITX,NP);
   best_iaH = best_adj_rateSixMonthlyExp(f,iCD,D,BOYLH,BSMH,NetEOYLH);
   [h1,h2,h3,h4,h5] = adj_real_ratesMortgage( best_iaH,f);
   PWH=CLH/((1+h3)^(12*n2));
  epwH =EOYH/(1+h1)^n2;
     if ((1+h5)^(n2*12))==1;
        EUME_OLH=PWH/(n2*12);
        EUME_expH=epwH/(n2*12);
     else
       EUME_OLH= PWH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
       EUME_expH= epwH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
     end
  H2=BCavH;
  H3=ei;
  H4=EOYH;
  H5=epwH;
  H6=PWH;
  H7=EUME_expH;
```

```
  H8=EUME_OLH;
  H9=H7+H8;
   % This section calculates property tax expenses and associated
  % opportunity loss
  NP=1; % this means propert tax is paid once a year (at the end of the year).
  BaseTax=SP*ptax_rate/100;
[CLI,NetEOYLI,BOYLI,NetintI,EOYI,BATI,BCavI] =
opp_loss_ptax(SP,pro_app,ptax_rate,ept,iCD,n2,RITX);
   best_iaI=NetintI/BOYLI;
   [i1,i2,i3,i4,i5] = adj_real_ratesMortgage( best_iaI,f);
   PWI=CLI/((1+i3)^(12*n2));
  epwI =EOYI/(1+i1)^n2;
    if ((1+i5)^(n2*12))==1;
      EUME_OLI=PWI/(n2*12);
      EUME_expI=epwI/(n2*12);
    else
      EUME_OLI= PWI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
      EUME_expI= epwI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
    end
  I2=BCavI;
  I3=ept;
  I4=EOYI;
  I5=epwI;
  I6=PWI;
  I7=EUME_expI;
  I8=EUME_OLI;
  I9=I7+I8;
  % End of Property Tax expense calculations
   % This section calculates tax return for discount points and associated opportunity
  % gain
  if PTA ==0;
    J2=0;J3=0; J4=0;J5=0;J6=0;J7=0;J8=0;J9=0;
  Else
[CLJ,NetEOYLJ,BOYLJ,EOYJ, DTYJ] = opp_loss_taxreturn_pt(
Loan,Discount_pt,iCD,n2,RITX);
    best_iaJ = best_adj_rate_taxreturn(f,iCD,D,BOYLJ,DTYJ,NetEOYLJ);
    [j1,j2,j3,j4,j5] = adj_real_ratesMortgage( best_iaJ,f);
    PWJ=CLJ/((1+j3)^(12*n2));
    epwJ =EOYJ/(1+j1)^n2;
      if ((1+j5)^(n2*12))==1;
         EUME_OLJ=PWJ/(n2*12);
         EUME_expJ=epwJ/(n2*12);
      else
        EUME_OLJ= PWJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
        EUME_expJ= epwJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
      end

    J2=-EOYJ;
```

```
    J3=0;
    J4=-NetEOYLJ;
    J5=-epwJ;
    J6=-PWJ;
    J7=-EUME_expJ;
    J8=-EUME_OLJ;
    J9=J7+J8;
  end
  % End of  Tax Return for discount points calculations
  % This section calculates tax return on mortgage paid and opportunity gain

   [DTYK, BOYLK, CLK, EOYK, NetEOYLK,Loan_remaining]=
opp_loss_taxreturn_mortgage (Loan, iM , iCD, n1, n2, RITX);
    best_iaK = best_adj_rate_taxreturn(f,iCD,D,BOYLK,DTYK,NetEOYLK);
    [k1,k2,k3,k4,k5] = adj_real_ratesMortgage( best_iaK,f);
  PWK=CLK/((1+k1)^(n2));
  epwK =EOYK/(1+k1)^n2;
    if ((1+k5)^(n2*12))==1;
      EUME_OLK=PWK/(n2*12);
      EUME_expK=epwK/(n2*12);
  else
    EUME_OLK= PWK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
    EUME_expK= epwK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
  end
  K2=EOYK;
  K3=0;
  K4=-NetEOYLK;
  K5=-epwK;
  K6=-PWK;
  K7=-EUME_expK;
  K8=-EUME_OLK;
  K9=K7+K8;
   %This section calculates the tax return on property tax paid and
  %opportunity gain
  [DTYL, BOYLL, CLL, EOYL, NetEOYLL]= opp_loss_taxreturn_proptax (SP,pro_app,
ptax_rate, ept, iCD, n1, n2, RITX)
  best_iaL = best_adj_rate_taxreturn(f,iCD,D,BOYLL,DTYL,NetEOYLL);
   [l1,l2,l3,l4,l5] = adj_real_ratesMortgage( best_iaL,f);
  PWL=CLL/((1+l3)^(n2*12));
  epwL =EOYL/(1+l1)^n2;
      if ((1+l5)^(n2*12))==1;
        EUME_OLL=PWL/(n2*12);
        EUME_expL=epwL/(n2*12);
    else
      EUME_OLL= PWL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
      EUME_expL= epwL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
    end
  L2=EOYL;
```

```
L3=0;
L4=-NetEOYLL;
L5=-epwL;
L6=-PWL;
L7=-EUME_expL;
L8=-EUME_OLL;
L9=L7+L8;

%End of tax return calculation on property tax paid.
% This section calculates the reroofing costs and associated
% opportunity loss
%RoofCost is the estimated cost for reroofing at the current price
%Rint is the interval of the works for example 15 years for reroofing
%emar is the cost escalation rate for reroofing works
 [CLM,BOYLM,EOYM,NetintM, NetEOYLM] = Periodic_RandM(RoofCost, Rint, emr, iCD,
n2, RITX);
 if NetintM==0 && BOYLM ==0;
   best_iaM=0.775*iCD/100;
else
  best_iaM = NetintM/BOYLM;
end
[m1,m2,m3,m4,m5] = adj_real_ratesMortgage( best_iaM,f);
PWM=CLM/((1+m3)^(n2*12));
epwM =EOYM/(1+m1)^n2;
  if ((1+m5)^(n2*12))==1;
    EUME_OLM= PWM/(n2*12);
    EUME_expM=epwM/(n2*12);
  else
    EUME_OLM= PWM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
    EUME_expM= epwM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
  end
M2=RoofCost;
M3=emr;
M4=EOYM;
M5=epwM;
M6=PWM;
M7=EUME_expM;
M8=EUME_OLM;
M9=M7+M8;
% End of reroofing cost
%This section calculates the repainting expenses and associated
%opportunity loss
%PaintCost is the estimated cost for repainting at the current price
%Pint is the interval of the works for example 5 years for repainting
%emar is the cost escalation rate for reroofing works

[CLN,BOYLN,EOYN,NetintN, NetEOYLN] = Periodic_RandM(PaintCost, Pint, emr, iCD,
n2, RITX);
```

```
if BOYLN ==0;
   best_iaN=0.775*iCD/100;
else
   best_iaN = NetintN/BOYLN;
end
[n11,n22,n33,n44,n55] = adj_real_ratesMortgage( best_iaN,f);

PWN=CLN/((1+n33)^(n2*12));
epwN =EOYN/(1+n11)^n2;
   if ((1+n55)^(n2*12))==1;
      EUME_OLN= PWN/(n2*12);
      EUME_expN=epwN/(n2*12);
   else
      EUME_OLN= PWN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
      EUME_expN= epwN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
   end
N2=PaintCost;
N3=emr;
N4=EOYN;
N5=epwN;
N6=PWN;
N7=EUME_expN;
N8=EUME_OLN;
N9=N7+N8;

 % This section calculates the remaining mortgage loan, and resale
 % value of the property at the end of the homeownership period

RP=Loan_remaining;
[P2,P3,P4,P5,P6,P7,P8,P9]= Property_Resalevalue (SP, pro_app,n2,b2,b6);

   % This section calculates seller's closing costs upon termination of the property ownership/
 [O22,O23,O24,O25,O26,O27,O28,O29,Resalevalue, FVadv] =
Sellers_Closing_Cost(SP,pro_app,n2,f, SCR, Advert,b2,b6 );
% This section calculates capital gain tax upon resale of the property
[O32,O33,O34,O35,O36,O37,O38,O39] = Capital_gain_tax(n2,Resalevalue,SP, CCA, PTA,
SCR, RP, FVadv, b2,b6, Exmpt,CGTrate);
O44 = RP;
O45= RP/((1+b2)^n2);
O46= 0;
if (1+b6)^(n2*12)==1
  O47=O45/(n2*12);
else
O47 =O45*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
end
O48=0;
O49=O47+O48;
```

```
% this section sums up all the expenses and revenues as EUNFME
YY(ii)=A9+B9+C9+D9+E9+F9+G9+H9+I9+J9+K9+L9+M9+N9+P9+O29+O39+O49+V9;
  %fprintf('EUNFME: $ %5.0f\n',YY);
  hold on;

end % edn of loop for ii
for ia1=1:length(X)
  EUNFMEmatrix(ia1,jj+1)=YY(1,ia1);
end

clr = [':o';'-d'; '-x'; ':s';'-*'; ':x'; '-s'; ':*'; '-v'; ':d';'-^'; ':+'; '-p'; ':p';'-+';':v'; '-o';':^'];
clr = [clr;clr;clr];
plot(X,YY,clr(jj,:),'LineWidth',2);
xlabel('CD Interest Rate, %','fontsize', 14); ylabel('EUNFME, $','fontsize', 14)
title(['For Ownership Period =', num2str(n2),' years, Downpayment =',
num2str(DownPayment*100),'%, ', 'and Sales Price = $ ', num2str(SP)],'fontsize', 14)
hold on
end % end of loop for jj
for ll=1:length(iM1)
  leg(ll,:) = ['Mortg. Rate=' num2str(iM1(ll)) '%'];
end
legend(leg);
% End of file Main_CDRate.m
```

Main_Downpayment.m

```
% This program constructs a graph of EUNFME vs Downpayment size
clear all;
close all;
Input_Downpayment % read input file
D=0.00000001;% This is the increment used for iteration steps
Forecasting_Coefficients % this file contains the forecasting coefficients for price escalation.
     n1=MortgagePeriod;
     n2=OwnershipPeriod;
     iM1 = MortgageRate;
     iCD=CDRate;
     Pt=Discount_pt/100; % Rate for points
     CCA = BCR/100*SP; % Buyer's closing cost in dollar amount
     SCR=SCR1+SCR2; % This is sellers closing costs rate including realtors fee.

% Define matrix to print out EUNFME in a tabular format
EUNFMEmatrix=zeros(length(DownPayment),iM1+1);
for i=1:length(DownPayment)
  EUNFMEmatrix(i,1)=DownPayment(i);
end
 % end of matrix for EUNFME in a tabular format

for jj=1:length(iM1)% this loop is for mortgage interest rate, and this defines the number of
curves in the graph
  iM=iM1(jj);

for ii=1:length(DownPayment);% this loop is for X-axis that represents downpayment size
 DPY(ii)=DownPayment(ii);
  % This section calculates the Downpayment
     DPA = SP*DPY (ii); % Downpayment amount
     Loan= SP-DPA; % Loan in dollar amount
     PTA = Pt*Loan; % Discount point in dollar amount
     Y2 = Y1+n2; % This is the home ownership termination year
     f= calc_escrate(CPI1,CPI2,Y1, n2); % CPI Index calculation
     emr = calc_escrate(PPI1,PPI2,Y1, n2); % Home maintenance cost escalation rate (PPI)
     eu = calc_escrate(Ku1,Ku2,Y1, n2); % Utilities cost escalation rate
     ei=calc_escrate(Khi1,Khi2,Y1, n2); % Home insurance escalation rate
     pro_app = calc_escrate(Kpap1,Kpap2,Y1, n2);%property appreciation rate
     eg = calc_escrate(Kg1,Kg2,Y1, n2);%Gasoline cost inflation rate
     ept=0; % Property tax escalation is zero in Hawaii

  % This section calculates the Downpayment expenses and associated opportunity loss
   if DPA ==0;
     A2=0;A3=0; A4=0;A5=0;A6=0;A7=0;A8=0;A9=0;
  else
```

```
  [CLA,FWA] = calc_fv_woint(DPA,iCD,n1,n2,f,RITX);
  [a1,a2,a3,a4,a5,a6 ] = adj_real_rates( FWA,DPA,n2,f);
  PWA=CLA/((1+a2)^n2);
  if ((1+a6)^(n2*12))==1;
    EUME_OLA = PWA/(n2*12);
    EUME_expA = DPA(ii)/(n2*12);
  else
     EUME_OLA = PWA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
    EUME_expA = DPA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
  end
  A4=CLA;
  A5=DPA;
  A6=PWA;
  A7=EUME_expA;
  A8=EUME_OLA;
  A9=A7+A8;
end
 % End of Downpayment Calculation
 % This section calculates the Closing Costs and associated opportunity loss
[CLB,FWB] = calc_fv_woint(CCA,iCD,n1,n2,f,RITX);
 [b1,b2,b3,b4,b5,b6 ] = adj_real_rates( FWB,CCA,n2,f);


PWB=CLB/((1+b2)^n2);
    if (((1+b6)^(n2*12)))== 1;
    EUME_OLB =PWB/(n2*12);
    EUME_expB =CCA/(n2*12);
  else
    EUME_OLB = PWB*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
    EUME_expB = CCA*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
  end
B4=CLB;
B5=CCA;
B6=PWB;
B7=EUME_expB;
B8=EUME_OLB;
B9=B7+B8;
% End of Closing Costs Calculation
 % This section calculates the Discount Points expenses and associatedopportunity loss
if PTA ==0;
  C2=0;C3=0; C4=0;C5=0;C6=0;C7=0;C8=0;C9=0;
else
  [CLC,FWC] = calc_fv_woint(PTA,iCD,n1,n2,f,RITX);
   [c1,c2,c3,c4,c5,c6 ] = adj_real_rates( FWC,PTA,n2,f);
   PWC=CLC/((1+c2)^n2);
     if (((1+c6)^(n2*12)))== 1;
       EUME_OLC =PWC/(n2*12);
       EUME_expC =PTA/(n2*12);
```

```
      else
        EUME_OLC = PWC*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
        EUME_expC = PTA*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
      end
   C4=CLC;
   C5=PTA;
   C6=PWC;
   C7=EUME_expC;
   C8=EUME_OLC;
   C9=C7+C8;
end
% End of Discount points calculation
 %This section calculates the mortgage expenses and associated opportunity loss
MM= mortgage (Loan, n1, iM);
 [CLD,NetEOYLD,BOYLD,EOYD]= opp_loss_mortgage(MM,iCD,n1,n2,RITX);
   best_iaD = best_adj_rate(f,iCD,D,MM, BOYLD, NetEOYLD);
   [d1,d2,d3,d4,d5] = adj_real_ratesMortgage( best_iaD,f);
PWD=CLD/((1+d3)^(12*n2));
epwD =NetEOYLD/(1+d1)^n2;
   if ((1+d5)^(n2*12))==1;
     EUME_OLD=PWD/(n2*12);
     EUME_expD =epwD/(n2*12);
   else
     EUME_OLD= PWD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
     EUME_expD= epwD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
   end
D2=MM;
D3=0;
D4=NetEOYLD;
D5=EOYD;
D6=PWD;
D7=EUME_expD;
D8=EUME_OLD;
D9=D7+D8;
% This section calculates the utility expenses and associated opportunity loss
 [CLE,NetEOYLE,BOYLE,EOYE,BMavE] = opp_loss_monthlyExp (BMu,eu,iCD,n2,RITX);
 best_iaE = best_adj_rateMonthlyExp(f,iCD,D,BOYLE,BMavE,NetEOYLE);
 [e1,e2,e3,e4,e5] = adj_real_ratesMortgage( best_iaE,f);
 PWE=CLE/((1+e3)^(12*n2));
epwE =EOYE/(1+e1)^n2;
   if ((1+e5)^(n2*12))==1;
     EUME_OLE=PWE/(n2*12);
     EUME_expE=epwE/(n2*12);
   else
     EUME_OLE= PWE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
     EUME_expE= epwE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
   end
E2=BMu;
```

```
E3=eu;
E4=EOYE;
E5=epwE;
E6=PWE;
E7=EUME_expE;
E8=EUME_OLE;
E9=E7+E8;
 % End of calculation for utility expenses
 % This section calculates Repair and Maintenance expenses and associated opportunity loss
   [CLF,NetEOYLF,BOYLF,EOYF,BMavF] = opp_loss_monthlyExp
(BMmr,emr,iCD,n2,RITX);
 best_iaF = best_adj_rateMonthlyExp(f,iCD,D,BOYLF,BMavF,NetEOYLF);
 [f1,f2,f3,f4,f5] = adj_real_ratesMortgage( best_iaF,f);
 PWF=CLF/((1+f3)^(12*n2));
epwF =EOYF/(1+f1)^n2;
  if ((1+f5)^(n2*12))==1;
     EUME_OLF=PWF/(n2*12);
     EUME_expF =epwF/(n2*12);
  else
    EUME_OLF= PWF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
    EUME_expF= epwF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
  end
F2=BMmr;
F3=emr;
F4=EOYF;
F5=epwF;
F6=PWF;
F7=EUME_expF;
F8=EUME_OLF;
F9=F7+F8;
%End of calculations for maintenance and repair costs
% This section calculates the monthly maintenance fee and associated opportunity loss ---if the
% purchase is a condominium
 [CLV,NetEOYLV,BOYLV,EOYV,BMavV] = opp_loss_monthlyExp
(BMCF,emr,iCD,n2,RITX);

best_iaV = best_adj_rateMonthlyExp(f,iCD,D,BOYLV,BMavV,NetEOYLV);
 [v1,v2,v3,v4,v5] = adj_real_ratesMortgage( best_iaV,f);
 PWV=CLV/((1+v3)^(12*n2));
epwV =EOYV/(1+v1)^n2;
  if ((1+v5)^(n2*12))==1;
     EUME_OLV=PWV/(n2*12);
     EUME_expV =epwV/(n2*12);
  else
    EUME_OLV= PWV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
    EUME_expV= epwV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
  end
V2=BMCF;
```

```
 V3=emr;
 V4=EOYV;
 V5=epwV;
 V6=PWV;
 V7=EUME_expV;
 V8=EUME_OLV;
 V9=V7+V8;
% end of monthly fee calculation
%This section calculates the excess gasoline expenses and associated opportunity loss
[CLG,NetEOYLG,BOYLG,EOYG,BMavG] = opp_loss_monthlyExp (BMg,eg,iCD,n2,RITX);
  best_iaG = best_adj_rateMonthlyExp(f,iCD,D,BOYLG,BMavG,NetEOYLG);
  [g1,g2,g3,g4,g5] = adj_real_ratesMortgage( best_iaG,f);
  PWG=CLG/((1+g3)^(12*n2));
 epwG =EOYG/(1+g1)^n2;
       if ((1+g5)^(n2*12))==1;
       EUME_OLG=PWG/(n2*12);
       EUME_expG=epwG/(n2*12);
    else
       EUME_OLG= PWG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
       EUME_expG= epwG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
    end
 G2=BMg;
 G3=eg;
 G4=EOYG;
 G5=epwG;
 G6=PWG;
 G7=EUME_expG;
 G8=EUME_OLG;
 G9=G7+G8;
  % End of calculations for excess gasoline expenses
  % This section calculates home insurance expenses and and associated
 % opportunity loss
 NP=2; % this means insurance is paid twice a year (six monthly)
 [CLH,NetEOYLH,BOYLH,EOYH,BSMH,BCavH] = opp_loss_ins (BAi,ei,iCD,n2,RITX,NP);
 best_iaH = best_adj_rateSixMonthlyExp(f,iCD,D,BOYLH,BSMH,NetEOYLH);
 [h1,h2,h3,h4,h5] = adj_real_ratesMortgage( best_iaH,f);
 PWH=CLH/((1+h3)^(12*n2));
 epwH =EOYH/(1+h1)^n2;
    if ((1+h5)^(n2*12))==1;
       EUME_OLH=PWH/(n2*12);
       EUME_expH=epwH/(n2*12);
    else
      EUME_OLH= PWH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
      EUME_expH= epwH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
    end
 H2=BCavH;
 H3=ei;
 H4=EOYH;
```

```
H5=epwH;
H6=PWH;
H7=EUME_expH;
H8=EUME_OLH;
H9=H7+H8;
% End of insurance expense calculations
% This section calculates property tax expenses and associated
% opportunity loss
NP=1; % this means propert tax is paid once a year (at the end of the year).
BaseTax=SP*ptax_rate/100;

[CLI,NetEOYLI,BOYLI,NetintI,EOYI,BATI,BCavI] =
opp_loss_ptax(SP,pro_app,ptax_rate,ept,iCD,n2,RITX);

best_iaI=NetintI/BOYLI;

[i1,i2,i3,i4,i5] = adj_real_ratesMortgage( best_iaI,f);

PWI=CLI/((1+i3)^(12*n2));
epwI =EOYI/(1+i1)^n2;
  if ((1+i5)^(n2*12))==1;
    EUME_OLI=PWI/(n2*12);
    EUME_expI=epwI/(n2*12);
  else
    EUME_OLI= PWI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
    EUME_expI= epwI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
  end
I2=BCavI;
I3=ept;
I4=EOYI;
I5=epwI;
I6=PWI;
I7=EUME_expI;
I8=EUME_OLI;
I9=I7+I8;
% End of Property Tax expense calculations
% This section calculates tax return for discount points and associated
% opportunity gain
if PTA ==0;
  J2=0;J3=0; J4=0;J5=0;J6=0;J7=0;J8=0;J9=0;
else
   [CLJ,NetEOYLJ,BOYLJ,EOYJ, DTYJ] = opp_loss_taxreturn_pt(
Loan,Discount_pt,iCD,n2,RITX);
  best_iaJ = best_adj_rate_taxreturn(f,iCD,D,BOYLJ,DTYJ,NetEOYLJ);
  [j1,j2,j3,j4,j5] = adj_real_ratesMortgage( best_iaJ,f);
  PWJ=CLJ/((1+j3)^(12*n2));
  epwJ =EOYJ/(1+j1)^n2;
    if ((1+j5)^(n2*12))==1;
```

```
            EUME_OLJ=PWJ/(n2*12);
            EUME_expJ=epwJ/(n2*12);
         else
            EUME_OLJ= PWJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
            EUME_expJ= epwJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
         end
      J2=-EOYJ;
      J3=0;
      J4=-NetEOYLJ;
      J5=-epwJ;
      J6=-PWJ;
      J7=-EUME_expJ;
      J8=-EUME_OLJ;
      J9=J7+J8;
   end
   % End of  Tax Return for discount points calculations
   % This section calculates tax return on mortgage paid and opportunity
   % gain
   [DTYK, BOYLK, CLK, EOYK, NetEOYLK,Loan_remaining]= opp_loss_taxreturn_mortgage
(Loan, iM , iCD, n1, n2, RITX);
   best_iaK = best_adj_rate_taxreturn(f,iCD,D,BOYLK,DTYK,NetEOYLK);
   [k1,k2,k3,k4,k5] = adj_real_ratesMortgage( best_iaK,f);
   PWK=CLK/((1+k1)^(n2));
   epwK =EOYK/(1+k1)^n2;

   if ((1+k5)^(n2*12))==1;
     EUME_OLK=PWK/(n2*12);
     EUME_expK=epwK/(n2*12);
   else

      EUME_OLK= PWK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
      EUME_expK= epwK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
   end
   K2=EOYK;
   K3=0;
   K4=-NetEOYLK;
   K5=-epwK;
   K6=-PWK;
   K7=-EUME_expK;
   K8=-EUME_OLK;
   K9=K7+K8;
   %This section calculates the tax return on property tax paid and
   %opportunity gain
   [DTYL, BOYLL, CLL, EOYL, NetEOYLL]= opp_loss_taxreturn_proptax (SP,pro_app,
ptax_rate, ept, iCD, n1, n2, RITX);
   best_iaL = best_adj_rate_taxreturn(f,iCD,D,BOYLL,DTYL,NetEOYLL);
   [l1,l2,l3,l4,l5] = adj_real_ratesMortgage( best_iaL,f);
   PWL=CLL/((1+l3)^(n2*12));
```

```
epwL =EOYL/(1+l1)^n2;

   if ((1+l5)^(n2*12))==1;
       EUME_OLL=PWL/(n2*12);
       EUME_expL=epwL/(n2*12);
   else
      EUME_OLL= PWL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
      EUME_expL= epwL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
   end
L2=EOYL;
L3=0;
L4=-NetEOYLL;
L5=-epwL;
L6=-PWL;
L7=-EUME_expL;
L8=-EUME_OLL;
L9=L7+L8;
%End of tax return calculation on property tax paid.
% This section calculates the reroofing costs and associated
% opportunity loss
%RoofCost is the estimated cost for reroofing at the current price
%Rint is the interval of the works for example 15 years for reroofing
%emar is the cost escalation rate for reroofing works
 [CLM,BOYLM,EOYM,NetintM, NetEOYLM] = Periodic_RandM(RoofCost, Rint, emr, iCD,
n2, RITX);
 if NetintM==0 && BOYLM ==0;
    best_iaM=0.775*iCD/100;
else
   best_iaM = NetintM/BOYLM;
end
[m1,m2,m3,m4,m5] = adj_real_ratesMortgage( best_iaM,f);
PWM=CLM/((1+m3)^(n2*12));
epwM =EOYM/(1+m1)^n2;
   if ((1+m5)^(n2*12))==1;
      EUME_OLM= PWM/(n2*12);
      EUME_expM=epwM/(n2*12);
   else
      EUME_OLM= PWM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
      EUME_expM= epwM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
   end
M2=RoofCost;
M3=emr;
M4=EOYM;
M5=epwM;
M6=PWM;
M7=EUME_expM;
M8=EUME_OLM;
M9=M7+M8;
```

```
% End of reroofing cost
%This section calculates the repainting expenses and associated
%opportunity loss
%PaintCost is the estimated cost for repainting at the current price
%Pint is the interval of the works for example 5 years for repainting
%emar is the cost escalation rate for reroofing works

[CLN,BOYLN,EOYN,NetintN, NetEOYLN] = Periodic_RandM(PaintCost, Pint, emr, iCD,
n2, RITX);

if BOYLN ==0;

  best_iaN=0.775*iCD/100;
else
  best_iaN = NetintN/BOYLN;
end
[n11,n22,n33,n44,n55] = adj_real_ratesMortgage( best_iaN,f);

PWN=CLN/((1+n33)^(n2*12));
epwN =EOYN/(1+n11)^n2;
  if ((1+n55)^(n2*12))==1;
    EUME_OLN= PWN/(n2*12);
    EUME_expN=epwN/(n2*12);
  else
    EUME_OLN= PWN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
    EUME_expN= epwN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
  end
N2=PaintCost;
N3=emr;
N4=EOYN;
N5=epwN;
N6=PWN;
N7=EUME_expN;
N8=EUME_OLN;
N9=N7+N8;
% This section calculates the remaining mortgage loan, and resale
 % value of the property at the end of the homeownership period
 RP=Loan_remaining;
[P2,P3,P4,P5,P6,P7,P8,P9]= Property_Resalevalue (SP, pro_app,n2,c2,c6);
% This section calculates seller's closing costs upon termination/ resale of the property
[O22,O23,O24,O25,O26,O27,O28,O29,Resalevalue, FVadv] =
Sellers_Closing_Cost(SP,pro_app,n2,f, SCR, Advert,c2,c6 );
% This section calculates capital gain tax upon resale of the property
[O32,O33,O34,O35,O36,O37,O38,O39] = Capital_gain_tax(n2,Resalevalue,SP, CCA, PTA,
SCR, RP, FVadv, c2,c6, Exmpt,CGTrate);
O44 = RP;
O45= RP/((1+c2)^n2);
O46= 0;
```

```
if (1+c6)^(n2*12)==1
   O47=O45/(n2*12);
else
O47 =O45*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
end
O48=0;
O49=O47+O48;
 % this section sums up all the expenses and revenues as EUNFME
YY(ii)=A9+B9+C9+D9+E9+F9+G9+H9+I9+J9+K9+L9+M9+N9+P9+O29+O39+O49+V9;
%    fprintf('EUNFME: $ %5.0f\n',YY);
   hold on;
end % edn of loop for ii
for ia1=1:length(DownPayment)
   EUNFMEmatrix(ia1,jj+1)=YY(1,ia1);
end
clr = [':o';'-d'; '-x'; ':s';'-*'; ':x'; '-s'; ':*'; '-v'; ':d';'-^'; ':+'; '-p'; ':p';'-+';':v'; '-o';':^'];
clr = [clr;clr;clr];
plot((100*DPY),YY,clr(jj,:));

xlabel('Downpayment, %'); ylabel('EUNFME, $')
title(['For CD Interest Rate =', num2str(iCD),' %, Ownership period =', num2str(n2),' years,','and
Sales Price = $ ', num2str(SP)])
hold on
end % end of loop for jj
for ll=1:length(iM1)
   leg(ll,:) = ['Mortg. Rate=' num2str(iM1(ll)) '%'];
end
legend(leg);

% End of file Main_Downpayment.m
```

Main_Ownership.m

```
% This program constructs a graph of EUNFME vs Ownership period

clear all;
close all;
Input_Ownership % read input file
D=0.00000001;% This is the increment used for iteration steps
Forecasting_Coefficients % this file contains the forecasting coefficients for price escalation.
    DownPayment = DownPay/SP; % This is the downpayment as fraction of sales price
    DPA = SP*DownPayment; % Downpayment amount
    Pt=Discount_pt/100; % Rate for points
    Loan = SP-DPA; % Loan in dollar amount
    PTA = Pt*Loan; % Discount point in dollar amount
    BCR=1.5; % Buyer's closing cost rate in % of purchase price
    CCA = BCR/100*SP; % Buyer's closing cost in dollar amount
    SCR=SCR1+SCR2; %This is the sellers closing cost rate including realtors fee
    iM1 = MortgageRate;
    iCD=CDRate;
    X=OwnershipPeriod;
    n1=MortgagePeriod;
 %Define matrix to print out EUNFME in a tabular format
EUNFMEmatrix=zeros(length(X),iM1+1);
for i=1:length(X)
  EUNFMEmatrix(i,1)=X(i);
end
 % end of matrix for EUNFME in a tabular format
 for jj=1:length(iM1);% this loop is for mortgage interest rate, and this defines the number of
curves in the graph
  iM=iM1(jj);
for ii=1:length(X);% this loop is for ownership period, and this is the X-axis in the graph
        n2=X(ii); %this is the ownership period
        Y2 = Y1+n2; % This is the home ownership termination year
        f= calc_escrate(CPI1,CPI2,Y1, n2); % CPI Index calculation
        emr = calc_escrate(PPI1,PPI2,Y1, n2); % Home maintenance cost escalation rate (PPI)
        eu = calc_escrate(Ku1,Ku2,Y1, n2); % Utilities cost escalation rate
        ei=calc_escrate(Khi1,Khi2,Y1, n2); % Home insurance escalation rate
        pro_app = calc_escrate(Kpap1,Kpap2,Y1, n2);%property appreciation rate
        eg = calc_escrate(Kg1,Kg2,Y1, n2);%Gasoline cost inflation rate
        ept=0; % Property tax escalation is zero in Hawaii

  % This section calculates the Downpayment expenses and associated opportunity loss
   if DPA ==0;
    A2=0;A3=0; A4=0;A5=0;A6=0;A7=0;A8=0;A9=0;
  else
    [CLA,FWA] = calc_fv_woint(DPA,iCD,n1,n2,f,RITX);
    [a1,a2,a3,a4,a5,a6 ] = adj_real_rates( FWA,DPA,n2,f);
    PWA=CLA/((1+a2)^n2);
```

```
  if ((1+a6)^(n2*12))==1;
    EUME_OLA = PWA/(n2*12);
    EUME_expA = DPA(ii)/(n2*12);
  else
    EUME_OLA = PWA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
    EUME_expA = DPA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
  end
  A4=CLA;
  A5=DPA;
  A6=PWA;
  A7=EUME_expA;
  A8=EUME_OLA;
  A9=A7+A8;
end
% End of Downpayment Calculation
% This section calculates the Closing Costs and associated
% opportunity loss
[CLB,FWB] = calc_fv_woint(CCA,iCD,n1,n2,f,RITX);
[b1,b2,b3,b4,b5,b6 ] = adj_real_rates( FWB,CCA,n2,f);
PWB=CLB/((1+b2)^n2);
  if (((1+b6)^(n2*12)))== 1;
    EUME_OLB =PWB/(n2*12);
    EUME_expB =CCA/(n2*12);
  else
    EUME_OLB = PWB*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
    EUME_expB = CCA*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
  end
B4=CLB;
B5=CCA;
B6=PWB;
B7=EUME_expB;
B8=EUME_OLB;
B9=B7+B8;
 % End of Closing Costs Calculation
 % This section calculates the Discount Points expenses and associated opportunity loss

if PTA ==0;
  C2=0;C3=0; C4=0;C5=0;C6=0;C7=0;C8=0;C9=0;
else
  [CLC,FWC] = calc_fv_woint(PTA,iCD,n1,n2,f,RITX);
  [c1,c2,c3,c4,c5,c6 ] = adj_real_rates( FWC,PTA,n2,f);
  PWC=CLC/((1+c2)^n2);
    if (((1+c6)^(n2*12)))== 1;
      EUME_OLC =PWC/(n2*12);
      EUME_expC =PTA/(n2*12);
    else
      EUME_OLC = PWC*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
      EUME_expC = PTA*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
```

```
      end
    C4=CLC;
    C5=PTA;
    C6=PWC;
    C7=EUME_expC;
    C8=EUME_OLC;
    C9=C7+C8;
end
% End of Discount points calculation
 %This section calculates the mortgage expenses and and associated opportunity loss
 MM= mortgage (Loan, n1, iM);
 [CLD,NetEOYLD,BOYLD,EOYD]= opp_loss_mortgage(MM,iCD,n1,n2,RITX);
   best_iaD = best_adj_rate(f,iCD,D,MM, BOYLD, NetEOYLD);
   [d1,d2,d3,d4,d5] = adj_real_ratesMortgage( best_iaD,f);
PWD=CLD/((1+d3)^(12*n2));
epwD =NetEOYLD/(1+d1)^n2;
   if ((1+d5)^(n2*12))==1;
      EUME_OLD=PWD/(n2*12);
      EUME_expD =epwD/(n2*12);
   else
      EUME_OLD= PWD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
      EUME_expD= epwD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
   end
D2=MM;
D3=0;
D4=NetEOYLD;
D5=EOYD;
D6=PWD;
D7=EUME_expD;
D8=EUME_OLD;
D9=D7+D8;
% This section calculates the utility expenses and associated opportunity loss

[CLE,NetEOYLE,BOYLE,EOYE,BMavE] = opp_loss_monthlyExp (BMu,eu,iCD,n2,RITX);
 best_iaE = best_adj_rateMonthlyExp(f,iCD,D,BOYLE,BMavE,NetEOYLE);
 [e1,e2,e3,e4,e5] = adj_real_ratesMortgage( best_iaE,f);
 PWE=CLE/((1+e3)^(12*n2));
epwE =EOYE/(1+e1)^n2;
   if ((1+e5)^(n2*12))==1;
      EUME_OLE=PWE/(n2*12);
      EUME_expE=epwE/(n2*12);
   else
      EUME_OLE= PWE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
      EUME_expE= epwE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
   end
E2=BMu;
E3=eu;
E4=EOYE;
```

```
E5=epwE;
E6=PWE;
E7=EUME_expE;
E8=EUME_OLE;
E9=E7+E8;
% End of calculation for utility expenses
 % This section calculates the Repair and Maintenance expenses and
% associated opportunity loss
[CLF,NetEOYLF,BOYLF,EOYF,BMavF] = opp_loss_monthlyExp (BMmr,emr,iCD,n2,RITX);
 best_iaF = best_adj_rateMonthlyExp(f,iCD,D,BOYLF,BMavF,NetEOYLF);
 [f1,f2,f3,f4,f5] = adj_real_ratesMortgage( best_iaF,f);
 PWF=CLF/((1+f3)^(12*n2));
epwF =EOYF/(1+f1)^n2;
  if ((1+f5)^(n2*12))==1;
     EUME_OLF=PWF/(n2*12);
     EUME_expF =epwF/(n2*12);
  else
    EUME_OLF= PWF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
    EUME_expF= epwF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
  end
F2=BMmr;
F3=emr;
F4=EOYF;
F5=epwF;
F6=PWF;
F7=EUME_expF;
F8=EUME_OLF;
F9=F7+F8;
 %End of calculations for maintenance and repair costs
% This section calculates the monthly maintenance fee and associated
% opportunity loss if the purchase is a condominium
  [CLV,NetEOYLV,BOYLV,EOYV,BMavV] = opp_loss_monthlyExp
(BMCF,emr,iCD,n2,RITX);
 best_iaV = best_adj_rateMonthlyExp(f,iCD,D,BOYLV,BMavV,NetEOYLV);
 [v1,v2,v3,v4,v5] = adj_real_ratesMortgage( best_iaV,f);
 PWV=CLV/((1+v3)^(12*n2));
epwV =EOYV/(1+v1)^n2;
  if ((1+v5)^(n2*12))==1;
     EUME_OLV=PWV/(n2*12);
     EUME_expV =epwV/(n2*12);
  else
    EUME_OLV= PWV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
    EUME_expV= epwV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
  end
V2=BMCF;
V3=emr;
V4=EOYV;
V5=epwV;
```

```
V6=PWV;
V7=EUME_expV;
V8=EUME_OLV;
V9=V7+V8;
% end of monthly fee calculation
 %This section calculates the excess gasoline expenses and associated opportunity loss
 [CLG,NetEOYLG,BOYLG,EOYG,BMavG] = opp_loss_monthlyExp
(BMg,eg,iCD,n2,RITX);
 best_iaG = best_adj_rateMonthlyExp(f,iCD,D,BOYLG,BMavG,NetEOYLG);
 [g1,g2,g3,g4,g5] = adj_real_ratesMortgage( best_iaG,f);
 PWG=CLG/((1+g3)^(12*n2));
epwG =EOYG/(1+g1)^n2;
    if ((1+g5)^(n2*12))==1;
    EUME_OLG=PWG/(n2*12);
    EUME_expG=epwG/(n2*12);
  else
    EUME_OLG= PWG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
    EUME_expG= epwG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
  end
G2=BMg;
G3=eg;
G4=EOYG;
G5=epwG;
G6=PWG;
G7=EUME_expG;
G8=EUME_OLG;
G9=G7+G8;
% End of calculations for excess gasoline expenses
 % This section calculates home insurance expenses and and associated opportunity loss
NP=2;
[CLH,NetEOYLH,BOYLH,EOYH,BSMH,BCavH] = opp_loss_ins (BAi,ei,iCD,n2,RITX,NP);
 best_iaH = best_adj_rateSixMonthlyExp(f,iCD,D,BOYLH,BSMH,NetEOYLH);
 [h1,h2,h3,h4,h5] = adj_real_ratesMortgage( best_iaH,f);
 PWH=CLH/((1+h3)^(12*n2));
epwH =EOYH/(1+h1)^n2;
  if ((1+h5)^(n2*12))==1;
     EUME_OLH=PWH/(n2*12);
     EUME_expH=epwH/(n2*12);
  else
    EUME_OLH= PWH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
    EUME_expH= epwH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
  end
H2=BCavH;
H3=ei;
H4=EOYH;
H5=epwH;
H6=PWH;
H7=EUME_expH;
```

```
H8=EUME_OLH;
H9=H7+H8;
% End of insurance expense calculations
 % This section calculates property tax expenses and associated
% opportunity loss
NP=1; % this means propert tax is paid once a year (at the end of the year).
BaseTax=SP*ptax_rate/100;
 [CLI,NetEOYLI,BOYLI,NetintI,EOYI,BATI,BCavI] =
opp_loss_ptax(SP,pro_app,ptax_rate,ept,iCD,n2,RITX);
 best_iaI=NetintI/BOYLI;
  [i1,i2,i3,i4,i5] = adj_real_ratesMortgage( best_iaI,f);
 PWI=CLI/((1+i3)^(12*n2));
epwI =EOYI/(1+i1)^n2;
  if ((1+i5)^(n2*12))==1;
     EUME_OLI=PWI/(n2*12);
     EUME_expI=epwI/(n2*12);
  else
     EUME_OLI= PWI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
     EUME_expI= epwI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
  end
I2=BCavI;
I3=ept;
I4=EOYI;
I5=epwI;
I6=PWI;
I7=EUME_expI;
I8=EUME_OLI;
I9=I7+I8;
% End of Property Tax expense calculations
 % This section calculates tax return for discount points and associated
% opportunity gain
if PTA ==0;
  J2=0;J3=0; J4=0;J5=0;J6=0;J7=0;J8=0;J9=0;
else
   [CLJ,NetEOYLJ,BOYLJ,EOYJ, DTYJ] = opp_loss_taxreturn_pt(
Loan,Discount_pt,iCD,n2,RITX);
  best_iaJ = best_adj_rate_taxreturn(f,iCD,D,BOYLJ,DTYJ,NetEOYLJ);
  [j1,j2,j3,j4,j5] = adj_real_ratesMortgage( best_iaJ,f);
  PWJ=CLJ/((1+j3)^(12*n2));
  epwJ =EOYJ/(1+j1)^n2;
    if ((1+j5)^(n2*12))==1;
       EUME_OLJ=PWJ/(n2*12);
       EUME_expJ=epwJ/(n2*12);
    else
      EUME_OLJ= PWJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
      EUME_expJ= epwJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
    end
  J2=-EOYJ;
```

```
    J3=0;
    J4=-NetEOYLJ;
    J5=-epwJ;
    J6=-PWJ;
    J7=-EUME_expJ;
    J8=-EUME_OLJ;
    J9=J7+J8;
  end
  % End of  Tax Return for discount points calculations
   % This section calculates tax return on mortgage paid and opportunity
  % gain

   [DTYK, BOYLK, CLK, EOYK, NetEOYLK,Loan_remaining]=
opp_loss_taxreturn_mortgage (Loan, iM , iCD, n1, n2, RITX);
   best_iaK = best_adj_rate_taxreturn(f,iCD,D,BOYLK,DTYK,NetEOYLK);
    [k1,k2,k3,k4,k5] = adj_real_ratesMortgage( best_iaK,f);
  PWK=CLK/((1+k1)^(n2));
  epwK =EOYK/(1+k1)^n2;
    if ((1+k5)^(n2*12))==1;
   EUME_OLK=PWK/(n2*12);
   EUME_expK=epwK/(n2*12);
  else
    EUME_OLK= PWK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
    EUME_expK= epwK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
  end
  K2=EOYK;
  K3=0;
  K4=-NetEOYLK;
  K5=-epwK;
  K6=-PWK;
  K7=-EUME_expK;
  K8=-EUME_OLK;
  K9=K7+K8;
  %This section calculates the tax return on property tax paid and
  %opportunity gain
   [DTYL, BOYLL, CLL, EOYL, NetEOYLL]= opp_loss_taxreturn_proptax (SP,pro_app,
ptax_rate, ept, iCD, n1, n2, RITX);
   best_iaL = best_adj_rate_taxreturn(f,iCD,D,BOYLL,DTYL,NetEOYLL);
    [l1,l2,l3,l4,l5] = adj_real_ratesMortgage( best_iaL,f);
  PWL=CLL/((1+l3)^(n2*12));
  epwL =EOYL/(1+l1)^n2;
      if ((1+l5)^(n2*12))==1;
       EUME_OLL=PWL/(n2*12);
       EUME_expL=epwL/(n2*12);
    else
      EUME_OLL= PWL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
      EUME_expL= epwL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
    end
```

```
L2=EOYL;
L3=0;
L4=-NetEOYLL;
L5=-epwL;
L6=-PWL;
L7=-EUME_expL;
L8=-EUME_OLL;
L9=L7+L8;
 %End of tax return calculation on property tax paid.
 % This section calculates the reroofing costs and associated
% opportunity loss
%RoofCost is the estimated cost for reroofing at the current price
%Rint is the interval of the works for example 15 years for reroofing
%emar is the cost escalation rate for reroofing works
 [CLM,BOYLM,EOYM,NetintM, NetEOYLM] = Periodic_RandM(RoofCost, Rint, emr, iCD,
n2, RITX);
 if NetintM==0 && BOYLM ==0;
   best_iaM=0.775*iCD/100;
else
   best_iaM = NetintM/BOYLM;
end
[m1,m2,m3,m4,m5] = adj_real_ratesMortgage( best_iaM,f);
PWM=CLM/((1+m3)^(n2*12));
epwM =EOYM/(1+m1)^n2;
  if ((1+m5)^(n2*12))==1;
     EUME_OLM= PWM/(n2*12);
     EUME_expM=epwM/(n2*12);
  else
     EUME_OLM= PWM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
     EUME_expM= epwM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
  end
M2=RoofCost;
M3=emr;
M4=EOYM;
M5=epwM;
M6=PWM;
M7=EUME_expM;
M8=EUME_OLM;
M9=M7+M8;
% End of reroofing cost
 %This section calculates the repainting expenses and associated
%opportunity loss
%PaintCost is the estimated cost for repainting at the current price
%Pint is the interval of the works for example 5 years for repainting
%emar is the cost escalation rate for reroofing works
 [CLN,BOYLN,EOYN,NetintN, NetEOYLN] = Periodic_RandM(PaintCost, Pint, emr, iCD,
n2, RITX);
 if BOYLN ==0;
```

```
    best_iaN=0.775*iCD/100;
  else
    best_iaN = NetintN/BOYLN;
  end
  [n11,n22,n33,n44,n55] = adj_real_ratesMortgage( best_iaN,f);
   PWN=CLN/((1+n33)^(n2*12));
  epwN =EOYN/(1+n11)^n2;
    if ((1+n55)^(n2*12))==1;
      EUME_OLN= PWN/(n2*12);
      EUME_expN=epwN/(n2*12);
    else
      EUME_OLN= PWN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
      EUME_expN= epwN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
    end
  N2=PaintCost;
  N3=emr;
  N4=EOYN;
  N5=epwN;
  N6=PWN;
  N7=EUME_expN;
  N8=EUME_OLN;
  N9=N7+N8;
   % This section calculates the remaining mortgage loan, and resale
   % value of the property at the end of the homeownership period
   RP=Loan_remaining;
  [P2,P3,P4,P5,P6,P7,P8,P9]= Property_Resalevalue (SP, pro_app,n2,c2,c6);
    % This section calculates seller's closing costs upon termination/
    % resale of the property
   [O22,O23,O24,O25,O26,O27,O28,O29,Resalevalue, FVadv] =
Sellers_Closing_Cost(SP,pro_app,n2,f, SCR, Advert,c2,c6 );

% This section calculates capital gain tax upon resale of the property
[O32,O33,O34,O35,O36,O37,O38,O39] = Capital_gain_tax(n2,Resalevalue,SP, CCA, PTA,
SCR, RP, FVadv, c2,c6, Exmpt,CGTrate);
O44 = RP;
O45= RP/((1+c2)^n2);
O46= 0;
if (1+c6)^(n2*12)==1
  O47=O45/(n2*12);
else
O47 =O45*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
end
O48=0;
O49=O47+O48;
 % this section sums up all the expenses and revenues as EUNFME

  Y(ii)=A9+B9+C9+D9+E9+F9+G9+H9+I9+J9+K9+L9+M9+N9+P9+O29+O39+O49+V9;
%    fprintf('EUNFME: $ %5.0f\n',YY);
```

```
  hold on;
end % edn of loop for ii
for ia1=1:length(X)
  EUNFMEmatrix(ia1,jj+1)=YY(1,ia1);
end
clr = [':o';'-d'; '-x'; ':s';'-*'; ':x'; '-s'; ':*'; '-v'; ':d';'-^'; ':+'; '-p'; ':p';'-+';':v'; '-o';':^'];
clr = [clr;clr;clr];
plot(X,YY,clr(jj,:));

xlabel('Ownership Period, Years'); ylabel('EUNFME, $')
title(['For CD Interest Rate =', num2str(iCD),'%, Downpayment =',
num2str(DownPayment*100),'%, ', 'and Sales Price = $ ', num2str(SP)])
hold on
end % end of loop for jj
for ll=1:length(iM1)
  leg(ll,:) = ['Mortg. Rate=' num2str(iM1(ll)) '%'];
end
legend(leg);

% End of file Main_Ownership.m
```

Main_Buying_Renting.m

```
% This program constructs a graph of Renting, mortgage severity and renting
% severity index

clear all;
close all;
Input_BuyingRenting %read input file
D=0.00000001;% This is the increment used for iteration steps
Forecasting_Coefficients % this file contains the forecasting coefficients for price escalation.
     iM1 = MortgageRate;
     X=CDRate;
     n1=MortgagePeriod;
     n2=OwnershipPeriod;
     DownPayment = DownPay/SP; % This is the downpayment as fraction of sales price
     DPA = SP*DownPayment; % Downpayment in dollar amount
     Pt=Discount_pt/100; % Rate for points
     Loan = SP-DPA; % Loan in dollar amount
     PTA = Pt*Loan; % Discount point in dollar amount
     CCA = BCR/100*SP; % Buyer's closing cost in dollar amount
     SCR=SCR1+SCR2; % This is the closing cost rate including realtors fee
 % Define matrix to print out EUNFME in a tabular format
EUNFMEmatrix=zeros(length(X),iM1+1);
for i=1:length(X)
   EUNFMEmatrix(i,1)=X(i);
end
 % end of matrix for EUNFME in a tabular format
 for jj=1:length(iM1);% this loop is for mortgage interest rate, and this defines the number of
curves in the graph
   iM=iM1(jj);
   for ii=1:length(X);% this loop is for CD interest rate, and this is the X-axis
     iCD=X(ii);
     Y2 = Y1+n2; % This is the home ownership termination year
     f= calc_escrate(CPI1,CPI2,Y1, n2); % CPI Index calculation
     emr = calc_escrate(PPI1,PPI2,Y1, n2); % Home maintenance cost escalation rate (PPI)
     eu = calc_escrate(Ku1,Ku2,Y1, n2); % Utilities cost escalation rate
     ei=calc_escrate(Khi1,Khi2,Y1, n2); % Home insurance escalation rate
     pro_app = calc_escrate(Kpap1,Kpap2,Y1, n2);%property appreciation rate
     eg = calc_escrate(Kg1,Kg2,Y1, n2);%Gasoline cost inflation rate
     ept=0; % Property tax escalation is zero in Hawaii
     eI = calc_escrate(Kei1,Kei2,Y1, n2);% Income escalation rate
   % This section calculates the Downpayment expenses and associated
   % opportunity loss
    if DPA ==0;
     A2=0;A3=0; A4=0;A5=0;A6=0;A7=0;A8=0;A9=0;
   else
     [CLA,FWA] = calc_fv_woint(DPA,iCD,n1,n2,f,RITX);
     [a1,a2,a3,a4,a5,a6 ] = adj_real_rates( FWA,DPA,n2,f);
```

```
    PWA=CLA/((1+a2)^n2);
    if ((1+a6)^(n2*12))==1;
      EUME_OLA = PWA/(n2*12);
      EUME_expA = DPA/(n2*12);
    else
       EUME_OLA = PWA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
      EUME_expA = DPA*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
    end
    A4=CLA;
    A5=DPA;
    A6=PWA;
    A7=EUME_expA;
    A8=EUME_OLA;
    A9=A7+A8;
end
% End of Downpayment Calculation
 % This section calculates the Closing Costs and associated
% opportunity loss
[CLB,FWB] = calc_fv_woint(CCA,iCD,n1,n2,f,RITX);
 [b1,b2,b3,b4,b5,b6 ] = adj_real_rates( FWB,CCA,n2,f);
 PWB=CLB/((1+b2)^n2);
    if (((1+b6)^(n2*12)))== 1;
      EUME_OLB =PWB/(n2*12);
      EUME_expB =CCA/(n2*12);
    else
      EUME_OLB = PWB*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
      EUME_expB = CCA*(b6*(1+b6)^(n2*12))/(((1+b6)^(n2*12))-1);
    end
B4=CLB;
B5=CCA;
B6=PWB;
B7=EUME_expB;
B8=EUME_OLB;
B9=B7+B8;
% End of Closing Costs Calculation
 % This section calculates the Discount Points expenses and associated
% opportunity loss
if PTA ==0;
    C2=0;C3=0; C4=0;C5=0;C6=0;C7=0;C8=0;C9=0;
else
    [CLC,FWC] = calc_fv_woint(PTA,iCD,n1,n2,f,RITX);
     [c1,c2,c3,c4,c5,c6 ] = adj_real_rates( FWC,PTA,n2,f);
     PWC=CLC/((1+c2)^n2);
       if (((1+c6)^(n2*12)))== 1;
         EUME_OLC =PWC/(n2*12);
         EUME_expC =PTA/(n2*12);
       else
         EUME_OLC = PWC*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
```

```
        EUME_expC = PTA*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
      end
    C4=CLC;
    C5=PTA;
    C6=PWC;
    C7=EUME_expC;
    C8=EUME_OLC;
    C9=C7+C8;
end
% End of Discount points calculation
 %This section calculates the mortgage expenses and and associated
% opportunity loss
MM= mortgage (Loan, n1, iM);
 [CLD,NetEOYLD,BOYLD,EOYD]= opp_loss_mortgage(MM,iCD,n1,n2,RITX);
   best_iaD = best_adj_rate(f,iCD,D,MM, BOYLD, NetEOYLD);
   [d1,d2,d3,d4,d5] = adj_real_ratesMortgage( best_iaD,f);
PWD=CLD/((1+d3)^(12*n2));
epwD =NetEOYLD/(1+d1)^n2;
   if ((1+d5)^(n2*12))==1;
      EUME_OLD=PWD/(n2*12);
      EUME_expD =epwD/(n2*12);
   else
      EUME_OLD= PWD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
      EUME_expD= epwD*(d5*(1+d5)^(n2*12))/(((1+d5)^(n2*12))-1);
   end
D2=MM;
D3=0;
D4=NetEOYLD;
D5=EOYD;
D6=PWD;
D7=EUME_expD;
D8=EUME_OLD;
D9=D7+D8;
 % This section calculates the utility expenses and associated opportunity loss
 [CLE,NetEOYLE,BOYLE,EOYE,BMavE] = opp_loss_monthlyExp (BMu,eu,iCD,n2,RITX);
 best_iaE = best_adj_rateMonthlyExp(f,iCD,D,BOYLE,BMavE,NetEOYLE);
 [e1,e2,e3,e4,e5] = adj_real_ratesMortgage( best_iaE,f);
 PWE=CLE/((1+e3)^(12*n2));
epwE =EOYE/(1+e1)^n2;
   if ((1+e5)^(n2*12))==1;
      EUME_OLE=PWE/(n2*12);
      EUME_expE=epwE/(n2*12);
   else
      EUME_OLE= PWE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
      EUME_expE= epwE*(e5*(1+e5)^(n2*12))/(((1+e5)^(n2*12))-1);
   end
E2=BMu;
E3=eu;
```

```
E4=EOYE;
E5=epwE;
E6=PWE;
E7=EUME_expE;
E8=EUME_OLE;
E9=E7+E8;
% End of calculation for utility expenses
% This section calculates the Repair and Maintenance expenses and
% associated opportunity loss
[CLF,NetEOYLF,BOYLF,EOYF,BMavF] = opp_loss_monthlyExp (BMmr,emr,iCD,n2,RITX);
best_iaF = best_adj_rateMonthlyExp(f,iCD,D,BOYLF,BMavF,NetEOYLF);
[f1,f2,f3,f4,f5] = adj_real_ratesMortgage( best_iaF,f);
PWF=CLF/((1+f3)^(12*n2));
epwF =EOYF/(1+f1)^n2;
  if ((1+f5)^(n2*12))==1;
     EUME_OLF=PWF/(n2*12);
     EUME_expF =epwF/(n2*12);
  else
     EUME_OLF= PWF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
     EUME_expF= epwF*(f5*(1+f5)^(n2*12))/(((1+f5)^(n2*12))-1);
  end
F2=BMmr;
F3=emr;
F4=EOYF;
F5=epwF;
F6=PWF;
F7=EUME_expF;
F8=EUME_OLF;
F9=F7+F8;
%End of calculations for maintenance and repair costs
% This section calculates the monthly maintenance fee and associated
% opportunity loss if the purchase is a condominium
[CLV,NetEOYLV,BOYLV,EOYV,BMavV] = opp_loss_monthlyExp
(BMCF,emr,iCD,n2,RITX);
best_iaV = best_adj_rateMonthlyExp(f,iCD,D,BOYLV,BMavV,NetEOYLV);
[v1,v2,v3,v4,v5] = adj_real_ratesMortgage( best_iaV,f);
PWV=CLV/((1+v3)^(12*n2));
epwV =EOYV/(1+v1)^n2;
  if ((1+v5)^(n2*12))==1;
     EUME_OLV=PWV/(n2*12);
     EUME_expV =epwV/(n2*12);
  else
     EUME_OLV= PWV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
     EUME_expV= epwV*(v5*(1+v5)^(n2*12))/(((1+v5)^(n2*12))-1);
  end
V2=BMCF;
V3=emr;
V4=EOYV;
```

```
V5=epwV;
V6=PWV;
V7=EUME_expV;
V8=EUME_OLV;
V9=V7+V8;
% end of monthly fee calculation
 %This section calculates the excess gasoline expenses and associated opportunity loss
 [CLG,NetEOYLG,BOYLG,EOYG,BMavG] = opp_loss_monthlyExp
(BMg,eg,iCD,n2,RITX);
 best_iaG = best_adj_rateMonthlyExp(f,iCD,D,BOYLG,BMavG,NetEOYLG);
 [g1,g2,g3,g4,g5] = adj_real_ratesMortgage( best_iaG,f);
 PWG=CLG/((1+g3)^(12*n2));
epwG =EOYG/(1+g1)^n2;
     if ((1+g5)^(n2*12))==1;
     EUME_OLG=PWG/(n2*12);
     EUME_expG=epwG/(n2*12);
   else
     EUME_OLG= PWG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
     EUME_expG= epwG*(g5*(1+g5)^(n2*12))/(((1+g5)^(n2*12))-1);
   end
G2=BMg;
G3=eg;
G4=EOYG;
G5=epwG;
G6=PWG;
G7=EUME_expG;
G8=EUME_OLG;
G9=G7+G8;
 % End of calculations for excess gasoline expenses
 % This section calculates home insurance expenses and and associated
% opportunity loss
NP=2; % this means insurance is paid twice a year (six monthly)
[CLH,NetEOYLH,BOYLH,EOYH,BSMH,BCavH] = opp_loss_ins (BAi,ei,iCD,n2,RITX,NP);
 best_iaH = best_adj_rateSixMonthlyExp(f,iCD,D,BOYLH,BSMH,NetEOYLH);
 [h1,h2,h3,h4,h5] = adj_real_ratesMortgage( best_iaH,f);
PWH=CLH/((1+h3)^(12*n2));
epwH =EOYH/(1+h1)^n2;
   if ((1+h5)^(n2*12))==1;
     EUME_OLH=PWH/(n2*12);
     EUME_expH=epwH/(n2*12);
   else
     EUME_OLH= PWH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
     EUME_expH= epwH*(h5*(1+h5)^(n2*12))/(((1+h5)^(n2*12))-1);
   end
H2=BCavH;
H3=ei;
H4=EOYH;
H5=epwH;
```

```
H6=PWH;
H7=EUME_expH;
H8=EUME_OLH;
H9=H7+H8;
% End of insurance expense calculations
 % This section calculates property tax expenses and associated
% opportunity loss
NP=1; % this means propert tax is paid once a year (at the end of the year).
BaseTax=SP*ptax_rate/100;
 [CLI,NetEOYLI,BOYLI,NetintI,EOYI,BATI,BCavI] =
opp_loss_ptax(SP,pro_app,ptax_rate,ept,iCD,n2,RITX);
  best_iaI=NetintI/BOYLI;
  [i1,i2,i3,i4,i5] = adj_real_ratesMortgage( best_iaI,f);
 PWI=CLI/((1+i3)^(12*n2));
epwI =EOYI/(1+i1)^n2;
   if ((1+i5)^(n2*12))==1;
      EUME_OLI=PWI/(n2*12);
      EUME_expI=epwI/(n2*12);
   else
      EUME_OLI= PWI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
      EUME_expI= epwI*(i5*(1+i5)^(n2*12))/(((1+i5)^(n2*12))-1);
   end
I2=BCavI;
I3=ept;
I4=EOYI;
I5=epwI;
I6=PWI;
I7=EUME_expI;
I8=EUME_OLI;
I9=I7+I8;
 % End of Property Tax expense calculations
 % This section calculates tax return for discount points and associated
% opportunity gain
if PTA ==0;
   J2=0;J3=0; J4=0;J5=0;J6=0;J7=0;J8=0;J9=0;
else
    [CLJ,NetEOYLJ,BOYLJ,EOYJ, DTYJ] = opp_loss_taxreturn_pt(
Loan,Discount_pt,iCD,n2,RITX);
   best_iaJ = best_adj_rate_taxreturn(f,iCD,D,BOYLJ,DTYJ,NetEOYLJ);
   [j1,j2,j3,j4,j5] = adj_real_ratesMortgage( best_iaJ,f);
   PWJ=CLJ/((1+j3)^(12*n2));
   epwJ =EOYJ/(1+j1)^n2;
      if ((1+j5)^(n2*12))==1;
         EUME_OLJ=PWJ/(n2*12);
         EUME_expJ=epwJ/(n2*12);
      else
         EUME_OLJ= PWJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
         EUME_expJ= epwJ*(j5*(1+j5)^(n2*12))/(((1+j5)^(n2*12))-1);
```

```
        end
      J2=-EOYJ;
      J3=0;
      J4=-NetEOYLJ;
      J5=-epwJ;
      J6=-PWJ;
      J7=-EUME_expJ;
      J8=-EUME_OLJ;
      J9=J7+J8;
    end
    % End of  Tax Return for discount points calculations
     % This section calculates tax return on mortgage paid and opportunity
    % gain
    [DTYK, BOYLK, CLK, EOYK, NetEOYLK,Loan_remaining]= opp_loss_taxreturn_mortgage
(Loan, iM , iCD, n1, n2, RITX);
     best_iaK = best_adj_rate_taxreturn(f,iCD,D,BOYLK,DTYK,NetEOYLK);
     [k1,k2,k3,k4,k5] = adj_real_ratesMortgage( best_iaK,f);
    PWK=CLK/((1+k1)^(n2));
    epwK =EOYK/(1+k1)^n2;
      if ((1+k5)^(n2*12))==1;
     EUME_OLK=PWK/(n2*12);
     EUME_expK=epwK/(n2*12);
    else
      EUME_OLK= PWK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
      EUME_expK= epwK*(k5*(1+k5)^(n2*12))/(((1+k5)^(n2*12))-1);
    end
    K2=EOYK;
    K3=0;
    K4=-NetEOYLK;
    K5=-epwK;
    K6=-PWK;
    K7=-EUME_expK;
    K8=-EUME_OLK;
    K9=K7+K8;
    %This section calculates the tax return on property tax paid and
    %opportunity gain
     [DTYL, BOYLL, CLL, EOYL, NetEOYLL]= opp_loss_taxreturn_proptax (SP,pro_app,
ptax_rate, ept, iCD, n1, n2, RITX);
     best_iaL = best_adj_rate_taxreturn(f,iCD,D,BOYLL,DTYL,NetEOYLL);
     [l1,l2,l3,l4,l5] = adj_real_ratesMortgage( best_iaL,f);
    PWL=CLL/((1+l3)^(n2*12));
    epwL =EOYL/(1+l1)^n2;
        if ((1+l5)^(n2*12))==1;
         EUME_OLL=PWL/(n2*12);
         EUME_expL=epwL/(n2*12);
      else
        EUME_OLL= PWL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
```

```
        EUME_expL= epwL*(l5*(1+l5)^(n2*12))/(((1+l5)^(n2*12))-1);
      end
    L2=EOYL;
    L3=0;
    L4=-NetEOYLL;
    L5=-epwL;
    L6=-PWL;
    L7=-EUME_expL;
    L8=-EUME_OLL;
    L9=L7+L8;
     %End of tax return calculation on property tax paid.
    % This section calculates the reroofing costs and associated
    % opportunity loss
    %RoofCost is the estimated cost for reroofing at the current price
    %Rint is the interval of the works for example 15 years for reroofing
    %emar is the cost escalation rate for reroofing works
     [CLM,BOYLM,EOYM,NetintM, NetEOYLM] = Periodic_RandM(RoofCost, Rint, emr, iCD,
n2, RITX);
    if NetintM==0 && BOYLM ==0;
      best_iaM=0.775*iCD/100;
    else
      best_iaM = NetintM/BOYLM;
    end
    [m1,m2,m3,m4,m5] = adj_real_ratesMortgage( best_iaM,f);
    PWM=CLM/((1+m3)^(n2*12));
    epwM =EOYM/(1+m1)^n2;
      if ((1+m5)^(n2*12))==1;
        EUME_OLM= PWM/(n2*12);
        EUME_expM=epwM/(n2*12);
      else
        EUME_OLM= PWM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
        EUME_expM= epwM*(m5*(1+m5)^(n2*12))/(((1+m5)^(n2*12))-1);
      end
    M2=RoofCost;
    M3=emr;
    M4=EOYM;
    M5=epwM;
    M6=PWM;
    M7=EUME_expM;
    M8=EUME_OLM;
    M9=M7+M8;
     % End of reroofing cost
    %This section calculates the repainting expenses and associated opportunity loss
    %PaintCost is the estimated cost for repainting at the current price
    %Pint is the interval of the works for example 5 years for repainting
    %emar is the cost escalation rate for reroofing works
     [CLN,BOYLN,EOYN,NetintN, NetEOYLN] = Periodic_RandM(PaintCost, Pint, emr, iCD,
n2, RITX);
```

```
 if BOYLN ==0;
    best_iaN=0.775*iCD/100;
 else
    best_iaN = NetintN/BOYLN;
 end
 [n11,n22,n33,n44,n55] = adj_real_ratesMortgage( best_iaN,f);
  PWN=CLN/((1+n33)^(n2*12));
 epwN =EOYN/(1+n11)^n2;
    if ((1+n55)^(n2*12))==1;
       EUME_OLN= PWN/(n2*12);
       EUME_expN=epwN/(n2*12);
    else
       EUME_OLN= PWN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
       EUME_expN= epwN*(n55*(1+n55)^(n2*12))/(((1+n55)^(n2*12))-1);
    end
 N2=PaintCost;
 N3=emr;
 N4=EOYN;
 N5=epwN;
 N6=PWN;
 N7=EUME_expN;
 N8=EUME_OLN;
 N9=N7+N8;
  % This section calculates the remaining mortgage loan, and resale
  % value of the property at the end of the homeownership period
  RP=Loan_remaining;
 [P2,P3,P4,P5,P6,P7,P8,P9]= Property_Resalevalue (SP, pro_app,n2,c2,c6);
    % This section calculates seller's closing costs upon termination/
    % resale of the property
[O22,O23,O24,O25,O26,O27,O28,O29,Resalevalue, FVadv] =
Sellers_Closing_Cost(SP,pro_app,n2,f, SCR, Advert,c2,c6 );
% This section calculates capital gain tax upon resale of the property
[O32,O33,O34,O35,O36,O37,O38,O39] = Capital_gain_tax(n2,Resalevalue,SP, CCA, PTA,
SCR, RP, FVadv, c2,c6, Exmpt,CGTrate);
 O44 = RP;
O45= RP/((1+c2)^n2);
O46= 0;
if (1+c6)^(n2*12)==1
   O47=O45/(n2*12);
else
O47 =O45*(c6*(1+c6)^(n2*12))/(((1+c6)^(n2*12))-1);
end
O48=0;
O49=O47+O48;
 % this section sums up all the expenses and revenues as EUNFME
YY=A9+B9+C9+D9+E9+F9+G9+H9+I9+J9+K9+L9+M9+N9+P9+O29+O39+O49+V9;
   fprintf('EUNFME: $ %5.0f\n',YY);
   EUNFME=YY;
```

```
  ZZ =D9+E9+F9+G9+H9+I9+J9+K9+L9+M9+N9+V9;
  EUNFMEO = ZZ;
end % edn of loop for ii
for ia1=1:length(X)
  EUNFMEmatrix(ia1,jj+1)=YY(1,ia1);
end
end % end of loop for jj
% End of Home buying Analysis
% This section computes the Renting Analysis
Z=CDRate;
  X=RentingPeriod;
% End of GLOBAL INPUT
EUNFMRmatrix=zeros(length(X), Z+1);
for i=1:length(X);
 EUNFMRmatrix(i,1)=X(i);
end

for jj=1:length(Z);
  iCD=Z(jj);
for ii=1:length(X)
  n2=X(ii);
    Y2 = Y1+n2; % This is the rental termination year
  % where Y1 is the rental starting year and n2 is the rental period in years
  f= calc_escrate(CPI1,CPI2,Y1, n2); % This is the inflation (CPI index)
   eu = calc_escrate(Ku1,Ku2,Y1, n2); % this is the utilities escalation index
  ehr = calc_escrate(Khr1,Khr2,Y1, n2);%House Rent inflation
   % This section calculates the monthly rental expenses
   [CLQ,NetEOYLQ,BOYLQ,EOYQ,BMavQ] =
opp_loss_monthlyExpRent(BM_rent,ehr,iCD,n2,RITX);
   best_iaQ = best_adj_rateMonthlyExp(f,iCD,D,BOYLQ,BMavQ,NetEOYLQ);
   [q1,q2,q3,q4,q5] = adj_real_ratesMortgage( best_iaQ,f);
   PWQ=CLQ/((1+q3)^(12*n2));
  epwQ =EOYQ/(1+q1)^n2;
  if (1+q5)^(n2*12)==1
     EUME_OLQ=PWQ/(n2*12);
     EUME_expQ =epwQ/(n2*12);
  else
     EUME_OLQ= PWQ*(q5*(1+q5)^(n2*12))/(((1+q5)^(n2*12))-1);
     EUME_expQ= epwQ*(q5*(1+q5)^(n2*12))/(((1+q5)^(n2*12))-1);
  end
  Q2=BM_rent;
  Q3=ehr;
  Q4=EOYQ;
  Q5=epwQ;
  Q6=PWQ;
  Q7=EUME_expQ;
  Q8=EUME_OLQ;
  Q9=Q7+Q8;
```

```
    %End of calculations for maintenance and repair costs
     % This section calculates the opportunity loss on utility expenses
    [CLR,NetEOYLR,BOYLR,EOYR,BMavR] = opp_loss_monthlyExp
(BMu_rent,eu,iCD,n2,RITX);
    best_iaR = best_adj_rateMonthlyExp(f,iCD,D,BOYLR,BMavR,NetEOYLR);
    [r1,r2,r3,r4,r5] = adj_real_ratesMortgage( best_iaR,f);
    PWR=CLR/((1+r3)^(12*n2));
   epwR =EOYR/(1+r1)^n2;
   if (1+r5)^(n2*12)==1
      EUME_OLR= PWR/(n2*12);
      EUME_expR= epwR/(n2*12);
   else
      EUME_OLR= PWR*(r5*(1+r5)^(n2*12))/(((1+r5)^(n2*12))-1);
      EUME_expR= epwR*(r5*(1+r5)^(n2*12))/(((1+r5)^(n2*12))-1);
   end
   R2=BMu_rent;
   R3=eu;
   R4=EOYR;
   R5=epwR;
   R6=PWR;
   R7=EUME_expR;
   R8=EUME_OLR;
   R9=R7+R8;
  % End of calculation for utility expenses
   Y(ii)=Q9+R9;
  % fprintf('EUNFMR: $ %5.0f\n',Y(ii));
  end % edn of loop for ii
EUNFMR =Y(ii);
for k=1:length(X)
   EUNFMRmatrix(k,jj+1)=Y(1,k);
end
 % End of Renting Analysis
 BRR=EUNFME/EUNFMR;
 fprintf('Buy/Rent Ratio: $ %5.4f\n',BRR);
end
 % This is Income Analyis
[EPV, EUMI] = income_calcs(BI,eI,n2,f,RITX);
  fprintf('EUMI: %5.0f\n', EUMI);
 % This section calculates the ownership severity Indeces
  LT_MSI = EUNFME/EUMI;
  fprintf('Long-term Ownership Severity Index (EUNFME/EUMI): %5.2f\n', LT_MSI);
  ST_MSI = EUNFMEO/EUMI;
  fprintf('Operational Severity Index (EUNFMEO/EUMI): %5.2f\n', ST_MSI);
  RSI = EUNFMR/EUMI;
  fprintf('Renting Severity Index (EUNFMER/EUMI): %5.2f\n', RSI);
% End of file Main_Buying_Renting.m
```

Input_CDRate.m

```
% This file generates input parameters for constructing a graph of EUNFME
% vs range of CD rates
clear all
SP = input('\n\nWhat is the Sales Price of the house, $:\n\n');
MortgagePeriod = input('\nWhat is the mortgage (loan) payback period? If it is 30 years, then enter "30":\n\n');
fprintf('Enter the desired range of mortgage interest rate in this format: 3:0.5:6\n');
fprintf('\nStarting value 3, interval =0.5 and ending value = 6\n');
MortgageRate = input('\nenter here:');
OwnershipPeriod = input('\nOwnership period - for how long you wish to own this house?, normally 30 years or less:\n\n');
DownPay =input ('\nEnter the amount of money available for Downpayment:$\n\n');
fprintf('What is the investment return such as CD interest rate?');
fprintf('Enter the desired range of CD interest rate in this format: 3:0.5:6');
fprintf('Starting value as 3%, 0.5  interval and 6% is the last value');
CDRate = input('\n Enter the desired range here:  ');
Discount_pt= input ('\nWhat is the Discount Points rate (as percentage of loan amount)?\n\n');
BCR=input('\nWhat is the Buyers closing cost rate as % of purchase price? \n');
RITX = input ('\nWhat is the income tax rate in percentage?\n\n');
BMu = input ('\nWhat is the monthly expense on utilities in dollar amount?\n\n');
BMmr = input ('\nWhat is the monthly R&M cost in dollar amount?\n\n');
BMCF = input ('\nWhat is the monthly fees (if Condominium) in dollar amount?\n\n');
BMg = input ('\nWhat is the excess gasoline costs in dollar amount:\n\n');
BAi = input ('\nWhat is the annual home insurance cost in dollar amount?\n\n');
ept=input ('\nEscalation rate for property tax, must be between 0 and 1:\n');
ptax_rate= input('\nEnter rate of property tax rate in % (it is 0.555% of property value in honolulu:\n\n');
RoofCost = input ('\nWhat is the reroofing cost in dollar amount? \n\n');
Rint= input('\nWhat is the frequency for roof replacement? if 15 years, then enter 15:\n\n');
PaintCost = input ('\nWhat is the repainting cost in dollar amount? \n\n');
Pint= input('\nWhat is the frequency for repainting? if 5 years, then enter 5:\n\n');
SCR1=input('\nWhat is the Realtors fee as % of resale price? \n');
SCR2=input('\nWhat are other sellers closing costs, if any, as % of resale price? \n');
Advert=input ('\nWhat is the home sales advertisement cost in dollar amount?  \n\n');
Exmpt= input('\nEnter Capital Gain Tax exemption in dollar amount: \n');
CGTrate=input ('\nEnter rate for capital gain tax, in percentage, for example 15%: \n\n');
Y1= input ('\nEnter the year of home purchase, for example 2008:\n\n');
% End of file Input_CDRate.m
```

Input_Downpayment.m

```
% This file generates the input parameters for constructing a graph EUNFME
% vs Downpayment size
clear all
SP = input('\n\nWhat is the Sales Price of the house, $:\n\n');
MortgagePeriod = input('\nWhat is the mortgage (loan) payback period? If it is 30 years, then
enter "30":\n\n');
fprintf('Enter the desired range of mortgage interest rate in this format: 3:0.5:6');
MortgageRate = input ('3 is the starting value as 3%, 0.5 is the interval and 6 is the last value as
being 6%');
OwnershipPeriod = input('\nOwnership period - for how long you wish to own this house?,
normally 30 years or less:\n\n');
DownPayment =input ('\nEnter the range for Downpayment size in ratio suc as: 0.1:0.1:1:$\n\n');
CDRate = input('\n What is the investment return such as CD interest rate?:  ');
Discount_pt= input ('\nWhat is the Discount Points rate (as percentage of loan amount)?\n\n');
BCR=input('\nWhat is the Buyers closing cost rate as % of purchase price? \n');
RITX = input ('\nWhat is the income tax rate in percentage?\n\n');
BMu = input ('\nWhat is the monthly expense on utilities in dollar amount?\n\n');
BMmr = input ('\nWhat is the monthly R&M cost in dollar amount?\n\n');
BMCF = input ('\nWhat is the monthly fees (if Condominium) in dollar amount?\n\n');
BMg = input ('\nWhat is the excess gasoline costs in dollar amount:\n\n');
BAi = input ('\nWhat is the annual home insurance cost in dollar amount?\n\n');
ept=input ('\nEscalation rate for property tax, must be between 0 and 1:\n');
ptax_rate= input('\nEnter rate of property tax rate in % (it is 0.555% of property value in
honolulu:\n\n');
RoofCost = input ('\nWhat is the reroofing cost in dollar amount? \n\n');
Rint= input('\nWhat is the frequency for roof replacement? if 15 years, then enter 15:\n\n');
PaintCost = input ('\nWhat is the repainting cost in dollar amount? \n\n');
Pint= input('\nWhat is the frequency for repainting? if 5 years, then enter 5:\n\n');
SCR1=input('\nWhat is the Realtors fee as % of resale price? \n');
SCR2=input('\nWhat are other sellers closing costs, if any, as % of resale price? \n');
Advert=input ('\nWhat is the home sales advertisement cost in dollar amount?  \n\n');
Exmpt= input('\nEnter Capital Gain Tax exemption in dollar amount: \n');
CGTrate=input ('\nEnter rate for capital gain tax, in percentage, for example 15%: \n\n');
Y1= input ('\nEnter the year of home purchase, for example 2008:\n\n');
% End of file Input_Downpayment.m
```

Input_Ownership.m

```
% This file generates the input parameters for drawing a graph EUNFME vs
% Ownership period
clear all
SP = input('\n\nWhat is the Sales Price of the house, $:\n\n');
MortgagePeriod = input('\nWhat is the mortgage (loan) payback period? If it is 30 years, then
enter "30":\n\n');
fprintf('Enter the desired range of mortgage interest rate in this format: 3:0.5:6');
MortgageRate = input ('3 is the starting value as 3%, 0.5 is the interval and 6 is the last value as
being 6%');
fprintf('Enter the desired range of ownership period in this format: 3:2:30');
fprintf('3 is the starting year, 2 is the interval and 30 is the end of ownership period');
OwnershipPeriod = input('\nOwnership period - for how long you wish to own this house?:\n\n');
DownPay =input ('\nEnter the amount of money available for Downpayment:$\n\n');
fprintf('What is the investment return such as CD interest rate?');
fprintf('Enter the desired range of CD interest rate in this format: 3:0.5:6');
fprintf('3 is the starting value, 0.5 is the interval and 6 is the last value');
CDRate = input('\n Enter the desired range here:  ');
Discount_pt= input ('\nWhat is the Discount Points rate (as percentage of loan amount)?\n\n');
BCR=input('\nWhat is the Buyers closing cost rate as % of purchase price? \n');
RITX = input ('\nWhat is the income tax rate in percentage?\n\n');
BMu = input ('\nWhat is the monthly expense on utilities in dollar amount?\n\n');
BMmr = input ('\nWhat is the monthly R&M cost in dollar amount?\n\n');
BMCF = input ('\nWhat is the monthly fees (if Condominium) in dollar amount?\n\n');
BMg = input ('\nWhat is the excess gasoline costs in dollar amount:\n\n');
BAi = input ('\nWhat is the annual home insurance cost in dollar amount?\n\n');
ept=input ('\nEscalation rate for property tax, must be between 0 and 1:\n');
ptax_rate= input('\nEnter rate of property tax rate in % (it is 0.555% of property value in
honolulu:\n\n');
RoofCost = input ('\nWhat is the reroofing cost in dollar amount? \n\n');
Rint= input('\nWhat is the frequency for roof replacement? if 15 years, then enter 15:\n\n');
PaintCost = input ('\nWhat is the repainting cost in dollar amount? \n\n');
Pint= input('\nWhat is the frequency for repainting? if 5 years, then enter 5:\n\n');
SCR1=input('\nWhat is the Realtors fee as % of resale price? \n');
SCR2=input('\nWhat are other sellers closing costs, if any, as % of resale price? \n');
Advert=input ('\nWhat is the home sales advertisement cost in dollar amount?  \n\n');
Exmpt= input('\nEnter Capital Gain Tax exemption in dollar amount: \n');
CGTrate=input ('\nEnter rate for capital gain tax, in percentage, for example 15%: \n\n');
Y1= input ('\nEnter the year of home purchase, for example 2008:\n\n');
% End of file Input_Ownership.m
```

Input_Buying Renting.m

```
% This program calculates the mortgage severity renting severity based on family income
clear all
SP = input('\n\nWhat is the Sales Price of the house, $:\n\n');
MortgagePeriod = input('\nWhat is the mortgage (loan) payback period? If it is 30 years, then
enter "30":\n\n');
MortgageRate = input('\nWhat is the nominal mortgage interest rate?:\n\n');
OwnershipPeriod = input('\nOwnership period - for how long you wish to own this house?:\n\n');
DownPay =input ('\nEnter the amount of money available for Downpayment:$\n\n');
CDRate = input('\n What is the investment return such as CD interest rate:   ');
Discount_pt= input ('\nWhat is the Discount Points rate?\n\n');
BCR=input('\nWhat is the Buyers closing cost rate as % of purchase price? \n');
RITX = input ('\nWhat is the income tax rate in percentage?\n\n');
BMu = input ('\nWhat is the monthly expense on utilities in dollar amount?\n\n');
BMmr = input ('\nWhat is the monthly R&M cost in dollar amount?\n\n');
BMCF = input ('\nWhat is the monthly fees (if Condominium) in dollar amount?\n\n');
BMg = input ('\nWhat is the excess gasoline costs in dollar amount:\n\n');
BAi = input ('\nWhat is the annual home insurance cost in dollar amount?\n\n');
ept=input ('\nEscalation rate for property tax, must be between 0 and 1:\n');
ptax_rate= input('\nEnter rate of property tax rate in % (it is 0.555% of property value in
honolulu:\n\n');
RoofCost = input ('\nWhat is the reroofing cost in dollar amount? \n\n');
Rint= input('\nWhat is the frequency for roof replacement? if 15 years, then enter 15:\n\n');
PaintCost = input ('\nWhat is the repainting cost in dollar amount? \n\n');
Pint= input('\nWhat is the frequency for repainting? if 5 years, then enter 5:\n\n');
SCR1=input('\nWhat is the Realtors fee as % of resale price? \n');
SCR2=input('\nWhat are other sellers closing costs, if any, as % of resale price? \n');
Advert=input ('\nWhat is the home sales advertisement cost in dollar amount?  \n\n');
Exmpt= input('\nEnter Capital Gain Tax exemption in dollar amount: \n');
CGTrate=input ('\nEnter rate for capital gain tax, in percentage, for example 15%: \n\n');
Y1= input ('\nEnter the year of home purchase, for example 2008:\n\n');
fprintf('\n\nNow, enter the information for Rental Analysis\n');
RentingPeriod=input('\nRenting period - for how long you wish to rent a house?, normally 30
years or less:\n\n');
BM_rent=input('\n\nWhat is the monthly rent of the house, $:\n\n');
BMu_rent = input ('\nWhat is the monthly expense on utilities of the rented house?\n\n');
fprintf('\n\nNow, enter the information of your income\n');
BI=input('\nWhat is your gross annual income? $:\n');

% End of file Input_Buying_Renting.m
```

adj_real_rates.m

```
% This function calculates the adjusted real rates

function [a1,a2,a3,a4,a5,a6 ] = adj_real_rates( FW,DPA,n2,f)
a1=((FW/DPA)^(1/n2))-1;
a2 = round(10000*a1)/10000; % adjusted effective annual rate of retutn rounded to two digits after decimal
a3 = round(10000*(12*(((1+a2)^(1/12))-1)))/10000; % adjusted nominal annual rate of retutn
a4 = round(10000*(a3/12))/10000; % adjusted nominal monthly rate of retutn
a5= round(10000*(((1+a3)/(1+f/100))-1))/10000; %adjusted nominal annual real interest rate
a6 = round(10000*(a5/12))/10000; %adjusted nominal monthly real interest rate
% End of the function - adjusted real rates


% End of file adj_real_rates.m
```

adj_real_ratesMortgage.m

```
% This function calculates the adjusted real rates for mortageg opportunity

function [a1,a2,a3,a4,a5] = adj_real_ratesMortgage( best_ia,f)
a1=round(1000*best_ia)/1000; %adjusted effective annualrate of retutn rounded to two digits
after decimal
a2 = round(10000*(12*(((1+a1)^(1/12))-1)))/10000; %% adjusted nominal annual rate of retutn
a3 = round(10000*(a2/12))/10000; % adjusted nominal monthly rate of retutn
a4= round(10000*(((1+a2)/(1+f/100))-1))/10000; %adjusted nominal annual real interest rate
a5 = round(10000*(a4/12))/10000; %adjusted nominal monthly real interest rate
% End of the function - adjusted real rates for mortgage section

% End of file adj_real_ratesMortgage.m
```

best_adj_rate.m

```
% This function calculates the best adjusted rates after tax - iteratively,

function best_ia = best_adj_rate(f,iCD,D,MM, BOYL, NetEOYL)
er=100;
ff=-f/100; icd=iCD/100;count=0; ia=ff:D:icd; len=length(ia);
while er > 0.5 && count<100 && icd>0
   ia=ff:D:icd;
   B=(1+ia/12);
   F1=BOYL*(B).^12;
   F2=MM*((((B).^12)-1)/(ia/12))*(B);
   F=F1+F2;
   er1 = abs(F-NetEOYL);
   [mn index] = min(er1);
   best_ia = ia(index);
   er=er1(index);
   diff=icd-ff;
   D=diff/len;
   icd=ia(index)+abs(ff)/1.1;
   ff=ia(index)-abs(ff)/1.1;
   count=count+1;

end

% End of file best_adj_rate.m
```

best_adj_rate_taxreturn.m

```
% This function calculates the best adjusted rates after tax - iteratively for monthly expenses such as utility, R&M, excess gasoline,

function best_ia = best_adj_rate_taxreturn(f,iCD,D,BOYL,DTY,NetEOYL)
er=100;
ff=-f/100; icd=iCD/100;count=0; ia=ff:D:icd; len=length(ia);
while er > 0.5 && count<100 && icd>0
   ia=ff:D:icd;
   B=1+ia/12;
   F1=BOYL*(B).^12;
   F2=DTY*((B).^8);
   F=F1+F2;
   er1 = abs(F-NetEOYL);
   NE=NetEOYL*ones(size(F));
   [mn index] = min(er1);
   best_ia = ia(index);
   er=er1(index);
   diff=icd-ff;
   D=diff/len;
   icd=ia(index)+abs(ff)/1.1;
   ff=ia(index)-abs(ff)/1.1;
   count=count+1;

end

% End of file best_adj_rate_taxreturn.m
```

best_adj_rateAnnualExp.m

% This function calculates the best adjusted rates after tax - iteratively for monthly expenses such as utility, R&M, excess gasoline,

```
function best_ia = best_adj_rateAnnualExp(f,iCD,D,BOYL,BSM,NetEOYL)

er=100;
ff=-f/100; icd=iCD/100;count=0; ia=ff:D:icd; len=length(ia);
while er > 0.5 && count<100 && icd>0
   ia=ff:D:icd;
   B=(1+ia/12);
   F1=(BOYL+BSM)*(B).^12;
   F2=BSM*((B).^6);
   F=F1+F2;
   er1 = abs(F-NetEOYL);
   NE=NetEOYL*ones(size(F));
   [mn index] = min(er1);
   best_ia = ia(index);
   er=er1(index);
   diff=icd-ff;
   D=diff/len;
   icd=ia(index)+abs(ff)/1.1;
   ff=ia(index)-abs(ff)/1.1;
   count=count+1;

end

% End of the best adjusted rates after tax calculation function

% End of file best_adj_rateAnnualExp.m
```

best_adj_rateMonthlyExp.m

```
% This function calculates the best adjusted rates after tax - iteratively for monthly expenses such
as utility, R&M, excess gasoline,

function best_ia = best_adj_rateMonthlyExp(f,iCD,D,NetBOYL,BMav,NetEOYL)

er=100;
ff=-f/100; icd=iCD/100;count=0; ia=ff:D:icd; len=length(ia);
while er > 0.5 && count<100 && icd>0
  ia=ff:D:icd;
  B=(1+ia/12);
  F1=NetBOYL*(B).^12;
  F2=BMav*((((B).^12)-1)/(ia/12));
  F=F1+F2;
  er1 = abs(F-NetEOYL);
  NE=NetEOYL*ones(size(F));
  [mn index] = min(er1);
  best_ia = ia(index);
  er=er1(index);
  diff=icd-ff;
  D=diff/len;
  icd=ia(index)+abs(ff)/1.1;
  ff=ia(index)-abs(ff)/1.1;
  count=count+1;

end

% End of the best adjusted rates after tax calculation function

% End of file best_adj_rateMonthlyExp.m
```

best_adj_rateSixMonthlyExp.m

```
% This function calculates the best adjusted rates after tax - iteratively for monthly expenses such
as utility, R&M, excess gasoline,

function best_ia = best_adj_rateSixMonthlyExp(f,iCD,D,BOYL,BSM,NetEOYL)

er=100;
ff=-f/100; icd=iCD/100;count=0; ia=ff:D:icd; len=length(ia);
while er > 0.5 && count<100 && icd>0
   ia=ff:D:icd;
   B=(1+ia/12);
   F1=(BOYL+BSM)*(B).^12;
   F2=BSM*((B).^6);
   F=F1+F2;
   er1 = abs(F-NetEOYL);
   NE=NetEOYL*ones(size(F));
   [mn index] = min(er1);
   best_ia = ia(index);
   er=er1(index);
   diff=icd-ff;
   D=diff/len;
   icd=ia(index)+abs(ff)/1.1;
   ff=ia(index)-abs(ff)/1.1;
   count=count+1;
end

% End of the best adjusted rates after tax calculation function


% End of file best_adj_rateSixMonthlyExp.m
```

calc_escrate.m

```
% This function calculates the escalation rates
% The format of the equation is: e=k1*log(Y)-k2

function esc_rate = calc_escrate(k1,k2,Y1,n2)
Y2=Y1+n2;
hr1=k1*log(Y1)-k2;
hr2=k1*log(Y2)-k2;
hr3=10000*((exp(log(hr2/hr1)/(Y2-Y1)))-1);
esc_rate=round(hr3)/100;

% End of the escalation calculation function
% End of file calc_escrate.m
```

calc_fv_woint.m

```
%This function calculates future worth without opportunity costs
function [CL,FV] = calc_fv_woint(P1,iCD,n1,n2,f,RITX)
CL=0;
for j=1:n2
    %fv =(P1*(1+(iCD/1200))^12);
    int = (P1*(1+(iCD/1200))^12)-P1; % Interest claculated
    tax=(RITX/100)*int; % tax paid
    netint = int-tax; % net interest earned after tax
%      fprintf('%2.0f\t\t', j);
%      fprintf('%5.0f\t\t', P1)
%      fprintf('%2.0f\t\t', fv);
%    fprintf('%5.0f\t\t', int);
%      fprintf('%5.0f\t\t', tax);
%    fprintf('%5.0f\t\t\t',netint);
    P1=P1+netint; % Cumulative capital at the end of year
    CL=CL+netint; % Cumulative net earned
%      fprintf('%5.0f\t\t',CL);
%      fprintf('%5.0f\n', P1);

end
CL=CL;
FV=P1;

% end of function future worth without opportunity costs


% End of file calc_fv_woint.m
```

Capital_gain_tax.m

```
% This function calculates the capital gain tax
function [O32,O33,O34,O35,O36,O37,O38,O39] = Capital_gain_tax(n2,Resalevalue,SP,
CCA,PTA, SCR, RP, FVadv, ia_eaA,ir_nmA, Exmpt,CGTrate )

CG=Resalevalue-SP-CCA-PTA-(((SCR/100)*Resalevalue)+FVadv)-RP-Exmpt; % This is the
taxable capital gain
if CG<=0
   CG=0;
   CGTax=0;
else
CGTax=(CGTrate/100)*CG;
end

PWCGT=CGTax/((1+ia_eaA)^n2);
if (1+ir_nmA)^(n2*12)==1;
   EUME_expCGTax=PWCGT/(n2*12);
else
EUME_expCGTax= PWCGT*(ir_nmA*(1+ir_nmA)^(n2*12))/(((1+ir_nmA)^(n2*12))-1);
end
O32= 0;
O33= 0;
O34=CGTax;
O35=PWCGT;
O36=0;
O37=EUME_expCGTax;
O38=0;
O39=O37+O38;
% end of function capital gain tax

% End of file Capital_gain_tax.m
```

Forecasting_Coefficients.m

```
%This file contains all the forecasting coefficients
% This information comes from the forecasting chapter of the text
% These data are location specific and dependant on personal desire of the analyst

%CPI index coefficient
  CPI1=9292.76; CPI2=70459.37;
% PPI index
  PPI1=6518.46; PPI2=49384.9;
% Utilities escalation index
  Ku1=164255.2;Ku2=1246084.88;
% Home insurance escalation index
  Khi1=100237.99; Khi2=761387.05;
%property appreciation index
  Kpap1=30338118.27;
  Kpap2=230189673.21;
%Gasoline inflation
  Kg1=22411.30;
  Kg2=170189.90;
%House Rent inflation
  Khr1=60575.91;
  Khr2=459313.04;
%Income escalation rates
  Kei1=3866716.70;
  Kei2=29324484.62;


% End of file Forecasting_Coefficients.m
```

income_calcs.m

```
%This pogram calculates family income
function [EPV, EUMI] = income_calcs(BI, eI, n2,f, RITX);
CuPV=0;
   for j=1:n2
      YIav(j)=BI*(1+eI/100)^j;
      TaxG(j)=(RITX/100)*YIav(j); % Tax paid
      ATX(j)=YIav(j)-TaxG(j); %Net interest
      PV(j) = ATX(j)/((1+f/100)^j);
      CuPV=CuPV+PV(j);
   end
   EPV=CuPV;
aari = (ATX(j)-ATX(j-1))/(ATX(j-1)); % This is after tax adjusted rate of increase  ria=(aari-
(f/100))/(1+(f/100));
rim=ria/12;
EUMI=EPV*(rim*(1+rim)^(12*n2))/((1+rim)^(12*n2)-1);


% End of file income_calcs.m
```

mortgage.m

```
% This function calculates mortgage
% n1 is loan paying period in years
% iM is mortgage interest rate in %.

function MM= mortgage (Loan, n1, iM)
r=iM/1200;
n3=n1*12; %n4 means loan paying period in months
MM = (r*Loan*(1+r)^n3)/(((1+r)^n3)-1);
% End of mortage calculation function

% End of file mortgage.m
```

opp_loss_ins.m

```
%This function calculates the monthly expenses such as ulility, repair and
%Maintenance and excess gasoline expenses
%NP is the number of payment in a year
function [CL,NetEOYL,BOYL,EOY,BSM,BCav] =
opp_loss_ins(BaseCost,esc,iCD,n2,RITX,NP)
Onepay=BaseCost/NP;
BOY =0;
BOYL=0;
CL=0;
   for j=1:n2
      BSM=Onepay*(1+esc/100)^j;
      DTY=BSM*NP;% Future value paid during this year
      EOY=BOY+DTY; %Enf of the year Future worth
      BOY=EOY; %BOY Capita
      if NP==2;
         FV=((BSM*(1+iCD/1200)^12)+(BSM*(1+iCD/1200)^6));% Future value paid during
this year
      else
         FV=DTY;
      end
      FVRC=BOYL*(1+iCD/1200)^12; % FV of running capital at BOY
      EOYL=FVRC+FV; % FV of all at EOY
      ITY = FV-DTY; % Interest earned this year
      IRC = FVRC-BOYL;% interest from running capital
      TINT=ITY+IRC; %Gross taxable interest
      Tax=(RITX/100)*TINT; % Tax paid
      Netint(j)=TINT-Tax; %Net interest
      CL=CL+Netint(j); % Cumulative interest lost
      NetEOYL(j)=EOYL-Tax;
      BOYLL(j)=NetEOYL(j);
      BOYL=NetEOYL(j);
   end
    CL=CL;
   NetEOYL=NetEOYL(j);
   BOYL=BOYLL(j-1);
   EOY=EOY;
   BSM=BSM;
   BCav=BaseCost*(1+esc/100)/NP;

% End of function opp_loss_ins.m
 % End of file opp_loss_ins.m
```

opp_loss_monthlyExp.m

```
%This function calculates the monthly expenses such as ulility, repair and
%Maintenance and excess gasoline expenses, rental expenses
function [CL,NetEOYL,BOYL,EOY,BMav] = opp_loss_monthlyExp
(BaseCost,esc,iCD,n2,RITX)
BOY =0;
BOYL=0;
CL=0;
  for j=1:n2
    Z1=BaseCost*(1+esc/100)^j;
    Z2=BaseCost*(1+esc/100)^(j+1);
    BMav=(Z1+Z2)/2;
    DTY=BMav*12;% Future value paid during this year
    EOY=BOY+DTY; %Enf of the year Future worth
    BOY=EOY; %BOY Capital
   % Start with opportunity loss
   FV=BMav*((1+iCD/1200)^12-1)/(iCD/1200);% Future value of the expenses paid during
this year
   FVRC=BOYL*(1+iCD/1200)^12; % FV of running capital at BOY
   EOYL=FVRC+FV; % FV of all at EOY
   ITY(j) = FV-DTY; % Interest earned this year
   IRC(j) = FVRC-BOYL;% interest from running capital
   TINT(j)=ITY(j)+IRC(j); %Gross taxable interest
   Tax(j)=(RITX/100)*TINT(j); % Tax paid
   Netint(j)=TINT(j)-Tax(j); %Net interest
   CL=CL+Netint(j); % Cumulative interest lost
   NetEOYL(j)=EOYL-Tax(j);
   BOYLL(j)=NetEOYL(j);
   BOYL=NetEOYL(j);
  end
  CL=CL;
  NetEOYL=NetEOYL(j);
  BOYL=BOYLL(j-1);
  EOY=EOY;
  BMav=BMav;

% End of function opp_loss_monthlyExp.m

% End of file opp_loss_monthlyExp.m
```

opp_loss_monthlyExpRent.m

```
%This function calculates the monthly expenses such as ulility, repair and
%Maintenance and excess gasoline expenses, rental expenses
function [CL,NetEOYL,BOYL,EOY,BMav] = opp_loss_monthlyExpRent
(BaseCost,esc,iCD,n2,RITX)
BOY =0;
BOYL=0;
CL=0;
  for j=1:n2
    Z1=BaseCost*(1+esc/100)^j;
    Z2=BaseCost*(1+esc/100)^(j+1);
    BMav=(Z1+Z2)/2;
    DTY=BMav*12;% Future value paid during this year
    EOY=BOY+DTY; %Enf of the year Future worth
    BOY=EOY; %BOY Capital
    % Start with opportunity loss
   FV=(1+iCD/1200)*BMav*((1+iCD/1200)^12-1)/(iCD/1200);% Future value of the expenses
paid during this year
   FVRC=BOYL*(1+iCD/1200)^12; % FV of running capital at BOY
   EOYL=FVRC+FV; % FV of all at EOY
   ITY(j) = FV-DTY; % Interest earned this year
   IRC(j) = FVRC-BOYL;% interest from running capital
   TINT(j)=ITY(j)+IRC(j); %Gross taxable interest
   Tax(j)=(RITX/100)*TINT(j); % Tax paid
   Netint(j)=TINT(j)-Tax(j); %Net interest
   CL=CL+Netint(j); % Cumulative interest lost
   NetEOYL(j)=EOYL-Tax(j);
   BOYLL(j)=NetEOYL(j);
   BOYL=NetEOYL(j);
  end
   CL=CL;
  NetEOYL=NetEOYL(j);
  BOYL=BOYLL(j-1);
  EOY=EOY;
  BMav=BMav;

% End of function opp_loss_monthlyExpRent

% End of file opp_loss_monthlyExpRent
```

opp_loss_mortgage.m

```
% This function calculates the opportunity loss on mortgage paid
function [CL,NetEOYL,BOYL,EOY]= opp_loss_mortgage(MM,iCD,n1,n2,RITX)
BOY = 0;
BOYL1 = 0;
EOY1 = 0;
CL1 = 0;
  for j=1:n2
    if j>n1
    MM=0;
    else
    MM=MM;
    end
      DTY=12*MM;
      EOY=BOY+DTY;
      BOY=EOY;
      FV(j)=MM*(1+iCD/1200)*(((1+iCD/1200)^12)-1)/(iCD/1200); % FV of monthly
mortgage paid during nth year OK
      FVRC(j)=BOYL1*(1+iCD/1200)^12; % FV of running capital at BOY
      EOYL(j)=FVRC(j)+FV(j); % FV of all at EOY
      ITY(j) = FV(j)-DTY; % Interest earned from the capital paid this year
      IRC(j) = FVRC(j)-BOYL1;% interest from running capital
      TINT(j)=ITY(j)+IRC(j); %Gross taxable interest
      Tax(j)=(RITX/100)*TINT(j); % Tax paid
      Netint(j)=TINT(j)-Tax(j); %Net interest
      CL(j)=CL1+Netint(j); % Cumulative interest loss
      CL1=CL(j);
      NetEOYL(j)=EOYL(j)-Tax(j); % net interest earned during this period
      BOYL(j)=NetEOYL(j);
      BOYL1=BOYL(j);
  end
  CL=CL(j);
  NetEOYL=NetEOYL(j);
  if n2<2
    BOYL =BOYL(j)
  else
  BOYL=BOYL(j-1);
  end
  EOY=EOY
% End of function opp_loss_mortgage

% End of file opp_loss_mortgage.m
```

opp_loss_ptax.m

```
%This function calculates the monthly expenses such as ulility, repair and
%Maintenance and excess gasoline expenses
%NP is the number of payment in a year
function [CL,NetEOYL,BOYL,Netint,EOY,BAT,BCav] =
opp_loss_ptax(SP,pro_app,ptax_rate,ept,iCD,n2,RITX)
BOY =0;
BOYL=0;
CL=0;
  for j=1:n2
    BAT=(SP*(1+pro_app/100)^j)*((ptax_rate/100)*(1+ept/100)^j);
    DTY=BAT;% Future value paid during this year
    EOY=BOY+DTY; %Enf of the year Future worth
    BOY=EOY; %BOY Capita
    FV=DTY;
    FVRC=BOYL*(1+iCD/1200)^12; % FV of running capital at BOY
    EOYL=FVRC+FV; % FV of all at EOY
    ITY = FV-DTY; % Interest earned this year
    IRC = FVRC-BOYL;% interest from running capital
    TINT=ITY+IRC; %Gross taxable interest
    Tax=(RITX/100)*TINT; % Tax paid
    Netint(j)=TINT-Tax; %Net interest
    CL=CL+Netint(j); % Cumulative interest lost
    NetEOYL(j)=EOYL-Tax;
    BOYLL(j)=NetEOYL(j);
    BOYL=NetEOYL(j);
  end
  CL=CL;
  NetEOYL=NetEOYL(j);
  BOYL=BOYLL(j-1);
  Netint=Netint(j);
  EOY=EOY;
  BAT=BAT;
  BCav=(SP*(ptax_rate/100));


% End of function opp_loss_ptax

% End of file opp_loss_ptax.m
```

opp_loss_taxreturn_mortgage.m

```
%Pogram calculates tax return from mortgage interest

function [DTY, BOYL, CL, EOY, NetEOYL, Loan_remaining]= opp_loss_taxreturn_mortgage
(Loan, iM , iCD, n1, n2, RITX)
 r=iM/1200;
n3=n1*12;
n4=n2*12; %n4 means loan paying period in months when n1 and n2 are different
MM = (r*Loan*(1+r)^n3)/(((1+r)^n3)-1);
 itot=0;
Tint=0;
BOY=0;
BOYL=0;
CL=0;
P=Loan;
PP=0;
  for j=2:n2+1
    for i=1:12

      if P<=0
        newP=0;
        P=0;
        MM=0;
      else
      newP = P +(r*P)-MM;
      end
     itot=itot+(r*P);
     int = r*P;
     Tint=Tint+int;
     PP=PP+(MM-r*P);
     P=newP;
     taxreturn(j)=RITX/100*Tint;
end
     Tint=0;
     Loan_remaining =P;
     % start without opportunity loss
     DTY=taxreturn(j);% Tax paid during this year
     EOY=BOY+DTY; %Enf of the year Future worth
     BOY=EOY; %BOY Capital
     % Start with opportunity loss
    FV= DTY*(1+iCD/1200)^8;% Future value paid during this year
    FVRC=BOYL*(1+iCD/1200)^12; % FV of running capital at BOY
    EOYL=FVRC+FV; % FV of all at EOY
    ITY = FV-DTY; % Interest earned this year
    IRC = FVRC-BOYL;% interest from running capital
    TINT=ITY+IRC; %Gross taxable interest
    Tax=(RITX/100)*TINT; % Tax paid
```

```
    Netint=TINT-Tax; %Net interest
    CL=CL+Netint; % Cumulative interest lost
    NetEOYL=EOYL-Tax;
    BOYLL(j)=NetEOYL;
    BOYL=NetEOYL;
  end
DTY =DTY;
BOYL=BOYLL(j-1);
CL=CL;
EOY=EOY;
NetEOYL =NetEOYL;
Loan_remaining = Loan_remaining;
% End of function opp_loss_taxreturn_mortgage

% End of file opp_loss_taxreturn_mortgage.m
```

opp_loss_taxreturn_proptax.m

```
%Pogram calculates tax retutn of Property Tax
function [DTY, BOYL, CL, EOY, NetEOYL]= opp_loss_taxreturn_proptax (SP,pro_app,
ptax_rate, ept, iCD, n1, n2, RITX)
n3=n1*12;
n4=n2*12;
itotL=0;
Tint=0;
BOY =0;
BOYL=0;
PTXR=0;
CL=0;
  for j=1:n2+1
    % start without opportunity loss
    if j <=1
      PTXR=0;
    else
    PValue=SP*(1+pro_app/100)^(j-1); % property value this year
    PTXR=PValue*(ptax_rate/100)*((1+ept/100)^(j-1))*(RITX/100); %amount of property tax
for this year
    end
    DTY=PTXR;
    EOY=BOY+DTY; %Enf of the year Future worth
    BOY=EOY; %BOY Capital
    FV= DTY*(1+iCD/1200)^8;% Future value paid during this year
    FVRC=BOYL*(1+iCD/1200)^12; % FV of running capital at BOY
    EOYL=FVRC+FV; % FV of all at EOY
    ITY = FV-DTY; % Interest earned this year
    IRC= FVRC-BOYL;% interest from running capital
    TINT=ITY+IRC; %Gross taxable interest
    Tax=(RITX/100)*TINT; % Tax paid
    Netint=TINT-Tax; %Net interest
    CL=CL+Netint; % Cumulative interest lost
    NetEOYL=EOYL-Tax;
    BOYLL(j)=NetEOYL;
    BOYL=NetEOYL;
  end
 DTY=DTY;
BOYL=BOYLL(j-1);
CL=CL;
EOY=EOY;
NetEOYL=NetEOYL;
% End of file opp_loss_taxreturn_proptax.m
```

opp_loss_taxreturn_pt.m

```
%Pogram calculates Tax return on Discount Points
function [CL,NetEOYL,BOYL,EOY, DTY] = opp_loss_taxreturn_pt( Loan,Pt,iCD,n2,RITX)
itot=0;
Tint=0;
BOY =0;
BOYL=0;
CL=0;
DTY= Loan*Pt/100*RITX/100;
  for j=1:n2
    EOY=BOY+DTY;
    BOY=EOY;
    FV= DTY*(1+iCD/1200)^8;
    FVRC=BOYL*(1+iCD/1200)^12;
    EOYL=FVRC+FV;
    ITY = FV-DTY; % Interest earned this year
    IRC = FVRC-BOYL;% interest from running capital
    TINT=ITY+IRC; %Gross taxable interest
    Tax=(RITX/100)*TINT; % Tax paid
    Netint=TINT-Tax; %Net interest
    CL=CL+Netint; % Cumulative interest lost
    NetEOYL=EOYL-Tax;
    BOYL=NetEOYL;
    DTY=0; % there is no tax return on points paid after first year.
    NetEOYL(j)=EOYL-Tax;
    BOYLL(j)=NetEOYL(j);
    BOYL=NetEOYL(j);
  end
  CL=CL;
  NetEOYL=NetEOYL(j);
  BOYL=BOYLL(j-1);
  EOY=EOY;
  DTY=DTY;


% End of function opp_loss_taxreturn_pt.m

% End of file opp_loss_taxreturn_pt.m
```

Periodic_RandM.m

```
%Pogram calculates Roofing costs
function [CL,BOYL,EOY,Netint,NetEOYL] = Periodic_RandM(BaseCost, Rint, emr, iCD, n2,
RITX)
BOY =0;
BOYL=0;
CL=0;
  for j=1:n2
    % start without opportunity loss
    k=rem(j,Rint);

    if k==0
      Rcost=BaseCost*(1+emr/100)^j;
    else
      Rcost=0;
    end
    DTY=Rcost;
    EOY=BOY+DTY; %Enf of the year Future worth
    FV= DTY;% Future value paid during this year
    FVRC=BOYL*(1+iCD/1200)^12; % FV of running capital at BOY
    EOYL=FVRC+FV; % FV of all at EOY
    ITY = FV-DTY; % Interest earned this year
    IRC = FVRC-BOYL;% interest from running capital
    TINT=ITY+IRC; %Gross taxable interest
    Tax=(RITX/100)*TINT; % Tax paid
    Netint=TINT-Tax; %Net interest
    CL=CL+Netint; % Cumulative interest lost
    NetEOYL=EOYL-Tax;
    XXX(j)=NetEOYL;
    BOYL=NetEOYL;
    BOY=EOY;
  end
CL=CL;
BOYL=XXX(j-1);
EOY=EOY;
Netint=Netint;
NetEOYL=NetEOYL;

% End of function Periodic_RandM

% End of file Periodic_RandM.m
```

Property_Resalevalue.m

```
% This function calculates the resale value
function [O12, O13, O14, O15, O16, O17, O18, O19]= Property_Resalevalue (SP,
pro_app,n2,a2,a6)

O12=-SP;
O13=pro_app;
O14=O12*(1+pro_app/100)^n2;
O15=O14/(1+a2)^n2;
O16 = 0;
if (1+a6)^(n2*12)==1;
  O17=O15/(n2*12);
else
O17= O15*(a6*(1+a6)^(n2*12))/(((1+a6)^(n2*12))-1);
end
O18=0;
O19=O17+O18;

% End of function Property_Resalevalue

% End of file Property_Resalevalue.m
```

Sellers_Closing_Cost.m

```
% This function caculates the Seller's Costs Costs
function [O22,O23,O24,O25,O26,O27,O28,O29,Resalevalue,FVadv] =
Sellers_Closing_Cost(SP,pro_app,n2,f, SCR, Advert,ia_eaA,ir_nmA )

Resalevalue = SP*(1+pro_app/100)^n2;
FVadv=Advert*(1+f/100)^n2;
O22=(SCR/100)*SP;
O23=SCR;
O24= ((SCR/100)*Resalevalue)+FVadv;
O25=O24/(1+ia_eaA)^n2;
O26 = 0;
if (1+ir_nmA)^(n2*12)==1;
   O27=O25/(n2*12);
else
O27= O25*(ir_nmA*(1+ir_nmA)^(n2*12))/(((1+ir_nmA)^(n2*12))-1);
end
O28=0;
O29=O27+O28;


% End of function Sellers_Closing_Cost.m

 % End of file Sellers_Closing_Cost.m
```

APPENDIX C: OWNERSHIP AND OPERATIONAL MSI RESULTS

Table C-1: Ranking of EUNFME in ascending order along with ownership MSI

Rank by EUNFME	EUNFME, $	Ownership MSI	Operational MSI	Mortgage Rate, %	Down-payment, %	CD Rate, %	Ownership period, Yrs
1	**1,468**	**0.235**	0.149	5	100	2	30
2	**1,468**	**0.235**	0.149	6	100	2	30
3	**1,468**	**0.235**	0.149	7	100	2	30
4	**1,510**	**0.244**	0.150	5	100	2	15
5	**1,510**	**0.244**	0.150	6	100	2	15
6	**1,510**	**0.244**	0.150	7	100	2	15
7	**1,755**	**0.281**	0.377	5	50	2	30
8	**1,817**	**0.294**	0.375	5	50	2	15
9	**1,884**	**0.308**	0.140	5	100	2	5
10	**1,884**	**0.308**	0.140	6	100	2	5
11	**1,884**	**0.308**	0.140	7	100	2	5
12	**1,904**	**0.305**	0.401	6	50	2	30
13	**1,928**	**0.309**	0.514	5	20	2	30
14	**1,999**	**0.324**	0.398	6	50	2	15
15	**2,001**	**0.324**	0.511	5	20	2	15
16	**2,061**	**0.330**	0.426	7	50	2	30
17	**2,166**	**0.347**	0.552	6	20	2	30
18	**2,187**	**0.354**	0.422	7	50	2	15
19	**2,197**	**0.359**	0.361	5	50	2	5
20	**2,293**	**0.371**	0.547	6	20	2	15
21	**2,384**	**0.390**	0.494	5	20	2	5
22	**2,391**	**0.391**	0.383	6	50	2	5
23	**2,417**	**0.387**	0.592	7	20	2	30
24	**2,588**	**0.423**	0.407	7	50	2	5
25	**2,593**	**0.420**	0.585	7	20	2	15
26	**2,696**	**0.441**	0.530	6	20	2	5
27	**2,755**	**0.446**	0.553	5	20	4	15
28	**2,859**	**0.463**	0.401	5	50	4	15
29	**2,876**	**0.470**	0.510	5	20	4	5
30	**2,967**	**0.475**	0.150	5	100	4	30
31	**2,967**	**0.475**	0.150	6	100	4	30
32	**2,967**	**0.475**	0.150	7	100	4	30
33	**3,010**	**0.492**	0.568	7	20	2	5
34	**3,030**	**0.491**	0.149	7	100	4	15

Table continued in the next page.

Table C-1 continued...

Rank by EUNFME	EUNFME, $	Ownership MSI	Operational MSI	Mortgage Rate, %	Down-payment, %	CD Rate, %	Ownership period, Yrs
35	**3,033**	**0.491**	0.149	5	100	4	15
36	**3,033**	**0.491**	0.149	6	100	4	15
37	**3,036**	**0.486**	0.428	5	50	4	30
38	**3,056**	**0.495**	0.427	6	50	4	15
39	**3,070**	**0.497**	0.594	6	20	4	15
40	**3,078**	**0.493**	0.595	5	20	4	30
41	**3,095**	**0.506**	0.371	5	50	4	5
42	**3,196**	**0.523**	0.548	6	20	4	5
43	**3,221**	**0.515**	0.458	6	50	4	30
44	**3,260**	**0.528**	0.455	7	50	4	15
45	**3,295**	**0.539**	0.395	6	50	4	5
46	**3,371**	**0.551**	0.527	5	20	6	5
47	**3,373**	**0.540**	0.642	6	20	4	30
48	**3,396**	**0.550**	0.638	7	20	4	15
49	**3,415**	**0.546**	0.489	7	50	4	30
50	**3,446**	**0.558**	0.587	5	20	6	15
51	**3,461**	**0.566**	0.139	5	100	4	5
52	**3,461**	**0.566**	0.139	6	100	4	5
53	**3,461**	**0.566**	0.139	7	100	4	5
54	**3,498**	**0.572**	0.420	7	50	4	5
55	**3,520**	**0.576**	0.588	7	20	4	5
56	**3,683**	**0.589**	0.692	7	20	4	30
57	**3,700**	**0.605**	0.566	6	20	6	5
58	**3,781**	**0.612**	0.632	6	20	6	15
59	**3,864**	**0.626**	0.422	5	50	6	15
60	**3,999**	**0.654**	0.381	5	50	6	5
61	**4,004**	**0.641**	0.647	5	20	6	30
62	**4,034**	**0.660**	0.609	7	20	6	5
63	**4,074**	**0.660**	0.450	6	50	6	15
64	**4,129**	**0.668**	0.681	7	20	6	15
65	**4,179**	**0.669**	0.460	5	50	6	30
66	**4,205**	**0.688**	0.406	6	50	6	5
67	**4,291**	**0.695**	0.480	7	50	6	15

Table continued in the next page.

Table C-1 continued...

Rank by EUNFME	EUNFME, $	Ownership MSI	Operational MSI	Mortgage Rate, %	Down-payment, %	CD Rate, %	Ownership period, Yrs
68	**4,338**	**0.694**	0.701	6	20	6	30
69	**4,388**	**0.702**	0.493	6	50	6	30
70	**4,413**	**0.722**	0.432	7	50	6	5
71	**4,472**	**0.716**	0.147	5	100	6	30
72	**4,472**	**0.716**	0.147	6	100	6	30
73	**4,472**	**0.716**	0.147	7	100	6	30
74	**4,561**	**0.739**	0.146	5	100	6	15
75	**4,561**	**0.739**	0.146	6	100	6	15
76	**4,561**	**0.739**	0.146	7	100	6	15
77	**4,608**	**0.737**	0.528	7	50	6	30
78	**4,689**	**0.750**	0.757	7	20	6	30
79	**5,046**	**0.825**	0.139	5	100	6	5
80	**5,046**	**0.825**	0.139	6	100	6	5
81	**5,046**	**0.825**	0.139	7	100	6	5

Table C-2: Ranking of operational MSI in ascending order.

Ranked by Operational MSI	EUNFME, $	Ownership MSI	Operational MSI	Mortgage Rate, %	Down-payment, %	CD Rate, %	Ownership period, Yrs
1	5,046	0.825	**0.139**	5	**100**	6	5
2	5,046	0.825	**0.139**	6	**100**	6	5
3	5,046	0.825	**0.139**	7	**100**	6	5
4	3,461	0.566	**0.139**	5	**100**	4	5
5	3,461	0.566	**0.139**	6	**100**	4	5
6	3,461	0.566	**0.139**	7	**100**	4	5
7	1,884	0.308	**0.140**	5	**100**	2	5
8	1,884	0.308	**0.140**	6	**100**	2	5
9	1,884	0.308	**0.140**	7	**100**	2	5
10	4,561	0.739	**0.146**	5	**100**	6	15
11	4,561	0.739	**0.146**	6	**100**	6	15
12	4,561	0.739	**0.146**	7	**100**	6	15
13	4,472	0.716	**0.147**	5	**100**	6	30
14	4,472	0.716	**0.147**	6	**100**	6	30
15	4,472	0.716	**0.147**	7	**100**	6	30
16	3,030	0.491	**0.149**	7	**100**	4	15
17	3,033	0.491	**0.149**	5	**100**	4	15
18	3,033	0.491	**0.149**	6	**100**	4	15
19	1,468	0.235	**0.149**	5	**100**	2	30
20	1,468	0.235	**0.149**	6	**100**	2	30
21	1,468	0.235	**0.149**	7	**100**	2	30
22	2,967	0.475	**0.150**	5	**100**	4	30
23	2,967	0.475	**0.150**	6	**100**	4	30
24	2,967	0.475	**0.150**	7	**100**	4	30
25	1,510	0.244	**0.150**	5	**100**	2	15
26	1,510	0.244	**0.150**	6	**100**	2	15
27	1,510	0.244	**0.150**	7	**100**	2	15
28	2,197	0.359	**0.361**	5	**50**	2	5
29	3,095	0.506	**0.371**	5	**50**	4	5
30	1,817	0.294	**0.375**	5	**50**	2	15
31	1,755	0.281	**0.377**	5	**50**	2	30
32	3,999	0.654	**0.381**	5	**50**	6	5
33	2,391	0.391	**0.383**	6	**50**	2	5

Table continued in the next page.

Table 2-C continued

Ranked by Operational MSI	EUNFME, $	Ownership MSI	Operational MSI	Mortgage Rate, %	Down-payment, %	CD Rate, %	Ownership period, Yrs
34	3,295	0.539	**0.395**	6	**50**	4	5
35	1,999	0.324	**0.398**	6	**50**	2	15
36	1,904	0.305	**0.401**	6	**50**	2	30
37	2,859	0.463	**0.401**	5	**50**	4	15
38	4,205	0.688	**0.406**	6	**50**	6	5
39	2,588	0.423	**0.407**	7	**50**	2	5
40	3,498	0.572	**0.420**	7	**50**	4	5
41	3,864	0.626	**0.422**	5	**50**	6	15
42	2,187	0.354	**0.422**	7	**50**	2	15
43	2,061	0.330	**0.426**	7	**50**	2	30
44	3,056	0.495	**0.427**	6	**50**	4	15
45	3,036	0.486	**0.428**	5	**50**	4	30
46	4,413	0.722	**0.432**	7	**50**	6	5
47	4,074	0.660	**0.450**	6	**50**	6	15
48	3,260	0.528	**0.455**	7	**50**	4	15
49	3,221	0.515	**0.458**	6	**50**	4	30
50	4,179	0.669	**0.460**	5	**50**	6	30
51	4,291	0.695	**0.480**	7	**50**	6	15
52	3,415	0.546	**0.489**	7	**50**	4	30
53	4,388	0.702	**0.493**	6	**50**	6	30
54	2,384	0.390	**0.494**	5	**20**	2	5
55	2,876	0.470	**0.510**	5	**20**	4	5
56	2,001	0.324	**0.511**	5	**20**	2	15
57	1,928	0.309	**0.514**	5	**20**	2	30
58	3,371	0.551	**0.527**	5	**20**	6	5
59	4,608	0.737	**0.528**	7	**50**	6	30
60	2,696	0.441	**0.530**	6	**20**	2	5
61	2,293	0.371	**0.547**	6	**20**	2	15
62	3,196	0.523	**0.548**	6	**20**	4	5
63	2,166	0.347	**0.552**	6	**20**	2	30
64	2,755	0.446	**0.553**	5	**20**	4	15
65	3,700	0.605	**0.566**	6	**20**	6	5
66	3,010	0.492	**0.568**	7	**20**	2	5
67	2,593	0.420	**0.585**	7	**20**	2	15

Table continued in the next page.

Table C-2 continued

Ranked by Operational MSI	EUNFME, $	Ownership MSI	Operational MSI	Mortgage Rate, %	Down-payment, %	CD Rate, %	Ownership period, Yrs
68	3,446	0.558	**0.587**	5	**20**	6	15
69	3,520	0.576	**0.588**	7	**20**	4	5
70	2,417	0.387	**0.592**	7	**20**	2	30
71	3,070	0.497	**0.594**	6	**20**	4	15
72	3,078	0.493	**0.595**	5	**20**	4	30
73	4,034	0.660	**0.609**	7	**20**	6	5
74	3,781	0.612	**0.632**	6	**20**	6	15
75	3,396	0.550	**0.638**	7	**20**	4	15
76	3,373	0.540	**0.642**	6	**20**	4	30
77	4,004	0.641	**0.647**	5	**20**	6	30
78	4,129	0.668	**0.681**	7	**20**	6	15
79	3,683	0.589	**0.692**	7	**20**	4	30
80	4,338	0.694	**0.701**	6	**20**	6	30
81	4,689	0.750	**0.757**	7	**20**	6	30