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LIFE CYCLE COSTING FOR

OFFICE BUILDINGS

IN CANADA

Ke Zhang

A Thesis

in

The Department of Building, Civil and Environmental Engineering

Presented in Partial Fulfillment of the Requirements for the Degree of Master of Applied Science (Building Engineering) at Concordia University, Montreal, Quebec, Canada

January 1999

CONCORDIA UNIVERSITY
Department of Building, Civil and Environmental Engineering

This is to certify that the thesis prepared

By: **Ke ZHANG**

Entitled: **Life Cycle Costing for Office Buildings in Canada**

and submitted in partial fulfilment of the requirements for the degree of

Master of Applied Science (Building Engineering)

complies with the regulations of the University and meets with the accepted standards with respect to originality and quality.

Signed by the final examining committee:

B. Ashtakala
Dr. B. Ashtakala — Chairman

Khaled El-Rayes
Dr. K. El-Rayes — BCEE Examiner

Dr. H. Rivard — BCEE Examiner

K. Khorasani
Dr. K. Khorasani — External Examiner

Dr. S. Alkass — Supervisor

Approved by
Dr. O. Moselhi, Chair, Department of Building, Civil & Environmental Engineering

April 9 1999
Dr. N. Esmail
Dean, Faculty of Engineering and Computer Science

ABSTRACT

Life Cycle Costing for Office Buildings in Canada

Ke Zhang

Life Cycle Costing (**LCC**) technique, is a useful and effective tool widely used in engineering, manufacturing, and business. It features easy-processing, cost-effectiveness, and directly provides numerical results, all of which can be used in the function of cost control, optimal alternatives selection, asset or products assessment, budget planning, preliminary design, project feasibility study, etc.

This research, "**Life Cycle Costing for Office Buildings in Canada**" has been carried out with emphases on investment, development, assessment and management decision-making at the early stage. The computing model is designed for quick and inexpensive OB property evaluating system.

The study of historical and current cost data for predicting future cost is one of the features of the LCC technique. The data is obtained from different data sources gathered by contact with government agencies, local real estate companies, BOMA International; as well as from surveys (questionnaires); e-mail; Internet; telephones and inter-library loans. The research has established a data treatment system and database management system; practiced statistics, financing modeling, data regression, and costs forecasting.

The main purpose of an LCC analysis is to provide numerical results, which is an important part in the decision-making process. The research methodology and computing model have been developed in order to measure the total net present value (TNPV). Computer programs entitled **OFFICE_LCC98** and **OFFICE_DB98** has been developed and implemented to assist the LCC study.

Lastly, this study is unique from previous works in that it assigns examples for explaining speculative office building development and determination of economic rental rates in real estate (**RE**) practice. And it applies the LCC technique with traditional RE appraisal methods for OB evaluation, as well as setting up a reference for other commercial RE market LCC applications.

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To My Parents

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Finally, I wish to dedicate this work to my parents for their love, patience, encouragement, moral and partial financial support. I appreciate, and would like to thank my father for providing his book "Telecommunication Engineering Economics" and his early guidance for this work. I also thank my wife and daughter for their patience and moral support.

TABLE OF CONTENTS

Chapter 6 Office_LCC98 Computing Model

Chapter 7 Study With Results

Chapter 8 Summary, Conclusions & Future Works

LIST OF FIGURES

LIST OF TABLES

ABBREVIATIONS

ASTM	American Society of Testing and Materials
LCC	Life Cycle Costing
NOI	Net Operating Income
OB	Office Building
O / M	Operating and Maintenance
PV	Present Value
RE	Real Estate
REIT	Real Estate Investment Trust
TNPV	Total Net Present Value
TOEFL	Total Operating cost and Expenses plus Fixed cost plus Leasing expense

Chapter 1

Introduction

Montreal

City of Montreal

Applications Make Theory Alive

The right time, right place and right decision is the secret to being successful in business. In real estate (**RE**), certain questions always arise in people's minds. For developers, "When and where should we go for our business on speculative building?" For investors, "Where should we put our money and how long can we BINGO, then, what is the resale value of our property?" (BINGO is used in the real estate field to mean the time it takes before generating returns and profits http://realdata-astc). For property owners and managers, "What should we pay more attention to in our day-to-day expenses, and how to make a budget plan for the next three years". For architects and financial advisors, "What should I tell my clients are the total costs of building and annual net operating income (NOI), annual operating and maintenance expenses for the next five year's operating period".

With these questions in mind, the research **"Life Cycle Costing for Office Buildings in Canada"** has been carried out. The research presents comprehensive life cycle costing (**LCC**) analysis, which studies all relevant cost performance to office buildings (**OB**), extended throughout eight target Canadian cities coast to coast. The aim of the research is to establish a comprehensive, systematic and consistent basis for LCC application. It emphasizes on LCC application in commercial real estate – Office Building's investment, development, assessment and management decision-making at an early stage. In order to reach its goal, this research attempts to give not only directive recommendations for decision-making, but also provides graphical and quantitative solutions by using LCC analysis assisting software – **OFFICE_LCC98**.

1 - 1 OFFICE BUILDING (OB) AND LIFE CYCLE COSTING (LCC)

OB cost performance, as an objective, is the major goal of the study. LCC technique, as an assessment tool, is used to achieve this goal. Office buildings are one of the most common types of building among residential buildings, schools, libraries, hospitals, hotels, shopping centers, etc. in the building industry. OB represents modern society and a modernized industry level. Typically, the tallest building in a city is an office building. In Canada, it increases every year as shown in Figure 1 – 1. Costs on OB, which include capital costs, operating & maintenance costs, as well as taxes etc. are much different than with other types of buildings. (There are more details on cost distribution in different types of buildings in Chapter Two) Therefore, in order to identify the explicit goal, and to avoid misunderstandings and confusions, it must clarify what is an Office Building.

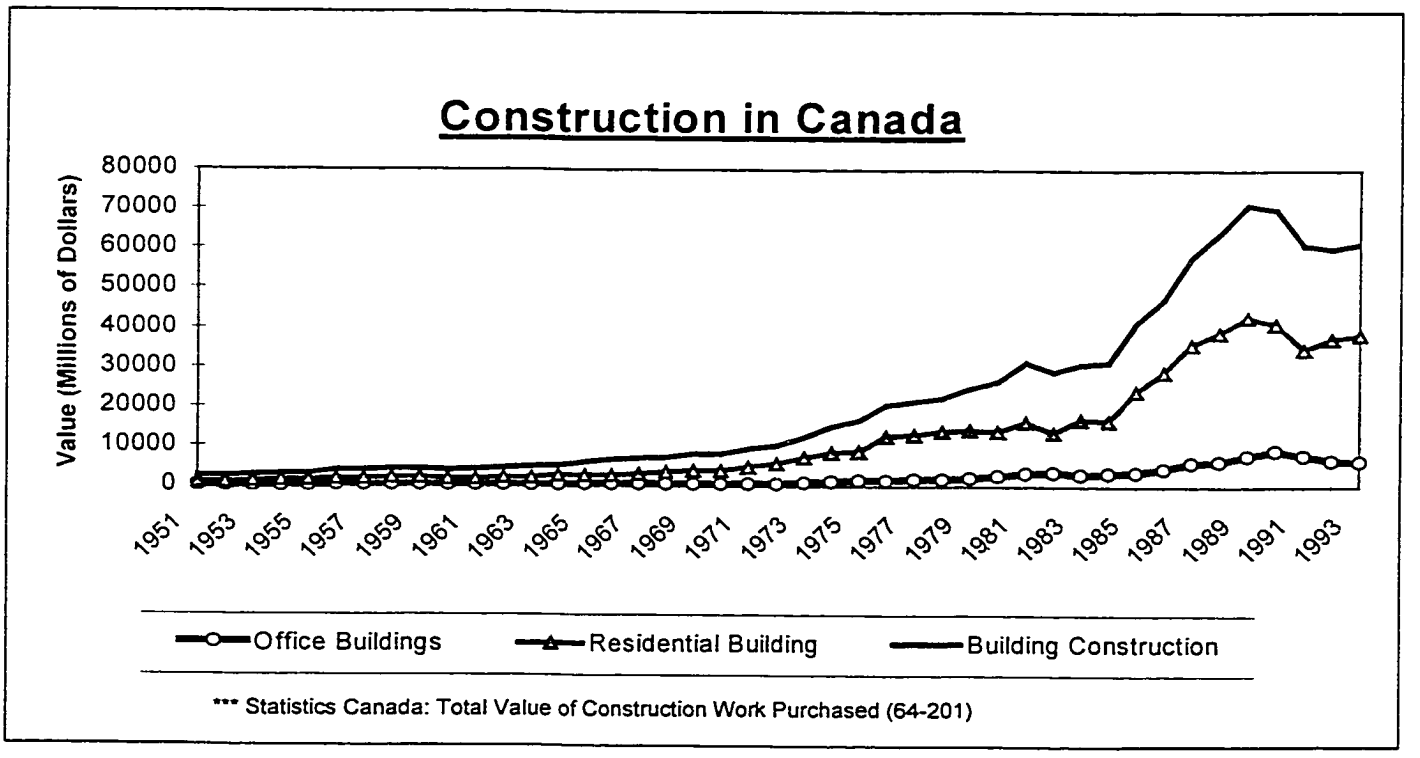


Figure 1 - 1 OB Construction in Canada

1-1-1Definition of Office Building (OB)

Construction Glossary [14] gives the following description. "Building designed for or used as the offices of professional, commercial, industrial, religious, institutional, public, or semipublic persons or organizations, provided no goods, wares, or merchandise are prepared or sold on the premises except that a portion of an office building may be occupied and used as a drug-store, barber shop, cosmetologist's shop, cigar stand, or news-stand, when such uses are located entirely within the building with no entrance from the street nor visible from any sidewalk and having no sign or display visible from the outside of the building indicating the existence of such use". This definition clearly describes the characteristics of an OB. The present research is based on this definition.

1-1-2 Office Building Development in Canada

"Why a study on office buildings"? "How does the office building industry perform in today's construction industry"? Statistics Canada has provided lots of useful data and drawn out the pictures to answer these questions.

As Statistics Canada reports, the construction industry is the largest single production activity of the Canadian economy. It involves all kinds of "build up", such as: residential house, commercial building, heavy industry, highway, utilities and other non-residential construction.

Units: (Millions of Dollars)	1989	1990	1991	1992	1993
Construction Work	100412	102367	94155	91861	94411
GDP	629253	645608	652864	664092	687527
% of GDP	15.9	15.8	14.4	13.8	10.9

*** Data source from Statistics Canada Construction in Canada 64-201 (89-93).
*** GDP - According to Catalogue 13-201 1994

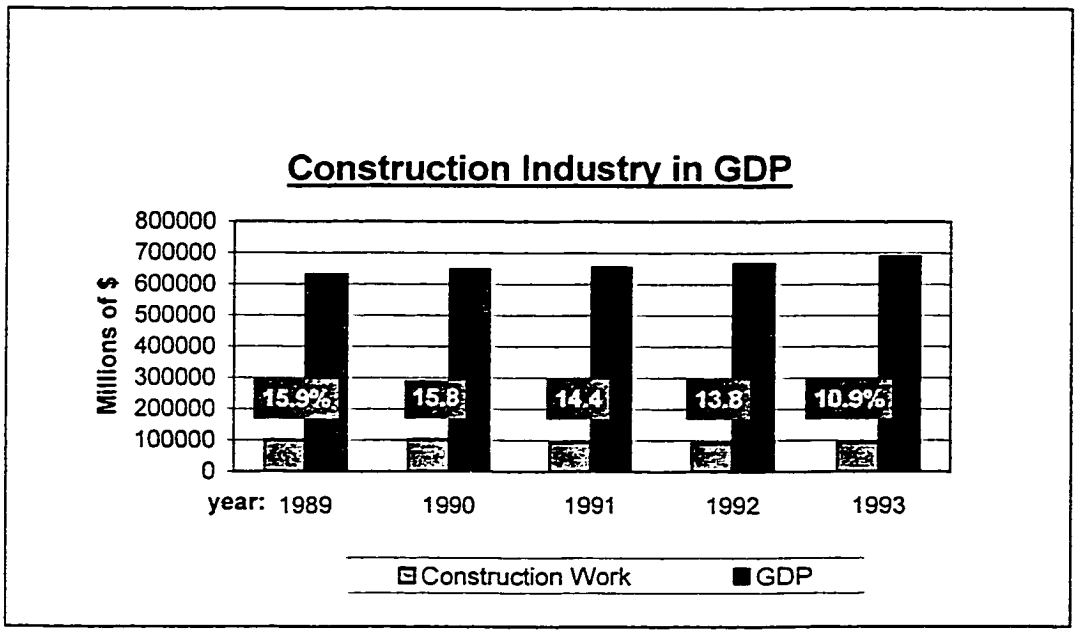


Figure 1 - 2 Construction Industry in GDP

Figure 1 - 2 illustrates an outline of Canadian construction work as a percentage of national Gross Domestic Product (GDP). It indicates that the construction industry plays an important role on the national economy scene.

OB has the largest single item expenditure in Commercial Building Construction. As Statistics Canada has reported, office building, (**OB**) ranks number one, consuming more than 40% of total capital expenditure in the Commercial Building market each year as shown in Table 1 - 1. Also, Statistics Canada reports, OB has the second largest expenditure item in overall Capital Expenditures of Total Building Construction subsequent to Residential Building Construction for overall single item comparison. It is noted that residential building construction leads the total building construction industry, which is the most important index to measure national economy.

Table 1 - 1 Office Building Capital Expenditure

Capital Expenditures in Commercial Buildings (1995)		
ITEMS	Total Expenditure	Units: Millions of $
Commercial Building Construction	**6,264.5**	
Service stations	367.3	
Automotive Dealerships	9.0	
Office Building	**2,507.4**	**40% of Commercial Building construction**
Hotels, Motels, Convention Centers	124.6	
Restaurant, Fast Food Outlines, Bar	211.6	
Shopping Centers, Malls, Stores	1,329.3	
Theatres, Performing art and Cultural Centers	303.6	
Indoor Recreational Buildings	1,024.5	
Outdoor Recreational Facilities	387.3	

*** Statistics Canada: Capital Expenditures by Type of Asset, 1995 (61-223)

*** For 1996, Office Building / Commercial Building Construction = 2764.1 / 6944.8 = 39.8%

1-1-3 Financial Assessment Systems

As assembling financial assessment techniques are shown in Figure 1 - 3 [3]. For the present research, combined LCCA with Sensitivity Analysis techniques are applied.

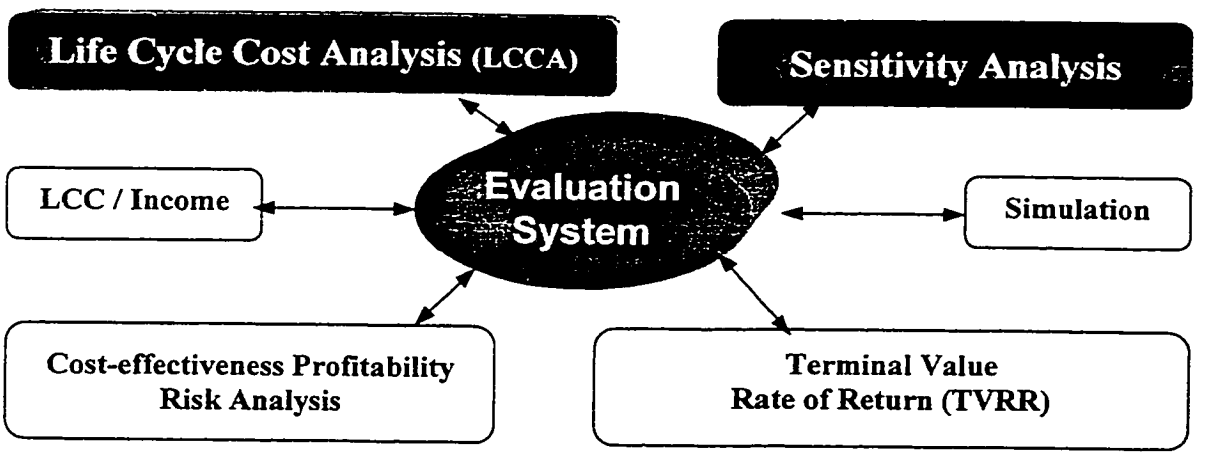


Figure 1 - 3 Assessment Techniques System Diagram

1-1-4 Definition of LCC

The *Building Contract Dictionary* [15] describes LCC as: A technique derived from the research of the Quantity Surveyor's Research and Development Committee and published by the Royal Institution of Chartered Surveyors in July 1983. It seeks to examine the total costs of a building throughout its useful life in order to evaluate and compare alternatives to achieve optimum long-term cost benefits.

1-1-5 Fundamental of LCC

LCC technique is a cost oriented method. It focuses on cost-effectiveness solutions and takes into account overall relevant costs in a specified time period. Net Present Value method is usually used to compare with alternatives or evaluate assets. Overall costs are here considered such as gathering capital, income, operating and maintenance cost, replacement costs, and salvage costs etc. Study of asset costs performance, which includes historical costs, current costs and forecasting future costs, is one of the typical features of LCC technique.

1-1-6 Remarkable Highlights of LCC

1. **Basic** *Life Cycle Costing* **Conception** - No longer the case, the lowest capital cost as an asset optimum selection criteria.
2. **LCC is cost-effectiveness or cost oriented technique** – Normally, LCC analysis for decision making is based on numerical results - the lowest overall cost in a period of time. No benefits, such as the factors of politics, safety, aesthetics, environment etc. are considered.
3. **Difference between Value Engineering (VE)** – VE, as an effective management tool, focuses on facility functions. VE is a function-oriented technique. LCC, as an efficient estimating tool, can be utilized in VE analysis.

4. **Difference between feasibility study** – LCC analysis is one part of feasibility analysis. LCC is included in feasibility analysis.
5. **Importance at cost control stages** – LCC technique is a cost-oriented approach that provides numerical solutions as its feature. It is an effective tool in the function of cost control. Figure 1 – 4 illustrates the decision-maker's level of influence on LCC. It shows that cost control with high influence at an early stage has more effectiveness than at a later.

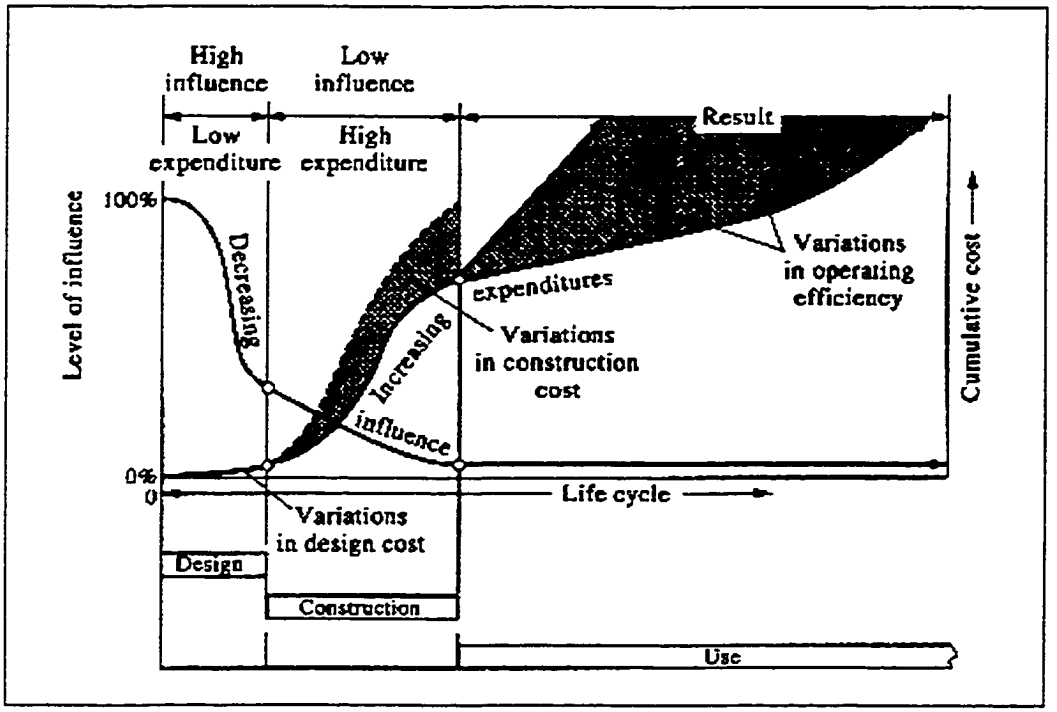


Figure 1 - 4 Importance at cost control Stages

(Dell'Isola, Alphonse J., 1981)

1-2 OBJECTIVES AND EMPHASES

Today, Life Cycle Costing technique, as a useful tool, is widely used in engineering, manufacturing and business. Its easy-processing, cost-effectiveness, and direct providing of numerical results, are features that can be used in functions of cost control, optimal alternatives selection, asset or products assessment, management system, preliminary design, investment and development decision-making, project feasibility studies, etc. In particular, LCC analysis plays an important part in the decision-making process. The major advantage of applying LCC technique is its feature of directly providing numerical results. In real estate practice, there is a great demand for providing quick and inexpensive measurement of evaluating office building market activities, such as investment, development, assessment and management.

In order to satisfy these requirements, the research "Life Cycle Costing for Office Buildings in Canada" has been carried out, and software **OFFICE_LCC98**, which assists the research, is designed for calculating the present value of an office building's economic performance.

1-2-1 What LCC for OB is about

What is the research of "Life Cycle Costing for Office Buildings in Canada"? It studies all relevant costs performance, which are associated with OB, in a specific time period. The aim of this research is to develop a decision-supporting system. Therefore, to clarify research objectives is a must.

1-2-2 Objectives of Research

The main objective of this research is to develop a life cycle costing analysis model for office buildings.

The sub-objectives are

- To make LCC technique available in office buildings (OB)
- To study OB all relevant cost performance
- To set up the frame of LCC analysis applied in building design stage
- To provide decision-making supporting material at early stage
- To combine LCC engineering technique with RE appraisal methods for evaluation
- To find the problems when carrying on LCC analysis in practice
- To build up replacement (maintenance) cost database
- To establish a systematic data treatment system

1-2-3 Emphasizes on Five Aspects

This study emphasizes four aspects:

1. **Investment** (Capitalization rate, Risk warning)
2. **Development** (Speculative office building, Economic rental rate)
3. **Assessment** (Property appraisal, Market value, Resale value)
4. **Management** (Budget planning, Costs control)
5. **Preliminary Design Stage** (Proposal selections, total cost)

1 - 3 PRINCIPLE AND SCOPE OF RESEARCH

The research presents comprehensive, systematic and consistent basis for LCC analysis of office buildings. The research studies all relevant costs associated with office building in appropriate time periods to measure economic performance. The general process of carrying out this research directly refers to **ASTM[1] E917** - "Standard Practice for Measuring Life Cycle Costs of Buildings and Building Systems".

[1] ASTM E917 standard can be found at TH 435 B846+ 1985

1-3-1 Basic Procedure (ASTM E917 - 83) of LCC Analysis

LCC study framework used for this practice:

1) Identify the objectives and constraints
2) Establish basic assumptions & determine the exact LCC procedure to be adopted
3) Compile the data
4) Discount all cash flows
5) Incorporate data into computational model, generate numerical & graphical results
6) Evaluate LCC results for uncertainty problems

1-3-2 Principle of Carrying Research

LCC analysis is a problem solving process. As guidance of the research, the problem solving process is listed as following:

1) Identifying problems – Objectives – finding problems
2) Understand problems – analysis of problems
3) Instruction for ways to solve problems
4) Selecting the best way to solve problems
5) Testing results
6) Improving results

1-3-3 Scope of Research

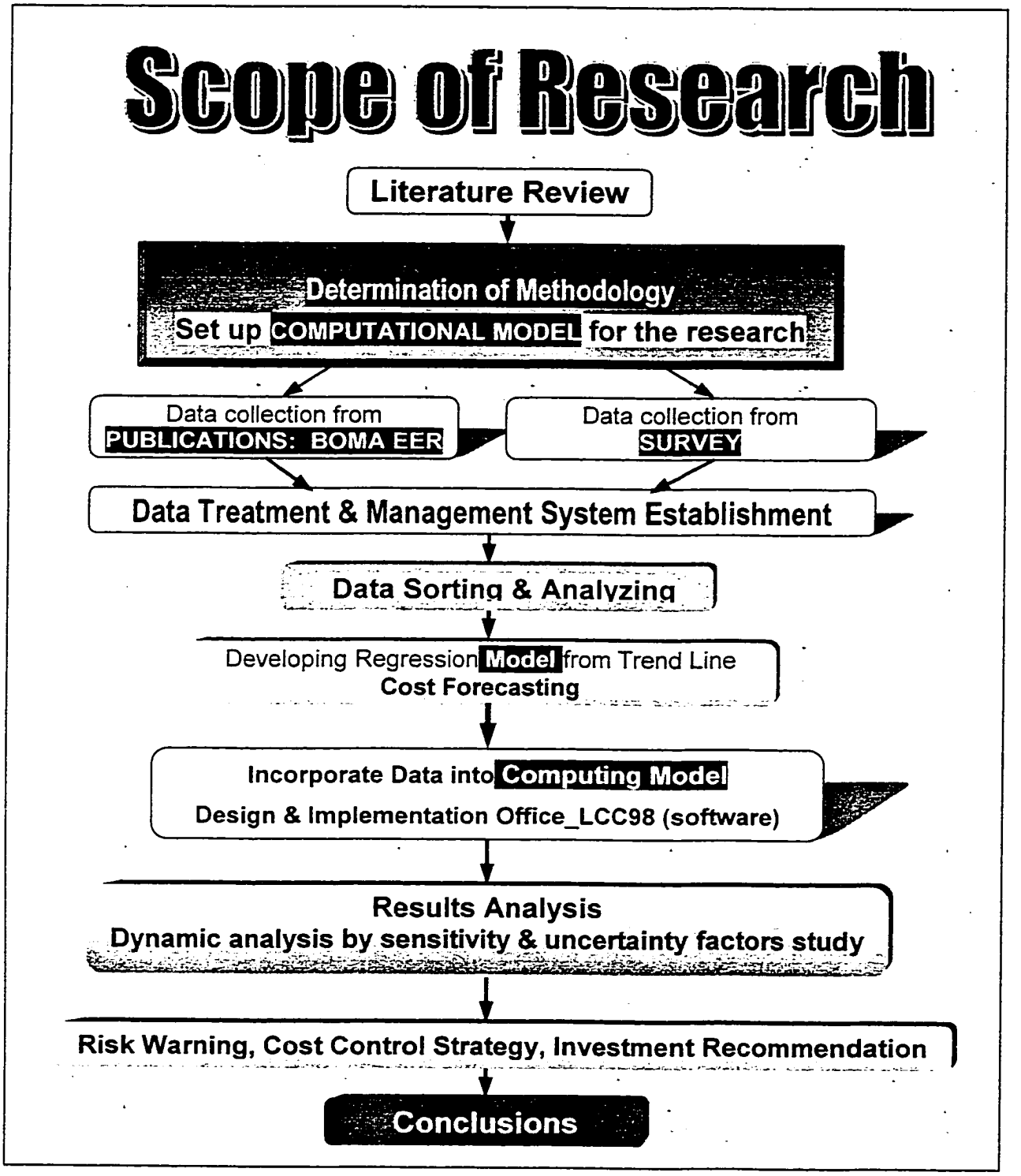


Figure 1 – 5 Research Scope

1 - 4 THESIS ORGANIZATION

The thesis is organized into an eight-chapter format along with four appendices.

Chapter Two, there are only a few complete studies on LCC applications for OB investment, development, assessment, and management. Few studies have been conducted building financial aspects for use with the LCC technique. Chapter Two will give a view of them. LCC application software, cash flow modeling, costs prediction methods, establishment of database and LCC technique development trends are also viewed in this chapter.

Chapter Three reviews property assessment methods in RE practice. Research methodology and LCC operating procedures are described. Some necessary knowledge, which is leading to establishing a computing model, is explained in this chapter as well.

Chapter Four introduces a data treatment system and database management system.

Chapter Five focuses on OFFICE_LCC98 computing model data treatment - data collecting, assembling, sorting, analyzing, data trend line regression formula, cost forecasting methods, etc.

Chapter Six covers the program - **OFFICE_LCC98** computing model design and software structure design process. A running case study is given at the end.

Chapter Seven discusses LCC analysis results, which is a necessary step for improvement of the LCC study. It includes uncertainty factors, risk warning, sensitivity study etc. LCC application in RE business, such as RE market analysis report, Capitalization rate, Speculative OB economic rental calculation examples.

Chapter Eight concludes with the work summary and contributions on the present study. Lastly, recommendations for extending the work are made.

Appendix 1: Sample of Data Treatment

Appendix 2: Sample of Running **OFFICE_LCC98**

Appendix 3: Canadian RE market Investigation and Analysis

Appendix 4: Knowledge Requisition

Chapter 2

Literature Review

Quebec City

To know others doing, always benefits your work

It is believed that taking advantage of previous work benefits current study. In the previous chapter, LCC definition and its features are briefly introduced. Today, the basic concept of LCC - "not just cheapest capital cost as adopted selection, but overall cost-effectiveness", is widely accepted and recognized, not only by the academic field, but also by engineering, industrial manufacturing and the commercial business field. For instance, a survey, investigating the use of LCC analysis in the United States, was conducted in the early part of 1995 for the largest municipalities. The survey indicated that about 40% of the municipalities have used LCC analysis and some of them had been using it for over 20 years (http://realdata-astc/). Most municipalities assessed their LCC analysis process as a successful or a somewhat successful operation. However, on the other side, 60% of municipalities have not used LCC analysis yet. This indicates that the acceptance of the LCC technique as part of the day to day routine still has a long way to go.

The LCC technique is still in its conceptual stage in the building industry, evident in the reaction when conducting questionnaires for the present research in remarks such as "You have studied on a big topic". It is true. To apply LCC technique in practice is not a "piece of cake". The following sections review previous works on seven selected topics that will better help in understanding the present work.

2-1 GUIDANCE AND STANDARDS

In the early 1980's, the American Society of Testing and Materials (**ASTM**) developed **ASTM E917**[1] - "Standard Practice for Measuring Life Cycle Costs of buildings and

[1] ASTM E917 standard can be found at TH 435 B846+ 1985

Building Systems". This standard is a comprehensive, systematic and consistent basis for applying LCC technique in buildings and building systems. The general methodology is to study all relevant costs associated with the building at an appropriate time period in order to measure economic performance. Similarly, in the UK and Australia, they use a different LCC measurement standard system, such as the "Draft Australian Standard on Life Cycle Costing". An LCC measurement standard for building and building systems in Canada has yet to be seen. The present research follows basic procedure of ASTM standards.

2-2 COSTS-ALLOCATION IN DIFFERENT TYPES OF BUILDINGS

In building LCC applications, the costs are generally divided into five cost categories, which are Capital, Income, Operating/Maintenance, Replacement and Salvage value. However, for different types of buildings, the cost components in each cost category are different and the ratio of each cost component in total life cycle expenses is also different. An early study was conducted by National Building Research Institute of South Africa (1985), wherein it was reported that Capital cost is only about 6-10% of Total life cycle cost for hospital buildings. The Operating costs exceed Capital cost within 2-3 years after construction completion. A detailed study indicated that personnel costs are the major portion of the Operating costs as shown in Figure 2 - 1 (Bull, John W, 1990).

Roger Flanagan in his book "Life Cycle Costing Theory and Practice" (1989) provided other LCC studies as shown in Figure 2 - 2 to Figure 2 - 4. The figures illustrate that having same cost components in each cost category, for different types of buildings such as in homes for the elderly, Primary schools, Secondary schools, etc, the ratio of cost-allocation is different from one to another. It implies that for the cost control emphasis, risk-warning point, uncertainty factors, annual expenses, etc are different. As a

conclusion, LCC professionals must develop a specified computing model to suit each type of building cost-allocation condition.

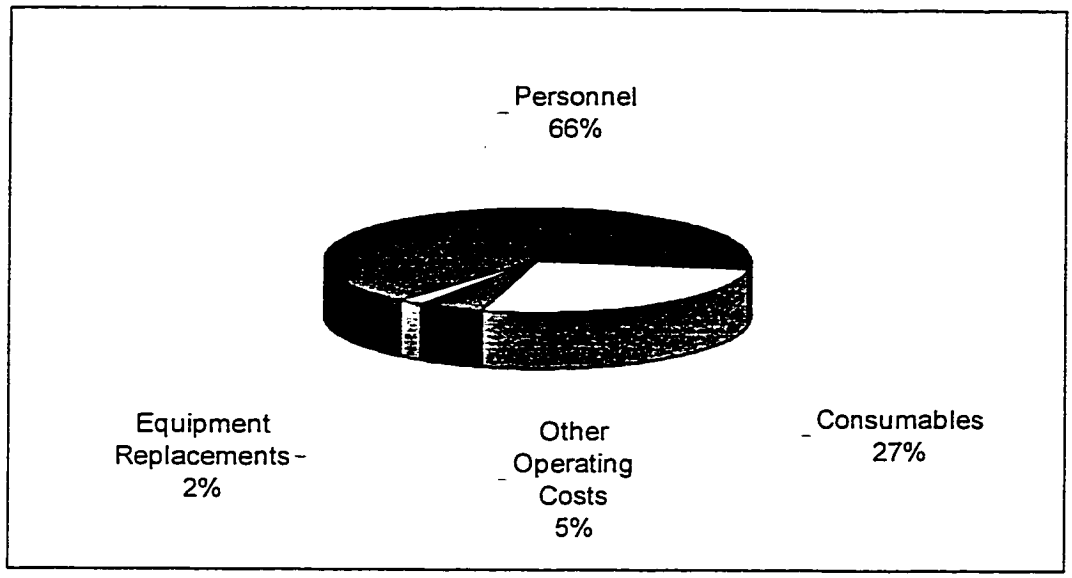


Figure 2 – 1 Percentage of Operating Cost Components in Hospital Buildings
*** (Bull, John W, 1990)

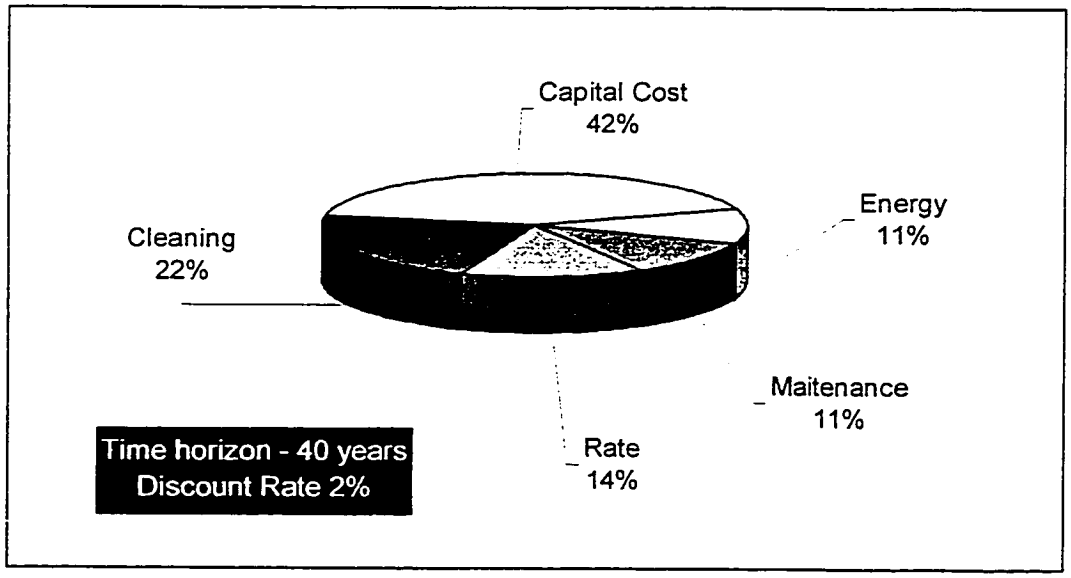


Figure 2 – 2 Elderly Persons' Home *** (Flanagon 1989)

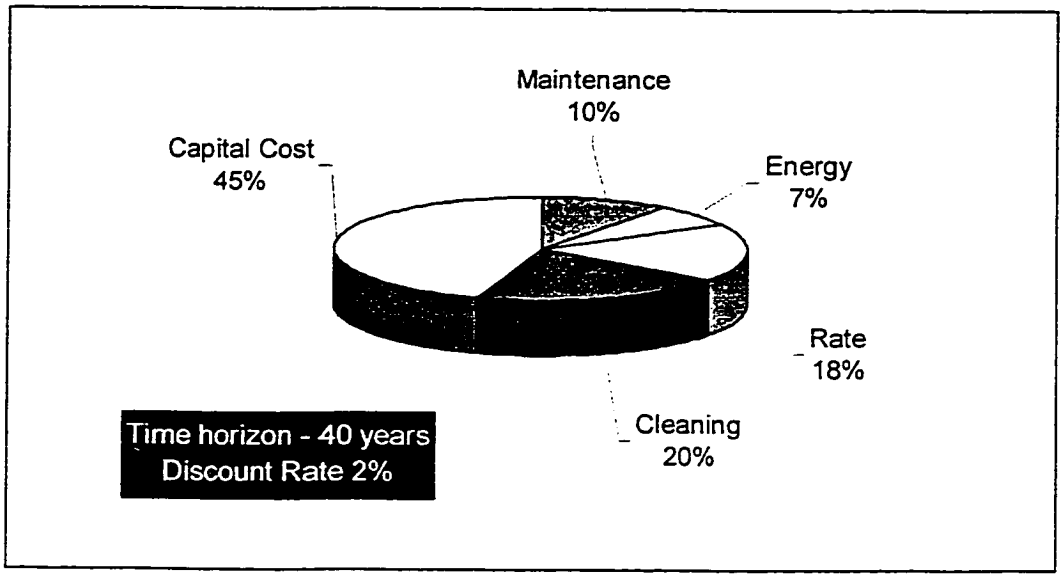


Figure 2 – 3 Primary School *** (Flanagon 1989)

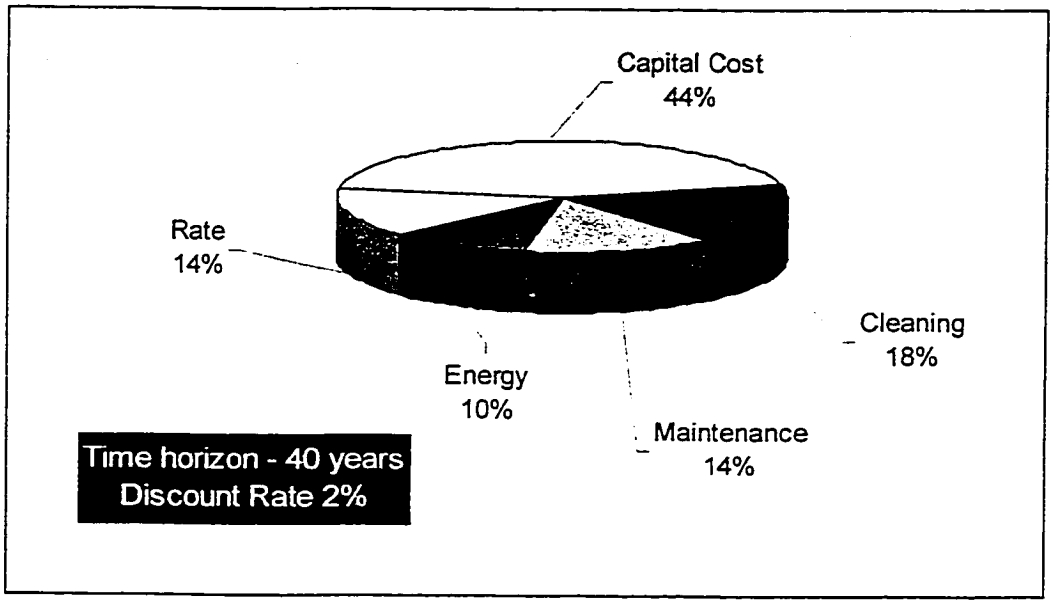


Figure 2 – 4 Secondary School *** (Flanagon 1989)

2-3 CASH FLOW MODEL & COST PREDICTION METHODS

Prediction of future cost is the most difficult and the most important part in LCC analysis. LCC analysis can be applied at any stages in a building' life period for specific purposes, such as investment, development, assessment and management. Therefore, in order to obtain reliable study results, a determination of cash flow for the LCC computing model is crucial. Gholam-All Arlani "Life-Cycle Cost and Risk Analysis" (1981) suggested using continuous compound modeling for revenue and expenses prediction in major building projects (Arlani, Gholam-All 1981). The feature of this method uses integrating formulae to account cost at interval time periods. The formula is complicated and theoretical, and difficult to apply in practice. Another work, A.C. Khanduri, C. Bédard and S. Alkass "Life Cycle Costing of Office Building at the Preliminary Design Stage" (1993) made a simplified cash flow model using a gradient series and an improved at computing model, which adopts a linear formula to predict future costs according to certain data analysis results. A new testing, which differs from the conventional way (statistics) for cost forecast, is introduced by He Zhi "Simulation Analysis in Project Life Cycle Cost" (1993). The research attempted to use simulation techniques to predict costs for a more reliable solution. The main feature of using simulation techniques is its combining of the impacts of many fluctuations at the same time. However, no one can be perfect. The results are all based on certain assumptions and constraints.

2-4 COSTS DATABASE

Data is the central of LCC study. All cash flows in the LCC computing model are built directly by carefully processed data. Therefore, valuable results of LCC analysis very much depend upon reliable data used. The establishment of a cost database is one of the most important parts in carrying out an LCC analysis process. Edgar Samuel Neely,

Jr and Robert Neathammer "Life-Cycle Maintenance Costs by Facility Use" (1991) introduced several databases for maintenance cost prediction, which were developed by the U.S. Army construction Engineering Research Laboratory, Champaign, Ill (1980). The data for these databases are collected from four similar medium-size cities and contain all facilities found in a typical city. These databases are adopted by American Society for Testing Materials (ASTM) and incorporated in their standards. However, these databases are limited by their regionality (United States or North American). For example, a research work for university buildings was carried out in Australia (1985), however, since historical data was not available, the data was obtained by "...estimates (that) were based on the joint experience of the writers and the University maintenance team" - F.J. Bromilow and M. R. Pawsey. For the U.S. Army construction Engineering Research Laboratory database, Dr. D.J.O Ferry & Roger Flanagan commented that "Huge volumes of detailed data were produced, based on what appear to be unrealistic assumptions. The approach was not user friendly and seemed unlikely to ever gain user acceptance" (Ferry, D, J & Roger Flanagan 1991).

Another referable database was made by Alphonse J. Dell'isola and Stephen J. Kirk in 1983. The data were collected from 24 different sources, which covered Structural, Architectural, Mechanical, Electrical, Equipment, Site work etc. cost elements for use by interested design professionals. As a consequence, LCC is not a one-time work. Data updating is always needed to modify current LCC management systems, and, as with any database, updating data is a big issue.

2-5 COMPUTER SOFTWARE FOR LCC STUDY

Although there is no comprehensive mathematical calculations involved in LCC analysis, many cost components make massive calculations in obtaining their future cost and

present values. For normal calculations, this work is tedious and complicated, and it is very easy to make mistakes. Some textbooks suggest using a uniform table assistant for LCC analysis. Today, computer technology is developing rapidly and is widely used in almost every corner of our society. An early computer program called Building Life-Cycle Cost was developed by the American Society for Testing Materials (ASTM) in the mid of 1980's. The BLCC was written in BASIC and works on a DOS operating system environment. The BLCC was consisted by five subprograms and a worksheet-generating program. The general methodology used in the BLCC program to compute life-cycle costs for buildings is based directly on ASTM E 917 - the Standard Practice for Measuring Life-Cycle Costs of Buildings and Building Systems. The BLCC uses the U.S. Army Construction Engineering Research Laboratory, Champaign, Ill, database as an LCC analysis source. The aim of BLCC is to attempt to provide a comprehensive, systematic, and consistent basis for computing life-cycle costs using Practice E 917. The problems with using BLCC are:

- It needs too much data input making it too complex and confusing for some users
- Users must be an LCC professional, well trained for using the BLCC program
- Consideration for taxes can be a problem in the program, because taxes are so variable, depending upon type, place, and/or time.

2-6 LCC TECHNIQUE DEVELOPMENT TREND

LCC technique is a typical engineering approach using an economic evaluation method. Engineering economic analysis is an economic analysis that deals with facilities planning, design, construction and operation. LCC analysis is a cost-centered engineering economic analysis with the objective to systematically determine the costs attributable to each of one or more alternative courses of action over a specified period of time.

Written records of LCC are somewhat obscure. The first government reference to LCC was published in 1933 by Comptroller General of the United States. LCC became more evident in the 1970's in developed countries, such as the U.K, United states, Australia, etc. From 1975 to 1989, utilizing a new technical fashion, LCC study developed rapidly and reached its peak. LCC applications were found everywhere, such as automobile, aircraft, computer software, manufacturing, business investment, telecommunication, medical products, construction industry, etc. Both the government and private sector responded with large financial support, and multi year efforts on developing a comprehensive research program. For instance, in the United States, people were seeking systematic measuring methods (ASTM E 917-89 & BLCC) and a national cost data bank (UCI & NUIFORMAT). Much research work was done during this period. However, after several years' practice, the benefits of using the LCC technique were not as great as people had expected. Frustration and failure made LCC practitioners search for other ways to utilize it. LCC practitioners have realized that the less uncertainty, the more reliable is LCC analysis. In another words, it is not a good idea for mega-projects (such as hospitals, universities, etc) to incorporate the LCC objective and to apply the LCC technique. Dr. D.J.O Ferry & Roger Flanagan in their "Life Cycle Costing – a Radical approach" (1991), recommended dividing the building lifetime for LCC analysis into eleven sections, as shown in Figure 2 - 5. In this way, the researcher can concentrate on one section, which has less uncertainty in the study. This reveals the significant change from the 1970's to the 1990's in LCC technique applications.

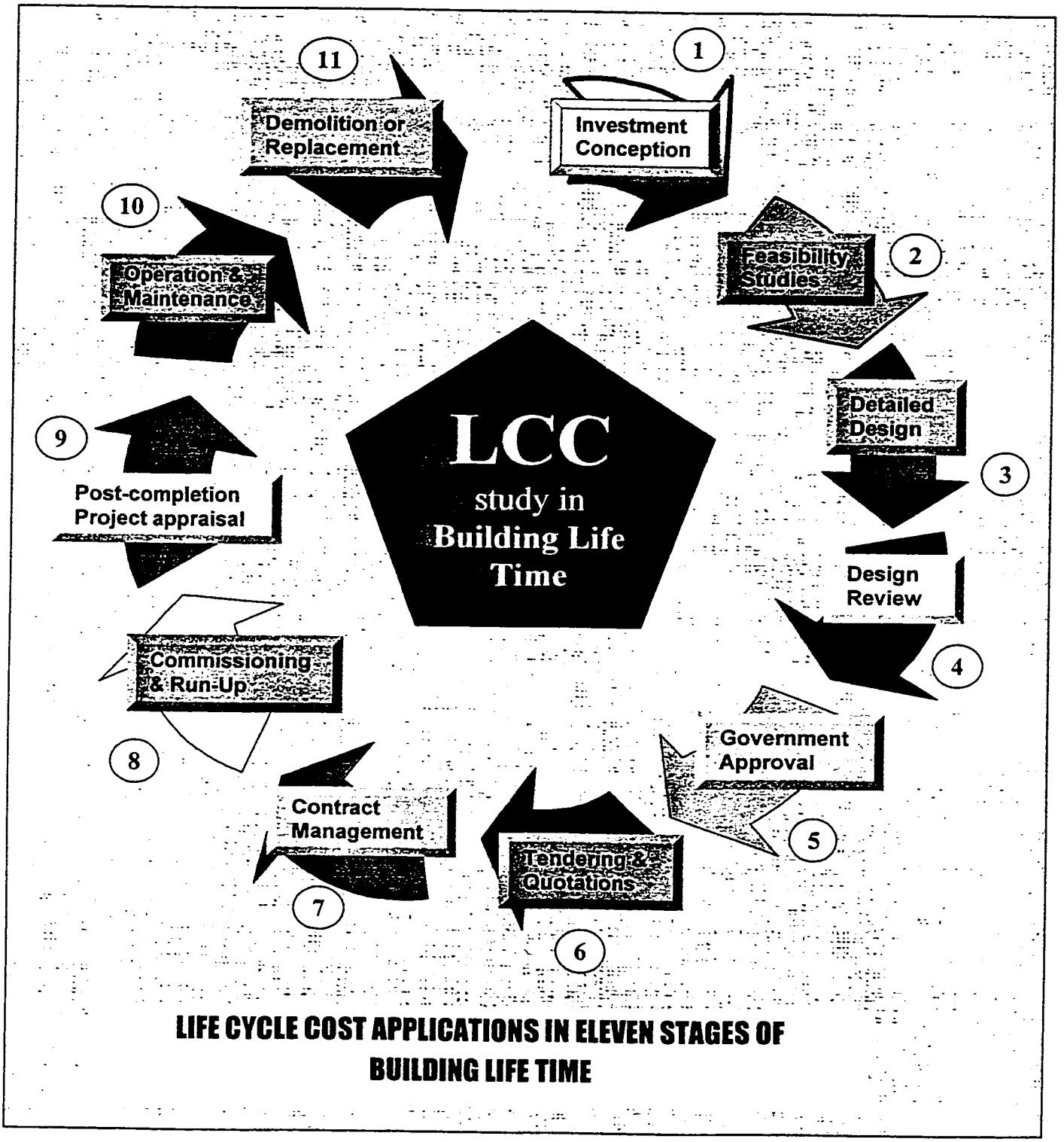


Figure 2 - 5 LCC Applications in Building Life Stages
Ferry, D, J & Roger Flanagan (1991)

This academic progress for LCC technique application has been widely accepted in practice today, and has been used in many places for different purposes.

Following are some considerations for LCC study categories.

1. **Facility Obsolescence**

   LCC is particularly useful for designers in assessing the life cycle consequence of alternatives being considered to minimize facility obsolescence.

2. **Environmental Sustainability**

   Ensuring environmental sustainability involves seeking materials and methods of construction that will not harm the environment.

3. **Operational staff Effectiveness**

   As introduced previously, operating and maintenance cost will excess capital cost in a very short period, as little as 2 – 3 years. LCC can be used to enhance work productivity.

4. **Total quality management**

   The use of LCC helps evaluate options for these problems, such as international competition, rising costs of Operating and Maintenance (O / M), overall business profitability.

5. **Value Engineering**

   Value engineering (VE) has been an effective management tool for seeking the best value for money in facilities design for over 30 years. LCC is a tool that can be a part of a VE process. It is used for total cost savings or evaluating various alternatives for the purpose of selecting the optimum solution. (Sievert, Richard W., Jr 1984)

Table 2 – 1 lists the recent trends and concerns, where the LCC technique can be utilized.

Table 2 – 1 Recent Trends and their Study Items

Recent LCC Application Trend					
LCC Study Items	Study Categories				
	Total Quality management	Facility Obsolescence	Environmental Sustainability	Operating Effectiveness	Value Engineering
Initial project cost					✖
Energy / fuel cost					✖
Maintenance & repair			✖		✖
Alternations & replacement		✖			✖
Administrative costs		✖	✖	✖	✖
Staffing cost	✖			✖	✖
Safety / security system	✖			✖	✖
RE taxes		✖			✖
Water / sewer costs			✖		✖
Fire insurance costs					✖
Flexible furniture system	✖		✖	✖	✖
Air / water quality		✖	✖		
Healthful environment		✖	✖		
Sustainable material			✖		
New business technology	✖	✖		✖	✖
Communication system	✖	✖		✖	✖
Automation equipment	✖	✖		✖	✖
Site environment			✖		
Occupant comfort / control	✖	✖	✖	✖	
Business profitability	✖	✖	✖	✖	✖
Bay size / floor height		✖		✖	✖

It should be mentioned that, especially in Canada, there is an on going LCC research project, which is conducted by The National Research Council's Institute for Research in Construction (IRC) and Public Works and Government Service Canada (PWGSC). The project is called "Building Envelope Life Cycle Asset Management (BELCAM)".

BELCAM is a three-year research project concentrating on service life and asset management issues dealing with low-slope and flat roofing systems. The BELCAM requires at least ten partners and a total of 2 million dollars to support this three-year research plan.

2-7 LCC STUDIES IN OFFICE BUILDINGS

While there have been many previous LCC applications in the building industry, very few efforts have been seen in developing an LCC analysis model for office buildings. Roger Flanagan provides a research result as shown in Figure 2 – 6, but has no further details.

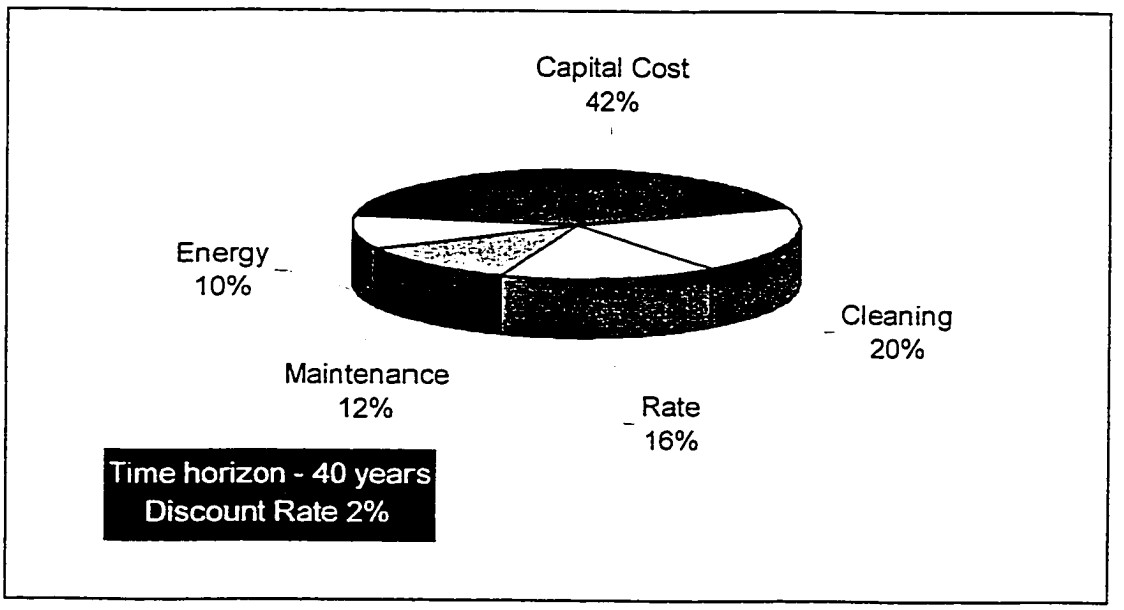


Figure 2 - 6 Office Building LCC Study (Flanagon 1989)

A most valuable reference work entitled "Assessing Office Building Life Cycle Costs at Preliminary Design Stage" was made by A.C. Khanduri, C. Bédard and S. Alkass in

1993. The work focuses on LCC application in the OB preliminary design stage. Although it is a small sized research with certain simplified assumptions and omissions. It is a good initiation into this research. The present research has maintained previous work ideas, and extended to new directions, i.e. office building investment, development, assessment, and management decision – making at the early stage.

Table 2 - 2 tabulates major modifications and differences between A.C. Khanduri's et al work and the present work. The following are some explanations.

1. **Cash flow model** – Previous work assumes that Income and Expenses escalates each year as a gradient series cash flow. In practice, it is difficult to prove. The present work uses one-time cash flow to calculate present value, avoiding this assumption. There are more details on cash flow models explained in Chapter Three.
2. **Cost forecasting equation** – the previous work states that "Income (category) is subjected to linear regression". But, actually, this assumption is based on a special report table (BOMA EER[2]) and in a special short period (1988 - 1992). The present work has studied BOMA EER since 1982 - 1998. It is notable that from 1991 - 1996, the Canadian office building industry experienced a big blow caused by the economic recession cycle. This subject will be discussed in later chapters.
3. **Data sources extension** – for previous work, the main LCC analysis data was only collected from Means Categories and BOMA EER. For the present work, data are collected from many publication sources and surveys, with some data having been done with local RE companies.

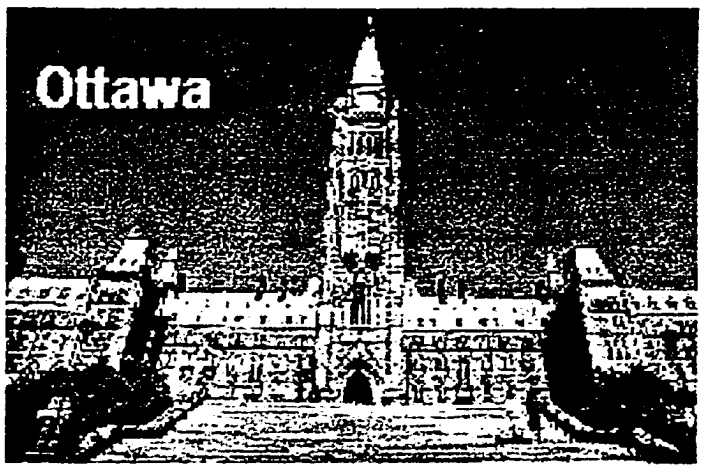
Table 2 - 2 Comparison of Previous Work and Present Research

Items	Previous Work	This Research
*** Cash flow model	Gradient series	One-time cash flow
*** Cash flow in computing model	Cash flow with linear relationship	According to regression formula
Total Net Present Value obtained	Use gradient formula	Cash flow back one by one
Model Design for:	Preliminary design	RE - Investment, Development Assessment, Management
Considering Construction Period	Yes	No
Data sources	Means, BOMA	Means, Construction Cost Manual, Statistics Canada, BOMA, PDA, JJ. Barnick, eSpace, Collier, Royal LaPage, OB Magazine,
Data Survey, Corporation	No	Yes
Database System	N/A	DBMS connected with Web
Software (LCC-O Vs Office_LCC98)	DOS	Windows 95/NT, Graphic
Studied Canadian Cities	Six	Eight
City correction factors for Operating, Maintenance & income	Use same table	Use different tables respectively
Retail Income adjusted factors	No	Yes
Ownership of building factors	No	Yes
Building location factors	No	Yes
Height factors	No	Yes
Age factors	No	Yes
Comprehensive adjusted factors	No	Yes

[2] Building Owner and Manager Association Experience Exchange Report (BOMA EER)

Chapter 3

Research Methodology



City of Ottawa

"METHODOLOGY"

"An organized, documented set of procedures and guidelines for one or more phases of the analysis or design. Many methodologies include a diagramming notation for documenting the results of the procedure; a step-by-step approach for carrying out the procedure; and an objective (ideally quantified) set of criteria for determining whether the results of the procedure are of acceptable quality". [http://www.dictionary.com]

"Time is money" is a common belief in our rapidly developing society. Short time decision-making could be extremely critical for a business' success. As Figure 1 - 4 illustrated in Chapter One, cost control at an early stage especially, has more influence than at later stages. In the RE field, to issue a reliable result in a short time becomes increasingly important in today's high competition environment.

3-1 RE ASSESSMENT METHODS OVERVIEW

Nowadays, people try to forecast the consequences of their decisions before they proceed, although they know there might be a large gap between forecasting and reality. They call this effort "better than nothing". However, if proper parameters are set and all the interested parties incorporate correct forecasting methods, then the generated results can be used for decision-supporting material. Reliable forecasting makes investors confidence higher, and might lead them to making a favorable decision. (Kirk, Stephen J., (1995)

3–1-1 Rule of Thumb in Practice

Rule of thumb methods are often used in RE practice for business decision-making. It may look unreliable, but it does work efficiently, and is widely used. They are utilized

because they are easy to process and get the required information quickly. The following provides three examples:

1. Professional investors or experienced property owners use this equation to calculate apartment building market value:

   Market Value = number of units × [each unit rental (gross) / per month] × 12 × 6

   (*** Mr. Daniel R. Boyer - assistant vice president of Marsh & McLennan Ltd.)

2. A professional real estate (**RE**) broker calculates required office space using the equation:

   OB floor area request = (Number of Employees × 220) + Extra requirements

   (*** http://www.e-space.com/index.cfm)

3. An architect or a financial RE accountant would tell his / her clients that "Running costs could be three times greater than Capital cost" [12], when they discuss financial planning for a building project proposal.

Certainly, the bases of rule of thumb methods come from experience. There is a lot of guesswork contained in it. It is not a logical, or rational knowledge, nor a scientific method. It does not deliver a rational assessment and precise calculations. The only advantage of rule of thumb is providing quick and approximate information for assisting in decision-making.

3–1-2 Professional Appraisal of Real Estate

Today, in real estate, buildings are becoming larger and more complex, and the economic environment in which they operate is becoming more uncertain. To invest in and develop a building could involve millions of dollars, hundreds of people, and years of time spent on it. In this case, use of experience is certainly not sufficient to form a right

decision. The determination of a decision must rely upon precise calculations, and a professional assessment.

Nature and Purpose of Appraisals

The process of evaluation of a property value is called property appraisement. Appraisal practice relies on an established body of knowledge and accepted technical approaches to estimate property value. (Appraisal Institute, 1992)

Function of Appraisement

- To estimate current equity or market value for purchase or sale
- To obtain financing
- To aid in investment and business decisions
- To confirm government values in tax and capital gains assessments
- To estimate value for expropriation compensation
- To serve as a basis for equitable settlements of estates and property in litigation
- To estimate value for insurance claims or coverage

Three Adopted Methods for Valuation

1) Direct Comparison Approach

The value estimate is based on the analysis of selling, listing or offering prices of comparable properties.

2) Cost Approach

Based on the depreciated cost of buildings and improvements plus the estimate of land value.

3) Income Approach

Based on the premise that value is equivalent to the worth of the income stream when a property is developed to its highest and best use. In Chapter Seven, two related case studies will be addressed and discussed.

Essentials of Professional Appraisal

Property appraisement is the art of solving an identified problem by finding and assembling facts analyzing the facts, and forming a conclusion. The appraiser will use any or all of the above approaches to ascertain value.

Professional appraisal requires selective research into appropriate market areas; assemblage of pertinent data; the application of appropriate analytical techniques; and the knowledge, experience, and professional judgment necessary to form conclusions.

Professional Appraisal Report

Normally, there are three major divisions included in RE professional reports:

Part One - Introduction

Title page, Letter of transmittal, Table of Contents, Summary of important conclusions

Part Two - Description, Analyses, and Conclusions

Identification of the property; Objective of the appraisal; Definition of value; Property rights appraised and data valuation applies; City; neighborhood, and location data; Zoning and Taxes; Site data; History; Description of improvements; Highest and best analysis; Land value; Cost approach; Market data approach; Income approach; Reconciliation of the value indications; Certification of value; Qualification of appraiser, etc

Part Three - The Addenda

Maps, plates, photographs, detailed statistical data, detailed property data, detailed market data, lease or lease summaries

In conclusion, professional appraisement with long history development is a comprehensive, systematic, and sophisticated estimating approach in the real estate field. It can provide precise calculations, professional analysis and judgment, detailed information and assist in the forming of reliable conclusions. (Appraisal Institute, 1992)

However, use of professional appraisement at investment early stage, has at least two drawbacks as listed below:

1) A long time for the processing and overly detailed information not necessarily required at the moment.
2) The professional fee charge can be very high

3–1–3 Aim of Present Research

Therefore, a compromise method between rule of thumb methods and professional assessment is definitely required to satisfy the wide demand for short cut evaluating in the RE business market.

Three basics should be considered in short cut method development, which can be used for property's investment, development, assessment and management decision-making at the early stage:

1. Reasonable accuracy
2. Quick and simple to process
3. Less expensive for obtaining the numerical results needed

Adopting a proper evaluating method is significant in ensuring a reliable result, and saving time and fees. The LCC technique, as a cost-effective tool, can be used with satisfaction of accuracy, saving of time, and requires a lower fee charge. Therefore, a decision-supporting system model must be established to accomplish this task. This is the major aim of this present work.

3-2 METHODOLOGY FOR PRESENT RESEARCH

Decision-makers need different information to make decisions at different building life time periods. The more complex the decision, the more accurate the information needed. The LCC technique can play an important role in the decision-making process.

LCC for OB is a cost-oriented estimating approach. It takes into consideration relevant building costs, such as capital, operations, maintenance, replacement and salvage value, etc,. Therefore, the LCC approach is an effective and sufficient tool for estimating a property value and managing its ongoing cost performance.

The present work developed an evaluating procedure for office buildings using a life cycle costing technique. The computing model of the research is designed to measure the present value of all relevant costs associated with office buildings.

The framework of research can be described as following eight major steps:

1) **Identification of objectives** - Constraints of the work
2) **Setting up assumptions** – yield with specified requests
3) **Identification of cost components** - Cost categories & Cost model
4) **Establishment of a computational model** - Cash flow model & NTPV method

5) **Development data treatment, DBMS system** – Data regression, forecasting
6) **Design of computing model & testing software** – Variables & impact factors
7) **Improvement of results** - Risks, uncertainties & sensitivity study
8) **Forming of conclusions and recommendations** - for next LCC study cycle

3-2-1 Objectives

The objectives have been introduced in Chapter One, section 1-2-2.

3-2-2 Assumptions

- Time of Cash Flow – cash flow arises at the end of the year in which they occur
- Discount rates and inflation rates do not change during the LCC study period
- Depreciation will not be considered in the computing model
- Construction period does not count in this model

3-2-3 Cost Categories and Cost Model

In office building LCC analysis, the costs (Income included) are usually divided into the following five categories as shown in Table 3 - 1.

According to cost categories, the cost model can be set up as cash flow matching with characteristics respectively. The Cost Model is shown in figure 3 – 1.

Cost Model:

❶ **Capital Costs** – also referred to as initial cost. They are considered as ONE TIME negative cash flow

❷ **Operating & Maintenance Costs** (O/M) – Running cost. They are considered as ANNUAL negative cash flow

❸ **Replacement cost** – They are ONE TIME periodical negative cash flow

❹ **Income** – They are considered as ANNUAL positive cash flow

❺ **Salvage Value** – Resale of a building is a ONE TIME positive cash flow and disposal of a building is a ONE TIME Negative cash flow

Table 3 – 1 Table of Cost Categories

Income & Expenses Items				
Capital Costs	O / M	Replacement	Income	Salvage
❶	❷	❸	❹	❺
Land Purchase	**Operating Cost**	**Periodic Replacement**	**Rental**	**Resale Value**
	Energy	Roof	**Retail**	
Acquisition Fee	Electricity	Exterior wall painting	**Parking**	**Scrap Value**
Commissioning	Gas	HVAC		
Professional Fee	Fuel-oil	Wages / supplies	**Others**	
Architect, Engineer	**Cleaning**			
Lawyer	**Security / Administration**			
	Wages / supplies			
Construction Cost	Legal Fees			
Site work	Office expenses			
Structural				
Electrical	**Leasing Expense**			
Mechanical	**Fixed Expense**			
	Real estate tax			
Promotion & Sales	Building insurance			
Funding Cost	**Maintenance Cost**			
	Elevator			
Management Cost	HVAC			
	Electrical			
	Structure			
	Plumbing			
	Fire Equipment			
	Wages / supplies			

3-2-4 Cash Flow and Computational Model

As previously stated, LCC for OB research is to study OB and all relevant costs performance in a specific period of time. To set up a computational model is to establish a mathematical expression (formula normally), which can reflect its physical condition.

For the OB LCC analysis, the basic components are costs. Cost categories and cost model have been designed and introduced in the last section. Cash flows are made up by relevant costs, which correspond to each cost model. Obviously, the positions of cash flow are determined by cost models in the LCC analysis time span as shown in Figure 3 – 1.

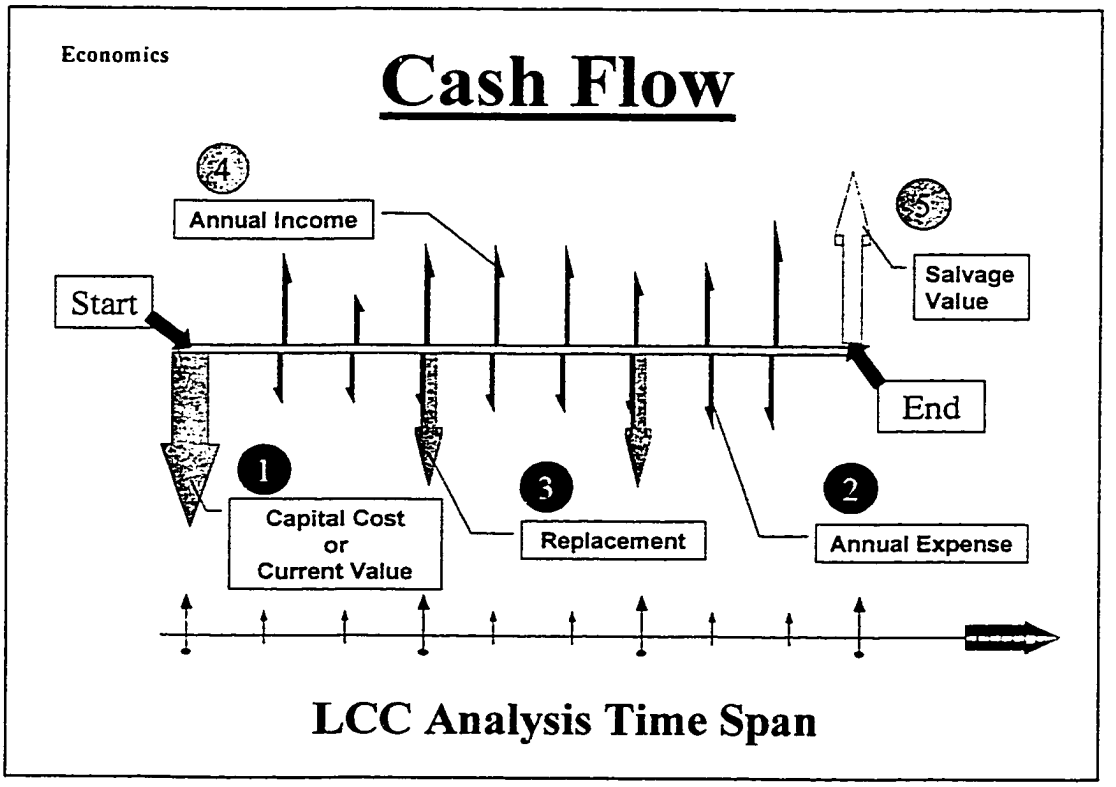


Figure 3 – 1 Cost Model & Cash Flow Demonstration

The LCC technique is a mathematical approach. Usually, it uses basic economic evaluation methods, such as Net Present Value (NPV), Annualized Equivalent Cost

(AEC), Annualized Equivalent Value (AEV), Discounted Benefit to Cost Ratio (BCR), Discounted Saving to Investment Ratio (SIR) etc. Any economic evaluation studies cash flow. The establishment of a computational model is based on the cash flows, which are shown in Figure 3 – 1. For the present research, the goal is to figure out total net present value (TNPV) and saving to investment ratio (SIR).

TNPV

Total net present value (TNPV) refers to the summing up of all relevant costs associated with OB investment by discounting future cash flows up to the starting point of the analysis period. This description can be expressed mathematically as follows:

TNPV = Σ { PV (**income**) + PV (**salvage**) - **Capital costs** - PV (**O/M**) - PV (**replacement**) }

Figure 3 – 2 provides a graphical explanation of principal TNPV - an economic evaluation method. The general formula of TNPV is shown in equation (E3 - 1):

$$TNPV = \sum_{t=0}^{t=n} \frac{(B_t - C_t)}{(1 + \frac{r}{100})^t} \qquad (E3-1)$$

Where: n = Time horizon in years - analysis period

B = Total monetary benefits in year t - income

C = Total monetary costs in year t - Capital, O/M, replacement

r = Real discount rate (more discussion in Chapter Six, E6 – 3)

SIR

The Saving to Investment Ratio (SIR) can be expressed in equation (E3 - 2):

$$S / I = \frac{\text{PV (income)} + \text{PV (salvage)}}{\text{Capital costs} + \text{PV (expenses)}} \qquad \text{(E3 – 2)}$$

Where: S = Saving value

I = Investment value

SIR is a convenient index to measure office building economical performance efficiency. When SIR value is greater than 1, in other word, TNPV is positive, this indicates that the project is worthwhile.

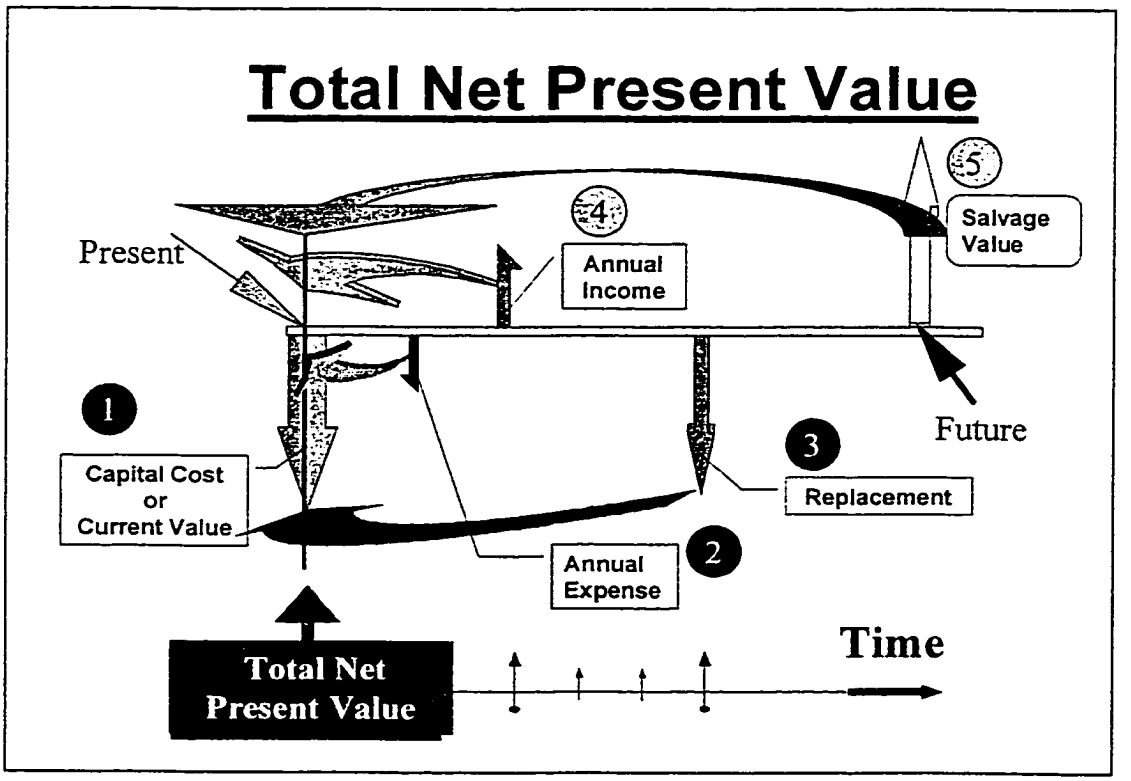
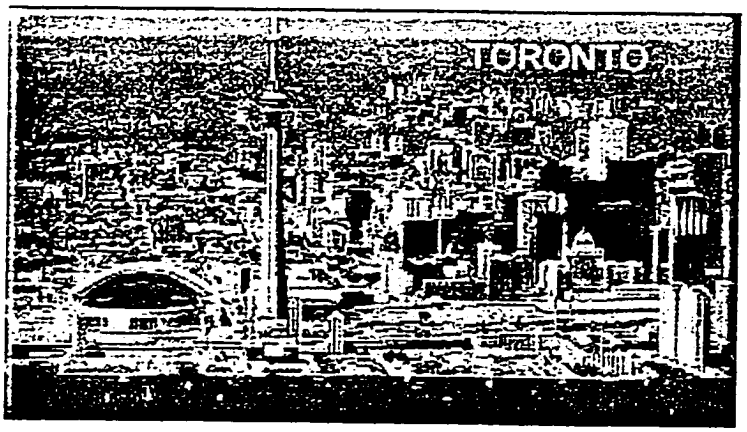


Figure 3 – 2 Total Net Present Value Demonstration

Chapter 4

Data Treatment System



City of Toronto

Data is the heart in LCC analysis

LCC analysis is a cost-oriented assessment approach. Studying cost performance and providing numerical results are its features. Data is synonymous with costs in the LCC computing process. For any LCC computing model, the incorporated data must reflect actual costs behavior in real conditions. In this case, only the results generated by a computing model are reliable. There is not any model or sophisticated method that can compensate inaccurate data and provide reliable results. Therefore, data treatment is the most important part in LCC analysis.

Data treatment is a comprehensive process. It is tedious work, and easy to make mistakes. The whole process of data treatment involves all kind of techniques, skills and experience, such as, common science, mathematics, statistics, logic, professional adjustment, etc. Generally, data treatment process for LCC analysis should contain the following works:

1. Defining data components
2. Searching data sources
3. Selecting database
4. Collecting, sorting, analyzing data
5. Data regression and forecasting
6. Setting up own database

4 – 1 DATA TREATMENT SYSTEM FOR PRESENT RESEARCH

As stated previously, this research studies OB costs performance in a specific time period. Reliable LCC results are much dependent on incorporated data entry into the LCC computing model. In order to incorporate meaningful and accurate data into the

LCC computing model, a data treatment system must be developed. A data treatment system will accomplish the following goals:

1. Determining costs future value based on historical and current data collecting, sorting, and analyzing with LCC specialist's final adjustment
2. Finding costs impact factors, which will significantly impact cost future value
3. Building costs database management system (DBMS)

It is noticed that the third goal is an additional work. Database management system (DBMS) is an advanced technique to modify data for current analysis and arrange for continuing work at the next cycle of the LCC study.

The data treatment system is a data processing procedure. In order to establish a data treatment system, a systematic procedure is needed, and necessitates the following:

1. Defining data components
2. Searching and use of data sources
3. Data management process:
   - Selecting, collecting, sorting and analyzing
   - Professional adjustment for obtained data - Market analysis
   - Data regression and forecasting
4. Establishment of database management system (DBMS)

4 - 2 DEFINING DATA (COST) COMPONENTS

Cost Categories and Cost Model have been introduced in Chapter Three. Based on this knowledge, a computerized LCC analysis model - ***OFFICE_LCC98 computing model***, is developed.

The cost components in each cost category, which are considered in the OFFICE_LCC98 computing model, are listed in Table 4 - 1. It should be noted that for the developing a quick and inexpensive property-estimating model, the OFFICE_LCC98 computing model omits some less important costs.

The data treatment work for the OFFICE_LCC98 computing model is divided into two parts:

1. Independent variables - the cost components considered in the LCC computing model
2. Coefficient of variables - Which are the costs variable adjustment coefficient

Table 4 – 1 Cost Components Considered in Office_LCC98 Computing Model

Capital Cost	TOEFL	Replacement	Total Income	Salvage
❶	❷	❸	❹	❺
Land	Clean	By user	Rental	By user
Construction	Repair		Retail	
Professional Fee	Utilities		Others	
	R.G.S.			
	Administration			
	Fixed Cost			
	Leasing			

4 - 3 SEARCHING AND USE OF DATA SOURCES

Searching for data, one should be aware of two things:

1. Data is changing frequently through time and place by market demands
2. Data is secret, never likely to have been disclosed

Data acquisition is the most difficult and time-consuming phase in the model development. Data in the RE field are not just numbers; they reflect market trends. In this competitive society, data self contains sort of money value. For this research, the data is obtained from different data sources as described below:

1. Published Literatures
2. Internet Web sites
3. Survey through questionnaires by e-mail, telephone, mail, etc.
4. Library loan, University database network
5. Directly visiting RE professionals, architects, engineers, accountants, etc.

The following provides some data sources for different cost components, which are shown in Table 4 – 1. Some examples are also given to explain the usage of data sources.

Land Cost

Land cost can be obtained from the local government agency, RE information companies, land development companies, appraisal firms, local RE companies or via Internet, such as:

City Edmonton land sale: http://www.cban.com/city_lands/forsale.html

ESpace conne/tion: http://www.espace.ca/

CB Commercial: http://www.wgbehr.com/

Pichnet: http://www.pikenet.com/

Construction Cost

Construction cost can be found from many published sources. They are *Building Construction Cost Data*, published by Robert Snow Means Company, Inc. *the Dodge Manual for Building Construction Pricing and Scheduling*, a yearly publication of the McGraw-Hill Information Systems Company, and *Building Cost File* published yearly by Van Nostrand Reinhold Co. The RS Means Company also has an early-stage systems pricing book, *Building Systems Cost Guide* and *Assemblies Cost Data* which are a very useful guide for making early design decisions and pricing the results. For the present research, Means **Assemblies Cost Data** is the main adopted reference.

Before introducing Means data, there are two things that should be kept in mind:

1. The cost in tables and usage of Indexes for Canada conditions are all calculated using Canadian prices. Therefore, the Canadian indexes can be used to convert U.S. National Averages to local costs in Canadian dollars.
2. The following impacting factors are not included in tabulated cost content:

- Managerial efficiency
- Competitive conditions
- Automation
- Restrictive union practices
- An owner's unique requirements
- Politics
- Weather
- Regional variations

RS Means Company, Inc. has been actively engaged in construction cost publishing and consulting throughout North America since 1942. Means Assemblies provides accurate and up-to-date construction cost information that helps owners, developers, architects, engineers, contractors and facility managers to carefully and precisely project and control the cost of both new building construction and renovation projects.

Means introduces new construction methods and materials by analyzing all factors of the industry. Data is collected and organized into a format that is instantly accessible. The data is useful for all phases of construction cost determination, from the preliminary budget to the detailed unit price estimate. Means divides the entire building construction process into twelve systems divisions and contained costs for fifty-nine different types of buildings. The twelve construction system divisions are described as below:

1. Foundation
2. Substructures
3. Superstructures
4. Exterior closure
5. Roofing
6. Interior construction
7. Conveying system
8. Mechanical
9. Electrical
10. General conditions & Profit
11. Special construction
12. Site work

The following tables and Indexes, which are taken from Means Assemblies Cost Data, are usefully adopted in this research.

Construction Time Requirements

Type of Building	*Construction Time*	*Project Value*	*Construction Time*
Commercial Building	15 Months	Up to $3,800,000	15 Months

*** Means

The above table gives average construction time in months for commercial building projects. The right side of the table is the construction time in months for different size projects. Design time runs 25% to 40% of construction time.

Square Foot Project Size Modifier

One factor that affects the S.F cost of a particular building is size. In general, for buildings built to the same specifications in the same locality, the larger building will have the lower S.F cost. The Area Conversion Scale shown adjusts cost for the particular project.

Example 1: Determine the cost per S.F for a 100,000 S.F mid-rise office building

$$\frac{\text{Proposed building area} = 100{,}000 \text{ S.F.}}{\text{Typical size from below} = 52{,}000 \text{ S.F.}} = 1.923$$

Enter Area Conversion scale at 1.923, intersect curve, read horizontally the appropriate cost multiplier of .94 (see Means Assemblies Cost Data p564). Size adjusted cost becomes 0.94 x $73.3 = $ 68.9 / S.F. based on national average costs.

1998 Means Construction Cost Square Foot Base Size $ / (S.F.)

Building Type	Median Cost Per S.F.	Typical Size Gross S.F.
Office, Low Rise	69.85	8,600
Office, Mid Rise	73.30	52,000
Office, High Rise	93.80	260,000

The median figures should present a fairly accurate estimate, when multiplied by the total city construction cost index figures and then multiplied by the project size modifier above. This fairly accurate base figure would then have to be adjusted in view of the estimator's experience, local economic conditions, code requirements, and the owner's particular requirements.

Architectural Fees Table

Table 4 – 2 Professional Fee Charge in Percentage (*** Means)

	Total Project Size in Thousands of Dollars						
Total Constr. Cost	100	250	500	1,000	5,000	10,000	50,000
Building Type: OB	11.7%	10.8	8.5	7.3	6.4	6.0	5.6%

Table 4 - 2 shows typical percentage fees by project size, for a professional architectural service. Fees may vary from those listed depending upon degree of difficulty and prevailing economic conditions in any particular area. Architectural fees tabulated above include Engineering Fees. Additionally, various portions of the same project requiring different rates should be adjusted proportionately. For alterations, add 50% to the fee for the first $500,000 of project cost, and 25% to the fee for project cost over $500,000.

City Cost Indexes

Means Assemblies Cost Data provides city cost indexes that are extremely useful tools for comparing cost city to city and region to region. Index figures for both material and installation are based on the 30 major cities' average (North American Cities) of 100 and represent the cost relationship as of July 1, of each year.

Example 1:

To calculate Montreal adjusted construction cost = (Total weighted average index 1-12) / 100 × (total cost) = 1.026 × $1,221,300 = $1253053.8

Example 2:

Known construction cost in Montreal is 1253053.8. For cost in Vancouver:

Vancouver construction cost = known construction cost × (unknown city Index) / (known city index) = 1253053.8 × (1.093/1.026) = $1334880.9

City Cost Index or Weighted Average

City Cost Index (CCI Index) is used to calculate another city's construction cost when using known information from another city.

Table 4 – 3 City Cost Index (*** Means)

Location Factors							
Vancouver	Alberta	Edmonton	Winnipeg	Toronto	Ottawa	Montreal	Quebec
109.3	99.1	99.0	99.6	112.6	109.8	102.6	103.1

History Cost Indexes

Means Assemblies Cost Data also provides a method to find the current cost from a project built previously in either the same city or a different city. The following formula is used:

Present Cost (city X) = [Present Index (city X) / Former Index (city Y)] × Former Cost (city Y)

History Cost Index Jan. 1, 1993 = 100					
Year	Estimated	Actual	Year	Estimated	Actual
1998	114.4		1991	114.4	96.8
1997		112.8	1990		94.3
1996		110.2	1989		92.1
1995		107.6	1988		89.9
1994		104.4	1987		87.7
1993		101.7	1986		84.2
1992		99.4	1985		82.6

Example 3:

Find the construction cost of a building to be built in Montreal as of January 1, 1998 when the identical building cost $800,000 in Ottawa on July 1, 1994.

Montreal construction cost (Jan. 1, 1998) =

$$\frac{\text{Estimated index} \times \text{Montreal}}{\text{Actual index} \times \text{Ottawa}} \times \cos t = \frac{114.4 \times 102.6}{104.4 \times 109.8} \times \$\,800{,}000 = \$\,819{,}144.52$$

Where 102.6 is the Montreal City Cost Index, and 109.8 is for Ottawa

Total Income and Operating & Maintenance (O /M) Cost

In OB LCC analysis, income and expenses information is more difficult to obtain and confirm than construction costs. It is not only that these data fluctuate with time and place, but also, most often, it is a business confidence that is not likely to tell. As a well-known publication for OB income and expenses information, the BOMA EER has been used for this research.

BOMA EER

BOMA refers to *Building Owners and Managers Association.* BOMA International is a company that began in 1902 in Chicago, Illinois. It is an organization for Commercial Real Estate specializing in office buildings.

The *BOMA Experience Exchange Report* (EER) provides published easy-to-read tables of operating income and expense data for office buildings throughout the United States and Canada. It features information from 130 cities making it the benchmark of the

industry. EER is an annual report that presents both private and government formats data. The data is based on a voluntary survey of over 4,000 office building owners and managers whose buildings represent more than 770 million square feet of office space. The National Cross-Tabulations grouping provides analyses based on building location, age, size, height, and occupancy characteristics.

BOMA EER is comprehensive and systemized, with a long history database. Its statistical tables, in which there are over 50 items, provide integrated office building cost information. Table 4 – 4 illustrates the detailed cost items in BOMA EER. In Table 4 - 4, TOEFL refers to Total Operating Expenses plus Fixed Value plus Leasing Costs. It is notable that, for corresponding BOMA EER data format, the following contexts use "TOEFL expenses" instead of "Operating and Maintenance (0 / M) Cost".

Table 4 – 4 BOMA EER Costs Details ($ / Sq. Ft.)

Total Income	
1	Office Rentable
2	Retail
3	Others (Net Parking Income, Services, Miscellaneous)

TOEFL						
①	②	③	④	⑤	⑥	⑦
Clean	**Repair/Maint.**	**Utilities**	**RDS/GDS/SEC**	**ADMIN.**	**FIXED Exp.**	**Leasing Exp.**
Payroll	Payroll	Electrical	RDS/GND Payroll	Payroll	RE Taxes	Advertisement/ Promotion
Contract	Elevator	Gas	Contract	Management Fee	Building Insurance	Commission
Supply/ Material	HVAC	Fuel Oil	Security Payroll	Professional Fee	Property Tax	Professional Fee
Trash remove	Electrical	Purchase Steam	Contract	General Office Fee	Other Tax	Tenant Alternative
	Structure/ Roof	Purchase Charged Water	Other	Administration Expense		Buy - OUTS
	Plumbing	Coal				Other Leasing
	Fire/Life Safety	Water/ Sewer				
	Other Maintenance					

Highlights of Using BOMA EER

BOMA EER data tables contain information about a building's yearly operating cost and rental income as well as data on the building's use and operating characteristics, which are compiled from building owners and managers surveys. Therefore, the following listed conditions should be considered when using EER:

- A good rule of thumb for obtaining more reliable information is to use tables of at least 25 buildings; if the number is much less than 25, use the data cautiously. Generally, the greater number of buildings reported, the more reliable the results generated.
- 60% - 80% buildings reported Leasing Cost
- Over 95% buildings reported the following six types of cost: Cleaning, Repairing, Utilities, R.G.S Administrative, and Fixed Expenses.
- More than 50% of buildings reported Retail Area Income
- Approximately 46% of the surveys' respondent buildings are Class A properties, 49% are Class B and 5% Class C (**OB classification** refers to Appendix 4, AP4-5)
- In BOMA EER, each statistic, whether an individual category or a category "total", can be considered meaningful in its own right and representative of the widest data available
- When estimating income and expenses for cities not available in the EER, the Consumer Price Index (CPI) method can be used for converting data from a neighboring city's data in EER.

  Target City $ / SF = (Target City CPI / Source City CPI) x Source City's $ / SF

  Where Target City CPI and Source City CPI can be found from Statistics Canada reports as shown in Table 4 – 5.

Table 4 – 5 Cities Consumer Price Index

Cities	1993	1994	1995	1996	1997
Vancouver	103.6	105.7	108.4	109.2	109.8
Calgary	101.3	102.8	105.1	107.4	109.7
Edmonton	100.8	102.4	104.5	106.8	108.7
Winnipeg	102.7	104.1	107.0	109.2	111.5
Toronto	101.6	101.7	104.2	106.0	107.9
Ottawa	102.2	102.8	105.7	107.3	109.2
Montreal	101.4	99.9	101.7	103.4	104.8
Quebec City	101.3	100.4	102.6	104.3	105.7

* Data source from Statistics Canada

Local RE Companies Market Report

It should be pointed out that although BOMA EER is a widely statistical and systemized database, BOMA data is limited by its less original data source report. In this case, local RE companies have an advantage by having more original data and reports of the market trends more frequently. For individual office building LCC study, besides BOMA data, Income and expense costs should also be obtained from local RE companies' reports for more reliable and updated cost information.

Location is one of the three most important impact factors for RE investment. (Location, Property Condition and Market Trend) Therefore, local RE companies market reports can provide more specific and direct cost information. For local RE data sources can be obtained from following Web addresses.

Montreal, Quebec City

In Appendix 3, Table AP3 - 1 and Table AP3 - 2 illustrate the Montreal downtown commercial central core income and expenses information from *Desjarlais Prévost & Associates Inc.* (DPA).

Desjarlais Prévost & Associates Inc. is primarily a firm of appraisers specializing in office buildings and shopping centers situated in the Province of Québec, Canada. Communiqués are published four times a year and deal with the Montréal and Québec City office markets. DPA Web address is: http://www.desjarlais-prevost.com

Nation wide

Collier International: http://www.colliers.com/colliers/wmc.nsf/publish/HomePage

JJ Barnike Oncor International: http://www.jjb.com/index.html

Avison Young: http://www.avisonyoung.com/index.html

Royal LePage Commercial Inc: http://www.royallepage.com/

BC Commercial: http://www.wgbehr.com/

Local Market Information Companies

Paul F. Smith Realty Ltd: http://www.smithrealty.on.ca/~pfsmith for Great Toronto Area

Ottawa Carlton E.D.C: http://www.ottawaregion.com/business/realestate/office.htm

For more local RE information, it can be found from http://alcor.concordia.ca/~kzhang, where assembled the most Canadian published RE Website.

Replacement Costs

Replacement costs, which usually involve such items as the cost of changing the roof, HVAC system, external wall, etc, are difficult to obtain, although some information can be found from Means and BOMA EER. As introduced in Chapter Two, the National Research Counsel is preparing to establish a cost control system on roofing and maintenance. For OFFICE_LCC98 software (introduced in Chapter 6), the value of replacement cost can be inputted by an LCC practitioner with professional experience.

Salvage Value

Salvage value can be positive as it has a residual economic value or negative if demolition is required. For OFFICE_LCC98 software, Salvage Value will be inputted by an LCC practitioner with professional experience. More discussion on resale value will be addressed in Chapter Seven.

4 - 4 DATA MANAGEMENT

Data collecting and sorting is tedious work and it can be easy to make mistakes. Original data is a base to set up LCC computing formula variables and their coefficients. No model or sophisticated method can compensate for an inaccurate database. Therefore, data management must be systemized to ensure the quality of data treatment work.

Data Assembling and Sorting

Data collection and sorting is not just simply gathering data from data sources. It is also a designing process. There are hundreds of pages of data in BOMA EERs. It is very important to be clear as to what is useful data, and how to apply it effectively. In Appendix 1, Table AP1 - 5 shows a sample of an original data collection format from

BOMA EER. According to cost value, Table AP1 - 5 data can build correction factors between Cities, Private and Government sectors, and Downtown and Suburban.

The principle goal of data assembling and sorting is to gather all useful data, making them meaningful, and formatting them into a logical order. The aim of this process is to prepare all information for the next step - data analyzing. A sample of completed BOMA EER data collecting and sorting format is addressed in Appendix 1 – "Data Collection - 1993 BOMA EER".

Analyzing

The purpose of data analysis is to eliminate "misleading" data and add meaningful subjective data, from other data sources or an LCC's professional experience. Data analyzing is a comprehensive process. It can involve all kinds of techniques, skills and experience, such as common science, mathematics, statistics, and logical knowledge. Data analysis is the process of ensuring that data is useful and meaningful for incorporation into the computing model. Because data are collected from different sources, there is always a potential for misleading or confusing results. (A sample of misleading data can be found in Table 5 - 2, red cycle area) To omit meaningless data and eliminate data with "odd" characters, a market analysis is necessary. Market analysis considers all aspects of the environment, which makes it important for an LCC study, and can assist LCC practitioners to make correct decisions.

Market investigation and Analysis

The general opinion is that the LCC technique features collecting, sorting, and analyzing of historical and current data, in order to forecast future costs.

In Chapter Six, the development of OFFICE_LCC98 computing model will be introduced. In the computing model, the basic elements are cost components, formed into two parts - independent variables and parameter coefficients. One of the functions of market analysis is to find out costs current value and their impact factor. Because cost future value is derived from original data regression, market analysis is a necessary step for OB income and expenses predictions in the data treatment process. More market analysis data can be referred to in Appendix Three – Canadian RE Market Investigation and analysis report. (Sievert, Richard W., Jr 1984)

4 - 5 DATA REGRESSION AND FORECASTING

Data regression is more of an art than a technique. Statistical methods have been used for a long time in fields as diverse as economics, genetics, meteorology and physics. With the development of modern facilities for collecting, storing and retrieving large amounts of statistical data, and with the explosive advancement of computer technology, statistics have become more important than ever before. The use of statistics is now widespread in the natural and social sciences; some knowledge of statistics is essential for the professional in industry or government, as well as in the public or educational sectors. No matter how fascinating and powerful modern quantitative techniques may appear, they should only be used to complement (and never to replace) intelligent common sense. (Pike, Richard, 1986)

Forecasting is interpreted as being the result of extrapolating the past into future. It is assumed that forecasting is derived from an objective series of calculations or computations involving data, whereas subjective estimates of future values are termed "Prediction". Forecasting is, by definition, an unbiased estimate of future data values.

Regression is one of the statistical methods that reflect relationships between data. The function of regression is to form formulae for data analysis. In the LCC study, RE data regression is used for the prediction of future income and expenses. (Mansfield, Edwin, 1983)

LCC techniques are heavily dependent upon forecasts of the future. Some forecasts will be no more than professional judgement, or even educated guesses. Others will involve the use of a forecasting model. (Dreger, Garvin T, 1985)

4 - 6 DATABASE MANAGEMENT SYSTEM (DBMS)

To establish a database management system (DBMS) is very important and helpful for data collecting, sorting, searching, storing, adding, deleting and retrieving functions. Besides what has been discussed previously in this chapter, DBMS functions are convenient for modifying a current LCC study and will benefit the next LCC analysis cycle. Following are some advantages in using DBMS:

- It offers consistency in the preparation of estimates over time and from city to city.
- It establishes a uniform relationship of cost information prepared at different stages in OB development.
- It provides a guidance or outline for cost control and budget planning functions.
- It supplies a checklist for the estimating process and referencing specifications.
- It facilitates improved communication between all LCC application practitioners.
- It is easier to find high-cost and low-value areas.

In order to facilitate of RE data acquisition and management, a RE internet web search engine at: http://alcor.concordia.ca/~kzhang/data-net.html and **OFFICE_DB98** database

software, which uses MS-Access connected with MS-Excel, have been developed for establishing a Database Management System. Figure 4 – 1 shows the RE data sources network, which keep connection of the most Canadian RE companies published on the Website. And Figure 4 – 2 and Figure 4 - 3 show the samples of DBMS – **OFFICE_DB98**, which has been used for data management in the present research. (Karl, Ranberg, 1996), (John, Robert, 1994)

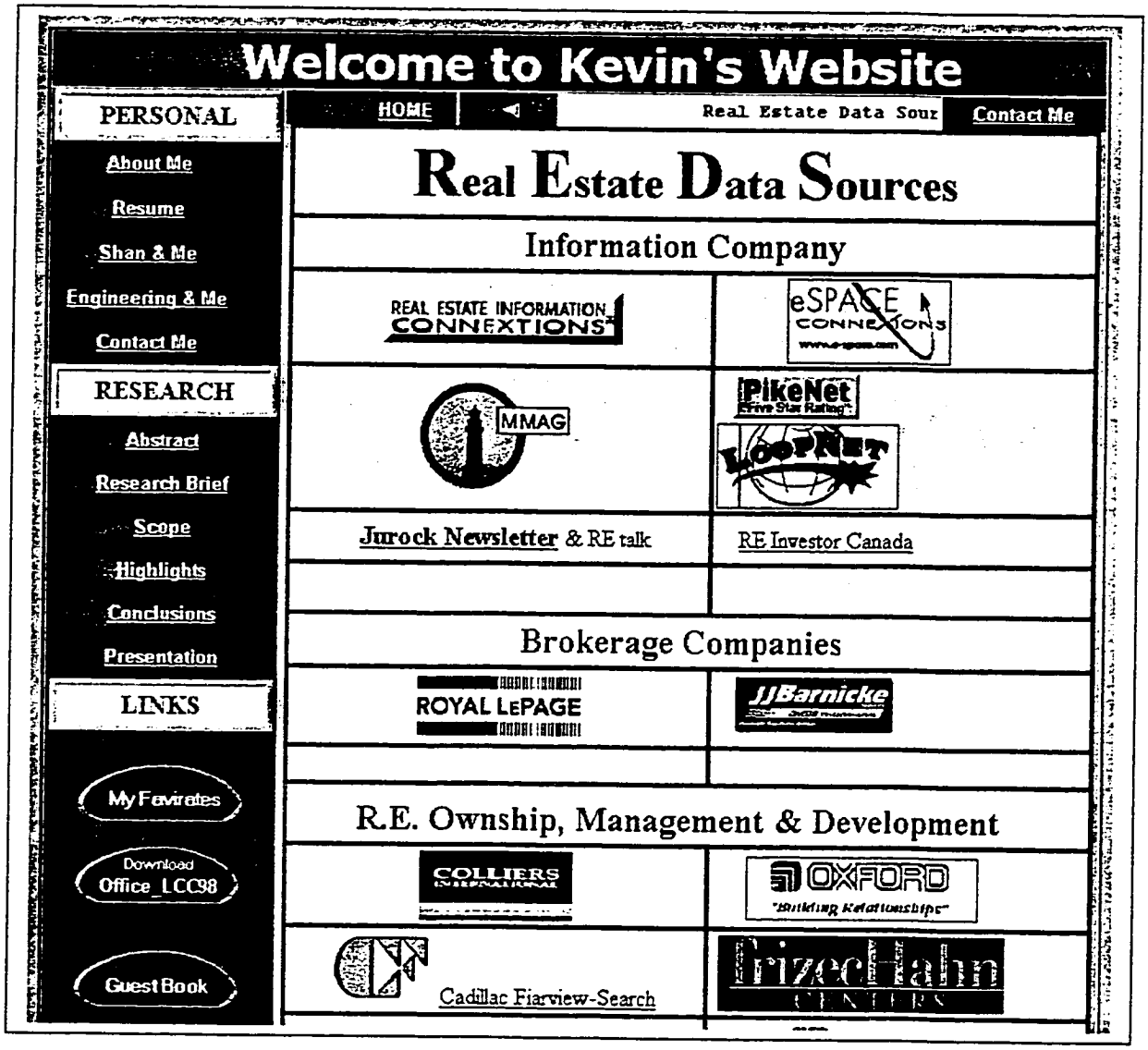


Figure 4 – 1 RE Data Sources Network

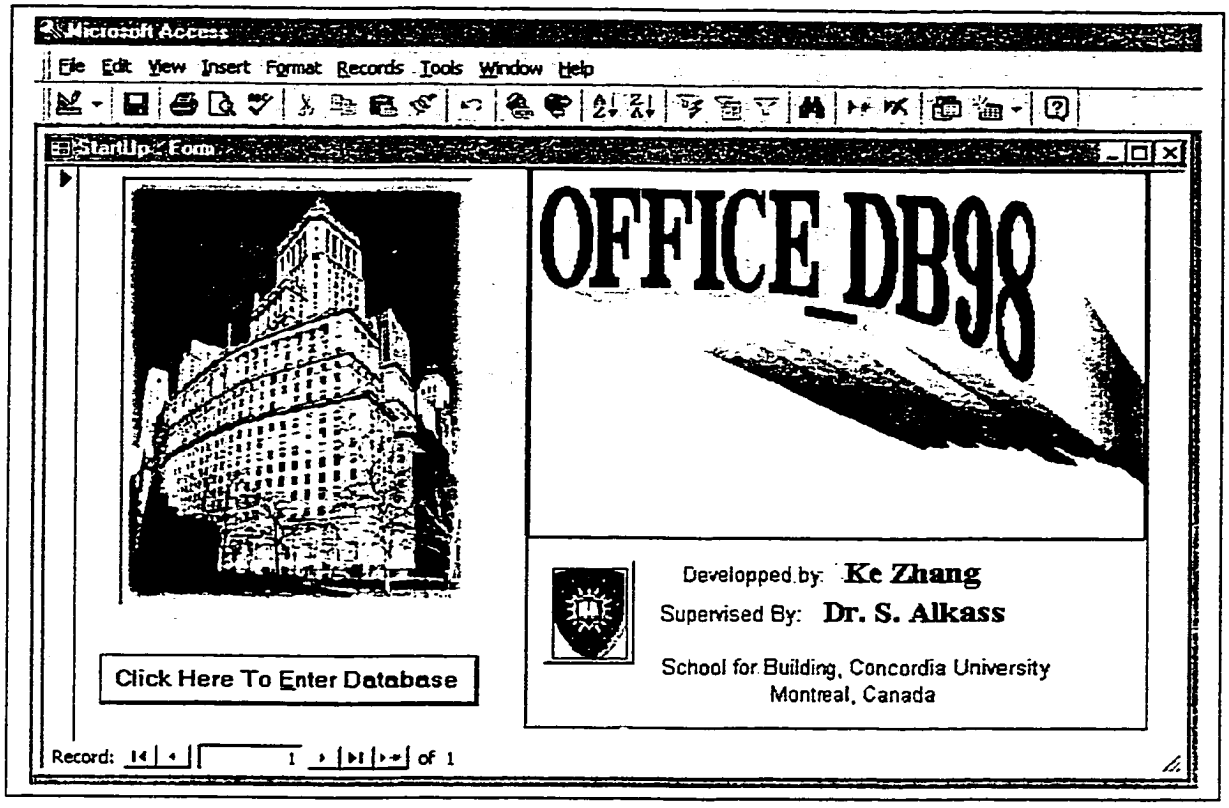


Figure 4 – 2 **OFFICE_DB98** Cover Page

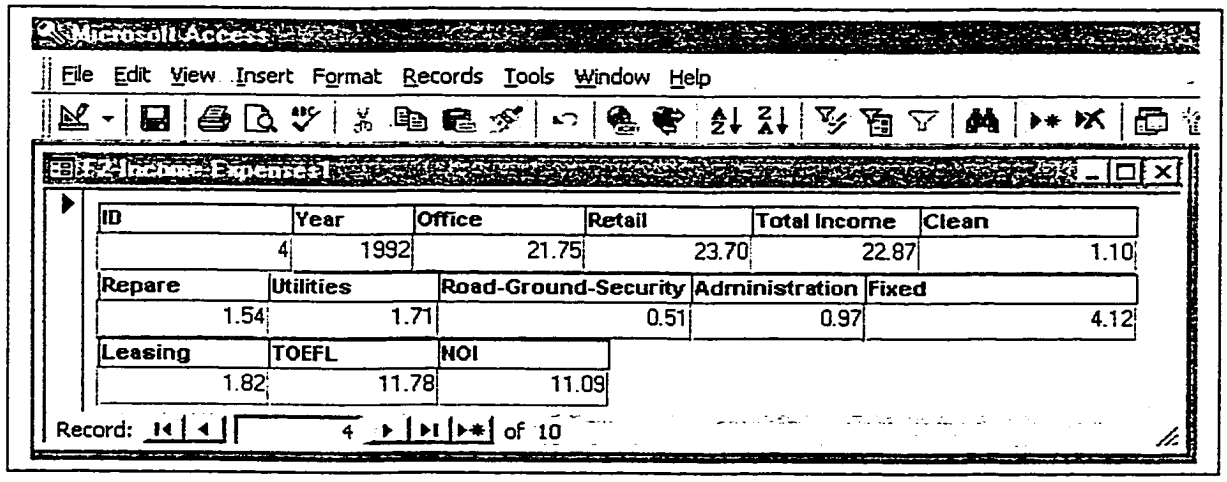
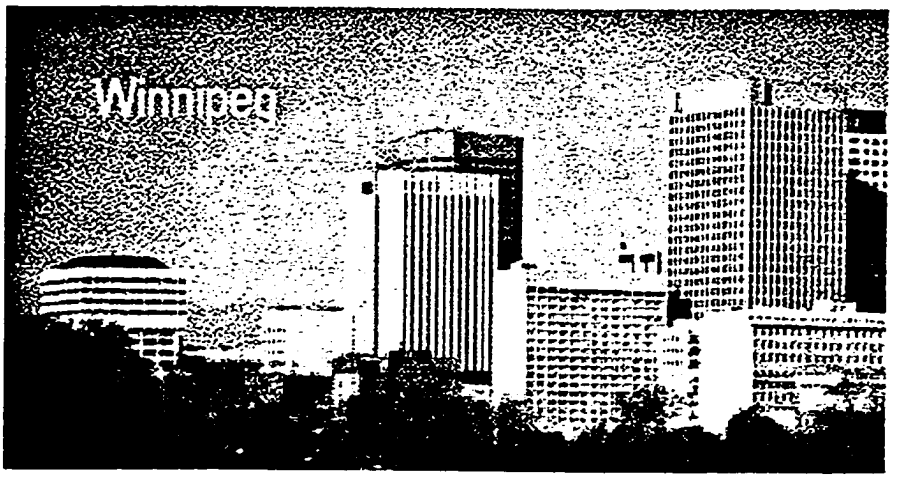


Figure 4 – 3 Income and Expenses Data in **OFFICE_DB98**

Chapter 5

Data Processing



City of Winnipeg

Forecasting needs all kinds of techniques with professional's adjustment

LCC professionals play an important role in costs (income) forecasting adjustments. Cost prediction requires all kinds of techniques and professional experience throughout all stages: selection of assumptions, determining and selecting the data required, and the choosing of the most appropriate forecasting techniques, etc. A variety of techniques are used, such as historical and current data searching, collecting, sorting, analyzing, and data regression methods. Certainly, at any particular moment, an LCC analyst with biased assumptions may reach biased conclusions. It is true that errors will always exist, and that the greater range the forecast, the greater the likelihood prediction errors will be generated.

5 – 1 DATA WORK OVERVIEW

As stated previously, providing numerical results is one feature of LCC analysis. Therefore, a fundamental of the LCC approach is a mathematical process as shown in Figure 5 - 1. Seeking TNPV (referring as Total Net Present Value) value is one of the present research goals. The OFFICE_LCC98 computing model, which will be introduced in Chapter Six, is designed for obtaining TNPV value.

The essential of data treatment work is to figure out the relationship between data. In order to obtain TNPV, the following should be done:

1. Forecasting costs future value
2. Figuring out cost impact factors

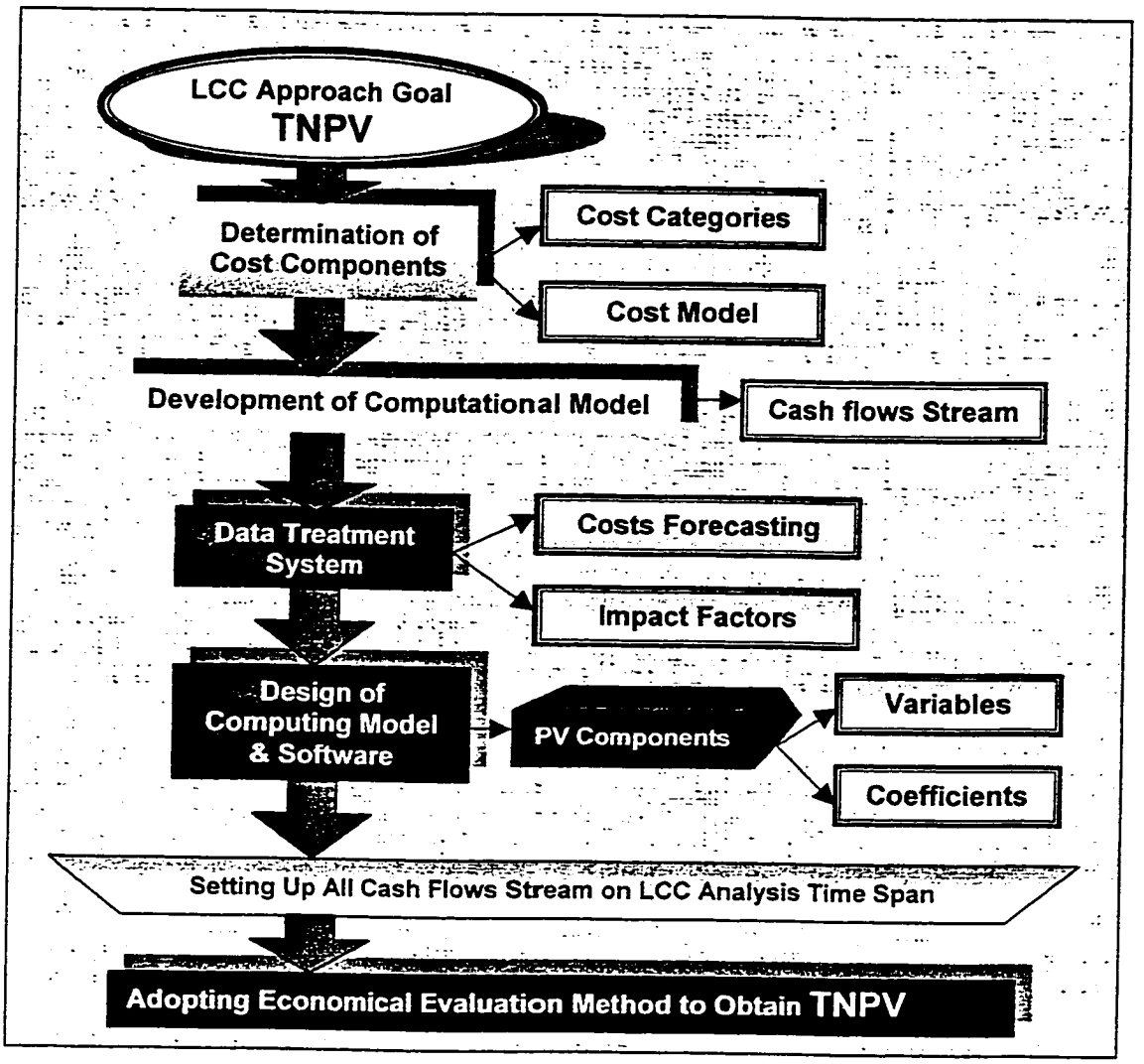


Figure 5 - 1 LCC Arithmetic Approach Diagram

It should be especially pointed out that methods adopted for cost forecasting are similar in all LCC applications generally. But cost impact factors, which are specially yielded with a computing model, are different in each LCC analysis model. Based upon this, this chapter focuses on using all kinds of techniques, such as historical and current data collecting, sorting, analyzing, and regression methods, etc, to forecast cost future values for each cost component as shown in Chapter Four, Table 4 – 1. For determination of cost impact factors that are represented by variable coefficients, will be extended to the next chapter that discusses the development of the OFFICE_LCC98 computing model.

5 – 2 CAPITAL COST FORECASTING

As Chapter Four, Table 4 – 1 indicates, Capital cost components in the OFFICE_LCC98 computing model will be considered as following:

- Land Cost
- Professional Fee
- Construction Cost

5-2-1 Land Cost

Land cost varies with time and place. Market investigation is the best way to obtain land price as introduced in Chapter Four. Setting up a Land Cost value in the OFFICE_LCC98 model will be discussed in next chapter.

5-2-2 Professional Fee

Compared with other costs, professional fees remain a constant value. It is considered a percentage of total construction cost varying upon the total project size in dollars as shown in Chapter Four, Table 4 – 2.

5-2-3 Construction Cost

Construction Cost data is collected from Means Assemblies Cost Data (1992 – 1998) as shown in Appendix 1, Figure AP1 - 1. As the most commonly used method, forecasting relies upon the assumption that future costs can be predicted to some extent by referring to patterns of cost that have existed in the past. According to this knowledge, after several data regression tests, a construction cost forecasting trend line can be described in Figure 5 – 2. Data forecasting formulas are also given in Figure 5 – 2.

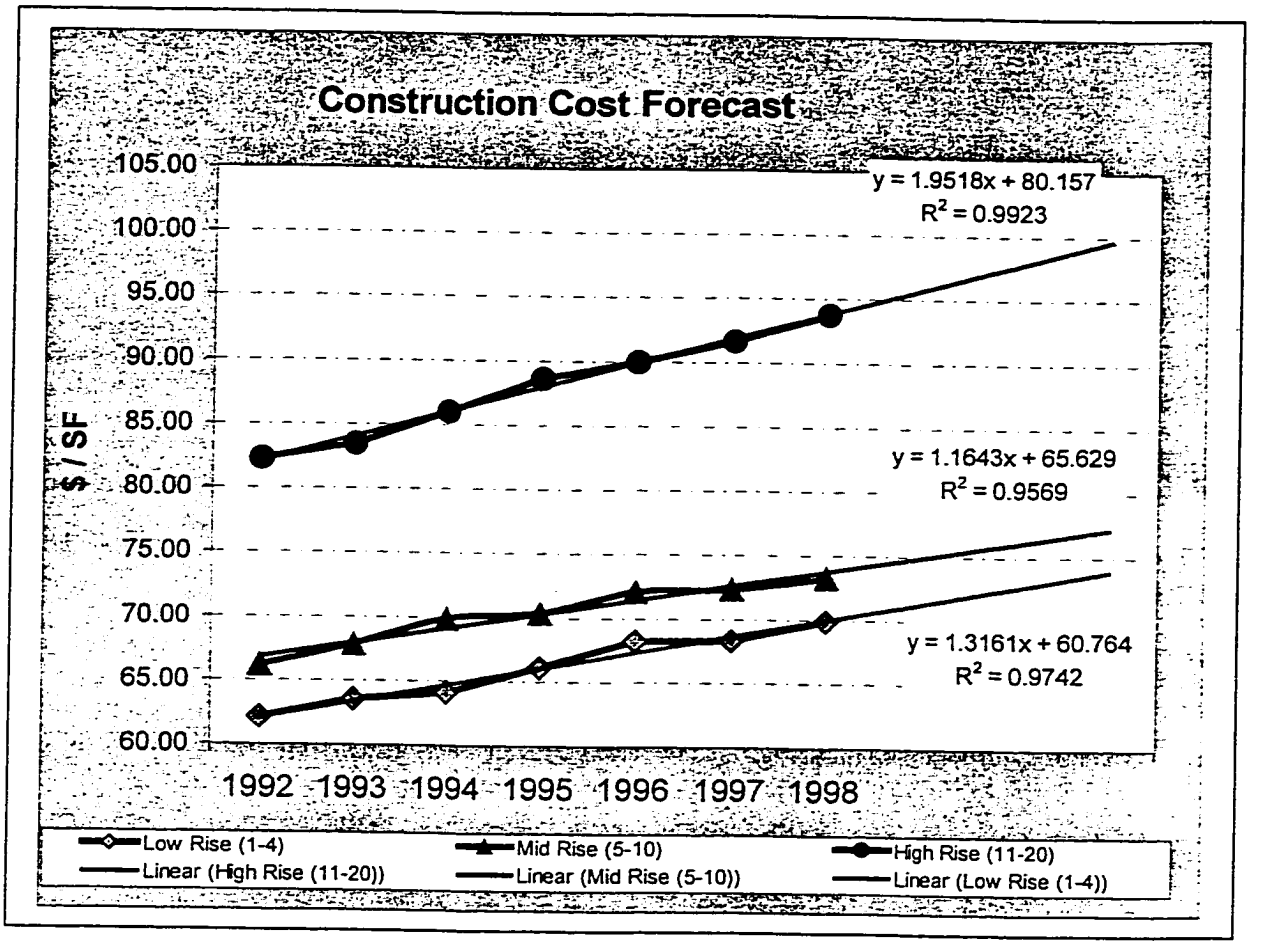


Figure 5 – 2 Construction Costs Prediction

5-2-4 Data Regression Types and Best Fitting Principle

Figure 5 – 2 presents linear relationships for construction cost data. Certainly, for data regression, there are many other types of trend lines that can be used, such as Exponential, Power, Polynomial and Logarithmic etc. The principal of selecting a regression type is based on the value of R^2. R^2 indicates the degree of the trend line fit, that is the total distance between the line and each of the data points. The higher percentage of R^2, a more accurate fitting with original data can be expected. Taking the

high-rise building trend line in Figure 5 – 2 as an example, the cost forecasting formulae is given as:

$$y = 1.9518x + 80.157$$

This formula is described as a linear fitting with historical and current data, and presents the relationship between historical, current and future data. Meanwhile, R^2 = 0.9923 indicates a nearly perfect fit with the base data.

5 – 3 INCOME TOEFL EXPENSES FORECASTING

For OB Income and expenses costs analysis, base data are obtained from BOMA Experience Exchange Report (EER). As a major OB running costs reference, this research work has accessed a total of ten years worth of data from BOMA EER from 1989 – 1998.

5-3-1 Data Assembling and Sorting

Use of history data to forecast future cost is one of the LCC analysis characteristics. The work starts with collection of original data. In Appendix 1, Tables AP1 - 1 to AP1 - 3 present samples of data collection format. In Appendix 1, Table AP1 – 4 shows the assembling of data and sorting of work, from BOMA EERs (years 1988 - 1997) table of "Special Studies - ALL Buildings". Following is an explanation of the symbols, and meaning of the tables:

1. All Buildings Study indicates the National Average cost value. It provides the scenario of the whole of the Canadian OB market condition.
2. **NOI** is Net Operating Income that usually reflects the profits for the building owner. It is an important index for measuring the value of an asset. NOI

(column 12 = 9.31) can be obtained from column 3 (18.58) minus column 11 (9. 27) in Table AP1 - 4.

3. **TI** is an abbreviation of Total Income. It is an average value. Detailed calculation can be referred to in the Table notes.
4. **TOEFL** refers to Total Operating Expenses (column 4 to column 8) plus Fixed value (column 9) plus Leasing expense (column 10)

Although about 200 coast to coast building sample data for each year, are collected in Table AP1 – 4, for individual cases, the LCC practitioner must use the local RE company's OB market report to justify these data, and then carry out an LCC analysis evaluation.

5-3-2 Incomes Data Analysis and Forecasting

Incomes in OB business are usually taken from the following three types of revenue: Office Rental, Retail Rental, and Others Income (such as Parking, Services etc.). Incomes for office buildings vary with time and place. Income prediction is the most difficult part of the whole cost prediction process because they fluctuate with market demands and many other factors, such as, economical circumstances, neighborhood rental, local major industry, population, employment rates, etc. There is more discussion regarding the impact of cost factors later in Chapter Seven.

Here is the principle for Incomes prediction:

1. OB Income must cover **TOEFL** expenses from a long-term point of view. It implies that the bottom line for business profit is that **NOI** values should be kept in a positive value. Otherwise, the OB industry will not survive.

2. "Property value increases by inflation and decreases by depreciation." This indicates that income and expense forecasting is always an upward trend.

Office rental and Retail rental data are collected in Table 5 – 1 and Table 5 – 2. They are heavily influenced and affected by the economic situation, as shown in Figure 5 – 3 and Figure 5 – 4.

In Figure 5-3, office rental reached its peak value in 1992, but appeared a slower than the actual condition at the start of the recession in 1991. Since then, office income fell down sharply until 1997. It is difficult to make a satisfied upward forecasting trend line if only using the data source, called the "BOMA Yearly Report" in the far right column in Table 5 – 1, from 1988 - 1997.

Fortunately, BOMA EER provides another specially formatted study report, called the "5 year Identical Buildings Special Report", from 1989 - 1996. These buildings generally have constant tenants, are well managed, have low vacancy rates and are prestigious in their condition. They have reported to BOMA International Inc. for five years consecutively, as shown at left side of Table 5 – 1 and Table 5 - 2.

For office Rental Income prediction, Figure 5 - 3 provides a forecasting formula:
$\mathbf{Y = 15.772\ X^{0.1574}}$ (Power curve regression model), which is derived from the set of data "5 Year Identical Buildings Special Report". $R^2 = 0.767$ is not a satisfactorily fitting value, but there is nothing better than this so far.

For Retail Income prediction, Figure 5 - 5 provides the following forecasting formula:

$Y = -0.0239X^2 + 1.3473X + 15.464$ (Polynomial curve regression model), and is derived from the set of data in the "5 Year Identical Buildings Special Report" as well. It has a better fitting value for $R^2 = 0.8526$.

Rental Income and Retail Income data should be adjusted by the local company's current market report data with LCC professional experience, before being incorporated into the OFFICE_LCC98 computing model. More details on market analysis will be addressed in Chapter Seven.

It should be noted that Table 5 – 2 has some useless data that is circled. The value of 5.68 is much lower than other year's average value. This data is definitely omitted from the Retail Income prediction.

Table 5 – 1 Rental Income Forecasting Data Collection

Office Rentable Income Index ($ / sq. ft.)

5 Year Identical Buildings Special Report (50 Buildings)								BOMA Yearly Report (200 Buildings)
YEAR OF BOMA EER								
Year	1989	1990	1991	1992	1993	1996	5-yr Average	
1984	16.65						16.65	
1985	16.84	16.73					16.79	
1986	17.35	17.28	17.92				17.52	
1987	18.73	18.41	18.91	19.03			18.77	
1988	19.96	19.47	20.16	20.64	20.98		20.24	18.63
1989		20.98	21.57	22.92	23.40		22.22	21.09
1990			20.63	21.17	20.96		20.92	20.62
1991				21.05	22.33	23.15	22.18	21.75
1992					26.72	26.80	26.76	23.63
1993						24.15	24.15	22.57
1994						22.16	22.16	22.28
1995						20.06	20.06	21.34
1996								19.79
1997								18.80

Table 5 – 2 Retail Income Data Collection

Retail Income Index ($ / SF)								
5 Year Identical Buildings Special Studies (50 Buildings)								BOMA Yearly Report (200 Buildings)
YEAR OF BOMA ERR								
Year	1989	1990	1991	1992	1993	1996	Average	
1984	18.25						18.25	
1985	19.26	17.28					18.27	
1986	19.27	17.86	17.62				18.25	
1987	20.96	19.83	19.51	18.76			19.77	
1988	21.72	21.56	21.83	22.19	5.68		21.83	22.31
1989		22.92	23.48	23.96	26.57		24.23	24.67
1990			21.53	21.56	24.98		22.69	21.78
1991				23.89	27.34	27.97	26.40	23.70
1992					27.63	28.56	28.10	25.80
1993						26.72	26.72	23.71
1994						26.72	26.72	23.47
1995						27.12	27.12	22.63
1996								22.57
1997								15.91

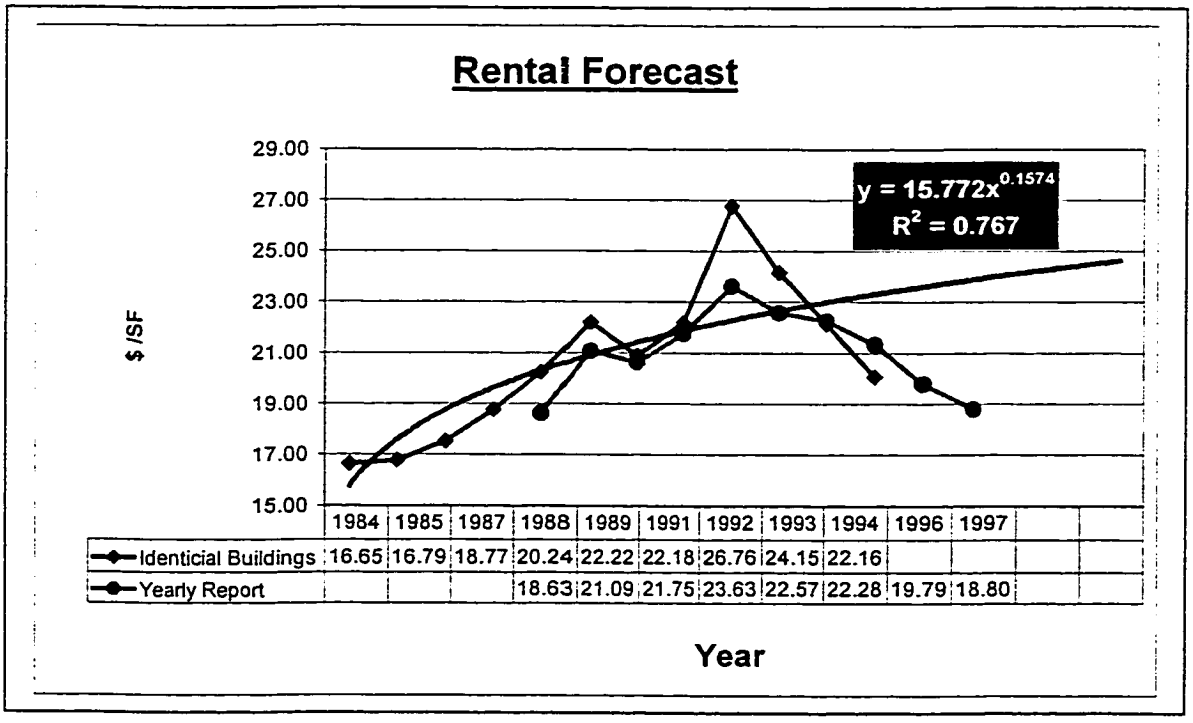


Figure 5 - 3 Rental Price Regression and Forecasting

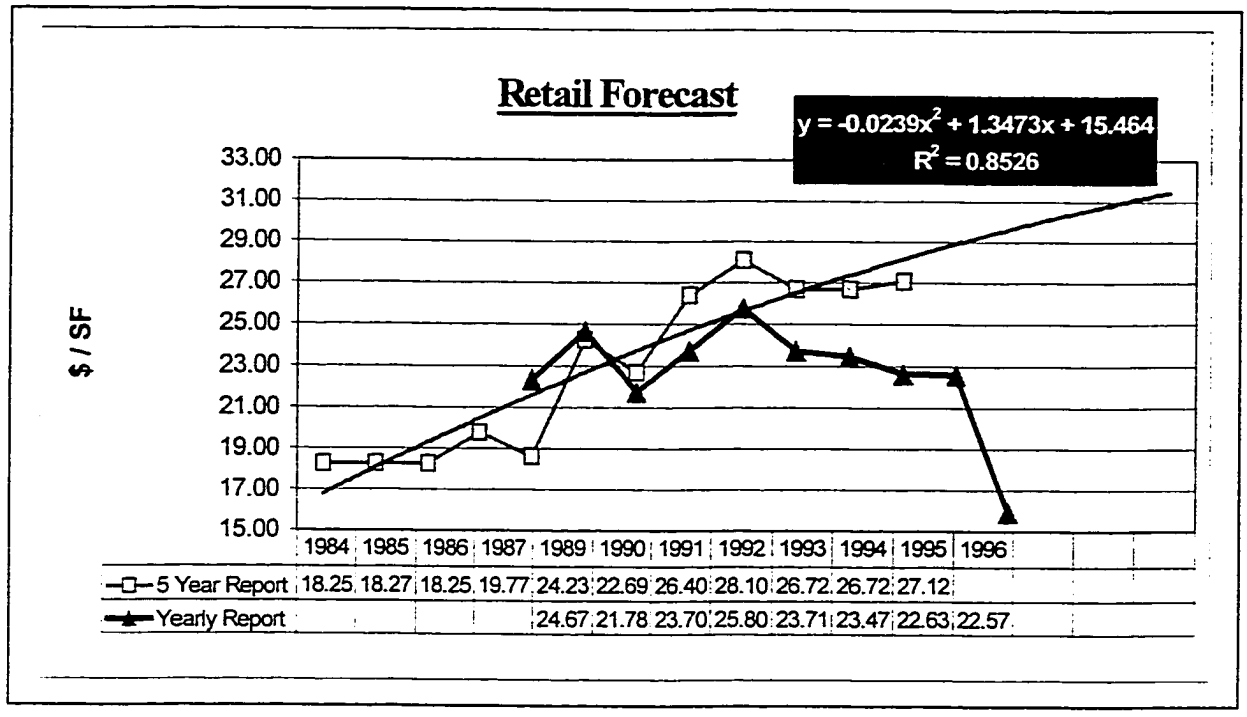


Figure 5 - 4 Retail Price Regression and Forecasting

5-3-3 TOEFL Costs Analysis and Forecasting

TOEFL or operating and maintenance costs are usually considered as having fixed values, compared to **net rent**, that involves negotiation of lease matters. According to Appendix1, Table AP1 – 4 data (column 11), the TOEFL expense trend line is shown in Figure 5 – 5 and provides the forecasting formula: **Y= 1.2218Ln(x) + 9.6756** (Exponent curve regression model). Figure 5 – 5 shows R^2 = 0.8376, which has better fitting data than Rental Income forecasting where R^2 = 0.767. In Figure 5 – 5, TOEFL presents a down trend indicating that property owners and managers tied their budget to control building expenses, especially in the recession period. This is what the LCC analysis can help for OB management.

There is more discussion regarding TOEFL items forecasting, applications of LCC techniques in OB management, and OB management strategy for a market downside, in Chapter Seven.

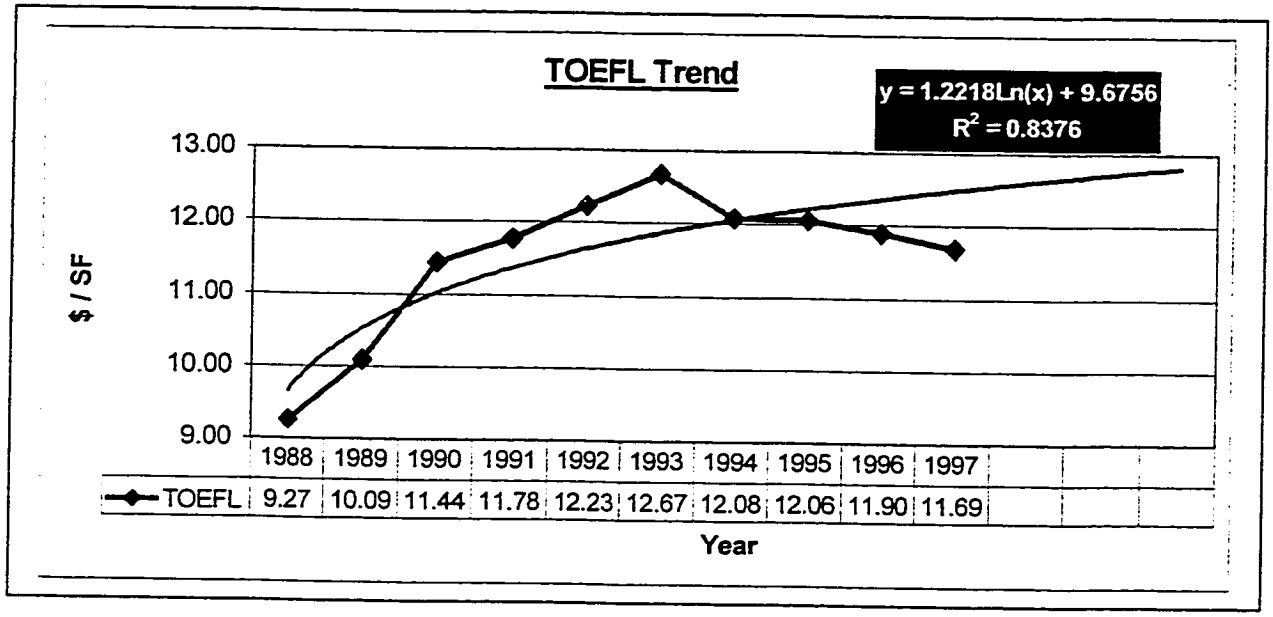


Figure 5 – 5 Total Operating Expenses Fixed, Leasing expense Prediction

5 - 4 CONCLUSION OF DATA WORK

Chapter Four and Chapter Five introduced the procedural and technical methods of data treatment called the data treatment system. The function of the data treatment system can be briefly concluded as:

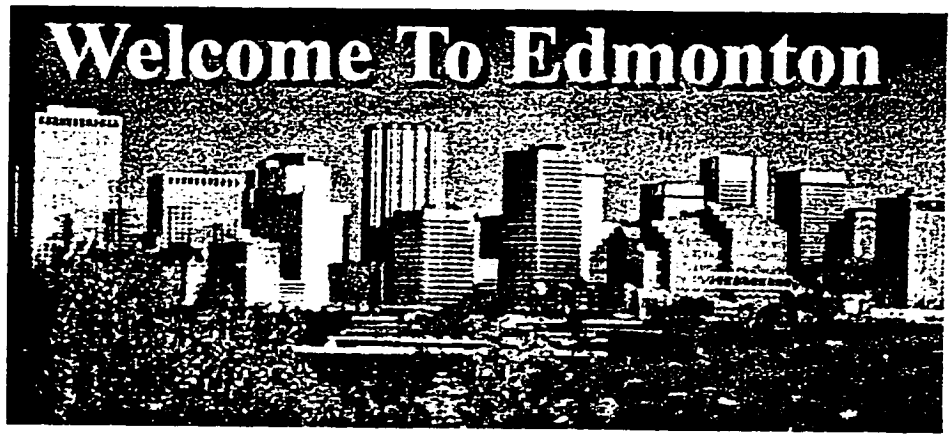
1. Data assembling to collect useful data from available data sources according to the OFFICE_LCC98 computing model.
2. Data sorting is to make data meaningful in order to establish relationships between data
3. Data analyzing is to eliminate incorrect data and less important data
4. Data regression is to figure out the best expression of data relationships for future cost prediction

5. Data forecasting is to determine the cost future value in order to build a cash flow stream during the LCC evaluation time span. The further forward the forecast, the greater the likelihood of prediction errors generated
6. Data adjusting is to the correct future value of costs according to market analysis and professional experience. Professional adjustment is the final step that ensures that accurate data are incorporated into the LCC computing model
7. The main function of data treatment work is the prediction of costs future value (Independent variable) and determination of costs impact factors (Coefficient of Independent variable) in the LCC computing model
8. A database management system establishes a facility for data selecting, sorting, analyzing, searching, storing, retrieving, executing, comparing, adding and deleting etc. for modifying of current LCC analysis and preparation for the next LCC study cycle.

Chapter 6

OFFICE_LCC98

Computing Model



City of Edmonton

LCC professional's adjustments are always needed

The technology available to LCC practitioners expands with computerized applications. The benefit of utilizing a computer technique is obvious. Today, computer technology, such as hardware, software and the worldwide web (WWW) network, is constantly developing. Fast running, large storage space, easy operating and network communication is becoming the norm. WWW Internet and database networks make communicating with each other easier, and data exchange more efficient. The 1990's computer technology development is being called the last revolution of the century.

6 - 1 LCC COMPUTER SOFTWARE AND LCC PROFESSIONAL

"Providing quick and inexpensive LCC evaluation results" is one of the objectives of the present research. **OFFICE_LCC98** has been developed for this particular requirement. It is true that computer technology makes LCC analysis quicker and more efficient, but LCC professionals are always needed to help in making a final decision.

Following are several reasons why computer software can not replace an LCC professional:

1. **Out-of-date data can not generate reliable results**. LCC studies cost performance and involves studying the historical and current costs, in an attempt to forecast future costs. Current cost data is the key to making a cost prediction formula. Therefore, the LCC professional plays an important role in obtaining current cost data through conducting market research.

2. **The LCC professional has the advantage of using LCC analysis software** An LCC professional can take advantage at data entry, examination results, cost control, cost warning, risk, uncertainties, impact factors, etc to assist the decision maker (investor, developer, owner and manager etc).
3. **LCC analysis is not a one-time undertaking.** Cost database is important to an LCC study. Setting variables and their coefficients in a computer model is based on a cost database. Updating the database is always needed for the next LCC analysis cycle, and so LCC professionals are needed to do this work.
4. **Computer model and software.** To set up and revise the LCC computing model, an LCC professional is certainly needed. Development and modification of LCC software is always the work of the LCC professional.

The software **OFFICE_LCC98** is designed for assisting LCC analysis. Software design is hard work and time consuming. It involves not only taking time to learn the language – syntax of Visual Basic 5.0 (VB5), Visual Basic Applications (VBA), MS – Excel and MS - Access Macros and modules, graphical design technique, etc, but also in making the program communicate directly with a database and WWW network, to generate results.

6 – 2 OFFICE_LCC98 PROGRAM FEATURES

The demo for OFFICE-LCC98 is a window software as shown in Figure 6 – 1. It provides quick and inexpensive LCC evaluation features designed for office building appraisement and management, using Life Cycle Costing techniques. The program is written in VB scripts, VBA and MS-Excel 7 built–in functions. It works on MS-Excel v7.0 or in the MS-Office97 environment. The source codes are written both in modules and macros, and use only 18 data entries that generate LCC analysis results.

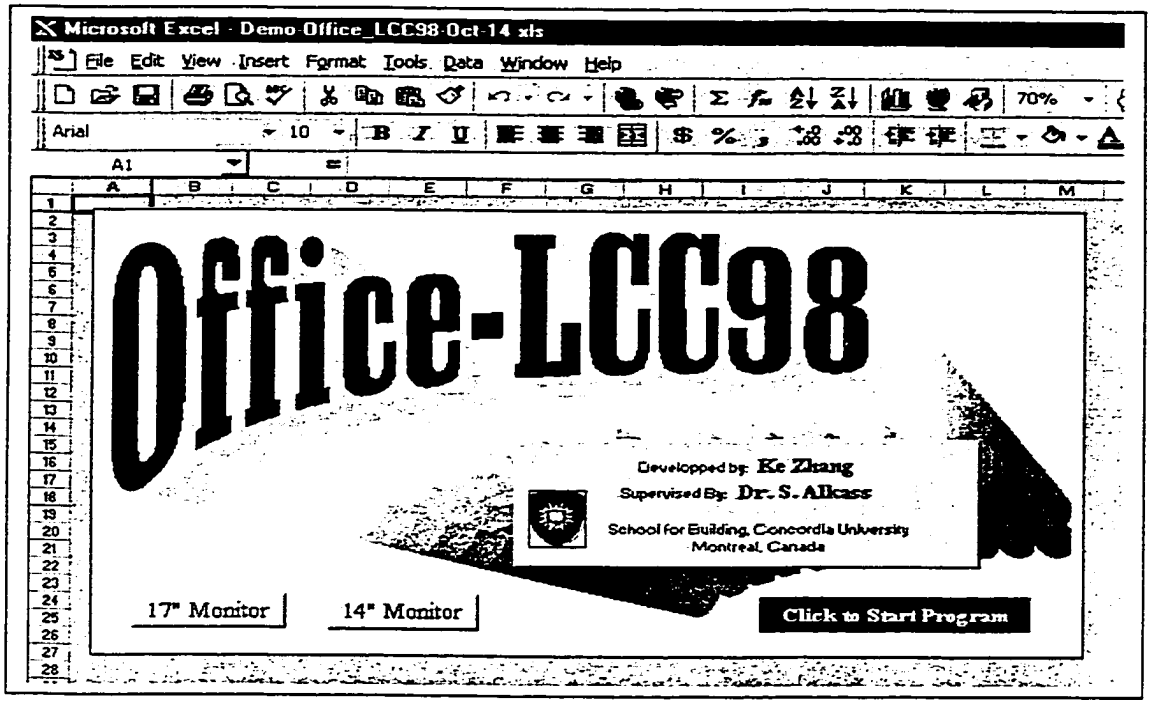


Figure 6 – 1 OFFICE_LCC98 Program Title Page

6–2–1 The Main Features

1) Evaluation and data available for eight Canadian cities. They are:

Vancouver	Calgary	Edmonton	Winnipeg	Toronto	Ottawa	Montreal	Quebec City

2) Calculation of the major financial items within a 20 year time span

3) Providing numerical results and fine graphics. The financial results include Total Net Present Value (**TNPV**), Annual Income, Annual Expenses, Net Operating Income (**NOI**), Total Capital Cost and Savings/Investment Ratio (**SIR**). The related graphics include Expenses (**TOEFL**) Distribution Pie, Expenses Vs Capital Cost Ratio, NOI Forecasting Trend Line, etc.

6–2–2 Users

OB property owners and managers, RE investors, developers, market analysts, appraisers, Facility managers, Economists, Architects, University professors & students could be users.

6–2–3 Functions

Investment advisement; Development guidance; Costs control; Leasing strategy; Economical rental rates determination reference; Preliminary design; Property management system; Budget plan; Optimal alternatives selection supporting; Asset appraisement; Dynamic studies functions (uncertainties & risks & sensitivity analysis); and to demonstrate LCC technique.

6 – 3 PROGRAM ASSUMPTIONS

Any design or research is based on certain assumptions. For the **OFFICE_LCC98** computing model, the assumptions are listed as following:

- Construction period is not taken into account
- Computing model design is based on current (income) upward market scenario
- Program presetting data and parameters are available only for Office Buildings
- Interest & Inflation rates are considered constant throughout the analysis period
- Cash flows occur at the end of each year
- The program is designed for class A office buildings
- Depreciation is not taken into account in this version of the program
- Major replacement costs are not considered in this program (such as roof, floors)
- Salvage value should be given by user (More discussion in Chapter Seven)

6 – 4 OFFIC_LCC98 COMPUTING MODEL

As described in Chapter Three, for this research, the computational model adopts a total net present value (TNPV) method. It is commonly used in economical estimation methods in LCC practice. In Chapter Four, section 4 – 2, the costs relationship and cost components have been introduced. The OFFICE_LCC98 computing model is built based on these pre-settings.

6-4-1 General LCC Computing Model

The computing model for any LCC analysis has been described as equation E3 - 1:

$$TNPV = \sum_{t=0}^{t=n} \frac{(B_t - C_t)}{(1 + \frac{r}{100})^t} \qquad \text{(E3 - 1)}$$

6-4-2 LCC Computing Model for Commercial Buildings

As introduced in the preceding chapter, the Commercial building category is among Residential and Industrial building categories in the real estate field. Generally, Commercial buildings include office buildings, apartment buildings, hotels, motels, and shopping centers. They posses similar cost categories and public service functions, such as income, expenses, taxes, insurance, electrical control systems and management systems etc.

The conceptual formula for the LCC computing model for Commercial category buildings is described in E6 – 1.

$$\textbf{TNPV} = PV(\text{Income}) + PV(\text{Salvage}) - PV(\text{Capital cost}) - PV(\text{TOEFL}) - PV(\text{Replacement}) \quad (E6-1)$$

6-4-3 OFFICE_LCC98 Program Computing Model

A more detailed OFFICE_LCC98 program computing model can be expressed in E6 - 2

$$\textbf{TNPV} = PV(K_{rent}\, I_{rent}) + PV(K_{retail}\, I_{retail}) + PV(K_{other}\, I_{other}) - PV(K_{land}\, E_{land}) - PV[K_{cons}(E_{construction} + E_{fee})] - PV(K_{exp}\, E_{TOEFL}) + PV(K_{sal}\, I_{salvage}) \quad (E6-2)$$

Where:

- TNPV --- Total Net Present Value
- PV () --- PV component, which is a present value of the cash flow stream
- $I_{()}$ or $E_{()}$ --- Independent variable. It is derived from cost forecasting
- $K_{()}$ --- Independent variable's coefficient, which is obtained by cost impact factors

It should be noted that **PV (Replacement)** does not appear in E6 – 2 for three reasons:

1) Replacement data was not collected due to lack of data sources
2) Considering an LCC analysis period might be short, (recommended 3 – 5 years), therefore, for building major renovation and replacement construction would occur only once during this period, and it is easy to add those costs afterwards.
3) PV (Replacement) implies major renovation and replacement costs, such as changing roof, floor renovation, external wall reparation, etc. For minor

replacement, such as the changing of pumps, elevator-repair, and general reparations, etc, these have already been taken into consideration in the TOEFL expenses.

6 – 5 DETERMINATION OF PV COMPONENTS

As introduced in 6 - 4 - 3, PV ( ) is called PV component. There are seven PV components considered in E6 – 2. Each PV component represents a sum of present values of a set of cash flow stream. The cash flow streams are shown in Figure 6 - 3. Its mathematical expression is described in E6 - 3 for Income Cash Flow Streams and E6 - 4 for Expenses Cash Flow Streams respectively.

$$PV\left(K_{(I)} \cdot (I_{(I)}\right) = K_{(I)} \sum_{t=0}^{t=n} pv\left(I_{(t=x)}\right) \qquad \text{(E6 - 3)}$$

$$PV\left(K_{(E)} \cdot (E_{(E)}\right) = K_{(E)} \sum_{t=0}^{t=n} pv\left(E_{(t=x)}\right) \qquad \text{(E6 - 4)}$$

As stated previously, obtaining a TNPV is the final goal of an LCC calculation. The LCC computing model consists of PV components, and PV components are contained two basic parts as expressed in E6 - 3 and E6 - 4:

1. **Independent variable $I_{()}$ or $E_{()}$** - It represents a one time cash flow in t = x
2. **Coefficient of variable $K_{()}$** – It represents an adjustment of future costs. They are considered as impact factors having an influence for future costs in year of t = x

The following sections will introduce and discuss those two elements respectively.

6-5-1 Interest & Inflation Rates In Obtaining PV

This research adopts a one-time cash flow present value method to calculating cost present values for all costs categories. Taking the first PV component $\mathbf{PV}\ (K_{rent}\ I_{rent})$ from E6 – 2 as an example, $\mathbf{PV}\ (K_{rent}\ I_{rent})$ indicates a summarized Office Rentable Income Present Value throughout the LCC analysis time period. Its mathematical expression is given in E6 - 5:

$$PV\,(K_{rent}\ I_{rent}) = K_{rent} \sum_{t=0}^{t=n} pv\,(I_{(t=x)}) \qquad \text{(E6 - 5)}$$

Where $pv\ (I_{t=x})$ is the single cash flow present value, which is also called one time cash flow present value.

The One time cash flow present value mathematical formula can be expressed as:

$$PV(I_{\ t=0}) = \frac{I_{t=x}}{(1+r)^{x}} \qquad \text{(E6 - 6)}$$

Where: $PV\ (I_{t=0})$ = Office Rentable Income present value at counting point t = 0;

$I_{t=x}$ = Office Rentable Income future value at year of t = x;

r = real discount rate or net of inflation discount rate;

Discount rate is a significant impact factor for calculating present value. It is necessary to point out that "Usually LCC studies ignore inflation and work in constant fiscal units, usually those prevailing at the time of the study." [15 - p141]. But LCC calculation does consider inflation, although it could generate much more complicated conditions, such as different cost items that have different inflation rates, for example energy escalation is 11%, meanwhile the labor escalation rate is 8%. According to the Statistics Canada Report, inflation rate in Canada is less than 2% as shown in table 6 – 1, and the market interest rate is about 4% in recent years.

Table 6 –1 Consumer Price Index – All Items Index

1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
84.8	89.0	93.3	98.5	100.0	101.8	102.0	104.2	105.9	107.6

*** Catalogue No. 62-557-XPB

If taking the average inflation rate for all cost items as shown in Table 6 – 1, and an inflation rate less than the market interest rate, the real discount rate can be expressed in E6 - 7:

$$r = \frac{1 + d}{1 + i} - 1 \qquad \text{(E6 - 7)}$$

*** Roger Flanagan (1991)

Where r = real discount rate or net inflation discount rate; d = market interest rate (nominal); i = all costs Items average inflation rate.

For inflation rates greater than market interest rates, refer to Mr. Roger Flanagan & George Norman's book "Life Cycle Costing" for a more detailed calculation.

6-5-2 Independent Variables In PV Components

The definition of Independent variables ($I_{(\ )}$ or $E_{(\ )}$) is introduced in 6 - 5. They are actually cash flow streams at the LCC analysis time span. The cash flow stream represents cost future value. The obtaining of costs future value has been introduced and discussed in Chapter Five. Figure 6 - 2 provides a summarized cost forecasting formula at the LCC evaluating time span.

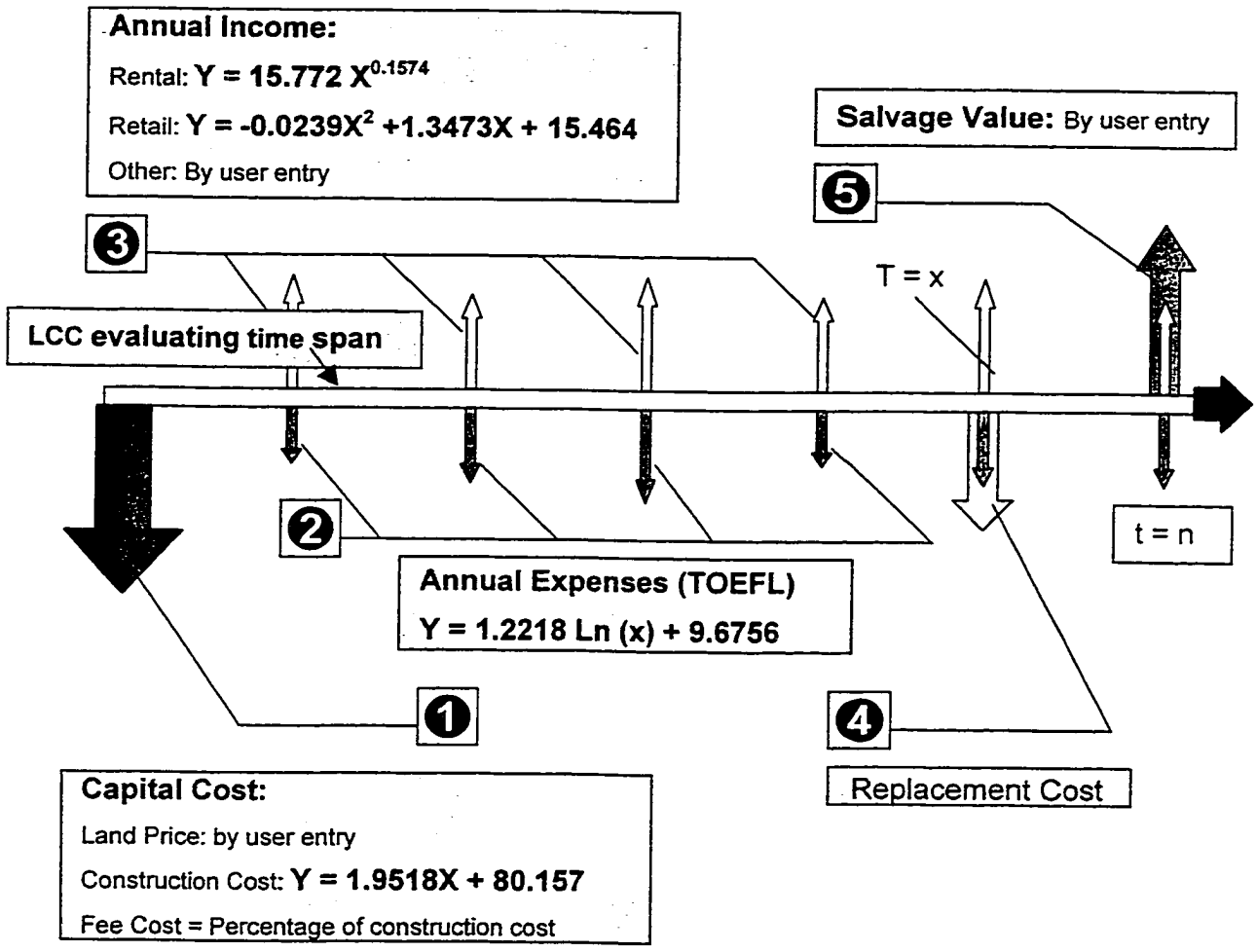


Figure 6 – 2 Cost Cash Flow Streams at LCC Evaluating Time Span

6-5-3 Coefficients In PV Components

$K_{(\ )}$ is the coefficient of Independent variables $I_{(\ )}$ or $E_{(\ )}$, and is one of two elements in the PV component from E6 - 2. $K_{(\ )}$ is a comprehensive parameter that reflects all cost impact factors.

- For Capital cost impact factors, this research has taken into consideration such features as location, size, height of building, inflation, interest rate, etc. K_{cons} is the coefficient for construction cost, involving City Factor, Size and Height Factor.

- For Incomes and TOEFL impact factors, such as rental income, the present research considers the following, as shown in Table 6 - 1.

Table 6 – 1 Costs (Income & Expenses) Impact Factors

Impact Factors	Explanations
City	Eight studied cities
Ownership	Private Vs. Government
Location	Downtown Vs. Suburban
Height	Floor Storage
Age & Size	Building age & building total square feet area

Continuing the discussion in Chapter Five, the purpose of data sorting is to make them relevant and to find relationships between data. In Appendix 1, TableAP1 - 6 and Table AP1 - 7 provide the format of data assembling, sorting and data composing for determining **City, Location, Height, Age** and **Size** cost (income & expenses) impact factors. Overall office building income and expense costs impact factors are formed in Appendix 1, Table AP1 - 8. The mathematical expression of K_{rent} and K_{exp} can be described as:

$$K_{rent} = IGF \times ICF \times ILF \times IHF \times IAF / 1.04$$

$$K_{exp} = EGF \times ECF \times ELF \times EHF \times EAF / 1.08$$

Note: 1). Meaning of symbols should refer to appropriate tables.

2). 1.04 and 1.08 are data converting constants (from All Canada to Montreal in BOMA EER).

- For Replacement cost impact factors, refer back to section 6 - 4 - 3.

- For Salvage value impact factors, see Chapter Seven.

6 – 6 PROGRAM DESIGN TIPS

1. As introduced at the beginning of this chapter, the OFFICE_LCC98 program is designed on an MS-Excel platform that takes the following advantages of this special environment.

   - It is easy to use one time cash flow present value methods to calculate each PV component and final TNPV. In other words, it is not necessary to convert whole cash flow stream to a special shape of cash flow, such as uniform series of cash flow, gradient series of cash flow, geometric series of cash flow etc, to calculate its present value. The use of the one time cash flow present value method is certainly more accurate than other methods.

   - Excel's tabulated format interface and fine graphics can provide better numerical and graphical reports, especially in hard printings.

   - All commands and actions can be written in modules and marcos by the use of Visual Basic scripts, Visual Basic Applications, and Excel built-in functions.

   - It is easy to connect with other Microsoft applications, such as MS-Access, Word and Internet Explorer. This is a significant advantage for data communication functions.

2. The OFFICE_LCC98 program uses equation E6 - 2 as its computing model. Certain cost forecasting formulas are modified.
3. Visual Basic 5.0, Visual Basic Applications, MS-Excel 7.0 build-in functions, Arts Graphic and Paint-Shop Pro are adopted for the OFFICE_LCC98 program, both the code and Interface design. Modules and macros are used to support the calculation process and generate fine graphics. The OFFICE_LCC98 program design structure can be found in Appendix 2, Figure AP2 – 18, Figure AP2 – 19, Figure AP2 - 20.
4. Data entry is divided into two parts:
   (a) *Building Description Data*, which are actually used for presetting costs impact factors. This process determines coefficients in the computing model.
   (b) *Calculating Data*, which are directly used for LCC evaluation.

6 – 7 LAUNCHING OFFICE_LCC98

Examination and verification of the **OFFICE_LCC98** program is necessary. Verification is defined as an area of validation with the distinction being that verification is concerned that the system operates correctly. It checks out sufficient conditions for LCC evaluation. Examination is considered testing with the system to find whether the correct solution can be generated for problem solving.

6–7–1 Data Entry

Building description data entry:

1. City: **Montreal**
2. Type: **New Building**
3. Ownership: **Private**
4. Location: **Downtown**
5. Size: **100 – 299 × 1000 sq. ft.**
6. Height; **5-9 floors**
7. Age: **New building**

Calculating data entry:

8. Land Area: **40, 000 sq. ft**
9. Land Price: **$20 /sq. ft**
10. Construction Cost: **Intermediate**
11. Gross floor area: **160,000 sq. ft.**
12. Other Income: **$25000**
13. Interest Rate: **4%**
14. LCC study period: **10 year**
15. Office Rentable Space: **100,000 sq. ft.**
16. Retail Space: **12,000 sq. ft.**
17. Salvage Value: **$16,000,000**
18. Rental price: **default**

6-7-2 Comments & Notes On Results

A part of OFFICE_LCC98 interface pages and running results samples are presented in Figure 6 - 3 to Figure 6 - 14. The entire **OFFICE_LCC98** running sample can be found in Appendix 2, "OFFICE_LCC98 Design & Running " Figure AP2 -1 to Figure AP2 - 17. Following is some comments and notes on program running results:

1. The testing results will be used for a case study - "Speculative Office Building Development Feasibility Study" in Chapter Seven.
2. It provides positive Total Net Present Value (**TNPV** = $ 2,340,439), which indicates the project is in a healthy condition, while Savings/Investment Ratio (**SIR** = 1.08) is greater than one in Figure 6 - 9.
3. **TOEFL** costs item distribution, which is shown in Figure 6 - 11 and each **TOEFL** cost item forecasting will be discussed in Chapter Seven.
4. Figure 6 - 12 indicates that **TOEFL** costs (52%) excesses **Capital** Cost (48%) after ten years operating time period.
5. **NOI** trend shown in Figure 6 - 13 and related topics will be discussed in Chapter Seven.

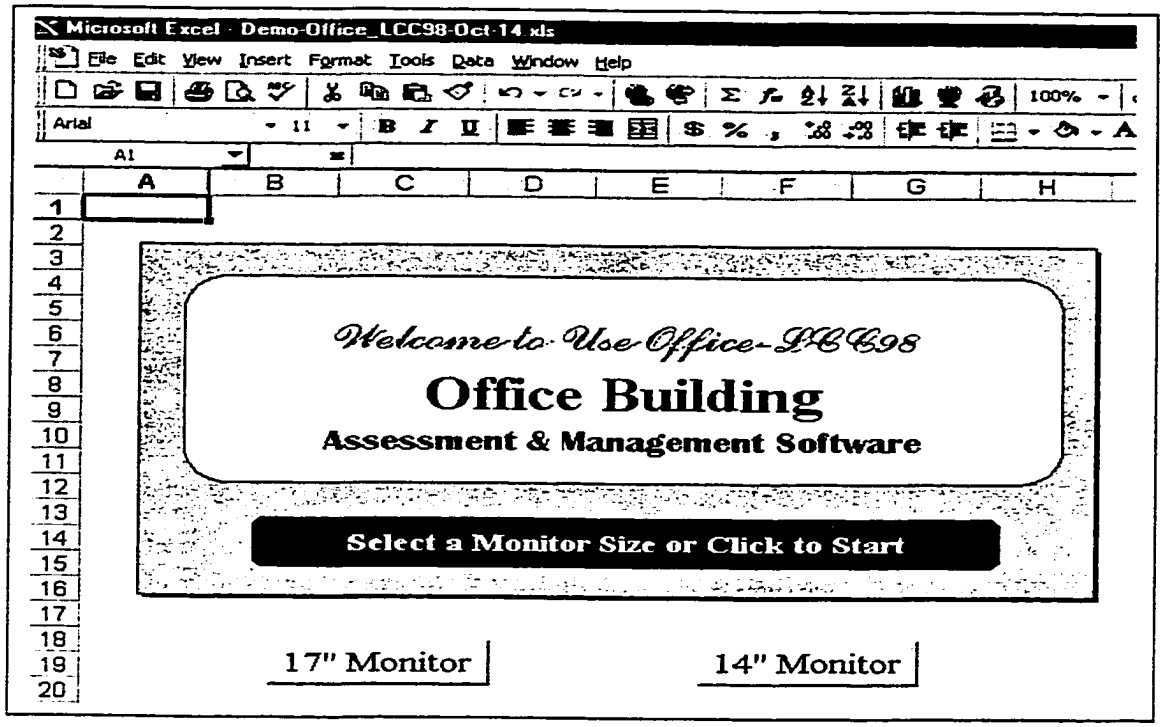


Figure 6 – 3 Cover

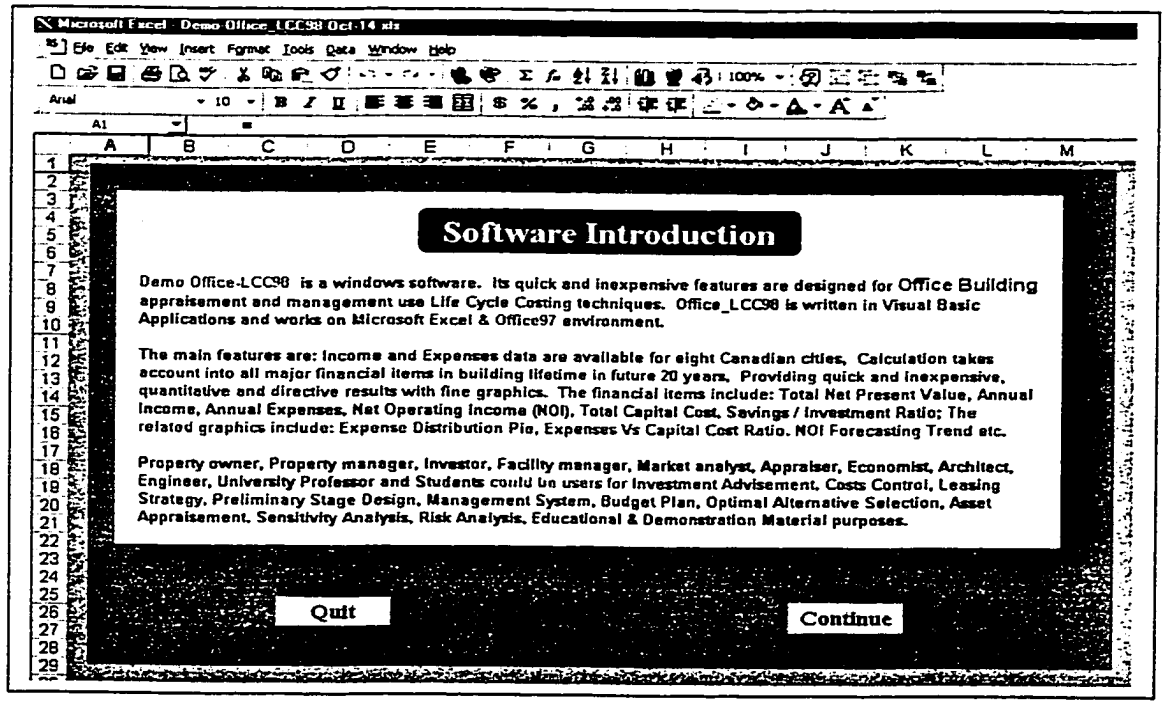


Figure 6 – 4 Software Introduction

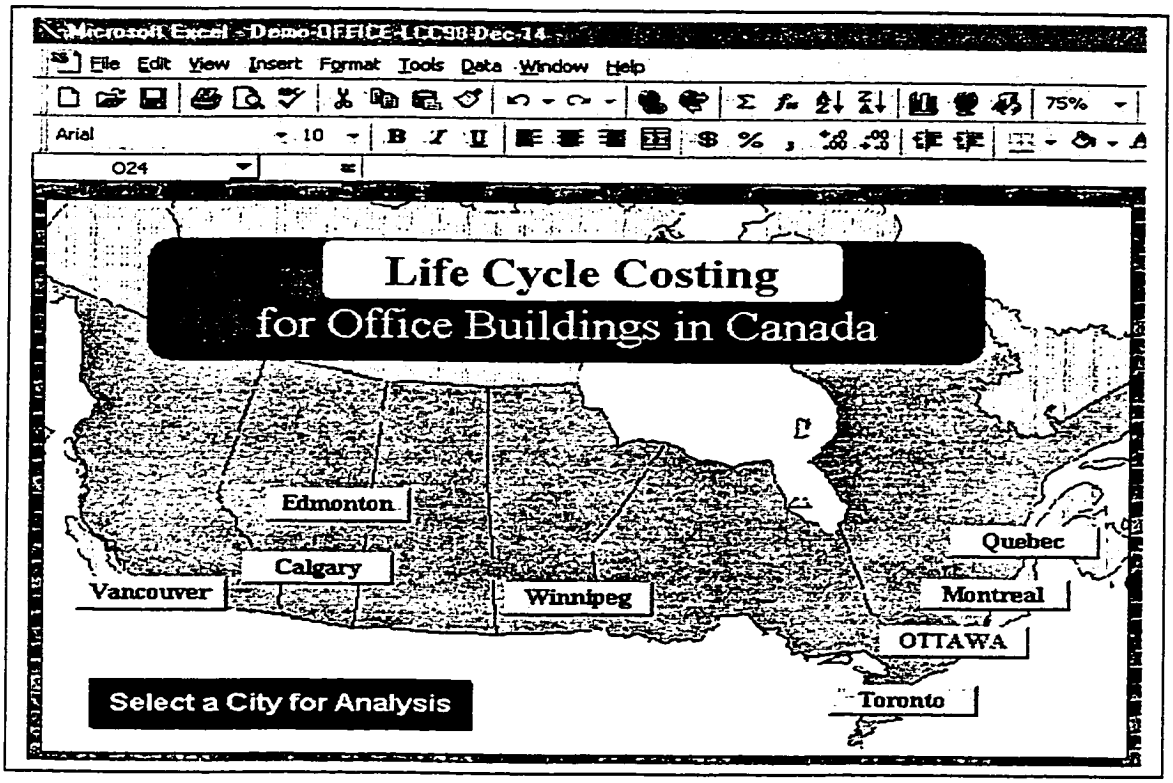


Figure 6 – 5 Study Cities Map

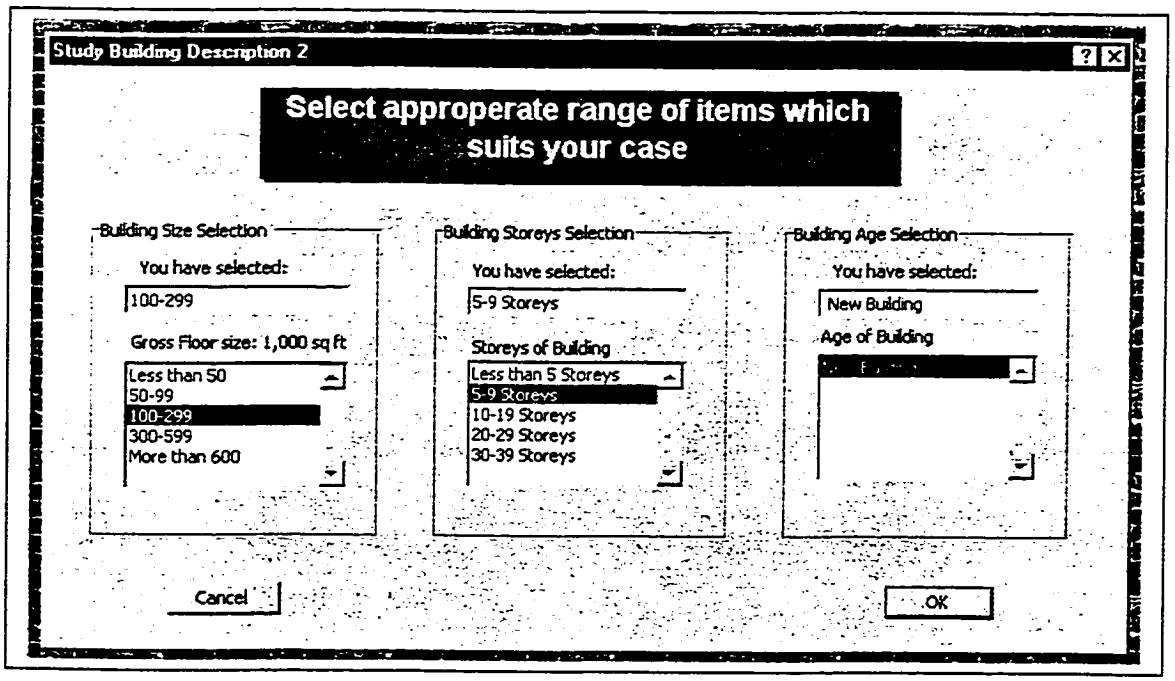


Figure 6 – 6 Description Data Entry

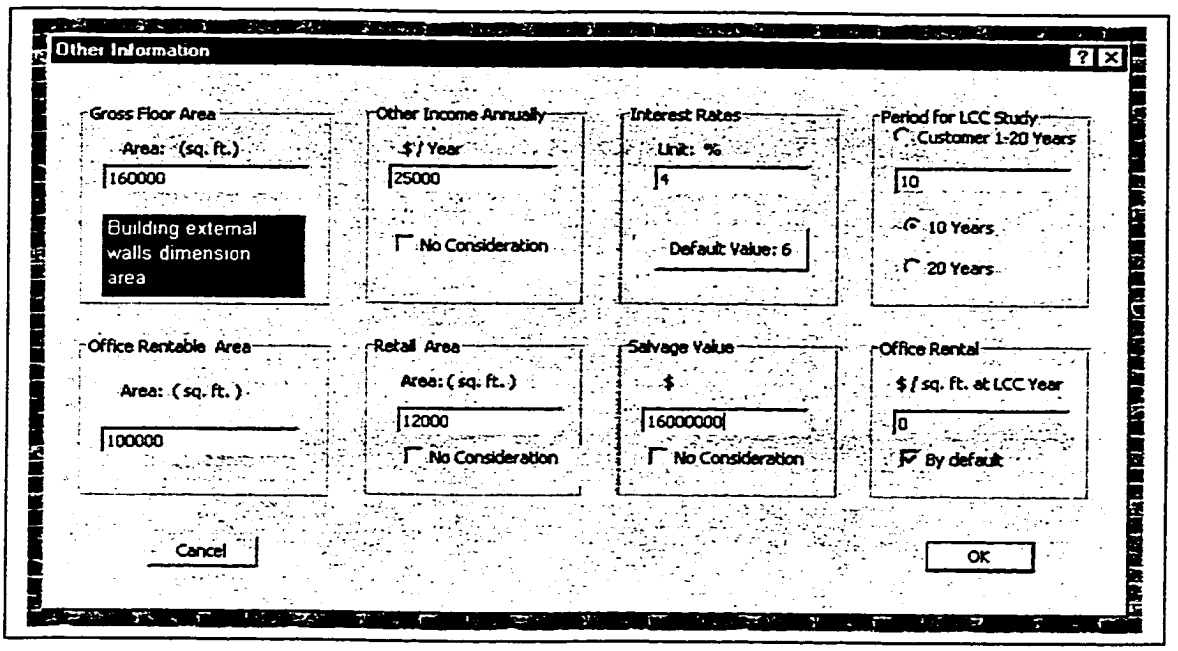


Figure 6 – 7 Evaluation Data Entry

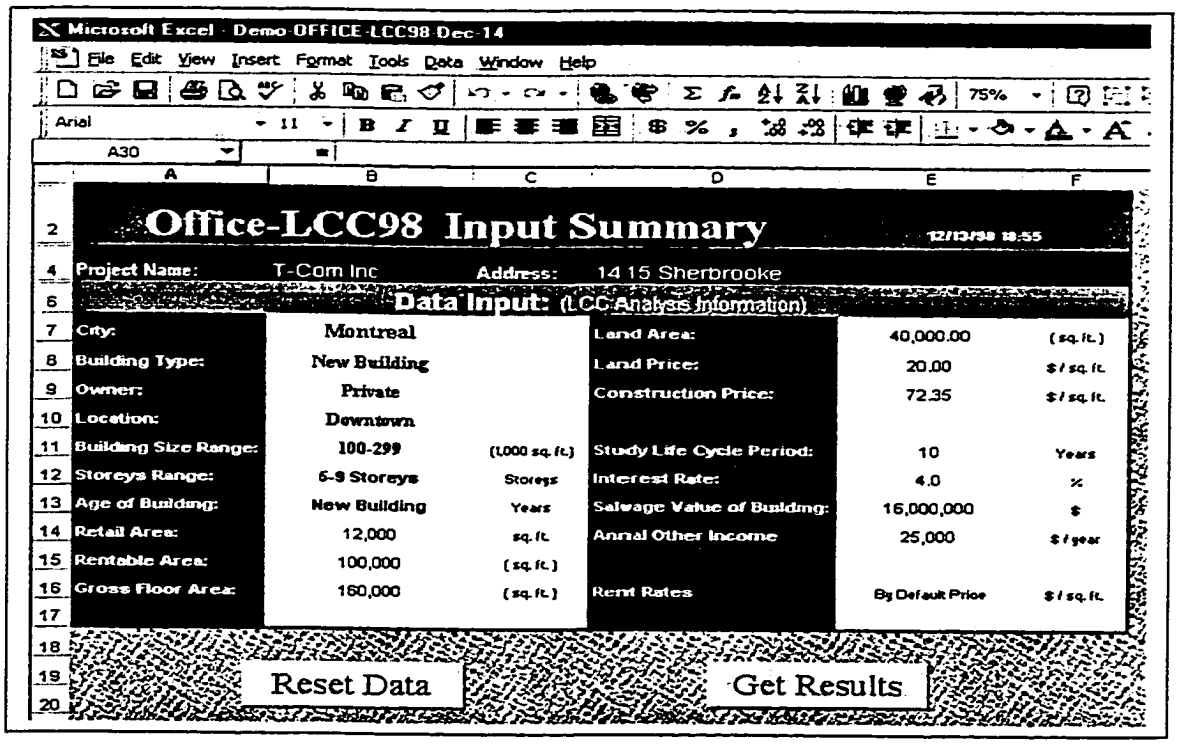


Figure 6 – 8 Data Entry Summary Interface

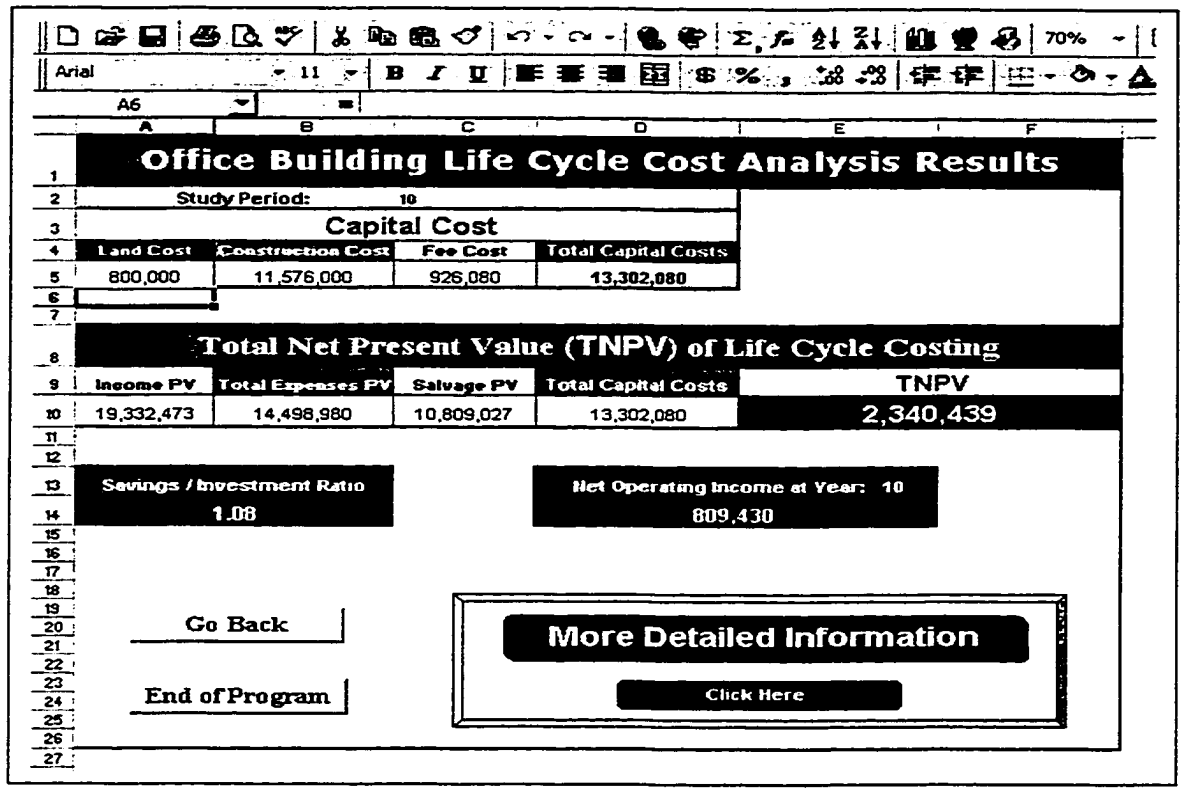


Figure 6 – 9 Results Summary

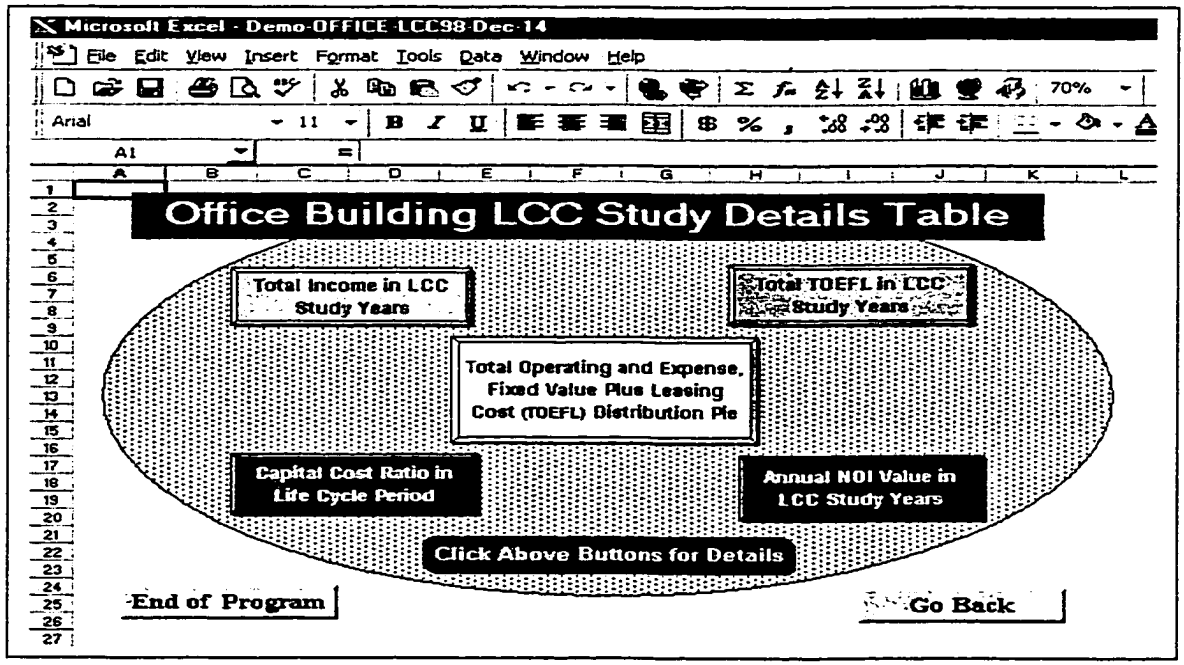


Figure 6 – 10 Details Results Control

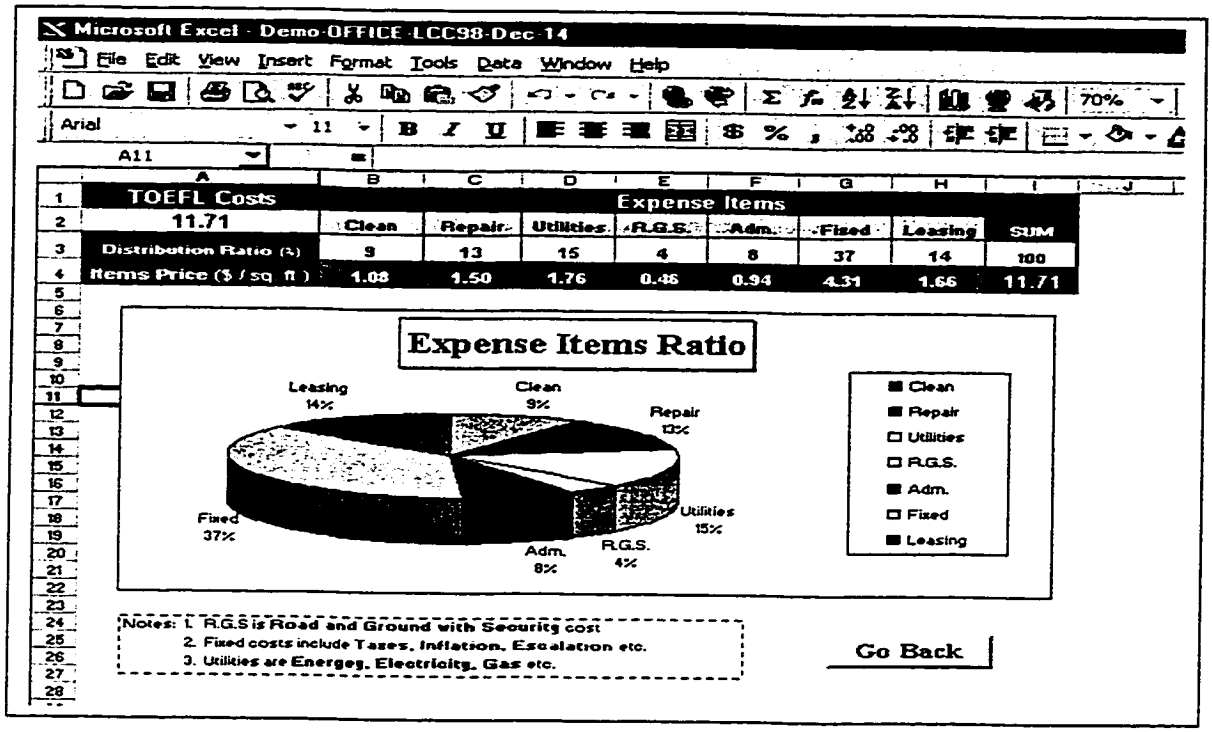


Figure 6 – 11 TOEFL Distribution Pie

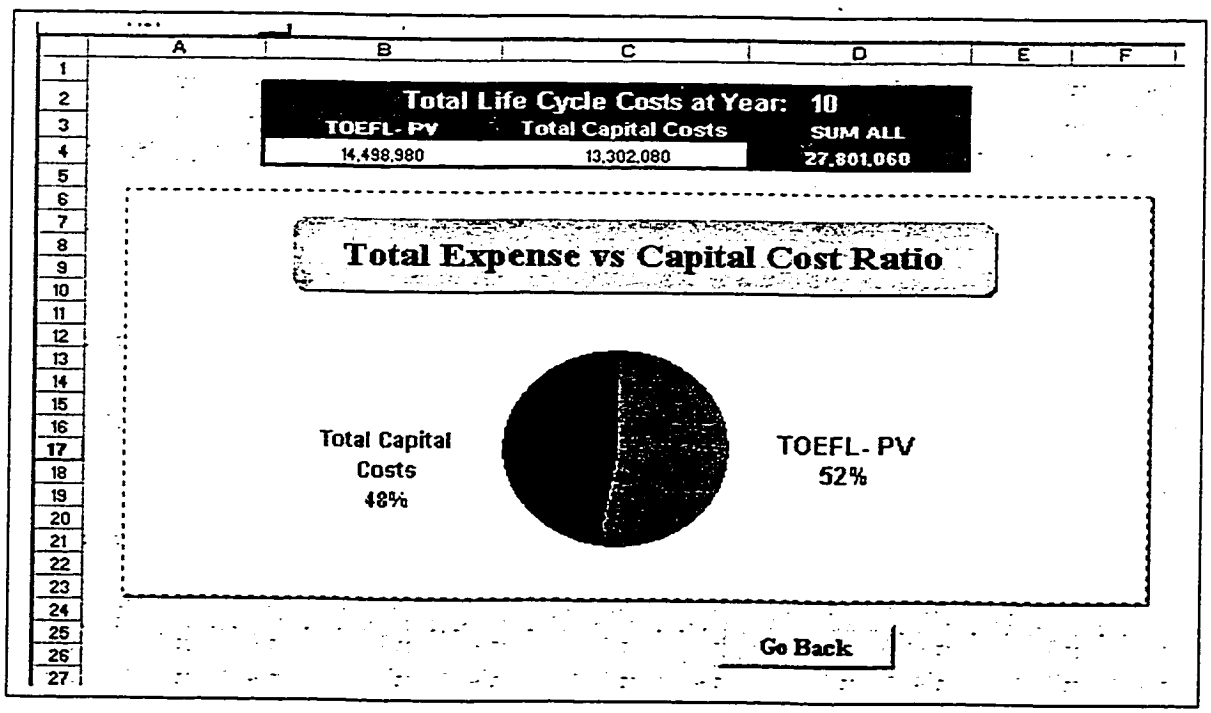


Figure 6 – 12 TOEFL vs. Capital Cost Ratio

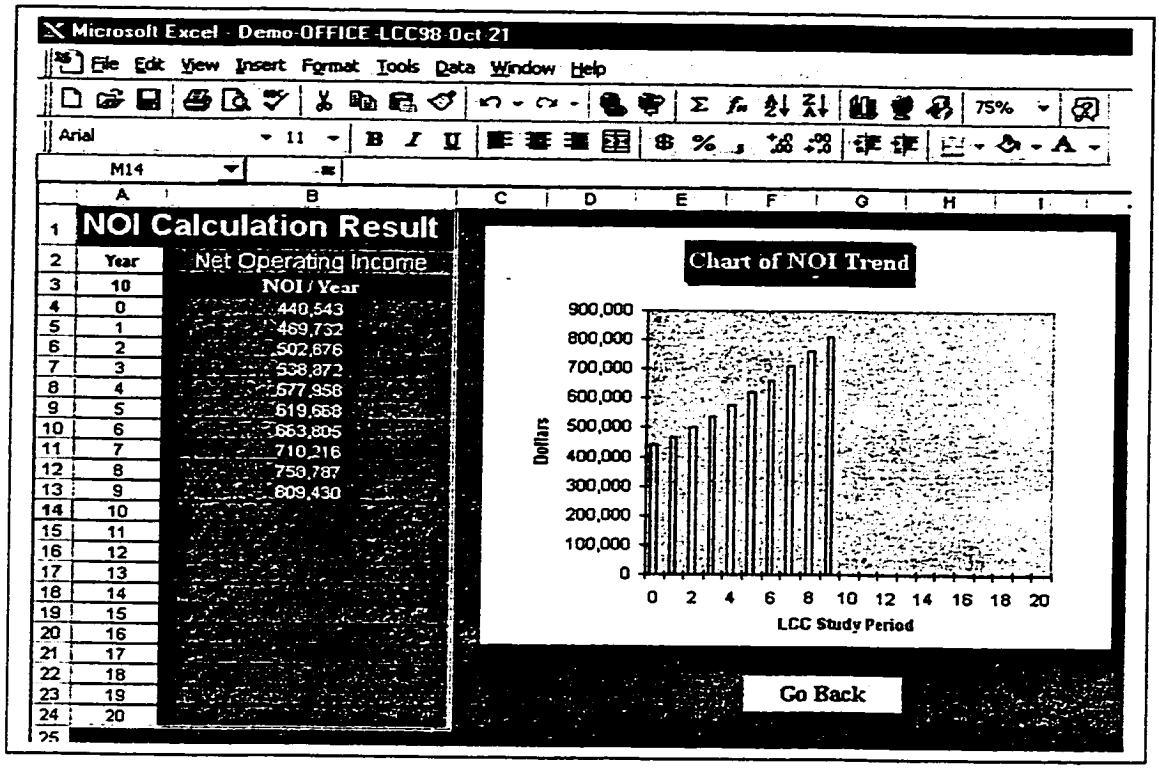


Figure 6 – 13 NOI Trend

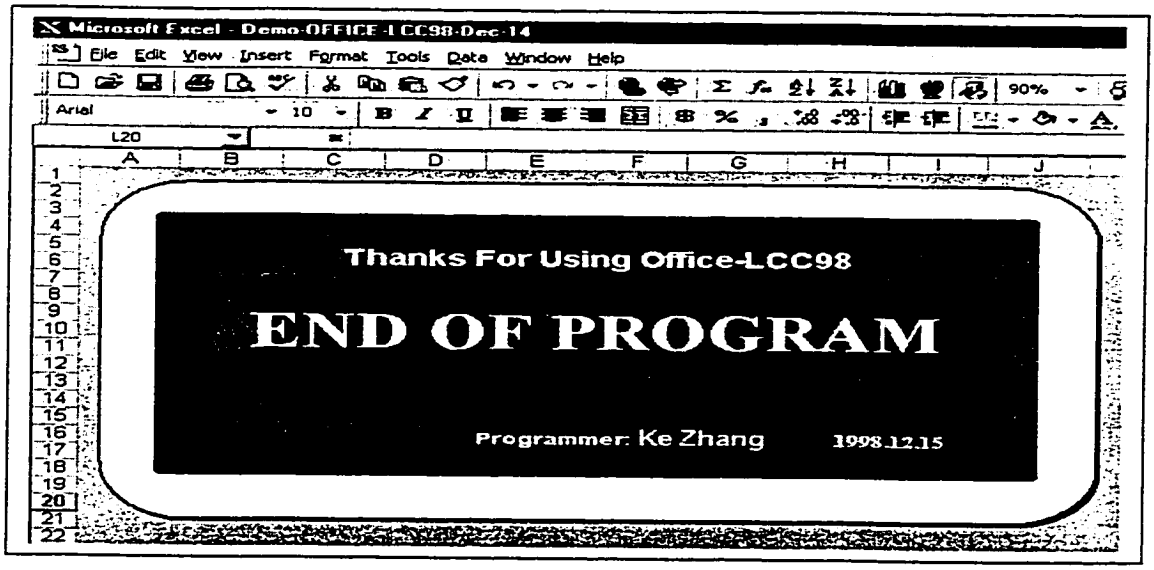
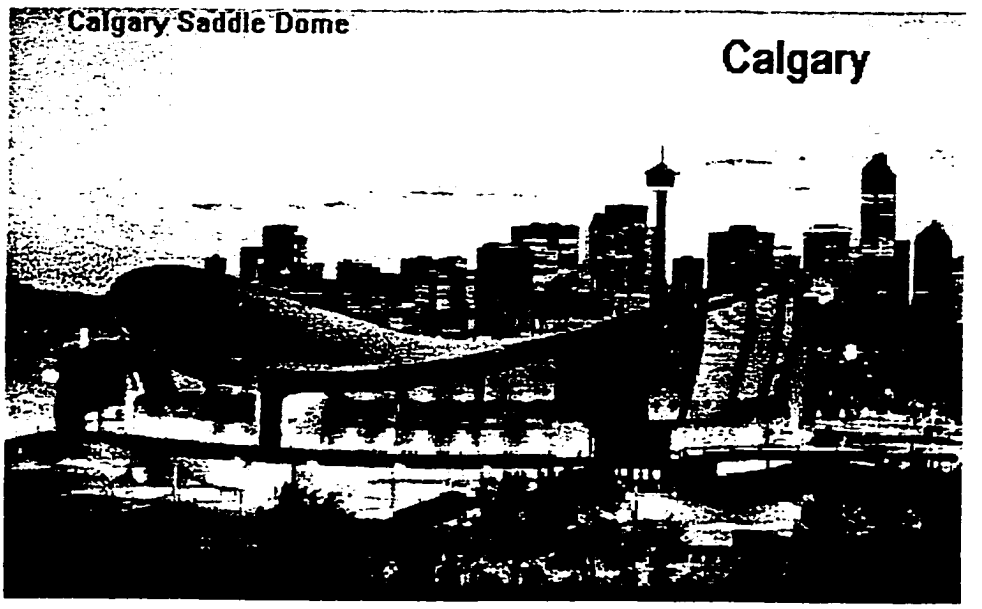


Figure 6 – 14 Ending Page

Chapter 7

Study with Results



City of Calgary

The more practiced, the more gained

Until now, the evaluating system (Theory + Technical methods + Carrying procedure) of applying a life cycle costing technique in the office building industry has been introduced and discussed. As intended, the total net present value (**TNPV**) has been drawn out by running the **OFFICE_LCC98** program, but it is not finished yet. There still remains many questions, discussions, and modifications. As mentioned in Chapter One, refining results is a necessary and important step in the problem solving procedure. This chapter will include the following:

1. Refining results - further exploring contents of research for extensive study
   - LCC analysis dynamic study
   - Study on building operating and maintenance expenses (TOEFL) items
   - Office building market investigation and analysis report
2. Applying results in RE practice - utilizing the LCC technique for property investment, development, assessment and management.
   - Income Capitalization Rate approach
   - Speculative office building development
   - Economic rental rates calculation
   - Yield Rate determination assumption

It is noticed that there are many RE concepts and terms used in this chapter. Reading Appendix 4 – "Knowledge Requisition" will help to understand them.

7 – 1 LCC ANALYSIS - DYNAMIC STUDY

Commonly, in LCC practice, dynamic study involves two parts: an uncertainty study and a sensitivity study.

7-1-1 Uncertainty and Risk Studies

Uncertainty refers to events whose probability of occurrence is unknown whereas risk is the name given to outcomes whose probability of occurrence is known. The LCC technique attempts to predict capital costs, future income and expenses, based upon uncertain information. Unfortunately, the future is full of uncertainty, particularly when development and technical innovation are necessary to the realization of the project. If all that change is the degree of uncertainty, the final results could be totally different. Risk analysis techniques can be used to identify the primary sources of potential surprises and their impact. Once this information system is established, it takes steps to change the design or specification of components, reducing potential uncertainties. Uncertainties and risks always exist, that is their nature. Therefore, taking them into consideration is a must.

In Chapter Five, uncertainties in data treatment have been discussed. It is true that there are too many uncertainties in real estate business. Investment and development in the real estate field involves taking big risks. The impact factors of uncertainty problems differ with location and time. In order to establish a risk analysis information system, the following lists the most direct impact factors when concerning uncertainty risks in OB LCC analysis: Economic environment, Interest Rate, Inflation, Taxation, Land cost, Construction cost, TOEFL and Rental income, etc.

7-1-2 Sensitivity Study

A Sensitivity study is a continuation of the study of the uncertainty problem. It is considered as part of a general risk management system. A Sensitivity study helps reduce the level of uncertainty. Sensitivity analysis techniques are used to evaluate the effects of different variables. Sensitivity analysis usually takes following components into consideration when in practice:

- The period of LCC analysis
- The interest and inflation rate
- The LCC analysis time span
- The various cost estimates
- The rate of tax

For instance, change in different interest rates to account TNPV over a long LCC study period is shown in Figure 7 - 1. Notice that Figure 7 - 1 also provides an Internal Rate of Return (IRR) value, which refers to the necessary interest rate required for the capital cost to be balanced against income to obtain a TNPV of zero.

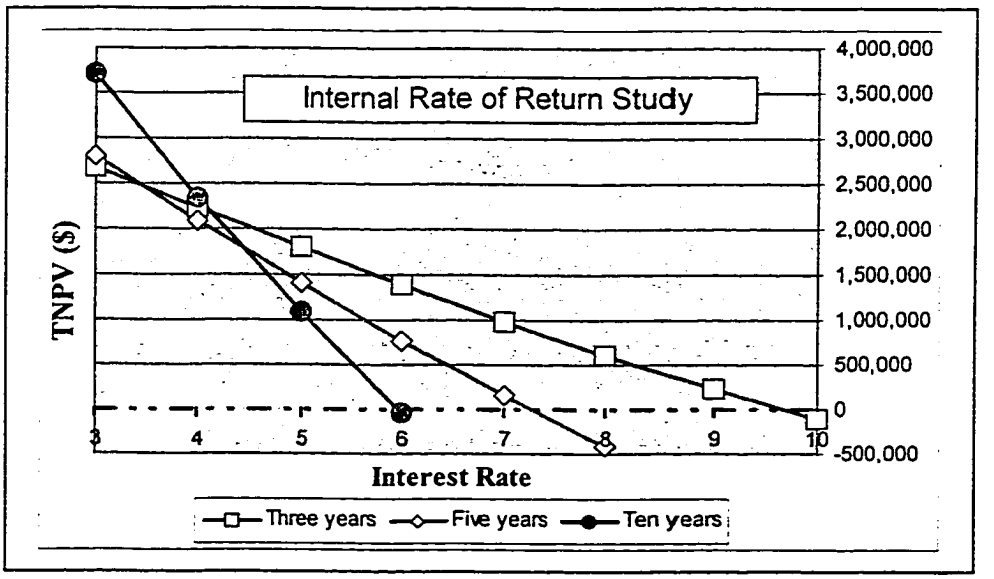


Figure 7 - 1 Sensitivity Study for Changing Interest Rates

Comments on Figure 7 - 1:

- Assigning an LCC period of ten years, the TNPV is a steep line (counterclockwise angle) , with the IRR at 6% reaching TNPV at zero point
- Assigning an LCC period of five years, the TNPV is a less steep line, with the IRR around 7.2% reaching TNPV at zero point
- Assigning an LCC period of three years, the trend line of TNPV is much less steep, with the IRR at about 10% reaching the TNPV at zero point

It should be pointed out that after several test runs are carried out by varying input parameters, the main finding from these runs is that "real discount rate or net of inflation discount rate" has a greater impact upon results than others when holding analysis period. The results show that net of inflation discount rate, which has been introduced in Chapter Six, section 6-5-1, is driven by the future uncertainty of inflation rates, and interest rates affect the results of a life cycle cost analysis considerably.

7 – 2 LCC FOR MANAGEMENT - STUDY ON TOEFL ITEMS

TOEFL refers to "**T**otal **O**perating **E**xpenses plus **F**ixed Value plus **L**easing Costs". Most office buildings have these expenses throughout their operating lifetime period. A study with TOEFL expenses will help office building property owners and managers better handle these costs, and this serves as one of the functions of an LCC analysis.

The TOEFL data regression trend line, shown in Figure 5 - 5, and forecasting formula, have been discussed in Chapter Five, 5-3-3. Appendix 1, Table AP1 – 9 presents the data collecting and sorting from BOMA EER (1988 – 1997). The TOEFL items distribution ratio is shown in Figure 7 – 2, which is from OFFICE_LCC98 running results.

TOEFL	Clean	Repair	Utilities	R.G.S.	Adm.	Fixed	Leasing	Total
%	9%	13%	15%	4%	8%	37%	14%	100%
$/Sq. ft.	1.06	1.47	1.73	0.45	0.93	4.22	1.62	11.48

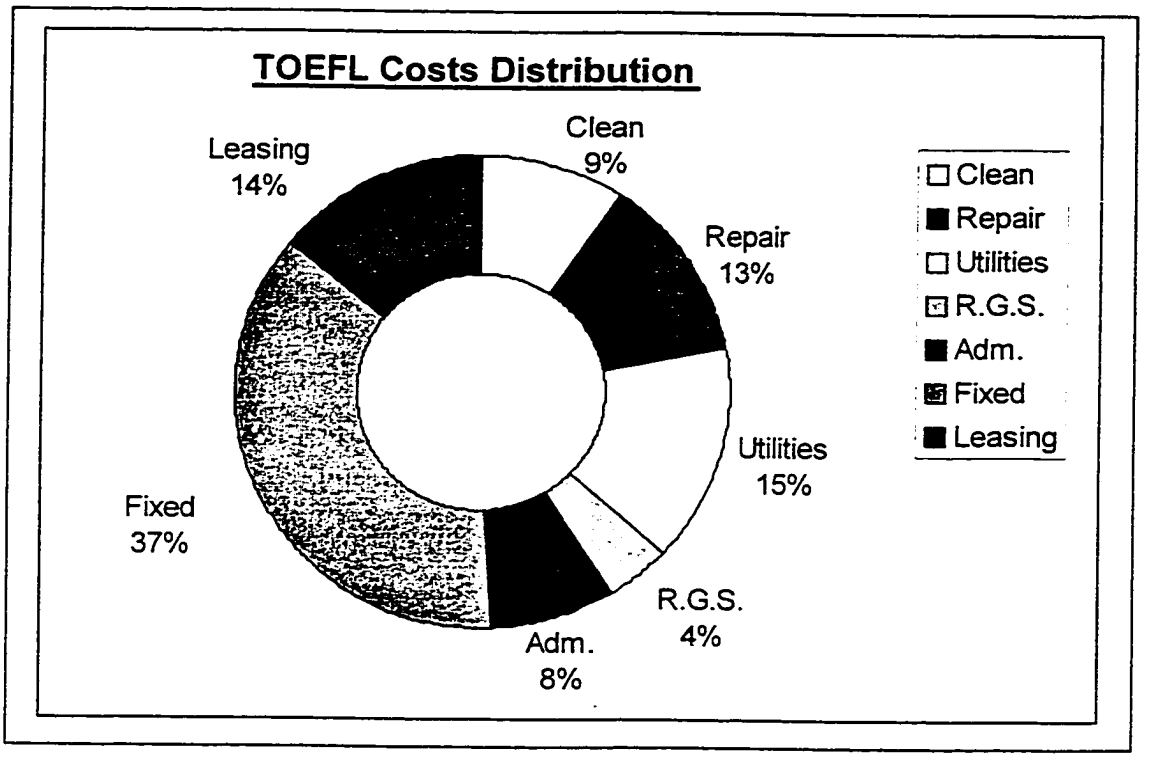


Figure 7 – 2 TOEFL Distribution Ratio

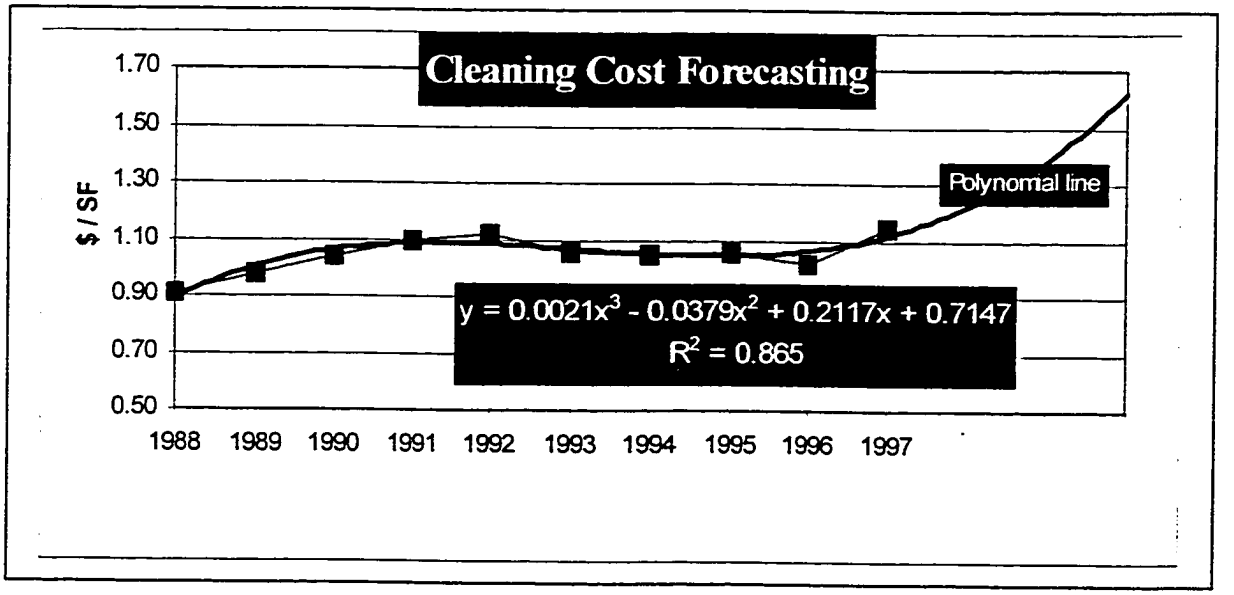


Figure 7 – 3 Cleaning Cost Prediction

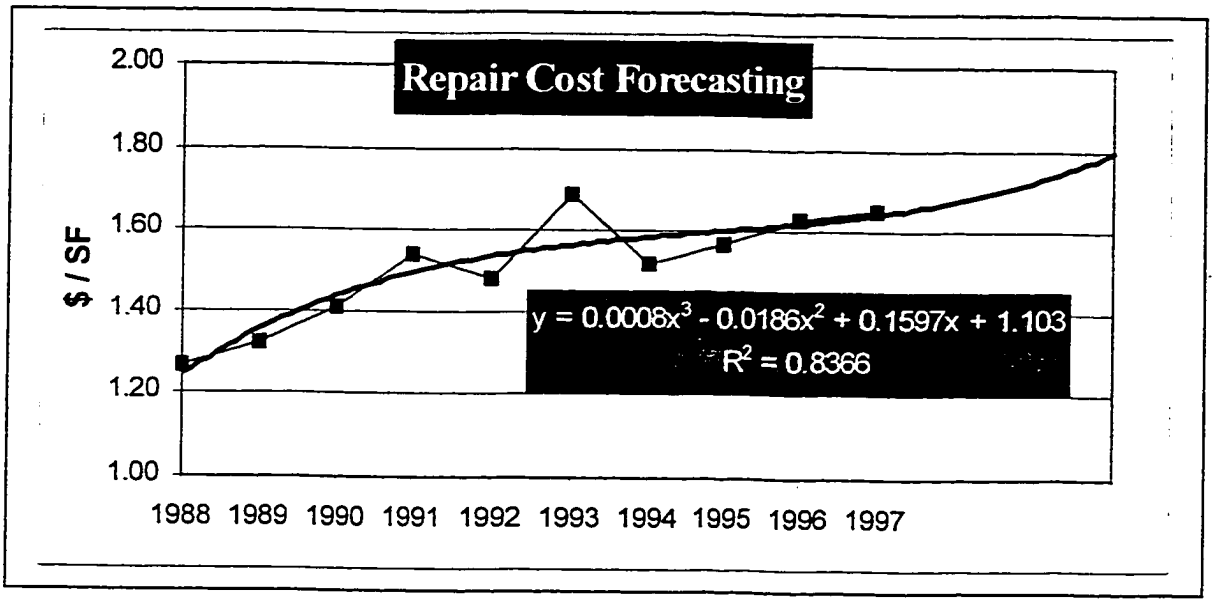


Figure 7 – 4 Repair Cost Prediction

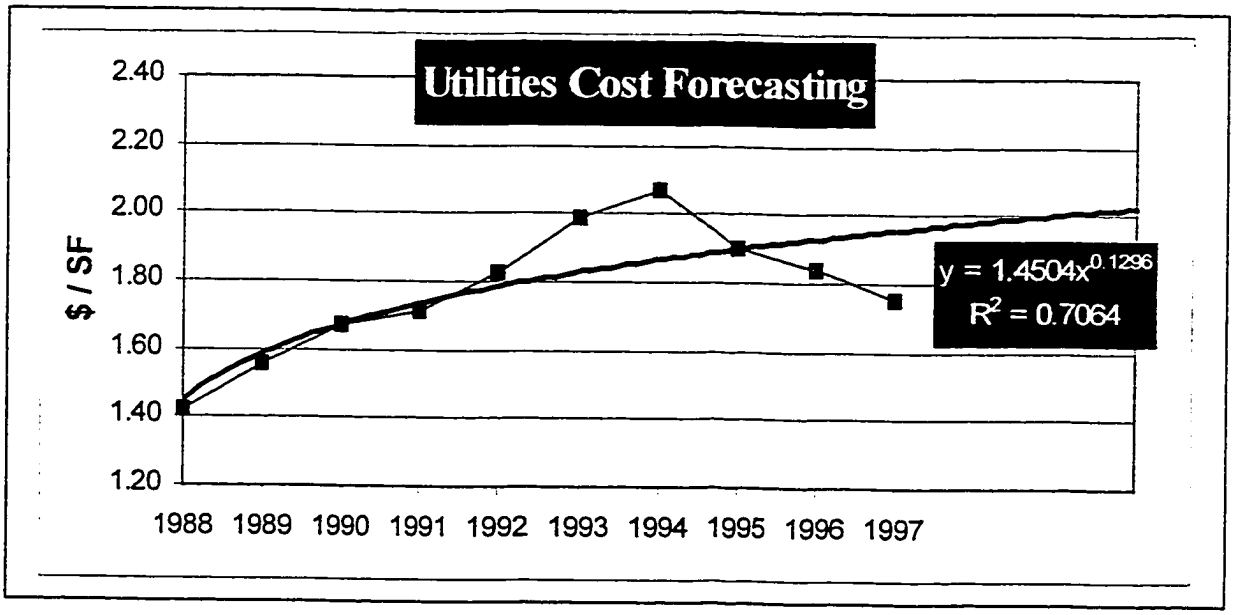


Figure 7 – 5 Utilities Cost Prediction

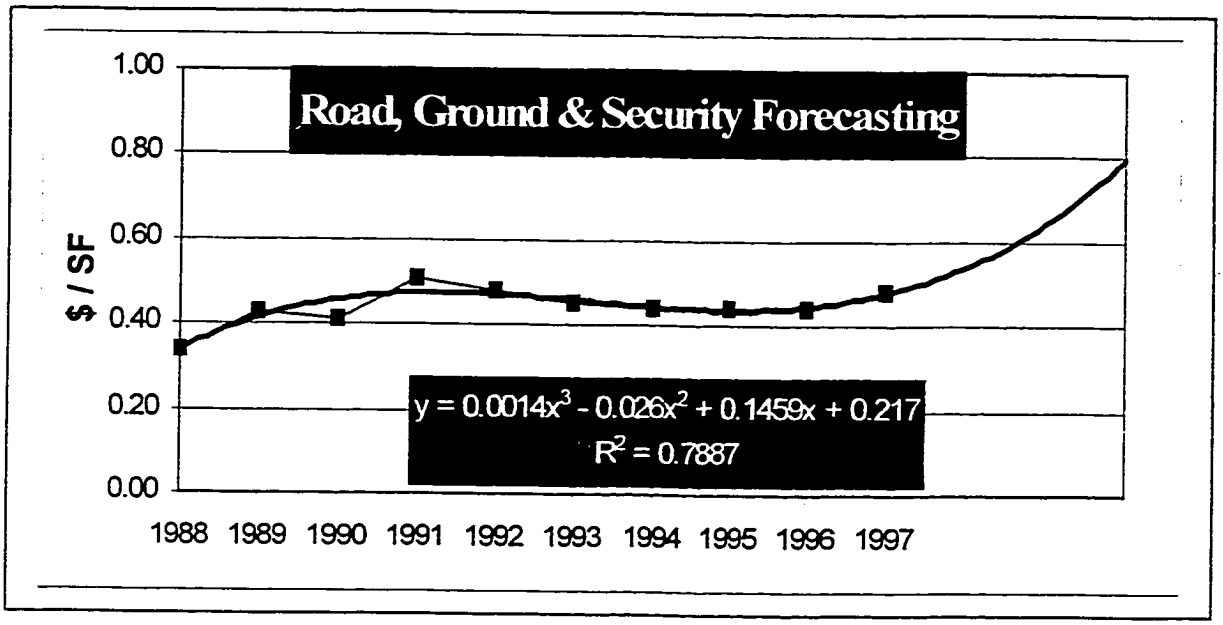


Figure 7 – 6 Road, Ground, Security Cost Prediction

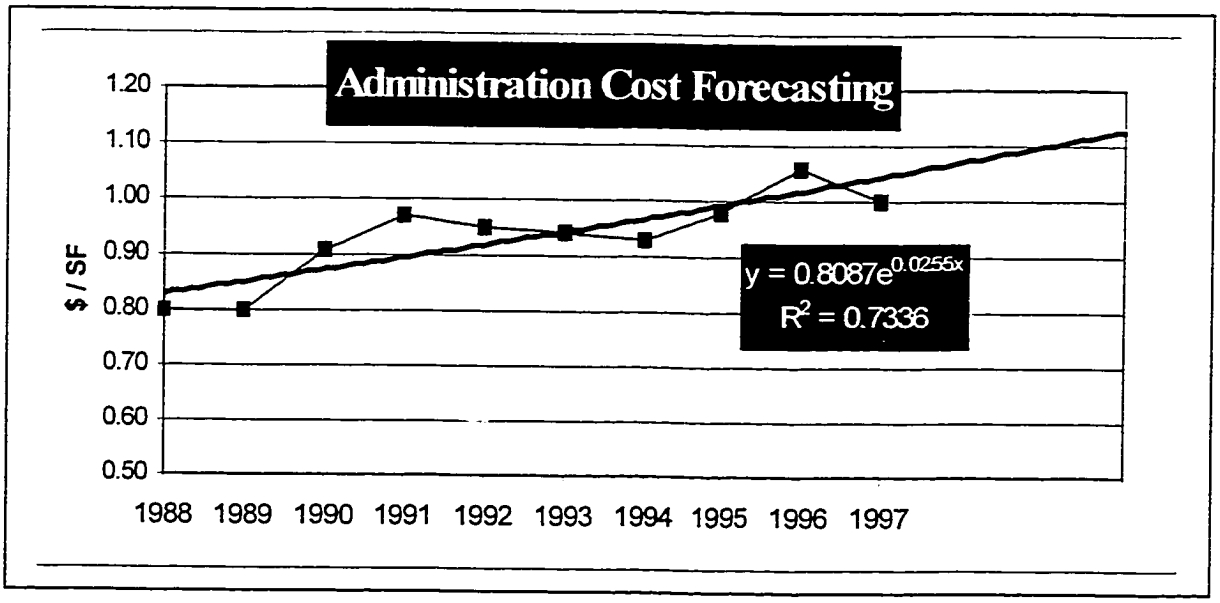


Figure 7 – 7 Administration Cost Prediction

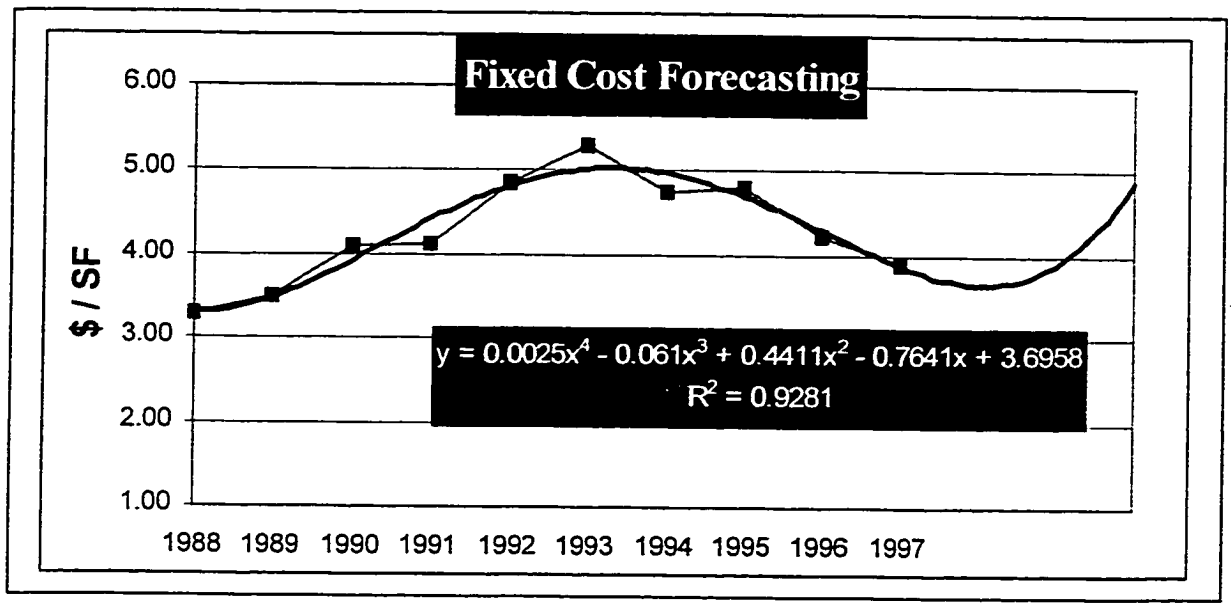


Figure 7 – 8 Fixed Costs Prediction

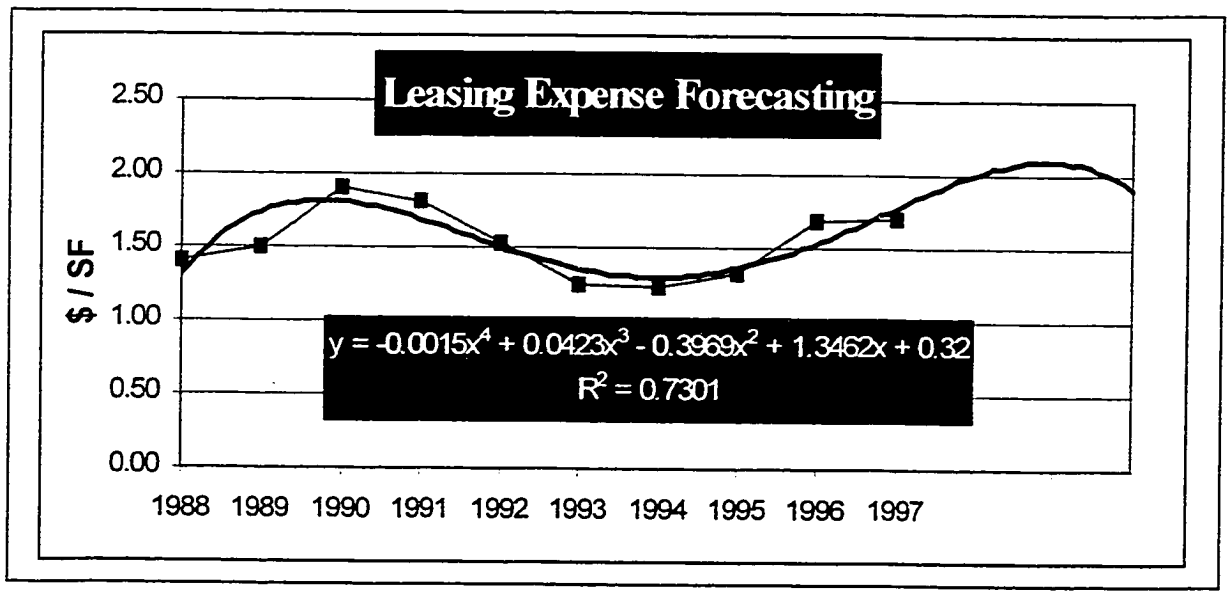


Figure 7 – 9 Leasing Expenses Prediction

Figure 7 – 3 to Figure 7 – 9 present individual TOEFL item trend line and its forecasting formula (prediction of next three years). Three points are notable:

1. Figure 7 – 2 shows that Fixed expense is about 37%, which includes real estate tax, building insurance, property tax, and other taxation. It is the largest percentage ratio in the total TOEFL value. Taxation is certainly a significant expense, and not only does it directly impact OB investor's profits, but is a variable affected by time and location. For example, in the 1980's, the Quebec Government collected business tax from business companies directly, but in the 1990's property owners have to collect the business tax from tenants themselves, then pay the Quebec Government. When tenants leave, this tax can be trouble for property owners. Normally, fixed expenses depend on the local business economical situation. For instance, Calgary taxation is higher than that of Winnipeg.

2. As stated previously, the principle of management strategy for a property is maximizing profits and minimizing expenses. Building owners and managers should want to do their best in reaching this goal. A convincing example is the large negative impact upon the Canadian office building industry during the recession period from 1991 – 1996. From Figure 5 – 5, TOEFL costs appear as a consecutively dropping tendency from 1993 ($12.67/sf) to 1997 ($11.69/sf), as shown in Table AP1 – 9. In this special period, the building owner and manager's strategy was:

   (a) Reducing TOEFL expenses

   (b) Attracting new tenants and retaining existing tenants

   (c) Saving money

3. As indicated in Table AP1 – 9, during the ten years period (1988 to 1997), TOEFL expenses have changed a little more than two dollars per square foot, which is much less than the amount of drop in the market rental income. It is a reminder that TOEFL cost is a solid part in the Gross Rent.

7 – 3 MARKET INVESTIGATION & ANALYSIS REPORT

Market analysis is a very important part of LCC analysis. An LCC professional's final adjustment is based upon market analysis and experience for cost prediction as discussed in Chapter Five. The office building market is not isolated in the society, but is part of the commercial building market as mentioned previously. The office building market connects with other categories in the building market, and is influenced by the local economical situation. To study an office building's life cycle costing, RE market investigation and analysis can not be avoided.

Market analysis is the identification and study of the market for a particular economic good or service. The market analysis components must specifically relate market conditions to the property under investigation. Following is a list extracted from a market analysis report, demonstrating investment potential for a certain place.

1) Economy recovery
2) Market upside investment potential
3) Evidence of sustain recovery
4) Improving operating
5) Vacancy rates down
6) Rent up
7) Population increasing
8) Employment rates growth
9) New industry sector
10) Tenant stability
11) People salary
12) Growth in local GDP

It is noted that although construction is cyclical and is not necessarily an indication of economic growth in the sense of the GDP, it nevertheless reflects an underlying economic activity and market demand. Certainly, it is significant that employment is the best measure index of the national and local economy. The following highlights the investigation and analysis of current Canadian OB market conditions.

National RE Market Scenario Glance

Since 1997, described as having had a dramatically improved OB market condition, all real estate markets and sectors have been characterized by increasing sales and leasing activity, tightening supply, rising rents and appreciating values. The outlook is for a full recovery in the near future, from the impact of the 1992 - 1996 recession cycle.

Montreal RE Market Situation

The Montreal OB market has currently caught up to the Toronto market. It appears to be very positive for RE in general, and demands for office space in particular. Local RE brokers describe the present situation as "crazy" (in the positive sense!). Prestige buildings are now leased with high a percentage occupancy rate and rental rates are rising. Asking face rental has increased by 8.1%, meanwhile, the net effective rate has increased by 15.4%. Class A building vacancy is 9.1%.

Local economy scenario: The unemployment rate is 9.9% in 1998. More details can be found in Appendix 3, Montreal OB market condition in 1998

Quebec City RE Market Situation

It should be pointed out that 43% of total office buildings in Quebec City are referred to as non-competitive buildings.

A recent general trend for Quebec City office market is a negative demand from the public sector, and a positive demand from the private sector. Class A building vacancy is 10.4% - a normal level. Asking face rental has increased by 7%, and inducement has decreased. The rental rate for Quebec City, Sainte-Foy is $17.27 / sf.

Local economy scenarios: The Province of Quebec Gross Domestic Product increased 2.4% in 1997. The Quebec City unemployment rate is 7.9% in 1998.

Interest Rates

- Interest rates in current value can be found from the Web at: http://www.canoe.com/MoneyRates/mortgage.html
- The Royal Bank has announced a prediction that interest rates and inflation will maintain a low level for the next two years (1999-2000).

Vacancy Rate and Rental Price

For a history of vacancy and rental rates for the provinces, refer to Appendix 3.

Land Cost

Montreal: West island: $8.5 / sf; Dorval: $4 – 5 / sf; Rosemont: $6 / sf.

Vancouver: $30 / sf from central business district; $6 / sf for suburban location

Toronto: $35-45 / sf for sale price in central business district.

Calgary: $4.24 / sf for land cost central district; $35-$45 for sale.

Edmonton: $4 – 6 /sf for served land

Winnipeg: $3 – 5 /sf for served land

NOI Tips

NOI refers to Net Operating Income. It is an important index in measuring investment profits. The following provides the NOI tendency, which is based on statistical analysis from BOMA EER and local RE companies reports.

- Downtown building NOI is higher than suburban building on average
- When building size is larger, the NOI is higher
- 300,000 – 600,000 sf. buildings have higher NOI value
- Tall building NOI is higher than lower building
- Amongst buildings aged 10 – 19 years, there is a decrease in the NOI value, meanwhile TOEFL is decreasing as well, although 30 –39 storey buildings remain unchanged
- With a building age in excess of 30 years, NOI value drops more than TOEFL does.

Balance of Demand and Supply

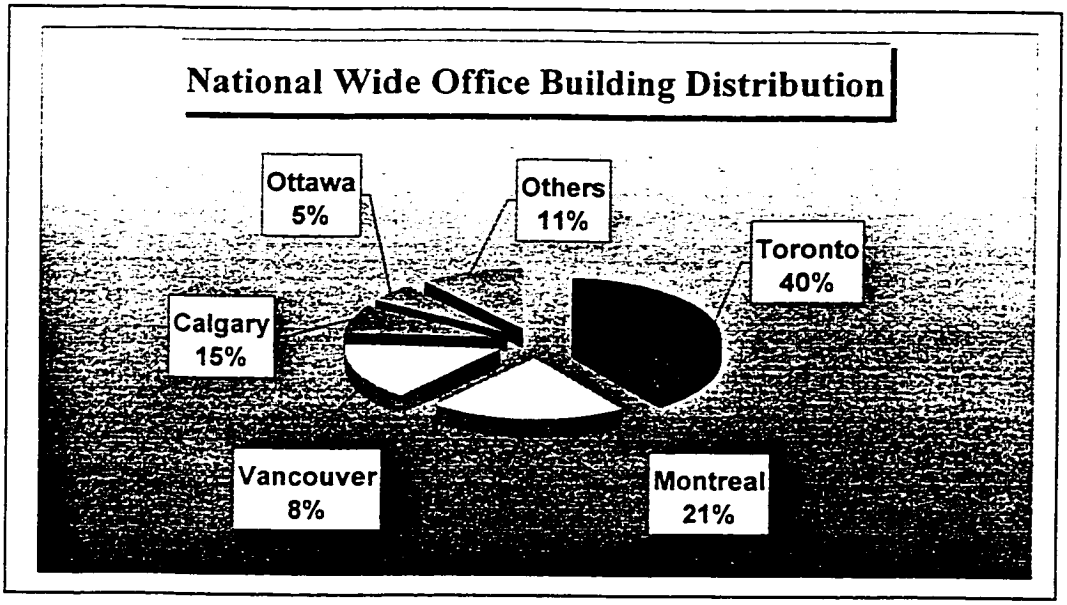
To summarize the situation of the early 1990s, office space demand in Canada peaked in 1987 at 13.3 million square feet, whereas developers continued to build office buildings until 1992, peaking at 14.8 million square feet in 1991. Demand began to fall as prices rose in the late 1980s and then demand for space virtually stopped for a two-

year period, and has slowly rebuilt over the 1992 – 1996 period. In 1997, demand returned with a vengeance and caught developers and those who finance them flatfooted. As table 7 – 1 indicates, 1987 Demand/Supply Ratio is 1.48, and in 1997, the demand is 121 times that of supply - a huge gap. The consequences of reaching this new balance are many: new development, rising rents, location alternatives that allow for the choosing of a place with lower taxes, or other alternative staffing models, such as working at home, hotel etc.

Table 7 – 1 Demand / Supply Ratio

Canadian Office Space Market Demand and Supply			
	Demand	Net New Supply	Demand/Supply Ratio
1987	13,300,000 sf	9,000,000 sf	1.48
1997	8,500,000 st	70,000 st	121.43

National Wide Office Building Distribution Ratio



Other RE Information

Other RE information, which is useful for LCC application, can be found in Appendix – 3, such as Effective Rental Rates, Major Investment Transactions by cities, Capitalized Rates in the Central Business District (1997) etc.

7 – 4 INCOME CAPITALIZATION RATE APPROACH

In preceding Chapters, the LCC for OB evaluating components, such as Net present value, Net operating income (NOI), Rent contents, Income and expenses (TOEFL), Capital costs (land, construction costs), Cash flows, Time value of money etc. have been introduced and applied in the present research.

In the RE field, capitalization of income methods for investors are most likely to be used for estimating property value. The income capitalization approach is typically used in market value appraisals of income-producing property. It assumes that an investment property's value bears a direct relation to the property's ability to throw off net income (NOI). LCC analysis is a fundamental part in the decision-making process. Therefore, combining an LCC technique approach with the capitalization rate approach in RE practice will be more effective for RE decision making.

Mathematically, a property's simple capitalization rate is the ratio between its net operating income (NOI) and its present value (market value here) shown as E7 - 1.

Capitalization Rates = NOI / Present Value (E7 – 1)

*** Appraisal Institute, (1992)

The Capitalization rate can be used to predict a property's future value. Example: Assuming a property generates NOI of $27,000 per year, and a new buyer requires a 9% rate of return (capitalization rate), then this property will estimate a resale price of $300,000.

To repeat again, NOI is the actual or anticipated net income remaining after all operating expenses are deducted from effective gross income, before the mortgage debt service and book depreciation are deducted. The mathematical expression can be described as E7 – 2.

NOI = Gross Office Rental Rates – Lease Inducement – TOEFL (E7 - 2)

*** Appraisal Institute, (1992)

It is noted that the income capitalization rate approach may also be used to estimate investment value, which is the value of a property to a particular investor. Market value and investment value may correspond if the client's investment criteria are typical of investors in the market. In this case, the two value estimates may have the same number, but the types of value are not interchangeable.

Market value is objective, impersonal, and detached. Investment value is based on subjective, personal parameters. There are three modifications, which are derived from the capitalization rates equation E7 – 1, used for different estimating purposes.

7-4-1 RE Assessment

Present Value = NOI / Capitalization Rates (E7 – 3)

*** Appraisal Institute, (1992)

Equation E7 – 1 can be deducted from E7 - 3 for property current market value evaluation. In this case, the LCC technique is the best way to obtain the Capitalization Rate.

7-4-2 RE Investment

Resale Value = NOI / Yield Rates (E7 – 4)

*** Appraisal Institute, (1992)

For property investment estimating purposes (resale or purchase), Equation E7 – 1 can be converted to equation E7 - 4. It sets Capitalization Rates as Yield Rates that reflect expected money return rates to the property owner when conducting a property transaction. Present Value is set as Resale Value (or sale price), which is a prediction of a property's current value. For instance, if a property generates NOI as $10,000 per year, and expected money return rates (yield rate) is 10% per year, then the resale value is $100,000.

It is noted that the Yield Rate applied here is a subjective assumption that is the expected return on the investment in a project. High return as an attractive tendency is the developer's target, even if the developers have no desire to operate the building. Attractive yield can make the building sell more easily. Most developers will build for

profit, which is a 15% yield rate representing the average expectation on an equity investment, from a sale on completion of construction. Any yield below the rate of return from Treasury Bonds or simple bank interest will discourage investors from the project. A 20% yield rate is a typical favorite target return for development for developers to undertake a construction risk, while their purchasers would not want to take risks associated with construction. In order to reach this high return, developers should first ensure that there are prospective tenants, who will provide the income, and secondly, to make buildings that can be sold as early as possible. In this case, purchasers must be attracted by a secured income.

Capitalization Rates can be determined by Treasury Bonds, gilt's, or local Interest Rates. A detailed calculation of Yield Rate is referred to in Appendix 4, section AP4-1-5.

7-4-3 RE Development

Development Cost = NOI / Yield Rates (E7 – 5)

*** Appraisal Institute, (1992)

E7 – 5 is another variation of E7 – 1 for investment value estimation. It can be used for a project feasibility study or for the purpose of calculating rent. The following two examples will incorporate the application of E7 - 5 in RE practice.

7-4-4 Example One – Speculative OB Development Feasibility Study

A speculative building definition can be found in Appendix 4. The conditions of constructing speculative OB should be:

1) Strong economy
2) Vacancy rate is low
3) Good location

The following example is a preliminary feasibility study using E7 - 5. **Total Capital Cost,** taken from section 6 – 7 *Launching OFFICE_LCC98* in Chapter Six. Note that **Lease Inducements** do not apply in this example.

Example One:

Total Capital Costs: $ 13,302,000 (Land plus Construction costs)

Developers profit 20%: $ 2,660,400

Sale Price: $ 15,962,400

Yield rate required by purchaser: 10.5% (see section 7 – 4 for detail)

NOI required from tenants = 10.5% × $ 15,962,400 = $ 1,676,052

If total rentable area: 112,000 sf

Net rent rate: $ 1,676,052 / 112,000 sf = $ 14.96 / sf

If TOEFL is $ 10.75 / sf, then making Gross Rent = 14.96 + 11.75 = $ 25.71 / sf

Round up: $ 26.00 / sf

This rental price can be currently applied to the Toronto, Vancouver and Montreal downtown Central Core class A office building market.

7-4-5 Example Two - Economic Rent Calculation

This example refers to *Desjarlais Prevost Inc.* appraisal "Montreal Office Market Analysis and Forecast" and introduces the calculation of required economic rent for a downtown Montreal, Class A building.

Project description: the building is an 8-storey high, concrete structure, located near a metro station. The net site area is 40,000 square-foot. Total above ground potential area: 120,000 sf. A parking capacity of 40 cars externally, and 100 cars internally. First

floor is used for commercial purposes, the above seven floors used as office space. The commercial rentable area is 12,000 sf and Office rentable area is 100,000 sf. Land cost is considered at the 1986 level of $20 / sf. Construction costs: parking: $27.02 / sf, commercial: $78.81 / sf and office: $67.55 / sf. Construction duration is ten months. Professional fees are 7.5% and development fees 4% of total construction costs. Development Yield Rate is considered as 10.5%. Calculation of Yield Rate can be found in Appendix 4, section AP4-1-5.

Development costs (1999 delivery)

Development costs:	Unit: per sf of Rentable Area
site-related	$0.44
construction	$88.77
professional fees	$6.66
leasing (excluding inducement)	$5.15
financing	$0.91
others(including tax on capital)	$1.83
interest (7.5%)	$4.42
development fees (4% of construction)	$3.55
	$111.73

Development costs influenced by market conditions:

Site	$7.14	
Interim financing of site	$0.46	
Capitalization lease-up costs	$4.39	
Inducements (including lease takeovers and free rent)		$39.20
	$51.19	

Total development costs	**$111.73 + $51.19 = $162.92**
Required development yield	10.50% (*** see appendix 4)
Net Operating Income required	$162.92 × 10.5% = **$17.11**
Plus: vacancy and non-recoverable	$1.57
Minus: non-office income	
Parking	$1.56
Commercial (in excess of office rent)	$0.73
Average office rent required:	**$16.38**
25% major tenants	$13.00
75% non-major tenants	$17.50

This example provides detailed information on determination of economic rental rates for speculative office building investment and development. Here, "**Average office rent required**" is the effective net rent. If considering cost of TOEFL at $10 /sf, this will make the major tenant a Gross Rent of $23 /sf and others $27.5 /sf. The meaning of rental terms can be found in Appendix 4.

It is noticed that **yield rate** calculation can refer to Appendix 4, section AP4-1-5 "Yield Rate Assumption For OB Investment".

7 – 5 LCC APPLICATIONS IN OFFICE BUILDING BUSINESS

There are many different parties involved in an OB endeavor, and certainly, they have different requirements and interests. The LCC technique is a fundamental part in the decision-making function. It can provide precise calculations, and generate numerical

results, which can satisfy people's requirements and confidentiality. Following are the requirements from people in the RE field:

Basic RE requirements

- Low cost
- Locality
- Prestigious building
- Functionality

Tenants

- Location
- Facilities
- Prestige
- Terms of lease (costs, review periods)
- Running costs (TOEFL)

Developers

- Make money fast
- Buy low
- Sell high
- Increase yields
- Attract potential tenants

Institutional investors

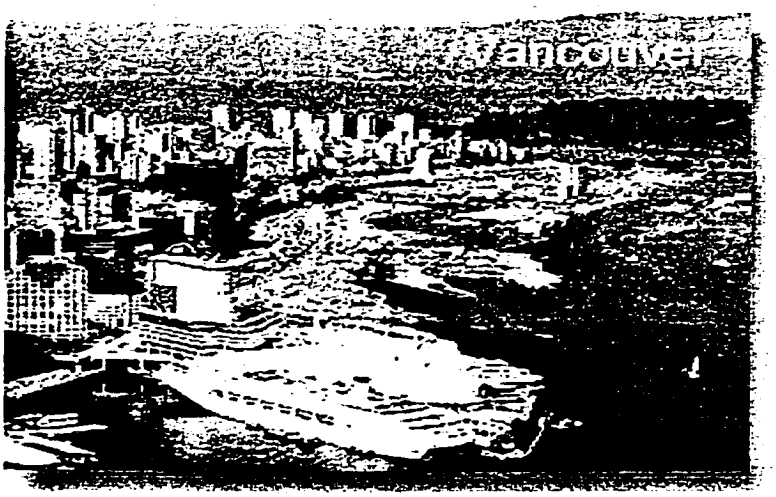
- High yield
- Long lease
- Low management cost
- Secure and happy tenants
- High retained value of building
- Frequent upwards-only rent reviews

Public sector (Government)

- Building functionality
- Cost effectiveness
- An audible decision making process

Chapter 8

Summary, Contributions & Future Work



City of Vancouver

The Work is never finished

As Statistics Canada's reports, office building consumes more than 40% of capital expenditure in the Commercial Building market each year, ranking it number one in this sector. Therefore, a study of office building economic performance is significant and meaningful.

This research, **"Life Cycle Costing for Office Buildings in Canada"** has been carried out with emphases on investment, development, assessment, management and function of preliminary design stage decision-making at the early stage. A computing model titled **OFFICE_LCC98** has been developed to assist LCC practitioner and individuals involved in commercial real estate profession to make better decision.

8 – 1 SUMMARY OF THE WORK

The following work has been done in the present research:

1. Reviewed Literature of the LCC theory and applications in industry
2. Established an OB evaluating & decision-supporting system using the LCC technique
3. Developed LCC for OB analysis model and methodology
4. Designed quick and inexpensive computing model for OB investment, development, assessment and management decision-making at the early stage
5. Set up an OB data treatment system

6. Measured TNPV value of all relevant costs, such as land, fees, construction cost, income, operating and maintenance cost, replacement cost, salvage value and resale value etc, associated with an OB lifetime.
7. Studied the Canadian office building market and other related industry
8. Collected, sorted, & analyzed a great deal of data from different sources:
   - BOMA International *Exchange Experience Report* (1982 - 1998)
   - *Montreal Office Market Analysis and Forecast* (94-98) from DPA Inc.
   - *Statistics Canada* (52-98)
   - *Means Assemblies Cost Data* (87-98), *Construction Cost Manual* (87, 90)
   - *Annual Marketing Report*: Royal LePage Commercial Inc. JJ. Barnicke Inc.
   - *Quarterly Report*: Colliers International, Smith Inc., Office Buildings Magazine
   - *Market reports*: eSpace, CB commercial, CMHC, RE/MAX,
9. Built up a database management system and designed a data communication system through the WWW network
10. Constructed an information network; Established OB income & expenses database
11. Contacted the government agency (CMHC), local RE companies, as well as BOMA International Inc. Conducted surveys (questionnaire) via e-mail, Internet, telephones and interviewed with businessman, lawyers, accountants, architects, engineers, etc.
12. Practiced Statistics, Financing elements Modeling, Data regression, Costs forecasting, Dynamic study - uncertainties (risks) & sensitivity factors analysis
13. Designed the **OFFICE_LCC98** software, which provides numerical & graphical results

14. Assigned examples to explain a speculative OB investment, development, assessment and determination of the economic rental rates in RE practice
15. Combined the LCC technique with traditional RE appraisal methods for OB evaluation
16. Discussed results, risk warning, uncertainties and sensitivity factors
17. Made recommendations on RE business requirements by applying LCC concept
18. Set reference for other commercial building evaluation

The following concludes few key points that has been identified from this research work:

- In order to reduce risks and uncertainties, breaking down the whole project into as many pieces as possible improves the accuracy and efficiency of the LCC technique.
- LCC is a cost-effective assessment technique.
- The LCC approach is a mathematical process. Providing numerical results is one of its features
- The LCC technique is a cost-oriented method, which uses an "engineering" approach
- Property assessment may take long time and can be expensive. A quick and inexpensive estimating model is needed for certain requirements.
- This research employs the LCC technique for application in the OB industry. Similarly, the methodology and computing model can also be applied for other commercial buildings such as shopping centers, apartment buildings, hotels, etc.
- The potential benefit of the LCC application is in management system functions. It includes long-range planning, budget, and cost control over an ongoing program

- Taking LCC technique advantages when the assets have short life with high TOEFL expenses characteristics
- The LCC time horizon is better 3 - 5 years for commercial property evaluation
- Extending historical cost data through current data for predicting future is not essential to the implementation of LCC, and can actually be misleading in some case
- In practice, non-quantified variables introduced during the project lifetime will eventually extend or foreshorten the project life that makes an LCC calculation potentially invalid. The updating of the LCC equation throughout the life of the project has considerable merit
- **Systemized** & **standardized LCC regulation** should be legislated in the National Building Design Code

8 – 2 CONTRIBUTIONS

- LCC evaluating model for OB has been developed
- Projected objectives have been accomplished
- Access of utilizing engineering approach to RE business has been set built
- Data collection and treatment methodology have been developed
- Reference for Commercial Building evaluation has been set
- LCC standard and its applications to construction industry in different countries has been studied

8 – 3 FUTURE WORK

Firstly, LCC analysis fully relies on data, and shall be ineffective if the data is out of date. This maintaining of up to date data is crucial. Today, Web networks have been developed rapidly. Automatically updated LCC database is the next step.

Secondly, there is a lack of replacement cost database. This cost item has not been seen in the regular OB market report, seeming not to pay more attention to this cost. But, eventually, replacement cost is significant for LCC practitioners and property managers. To clarify the replacement cost on LCC reports is advantageous and practical.

Thirdly, **OFFICE_LCC98** is a demo software package to assist LCC analysis. Following functions should be added later:

- Making it works directly on WWW network
- Providing the calculation of OB economic rental rate, resale value, Capitalization rates etc.

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The project completed in Beijing, China,
when I was a structural engineer in 1989.

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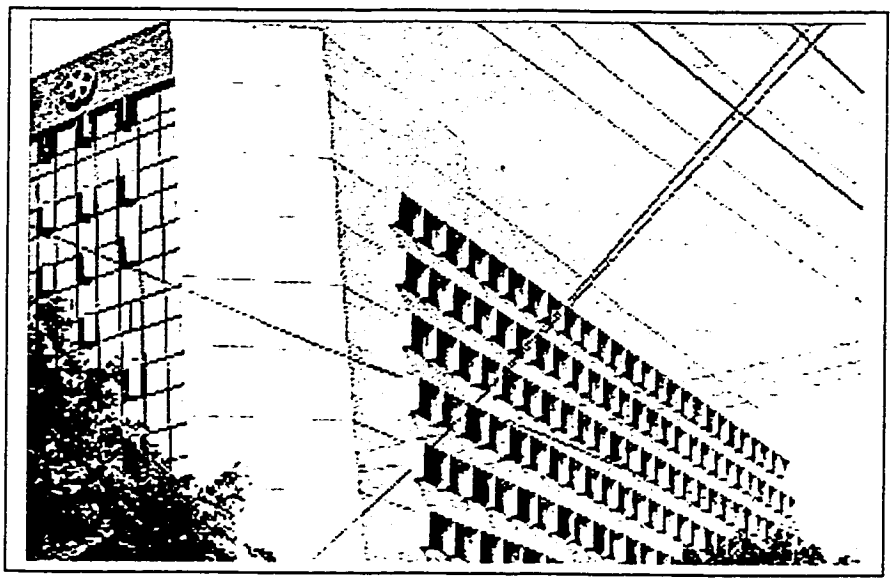
Appendix 1

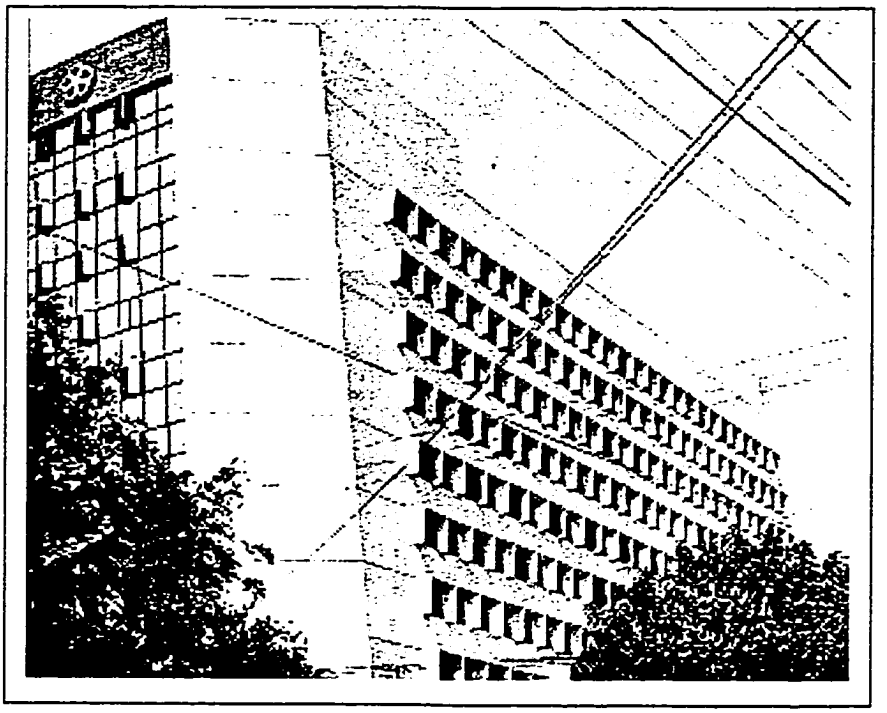
SAMPLE OF DATA TREATMENT



My Project in Shan Dong Province, China (1984)

Appendix 1

SAMPLE OF DATA TREATMENT



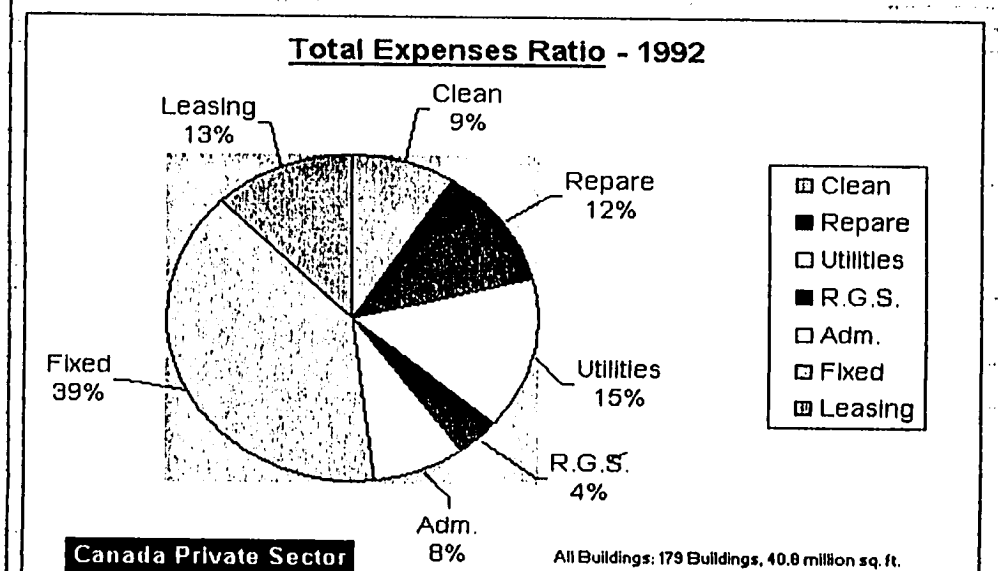
My Project in Shan Dong Province, China (1984)

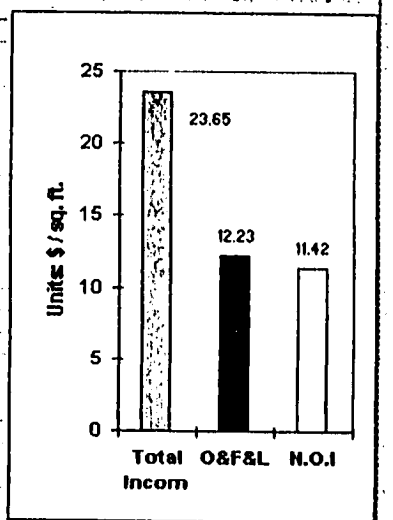
Data Treatment Samples

Sample of Data Collecting – Sorting - Analyzing – Forecasting

Table AP1 – 1 (5) *** Number in ( ) indicates table or figure used in chapters

DATA COLLECTING & SORTING From BOMA EER-1993 by Ke Zhang, 22 Aug, 1997





1	Total Incom	23.65
2	TOEFL	12.23
3	N.O.I	11.42

ALL BUILDINGS-1992 $/ sq. ft. 179 BLDGs

Income			Expense								
1	2	3	1	2	3	4	5	6	7		
Office	Retail	TI	Clean	Repare	Utilities	R.G.S.	Adm.	Fixed	Leasing	TOEFL	NOI
23.63	25.8	23.65	1.12	1.48	1.83	0.48	0.95	4.85	1.53	12.23	11.42

Table AP1 – 2 (5)

DATA COLLECTION From BOMA EER-1993 by Ke Zhang, 22 Aug, 1997

City Factor and Location Factor

	City	Private 1992							
		Downtown				Suburban			
		TI-d	ICF	TOEFL-d	ECF	TI-s	ILF	TOEFL-s	ELF
0.01	All Canad	23.65	1.01	12.23	1.09		0.00		0.00
1	Vancouve	24.59	1.05	12.63	1.13	18.18	0.74	9.74	0.77
2	Calgary	17.07	0.73	8.65	0.77	15.38	0.90	7.7	0.89
3	Edmonto	18.7	0.80	10.26	0.92	10.16	0.54	7.59	0.74
4	Winnipeg	20.09	0.86	10.72	0.96	#N/A	#N/A	#N/A	#N/A
5	Toronto	35.96	1.53	18.26	1.63	21.63	0.60	14.55	0.80
6	Ottawa	25.82	1.10	11.85	1.06	14.88	0.58	8.14	0.69
7	Montreal	23.47	1.00	11.18	1.00	18.99	0.81	9.52	0.85
8	Quebec	#N/A	#N/A	#N/A	#N/A	14.88	#N/A	8.14	#N/A
	Note: N/A indicates no data available from BOMA								

ICF= Income City Factor = City TI-d / MTL TI-d)

ECF = Expense City Factor (City TOEFL-d / MTL TOEFL-d)

ILF = Income Location Factor (TI-s / TI-d)

ELF = Epense Location Factor (TOEFL-s / TOEFL-d)

TI-d = Total Income - Downtown

TOEFL-d = Total Operating Expense with Fixed Value plus Leasing cost - Downtown

TI-s = Total Income - Suburban

TOEFL = Total Operating Expense with Fixed Value plus Leasing cost - Suburban

Location/Size Analysis 1992

1992	Size Factor			
AREA	Private			
1,000 sf	TI	ISF	TOEFL	ESF
Less 50	18.27	1.00	10.47	1.00
50-99	18.44	1.01	10.7	1.02
100-299	22.41	1.23	11.01	1.05
300-599	25.09	1.37	12.97	1.24
More-600	26.95	1.48	12.27	1.17

Table AP1 – 3 (5)

Height/Age Analysis 1992				
1992	Height Factor			
	Private			
	0-9 years			
Storey	TI	IHF	TOEFL	EHF
Less 5s	15.14	1.00	11.05	1.00
5-9s	25.74	1.70	10.83	0.98
10-19s	28.6	1.89	14.65	1.33
20-29s	29.4	1.94	13.39	1.21
30-39s	28.29	1.87	10.71	0.97
	10-19 years			
Storey	TI	IHF	TOEFL	EHF
Less 5s	10.17	0.67	6.72	0.61
5-9s	16.87	1.11	9.27	0.84
10-19s	17.71	1.17	10.32	0.93
20-29s	26	1.72	13.72	1.24
30-39s	20.43	1.35	11.74	1.06
	20-29 years			
Storey	TI	IHF	TOEFL	EHF
Less 5s	15.15	1.00	5.21	0.47
5-9s	22.1	1.46	9.99	0.90
10-19s	24.97	1.65	14.42	1.30
20-29s	23.14	1.53	10.44	0.94
30-39s	#N/A	#N/A	#N/A	#N/A

Age/Size Analysis 1992				
1992	Age Factor			
	Private			
AREA	0-9 years			
1,000 sf	TI	IAF	TOEFL	EAF
Less 50	20.34	1.00	8.17	1.00
50-99	22.57	1.11	9.38	1.15
100-299	25.58	1.26	12.57	1.54
300-599	28.01	1.38	13.3	1.63
More-600	27.71	1.36	12.27	1.50
AREA	10-19 years			
1,000 ft	TI	IAF	TOEFL	EAF
Less 50	12.57	0.62	7.6	0.93
50-99	11.24	0.55	8.55	1.05
100-299	18.09	0.89	9.77	1.20
300-599	21.91	1.08	11.42	1.40
More-600	17.56	0.86	10.55	1.29
AREA	20-29 years			
1,000 ft	TI	IAF	TOEFL	EAF
Less 50	17.27	0.85	9.77	1.20
50-99	21.3	1.05	8.46	1.04
100-299	22.51	1.11	11.81	1.45
300-599	26.87	1.32	18.15	2.22
More-600	#N/A	#N/A	#N/A	#N/A

Table AP1 - 4 (5) Sample of BOMA EER Data Assembling and Sorting

Data Assembling From BOMA EER: ALL BUILDINGS STUDY ($ / SF)													
Year	Income			Expenses (TOEFL)									
	1	2	3	4	5	6	7	8	9	10	11	12
	Office	Retail	TI	Clean	Repare	Utilities	R.G.S.	Adm.	Fixed	Leasing	TOEFL	NOI
1988	18.63	22.31	**18.58**	0.91	1.27	1.42	0.34	0.80	3.29	1.40	**9.27**	**9.31**
1989	21.09	24.67	**21.19**	0.98	1.32	1.56	0.43	0.80	3.50	1.50	**10.09**	**11.10**
1990	20.62	21.78	**21.67**	1.04	1.41	1.67	0.41	0.91	4.10	1.91	**11.44**	**10.23**
1991	21.75	23.70	**22.87**	1.10	1.54	1.71	0.51	0.97	4.12	1.82	**11.78**	**11.09**
1992	23.63	25.80	**23.65**	1.12	1.48	1.83	0.48	0.95	4.85	1.53	**12.23**	**11.42**
1993	22.57	23.71	**22.72**	1.06	1.69	1.99	0.45	0.94	5.29	1.25	**12.67**	**10.05**
1994	22.28	23.47	**22.17**	1.05	1.52	2.07	0.44	0.93	4.75	1.24	**12.08**	**10.09**
1995	21.34	22.63	**21.61**	1.06	1.57	1.90	0.44	0.98	4.80	1.33	**12.06**	**9.55**
1996	19.79	22.57	**20.04**	1.02	1.63	1.84	0.44	1.06	4.24	1.69	**11.90**	**8.14**
1997	18.80	15.91	**19.28**	1.14	1.65	1.75	0.48	1.00	3.90	1.71	**11.69**	**7.59**
Avg.	21.05	22.66	21.38	1.05	1.51	1.77	0.44	0.93	4.28	1.54	11.52	9.86

Note:

$$TI = \frac{\text{Office rental price} \times \text{office space occupied} + \text{Retail rental price} \times \text{retail space occupied} + \text{Other income}}{\text{Total Occupied (office space + total retail space)}}$$

Table AP1 - 5 (4) Data Collecting from BOMA EER 1996

Unit: $ /SF	Private				Government			
	Downtown		Suburban		Downtown		Suburban	
City	TI	TOEFL	TI	TOEFL	TI	TOEFL	TI	TOEFL
0 All Canada	21.61	12.06	NA	NA	NA	NA	NA	NA
1 Vancouver	22.69	10.13	23.44	10.24	21.05	9.14	9.10	7.44
2 Calgary	18.47	7.52	12.15	6.22	15.80	NA	10.01	7.11
3 Edmonton	12.32	6.94	NA	NA	NA	NA	NA	NA
4 Winnipeg	NA	NA	NA	NA	18.31	9.66	6.62	6.30
5 Toronto	26.96	15.56	18.24	10.37	25.13	13.16	NA	6.63
6 Ottawa	21.89	9.40	20.44	8.39	19.05	11.25	NA	NA
7 Montreal	23.16	10.80	16.86	7.92	20.14	12.53	11.61	8.70
8 Quebec City	NA	NA	NA	NA	14.72	11.91	10.76	12.81

Explanation of symbols in Table AP1 - 5:

1. All Canada presents Canada office building National Average value. It is adding all surveyed building's total dollars dividing by all surveyed building's total square footage.

2. TI indicates Total Income. It reflects average square footage income including office rental, retail, parking, and other income.
3. TOEFL is abbreviation of Total Operating Expense plus Fixed value plus Leasing expense.
4. NA indicates Not Available from BOMA EER.

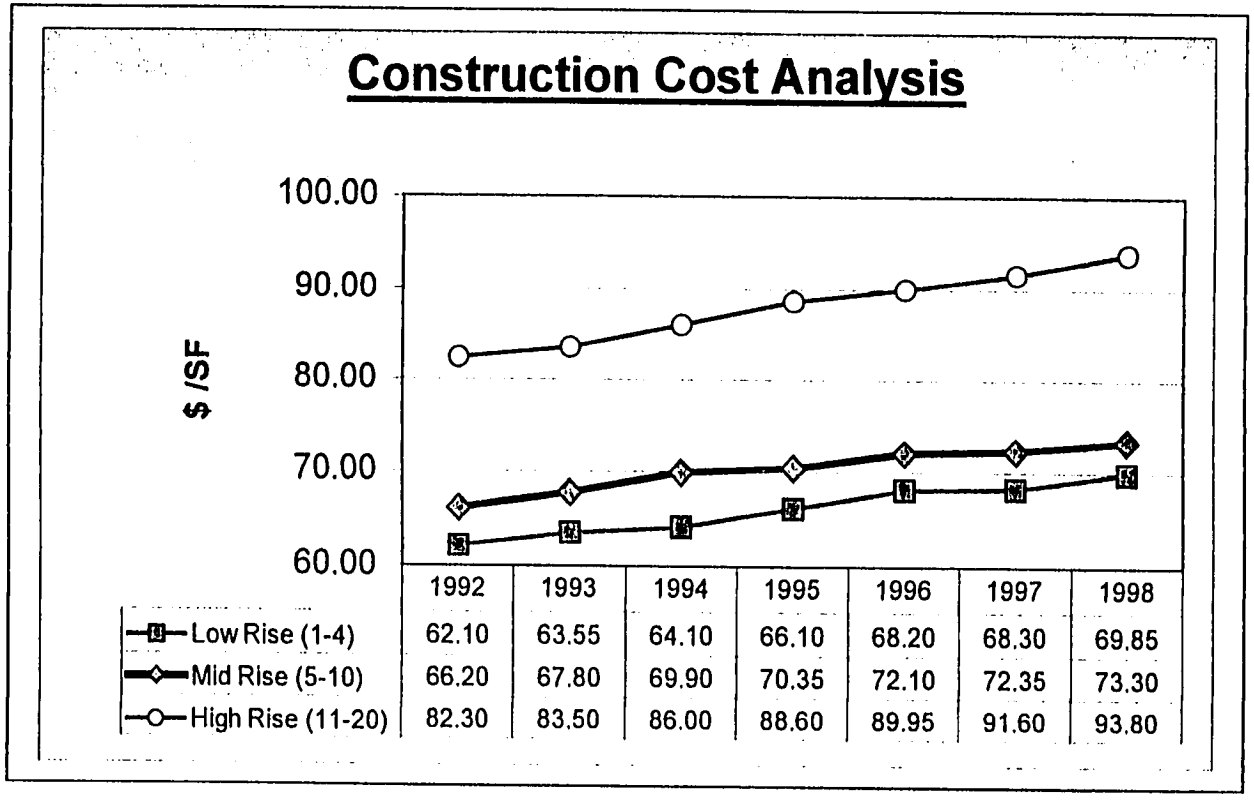


Figure AP1 – 6 (5) Construction Cost Collection and Analysis

Table AP1 – 6 (6) Data Assembling & Sorting for City and Location

DATA Sorting From BOMA EER-1996 by Ke Zhang, 22 Aug, 1997

City and Location Factor (Year of 1995)

	City	Private							
		Downtown				Suburban			
		TI-d	ICF	TOEFL-d	ECF	TI-s	ILF	TOEFL-s	ELF
0	All Canada	21.61	0.93	12.06	1.12	#N/A	#N/A		0.00
1	Vancouver	22.69	0.98	10.13	0.94	23.44	1.03	10.24	1.01
2	Calgary	18.47	0.80	7.52	0.70	12.15	0.66	6.22	0.83
3	Edmonton	12.32	0.53	6.94	0.64	#N/A	#N/A	#N/A	#N/A
4	Winnipeg	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
5	Toronto	26.96	1.16	15.56	1.44	18.24	0.68	10.37	0.67
6	Ottawa	21.89	0.95	9.4	0.87	20.44	0.93	8.39	0.89
7	Montreal	23.16	1.00	10.8	1.00	16.86	0.73	7.92	0.73
8	Quebec	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
	Note: Number = N/A means no data available from BOMA								

ICF= Income City Factor (City TI-d / MTL TI-d)

ECF = Expense City Factor (City TOEFL-d / MTL TOEFL-d)

ILF = Income Location Factor (TI-s / TI-d)

ELF = Epense Location Factor (TOEFL-s / TOEFL-d)

TI-d = Total Income - Downtown

TOEFL-d = Total Operating Expense with Fixed Value plus Leasing cost - Downtown

TI-s = Total Income - Suburban

TOEFL = Total Operating Expense with Fixed Value plus Leasing cost - Suburban

Table AP – 7 (6) Sample of Data Collecting and Sorting for Size, Age and Height Factors

BOMA EER 1996 (Private) Unit: $ /SF

Size Factor

AREA (1,000SF)	TI	ISF	TOEFL	ESF
Less 50	13.28	1.00	8.02	1.00
50-99	19.97	1.50	9.35	1.17
100-299	19.74	1.49	9.71	1.21
300-599	23.55	1.77	11.4	1.42
More-600	23.49	1.77	10.58	1.32

ISF = Income Size Factor

ESF = Expense Size Factor

IAF = Income Age Factor

EAF = Expense Age Factor

IHF = Income Height Factor

EHF = Expense Height Factor

Age/Size Factor

0-9 years				
AREA (1,000SF)	TI	IAF	TOEFL	EAF
Less 50	19.07	1.00	9.34	1.00
50-99	19.11	1.00	8.27	0.89
100-299	25.69	1.35	10.97	1.17
300-599	30.46	1.60	12.64	1.35
More-600	#N/A	#N/A	#N/A	#N/A

10-19 years				
AREA (1,000SF)	TI	IAF	TOEFL	EAF
Less 50	11.58	0.61	7.13	0.76
50-99	18.51	0.97	8.45	0.90
100-299	16.96	0.89	8.81	0.94
300-599	21.21	1.11	10.65	1.14
More-600	21.08	1.11	10.2	1.09

20-29 years				
AREA (1,000SF)	TI	IAF	TOEFL	EAF
Less 50	11.66	0.61	8.28	0.89
50-99	18.48	0.97	10.17	1.09
100-299	19.11	1.00	9.97	1.07
300-599	19.96	1.05	11.33	1.21
More-600	#N/A	#N/A	#N/A	#N/A

Height Factor

0-9 years				
Storey	TI	IHF	TOEFL	EHF
Less 5s	14.5	1.00	8.15	1.00
5-9s	24.87	1.72	9.41	1.15
10-19s	26.64	1.84	11.1	1.36
20-29s	29.02	2.00	12.24	1.50
30-39s	#N/A	#N/A	#N/A	#N/A

10-19 years				
Storey	TI	IHF	TOEFL	EHF
Less 5s	9.56	0.66	6.14	0.75
5-9s	17.08	1.18	8.6	1.06
10-19s	17.21	1.19	8.79	1.08
20-29s	21.06	1.45	10.44	1.28
30-39s	21.91	1.51	12.55	1.54

20-29 years				
Storey	TI	IHF	TOEFL	EHF
Less 5s	12.7	0.88	6.22	0.76
5-9s	15.73	1.08	10.74	1.32
10-19s	17.67	1.22	9.27	1.14
20-29s	20.21	1.39	9.46	1.16
30-39s	#N/A	#N/A	#N/A	#N/A

Table AP1 – 8 (6) Overall Impact Factors Collection

Impact Adjusted Facotrs

City Factor

	Adjusted	
	ICF	ECF
All Canada	**1.04**	**1.08**
Vancouver	1.06	1.13
Calgary	0.90	0.81
Edmonton	0.80	0.79
Winnipeg	0.93	0.89
Toronto	1.30	1.35
Ottawa	1.02	0.96
Montreal	**1.00**	**1.00**
Quebec	0.80	0.72

Location Factor

	Adjusted	
	ILF	ELF
All Canada		
Vancouver	0.80	0.89
Calgary	0.89	0.81
Edmonton	0.86	0.78
Winnipeg	0.73	0.77
Toronto	0.70	0.83
Ottawa	0.82	0.83
Montreal	**0.95**	**0.94**
Quebec	0.69	0.87

Adjusted Height Factor

	Rental	TOEFL
	IHF	EHF
0-9 / Less 5s	0.94	0.99
5-9s	0.98	0.98
10-19s	1.00	1.02
20-29s	1.00	1.01
30-39s	1.01	0.97

Note: Set C5 & C7 = 1 for Location/Size F, Because Location and Size has been considered in other factors

Adjusted Size & Age Factor

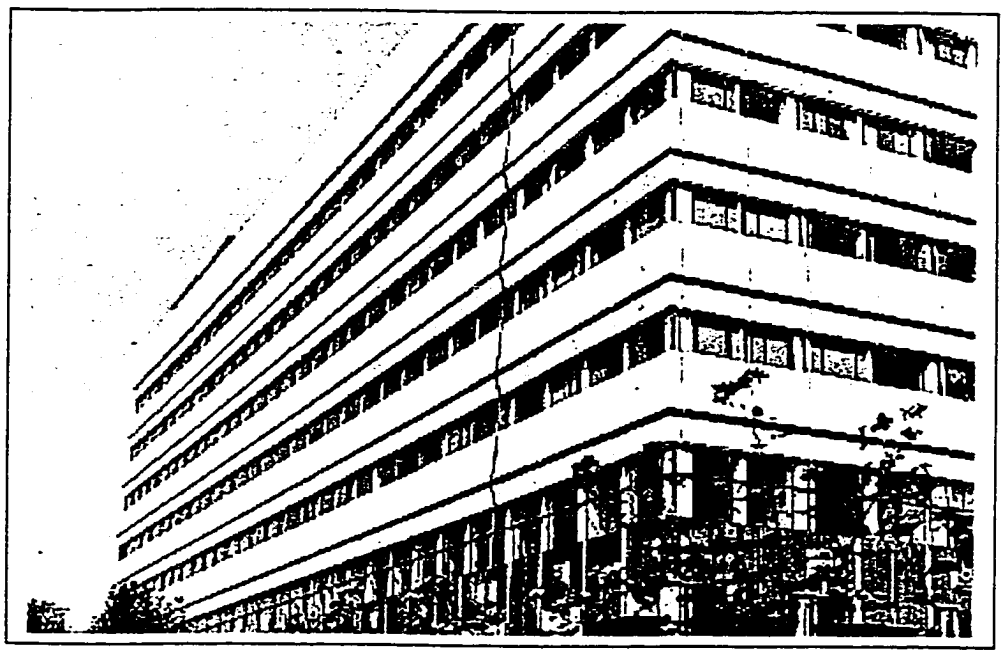
Unit: (1,000 SF)	Rental	TOEFL	Renatl	TOEFL	Rental	TOEFL
	0-9 Year		10-19 Years		20-29 Years	
	IAF	EAF	IAF	EAF	IAF	EAF
Less 50	0.70	0.65	0.65	0.60	0.71	0.75
50-99	**1.00**	**1.00**	0.69	0.67	0.77	0.70
100-299	1.07	0.97	0.97	0.75	0.98	0.92
300-599	1.20	0.99	1.01	0.85	1.02	0.99
More-600	1.25	0.90	1.03	0.80	1.05	0.85

Table AP1 – 9 (7) BOMA TOEFL Data Collecting and Sorting

Year	Expenses (TOEFL) 1	2	3	4	5	6	7	
	Clean	Repair	Utilities	R.G.S.	Adm.	Fixed	Leasing	TOEFL
1988	0.91	1.27	1.42	0.34	0.80	3.29	1.40	**9.27**
1989	0.98	1.32	1.56	0.43	0.80	3.50	1.50	**10.09**
1990	1.04	1.41	1.67	0.41	0.91	4.10	1.91	**11.44**
1991	1.10	1.54	1.71	0.51	0.97	4.12	1.82	**11.78**
1992	1.12	1.48	1.83	0.48	0.95	4.85	1.53	**12.23**
1993	1.06	1.69	1.99	0.45	0.94	5.29	1.25	**12.67**
1994	1.05	1.52	2.07	0.44	0.93	4.75	1.24	**12.08**
1995	1.06	1.57	1.90	0.44	0.98	4.80	1.33	**12.06**
1996	1.02	1.63	1.84	0.44	1.06	4.24	1.69	**11.90**
1997	1.14	1.65	1.75	0.48	1.00	3.90	1.71	**11.69**
Avg.	1.05	1.51	1.77	0.44	0.93	4.28	1.54	11.52

Appendix 2

OFFICE_LCC98 DESIGN & RUNNING



My Project in Beijing, China (1986)

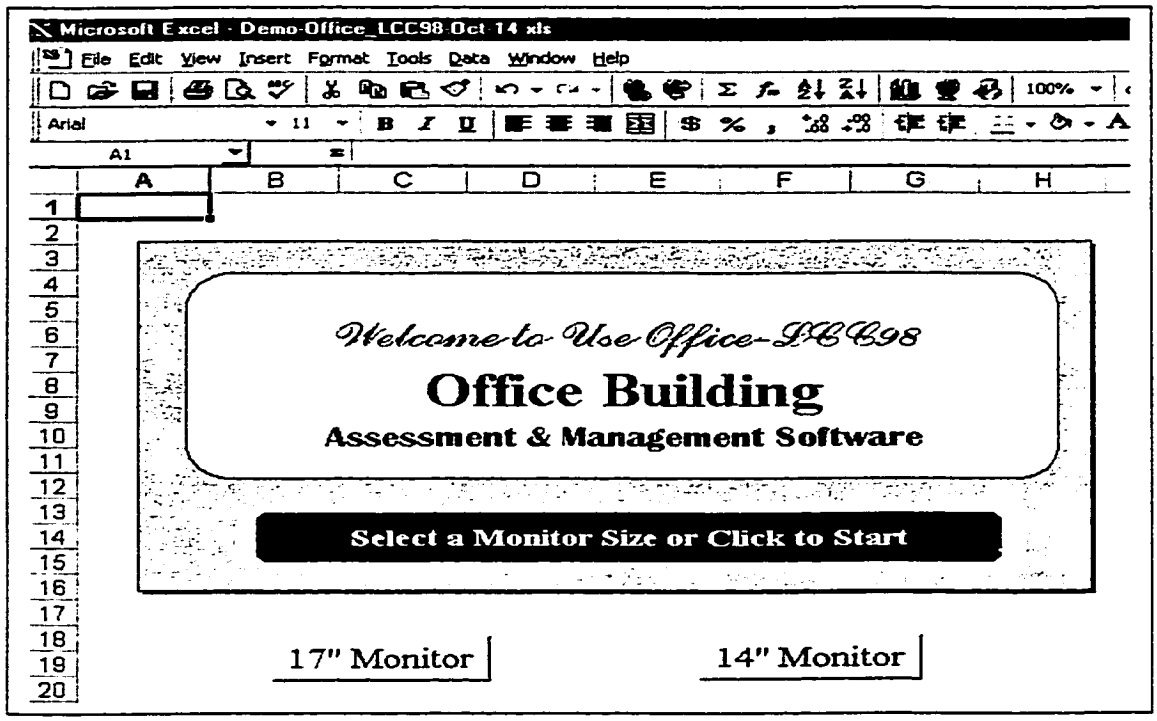
Sample Of Running **OFFICE_LCC98**

BUILDING DESCRIPTION DATA ENTRY

1. **City:** Montreal
2. **Type:** New Building
3. **Ownership:** Private
4. **Location:** Downtown
5. **Size:** 100 – 299 × 1000 sq. ft.
6. **Height:** 5-9 floors
7. **Age:** New building

CALCULATING DATA ENTRY

8. **Land Area:** 40, 000 sq. ft.
9. **Land Price:** $20 /sq. ft.
10. **Construction Cost:** Intermediate
11. **Gross floor area:** 160,000 sq. ft.
12. **Other Income:** $25000
13. **Interest Rate:** 4%
14. **LCC study period:** 10 year
15. **Office Rentable Space:** 100,000 sq. ft.
16. **Retail Space:** 12,000 sq. ft.
17. **Salvage Value:** $16,000,000
18. **Rental price:** default



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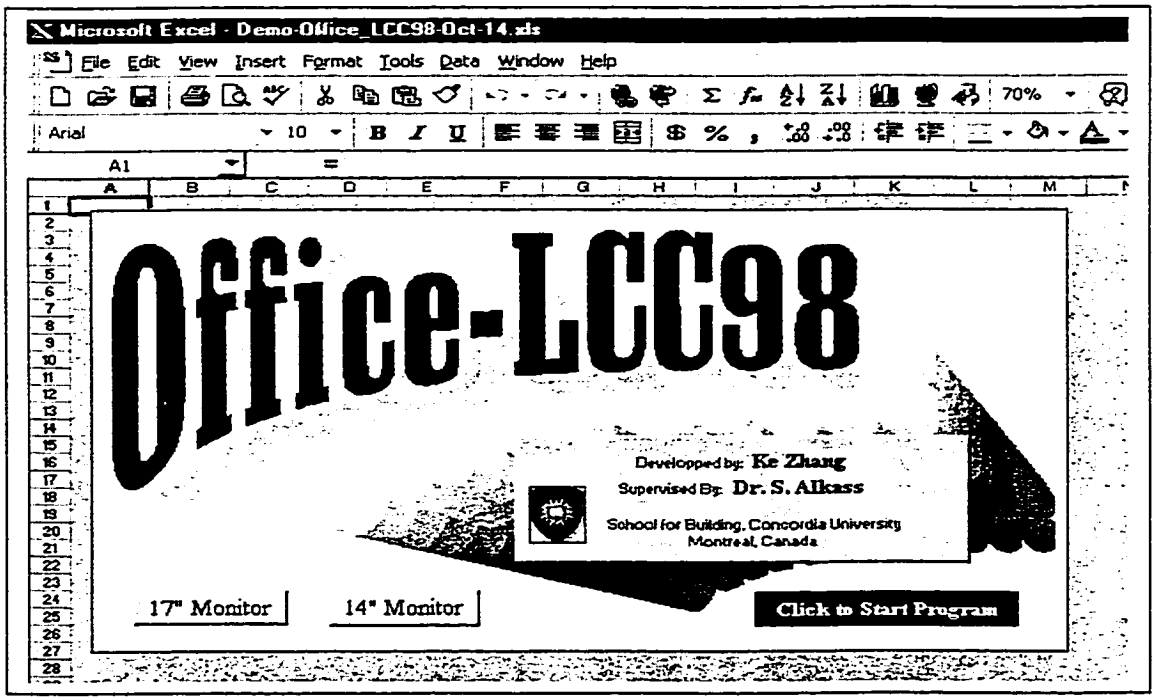

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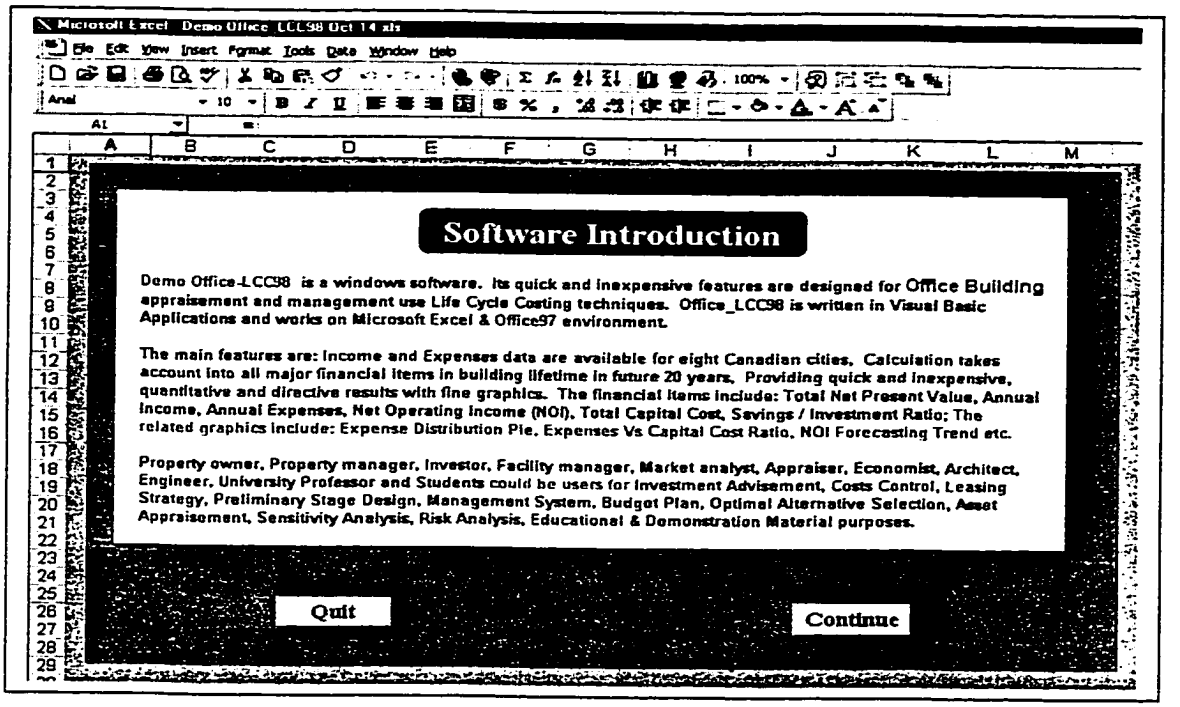

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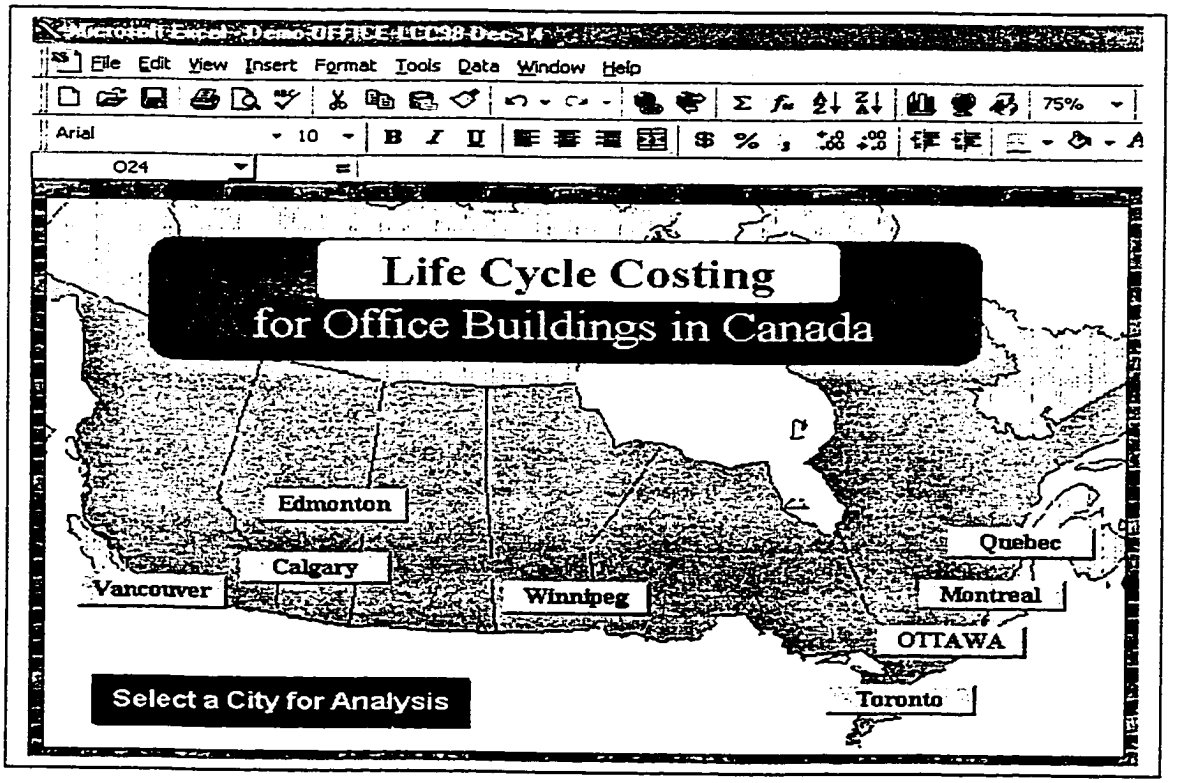

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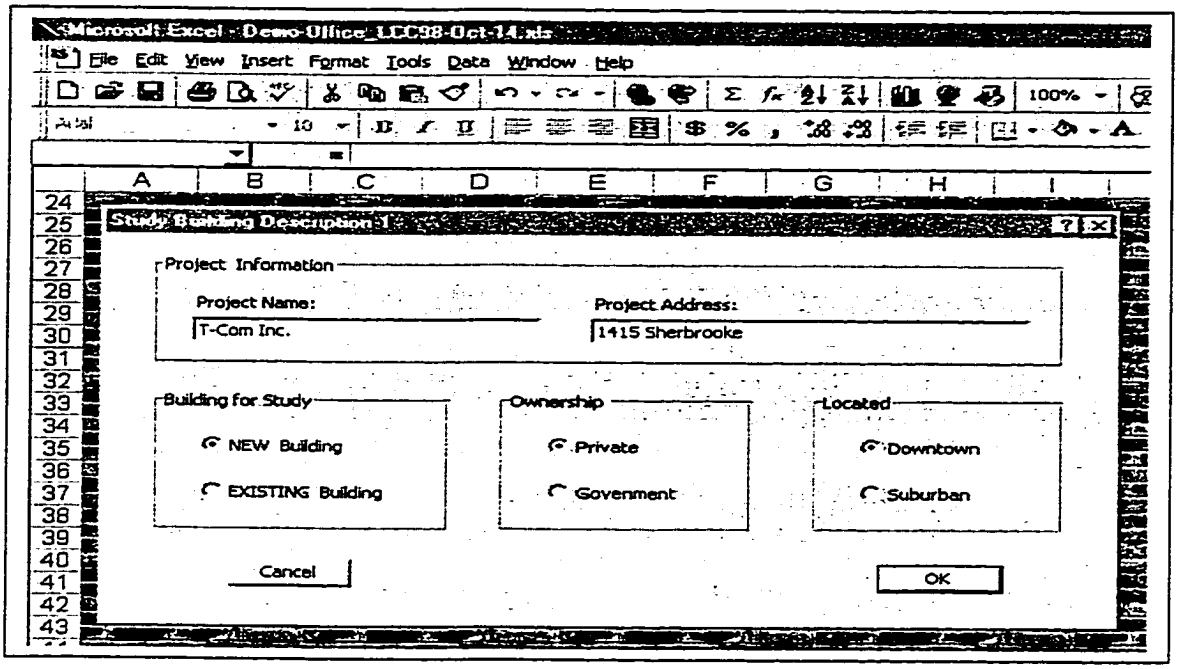

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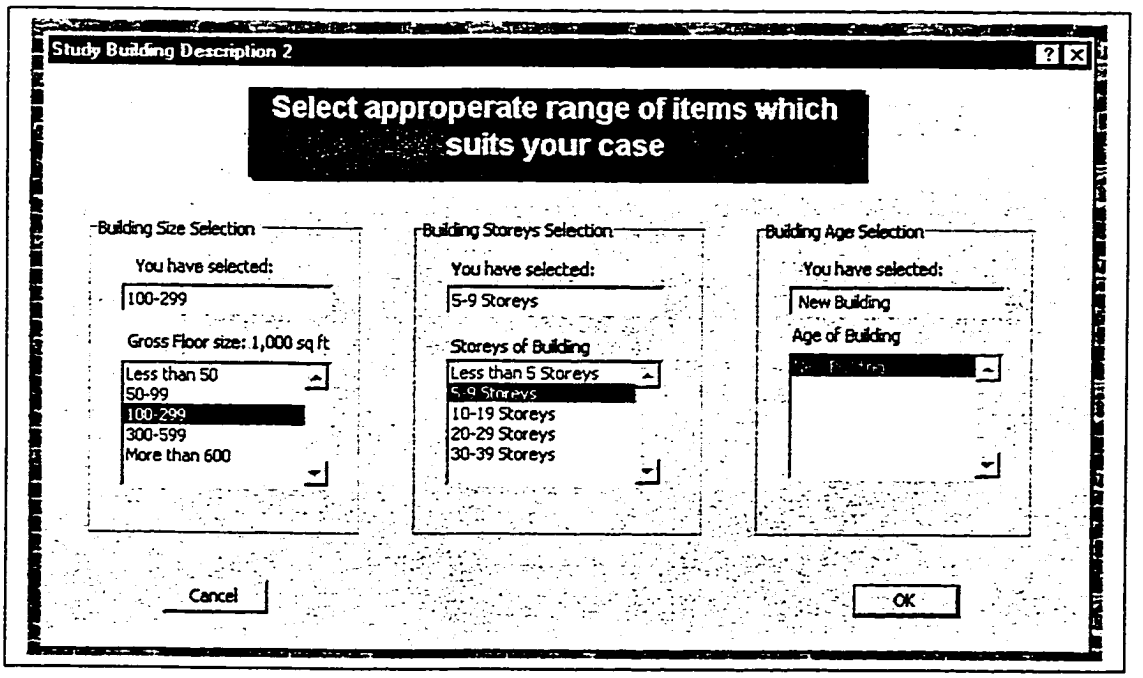

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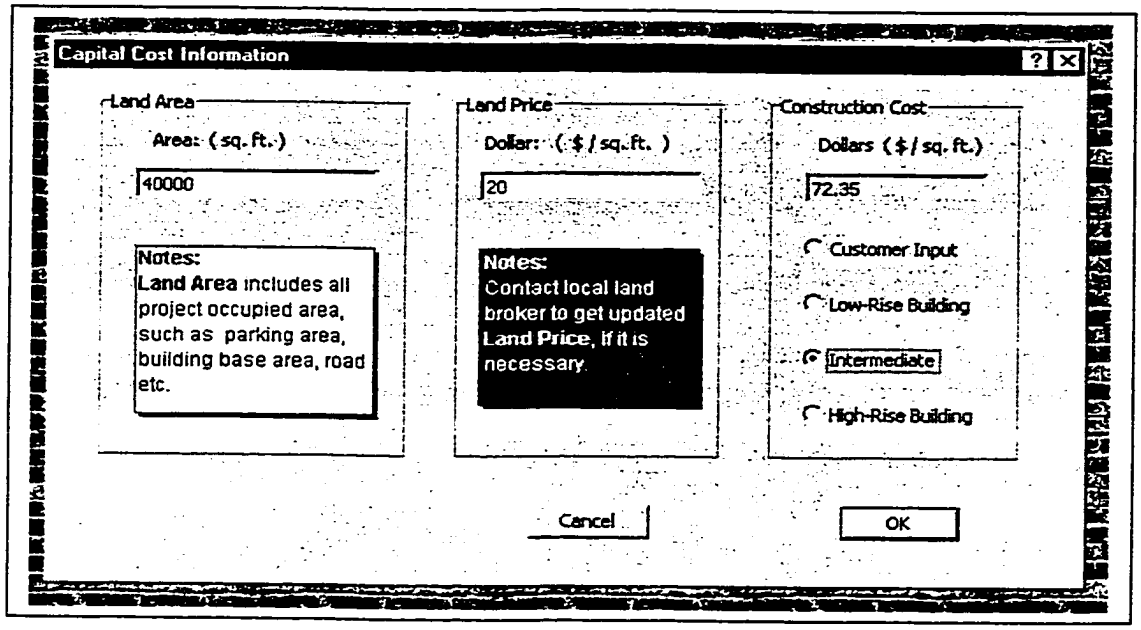

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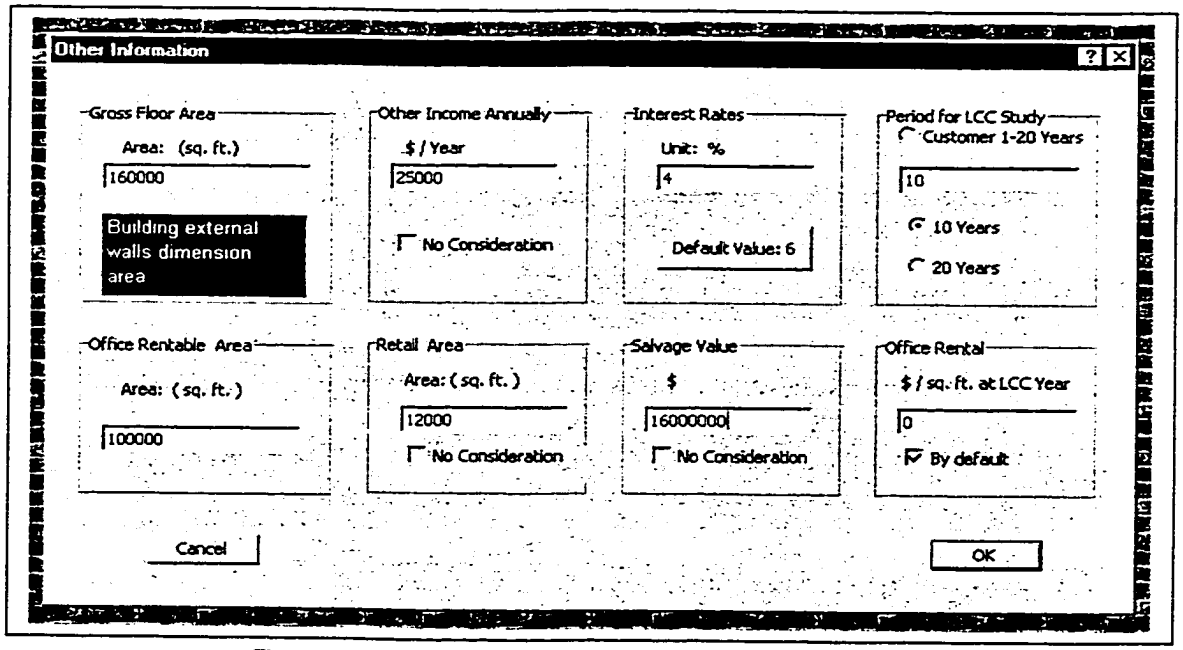

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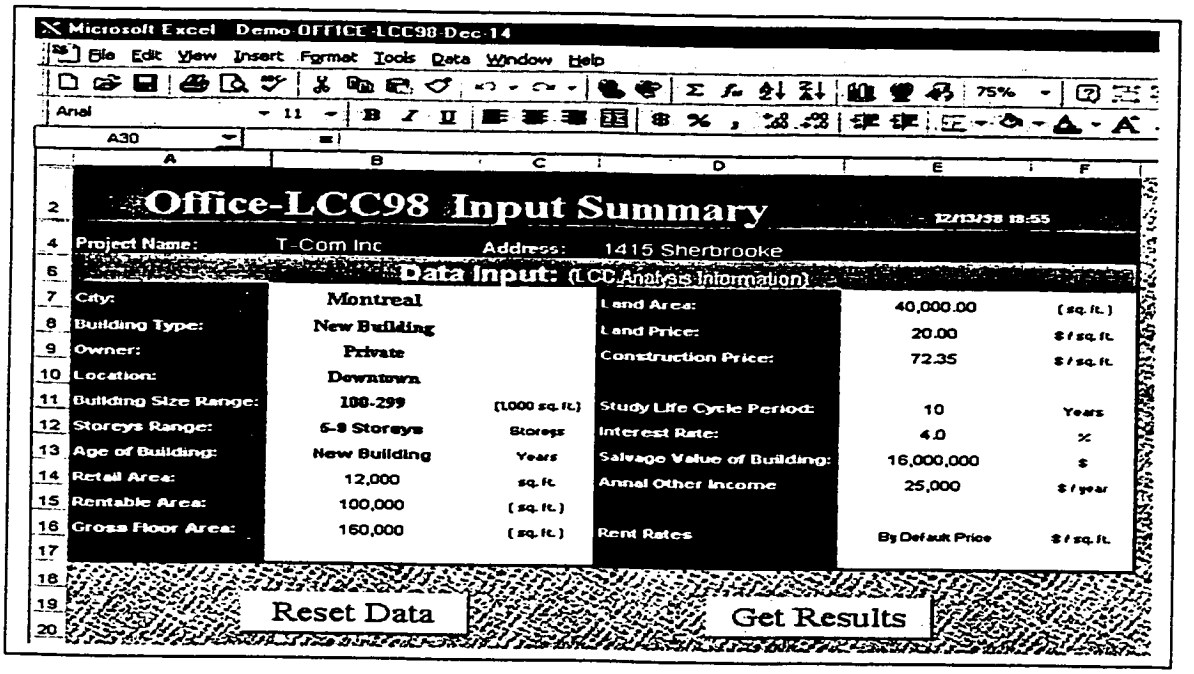

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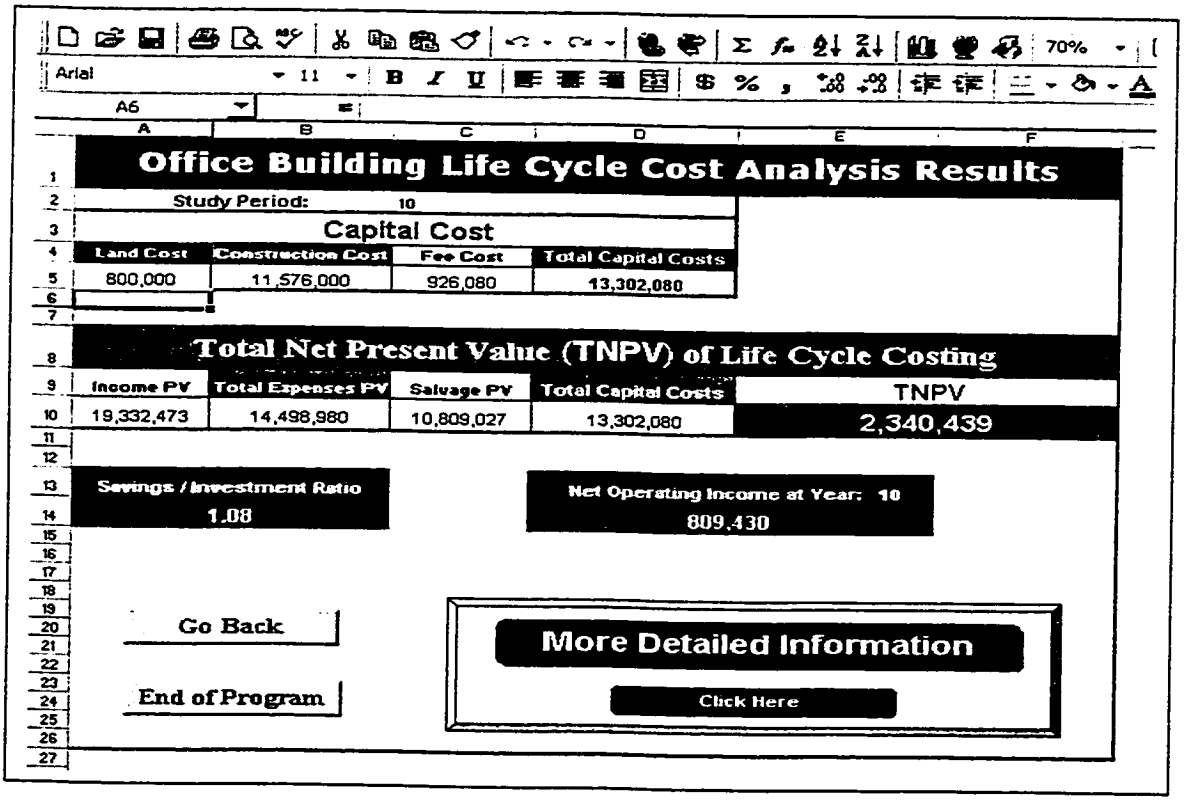

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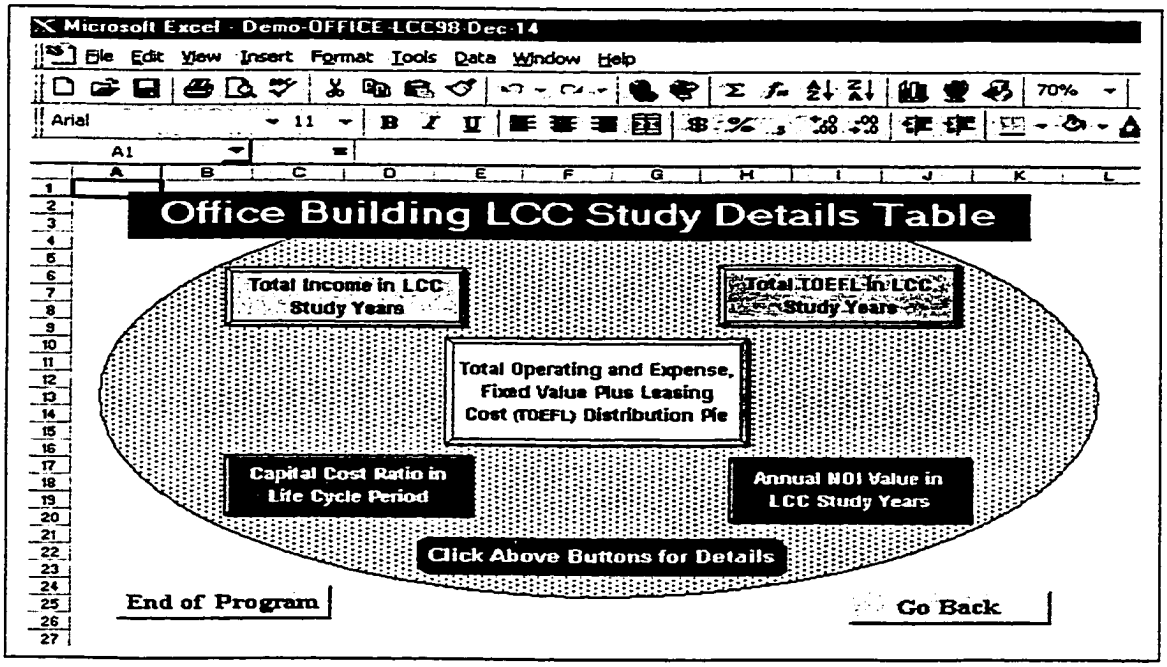

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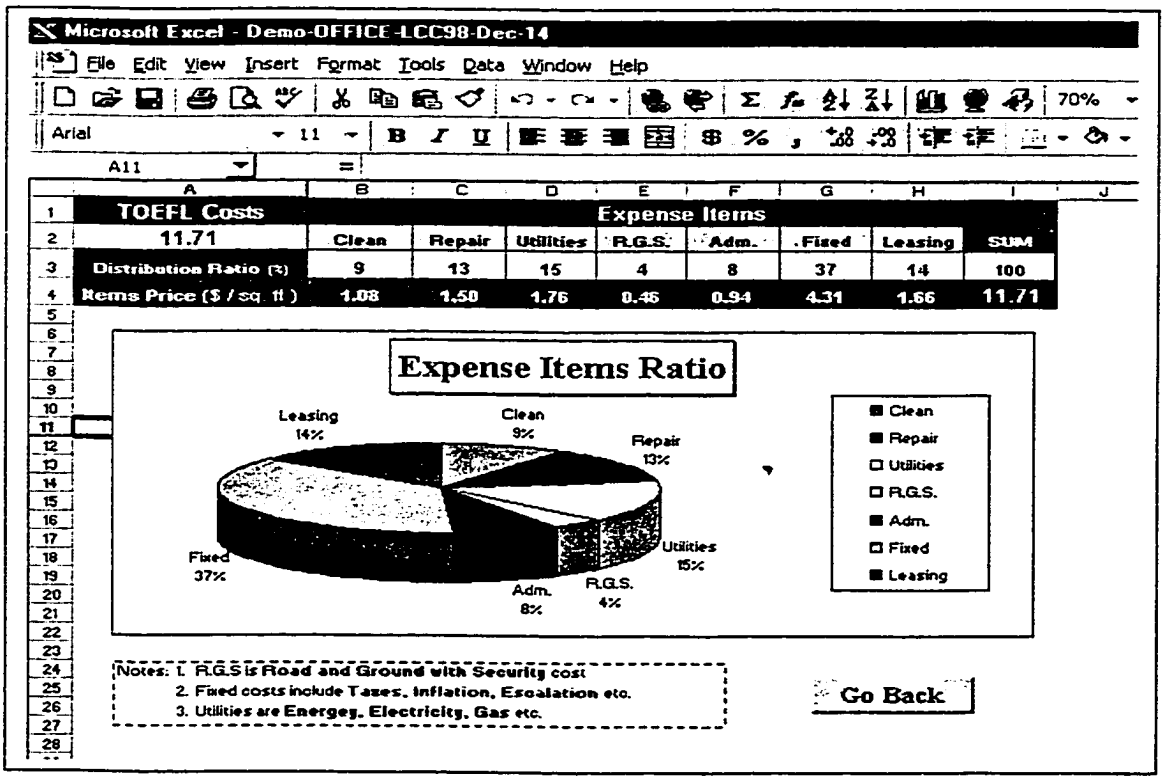

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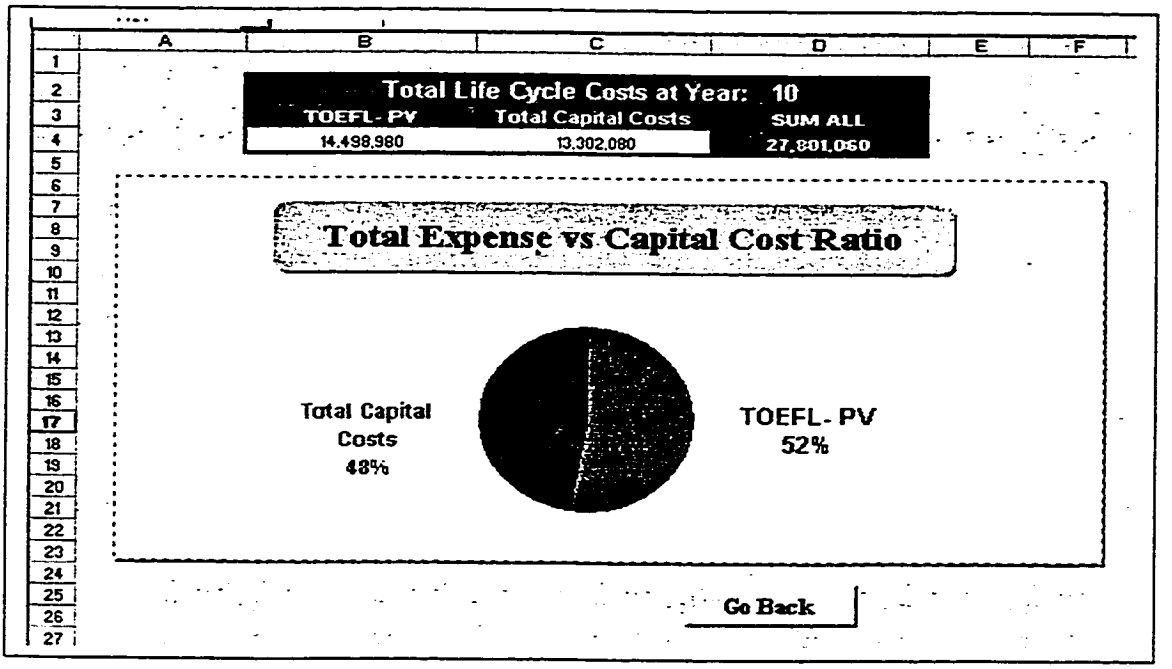

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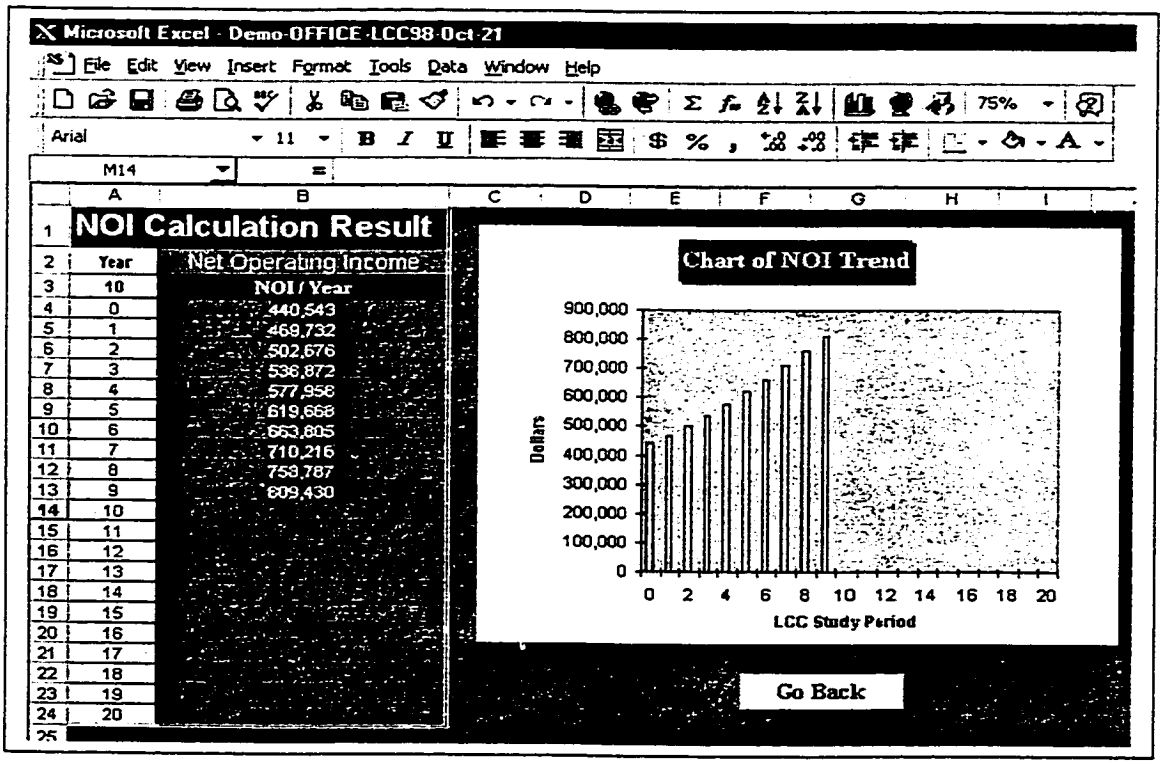

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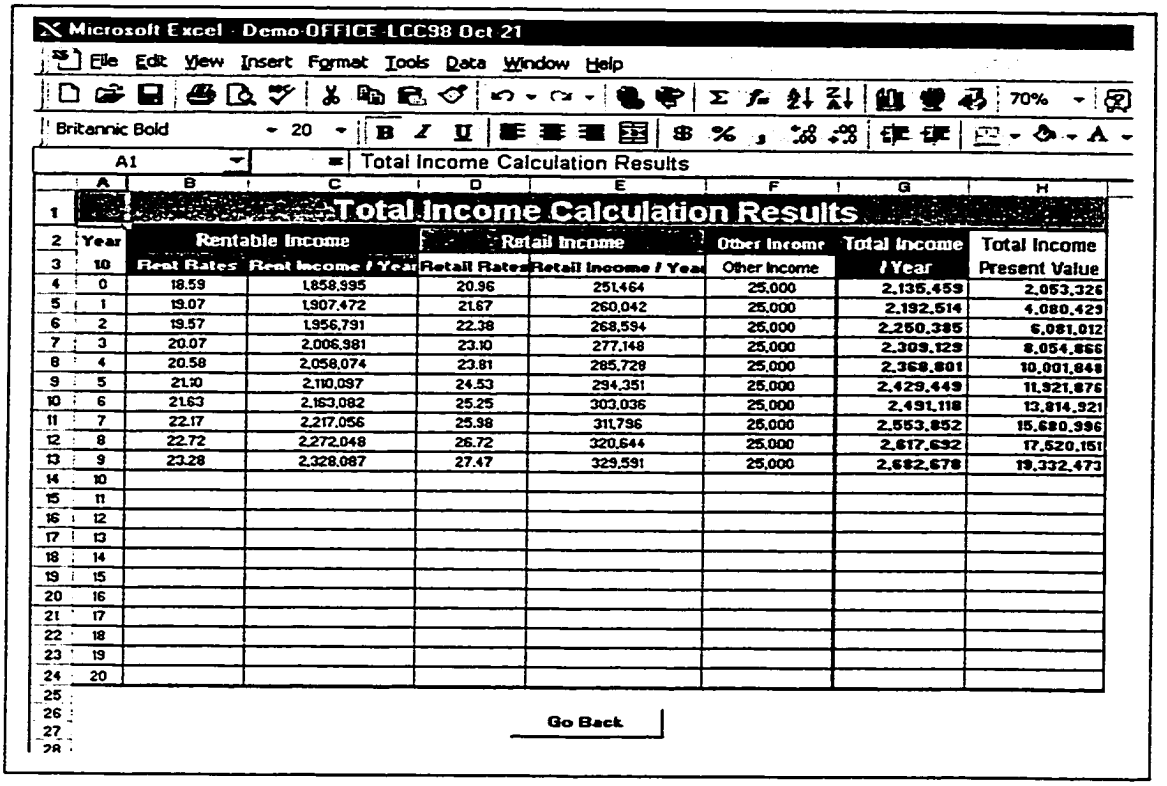

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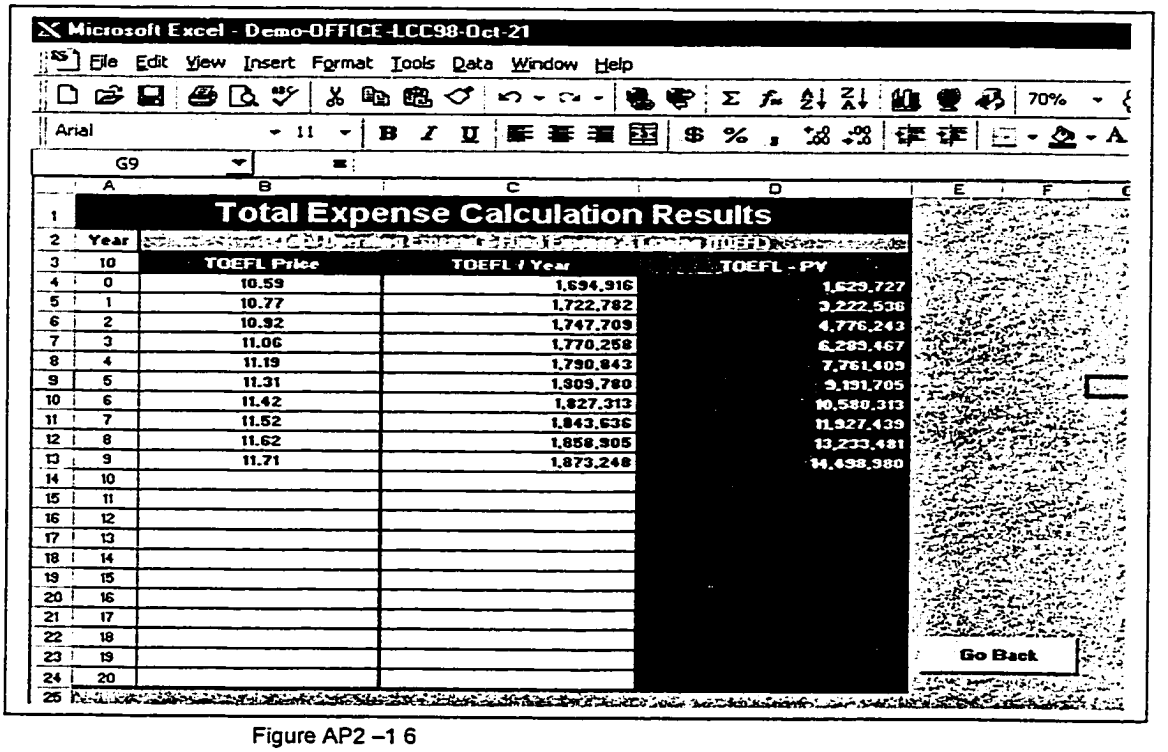

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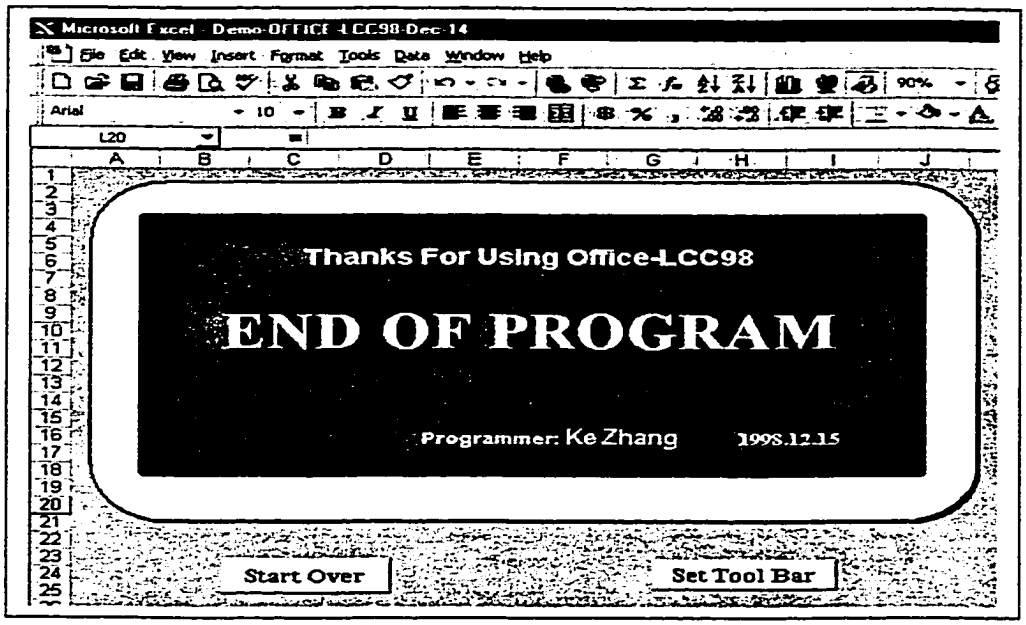


Figure AP2 – 17

OFFICE_LCC98 Program Structure

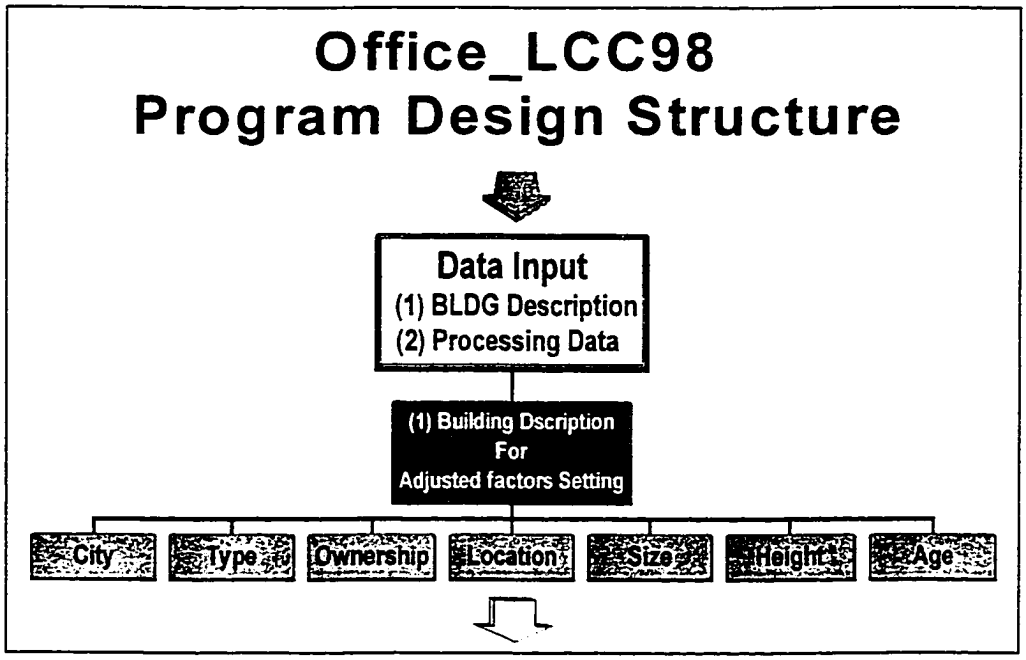


Figure AP2 – 18 Building Description Data Entry Diagram

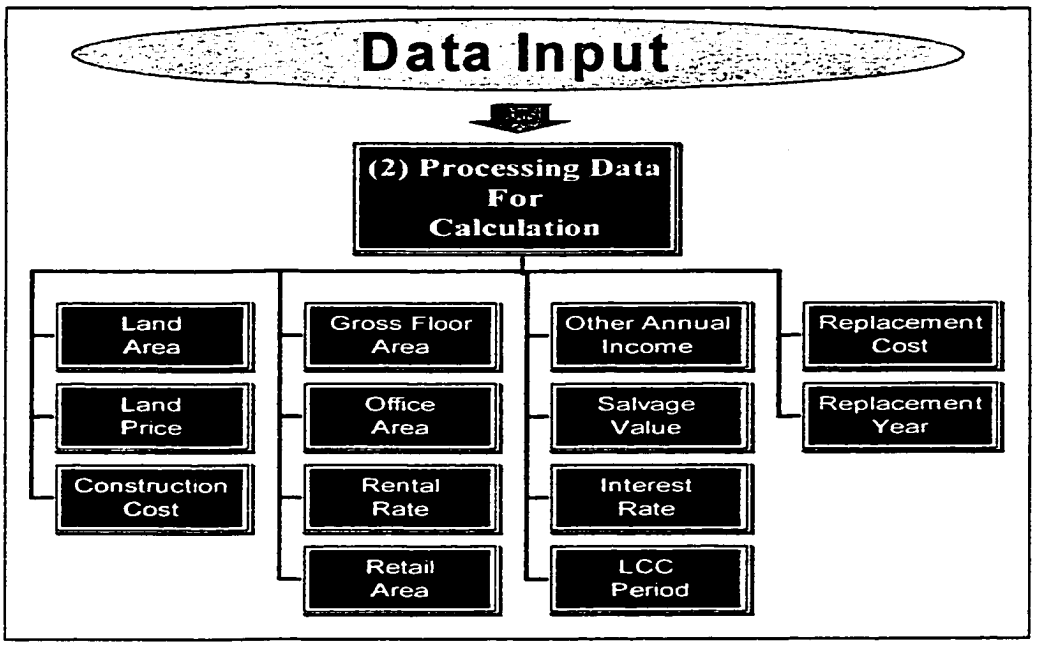


Figure AP2 – 19 Calculating Data Entry

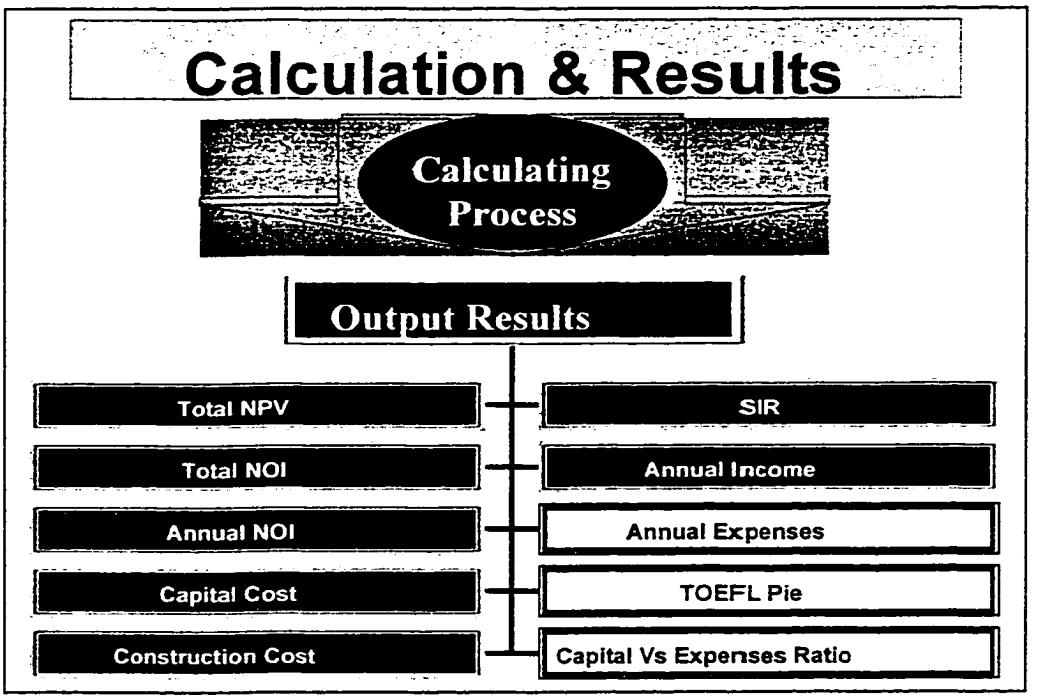
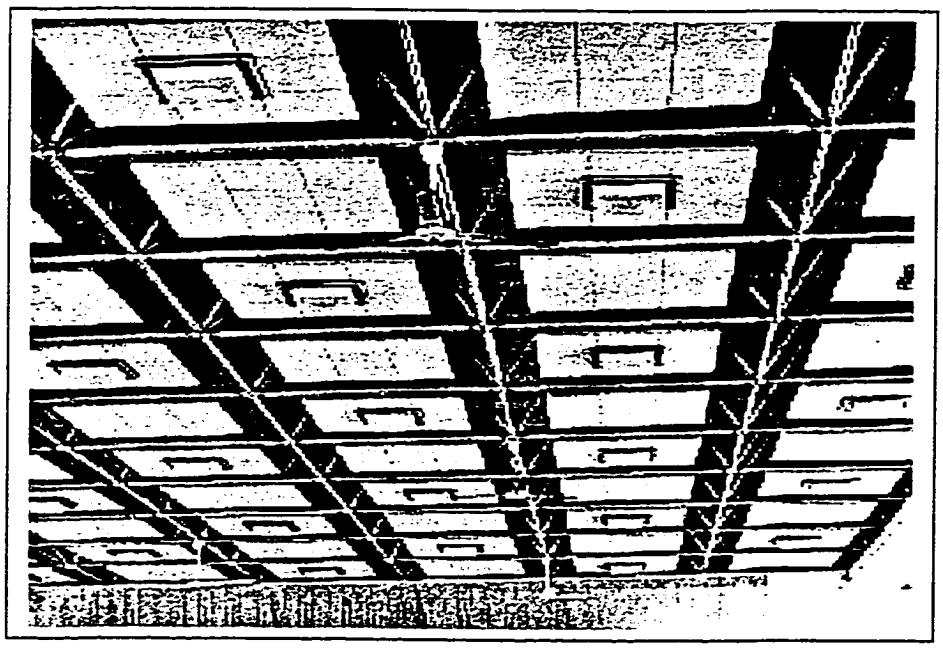


Figure AP2 – 20 Results Output

Appendix 3

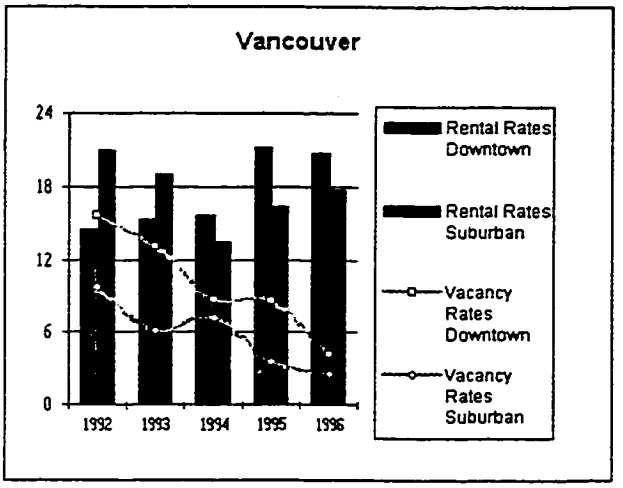
Real Estate Market Investigation and Analysis Report



My Project in Beijing, China (1988)

RE Market Investigation & Analysis Report

Vacancy Rate and Rental Price



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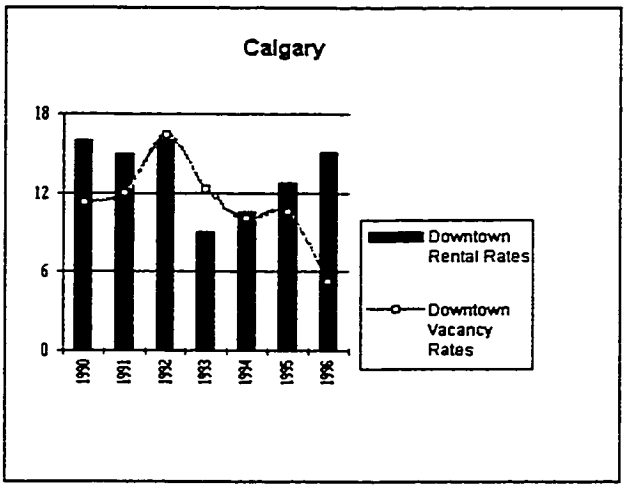


Figure AP3 - 2

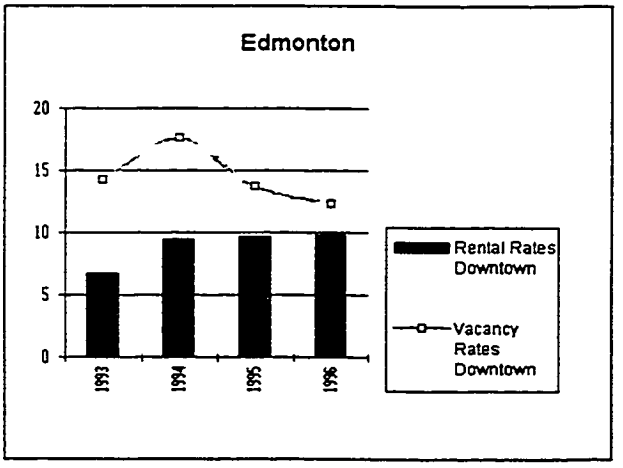
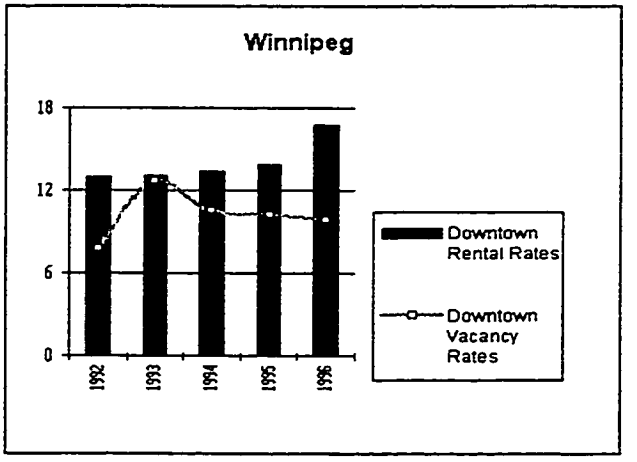


Figure AP3 - 3



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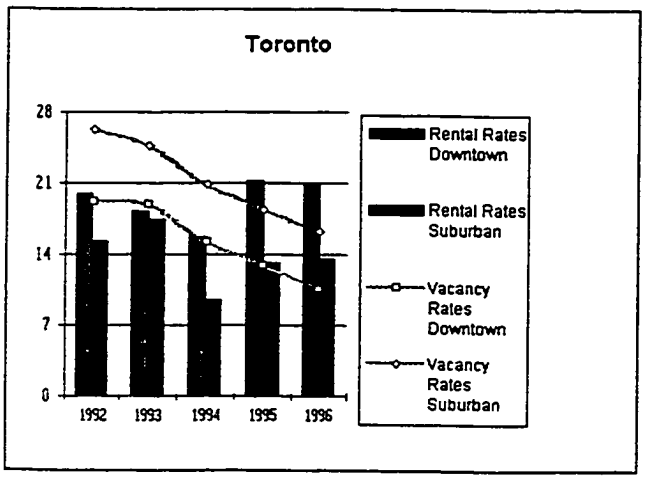
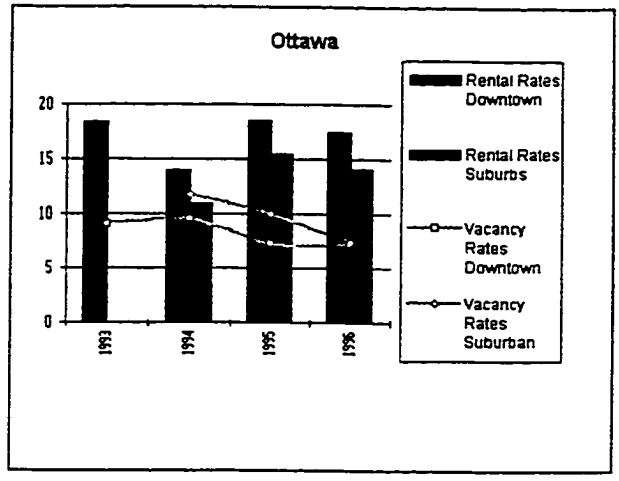


Figure AP3 - 5



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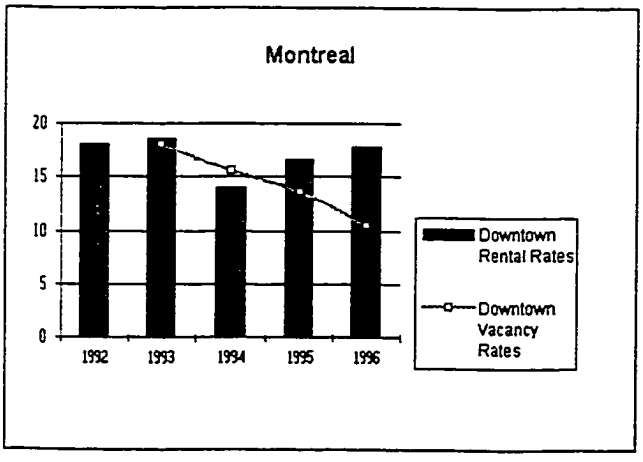

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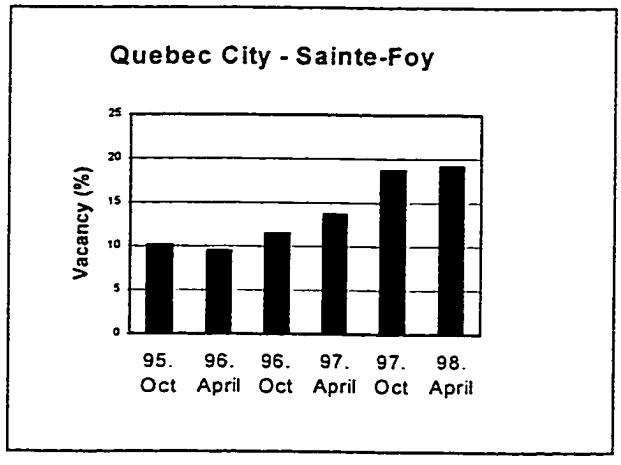


Figure AP3 - 8

Montreal Office Building Market Condition Overview:

Commercial real estate: The city's commercial real-estate business had a good year in 1998, thanks mostly to growing demand for office space from booming high-tech companies.

The so-called absorption rate of downtown office space - the rate at which empty offices are filled - was at the strongest level seen in seven years. An estimated 750,000 square feet of central Montreal space was filled in 1998.

In 1996 and 1997, the bulk of space absorbed was in high-end, Class A buildings but this year the majority was in Class B buildings. That suggests that rising prices for the highest-quality buildings are forcing tenants to lower their sights a bit.

Class A downtown buildings, such as Place Ville Marie, had a vacancy rate of 8.3 per cent at the end of September, while the vacancy rate for Class B buildings was at 15.5 per cent. Over-all, the downtown vacancy rate was 13.2 per cent. The over-all vacancy rate in the suburbs was 14.2 per cent.

Large U.S. real-estate concerns continued to buy up office buildings in Montreal last year in a continuation of a trend that began in 1997. The buying activity did slacken, however, toward the end of the year as the stock-market correction took a bite out of real-estate investment trusts south of the border.

"Over-all, it's been a strong year that was pretty close to 1997 in terms of activity," said Louis Burgos, senior vice-president at Royal LePage Commercial Inc. "We did start to see weakness in the fourth quarter because of the economic slowdown and the stock market volatility."

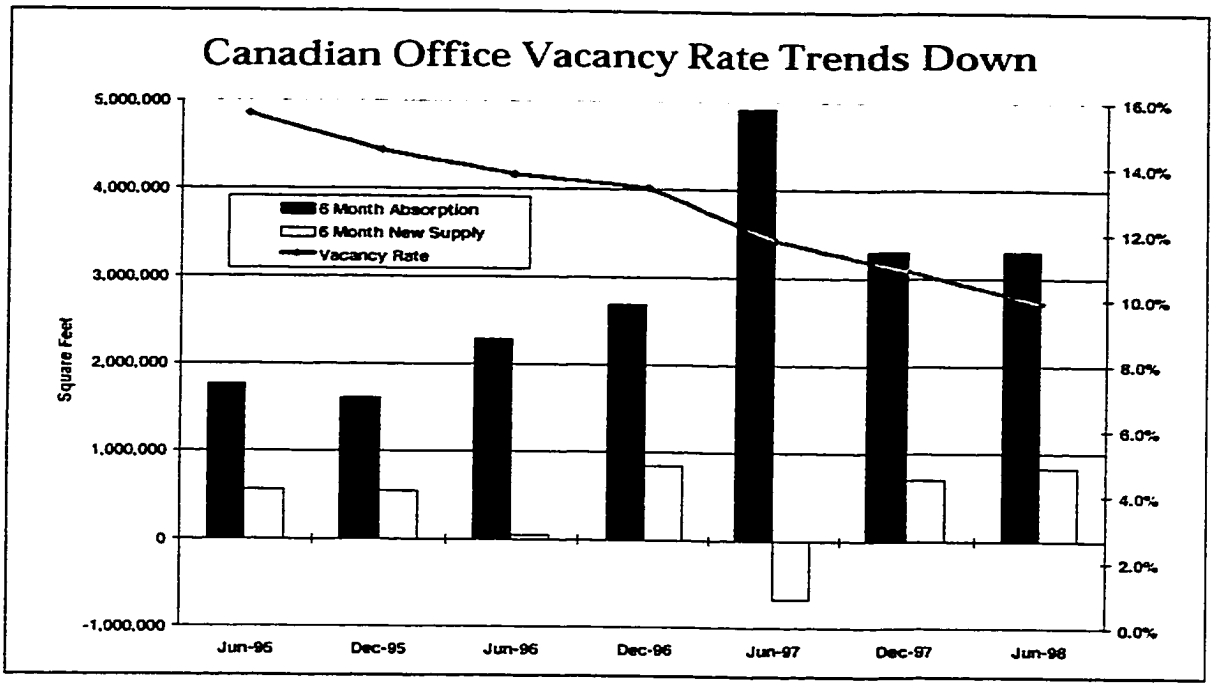


Figure AP3 - 9

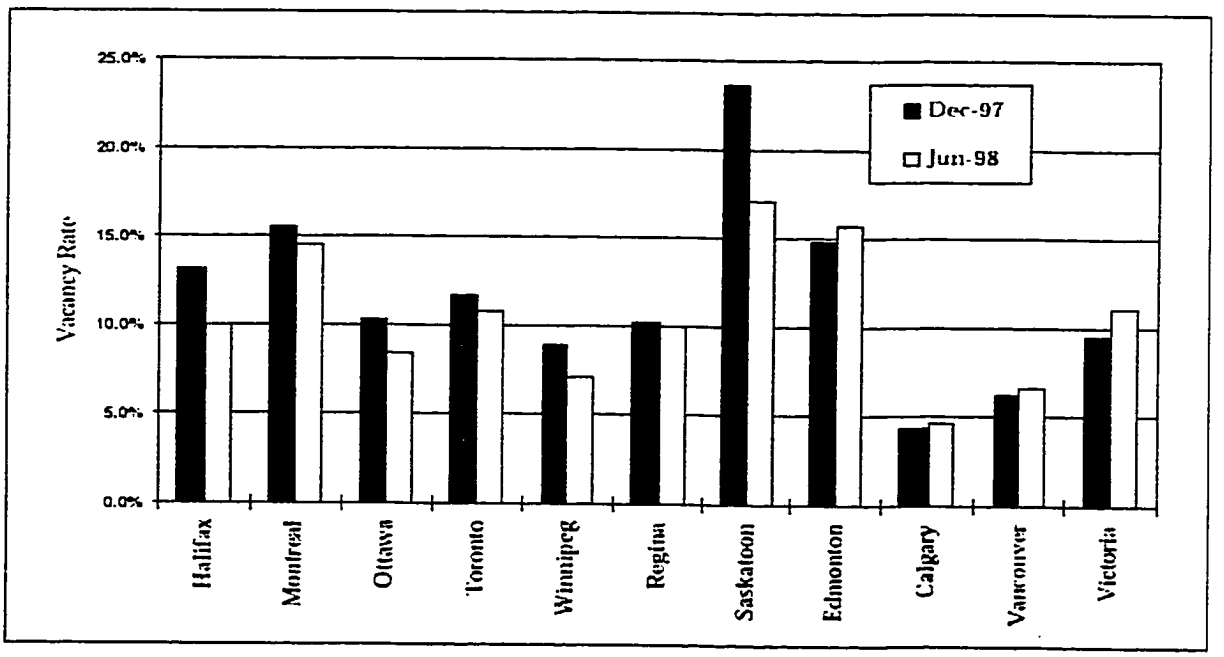
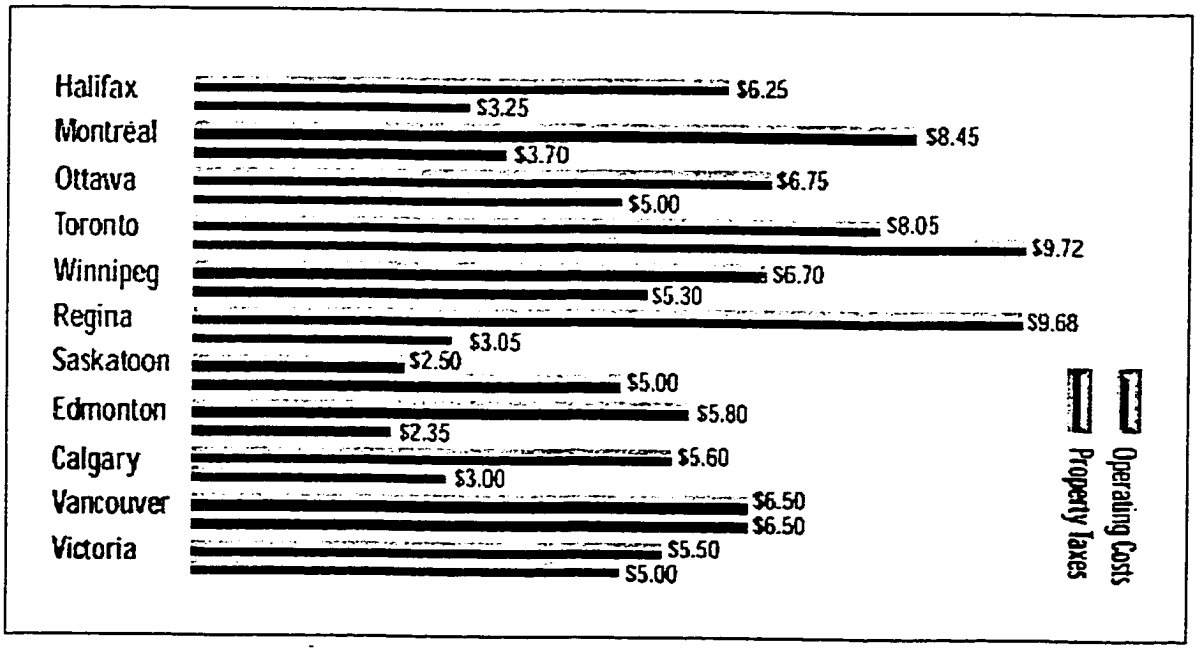


Figure AP3 - 10

National Class A Office Market Indicators - June 30, 1998

City	Number of Buildings Surveyed	Office Inventory (Sq. Ft.)	Jan - June New Supply (Sq. Ft.)	6 Month Absorption (Sq. Ft.)	Vacant Space (Sq. Ft.)	Vacancy Rate Jun-97	Vacancy Rate Dec-97	Vacancy Rate Jun-98
Halifax	34	3,396,414	0	118,516	163,949	n/a	6.7%	4.8%
Montreal	50	20,620,301	0	(46,669)	1,897,216	8.8%	8.7%	9.2%
Ottawa	114	15,079,753	260,817	510,638	525,849	6.3%	5.2%	3.5%
Toronto	331	68,665,908	226,812	730,778	5,920,824	11.3%	9.7%	8.6%
Winnipeg	6	1,939,447	0	19,493	34,812	6.4%	2.8%	1.8%
Regina	7	990,000	0	11,599	28,100	n/a	4.0%	2.8%
Saskatoon	8	784,657	-8,350	2,982	91,070	16.6%	12.0%	11.6%
Edmonton	25	7,299,300	0	-55,222	1,040,600	13.1%	13.5%	14.3%
Calgary	35	17,328,412	0	-66,732	243,967	2.3%	1.0%	1.4%
Vancouver	88	12,850,600	49,500	51,600	609,700	3.4%	4.7%	4.7%
Victoria	8	596,748	87,068	16,925	102,098	2.2%	6.3%	17.1%
Total	706	149,551,540	615,847	1,293,908	10,658,185	8.8%	7.6%	7.1%

Figure AP3 - 11



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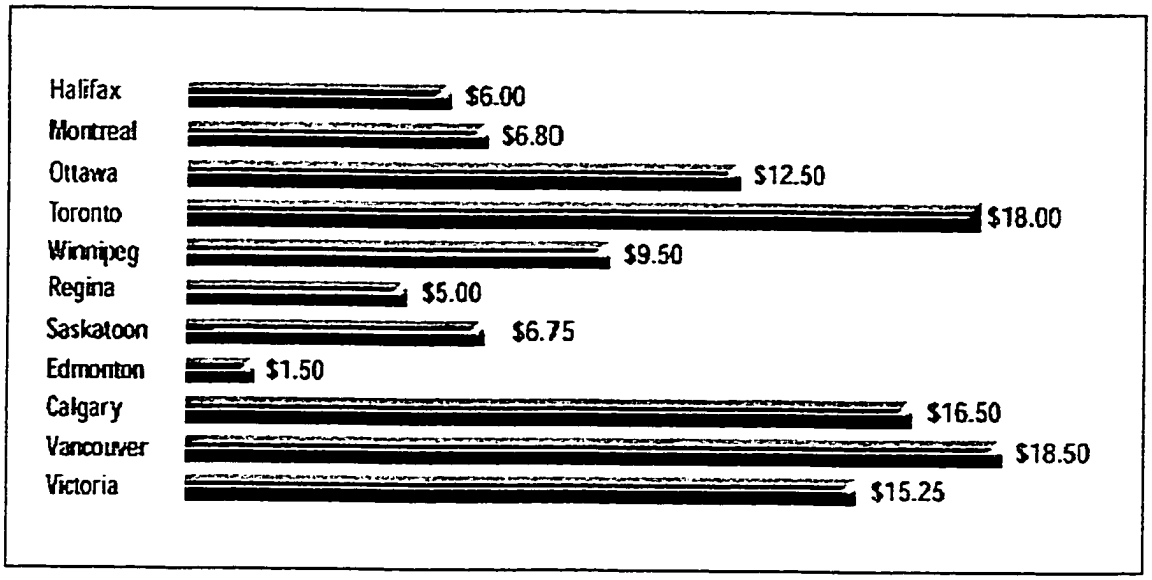

Figure AP3 - 13 Canada Office Market Effective Rental Rates (1997)
Downtown Class A Building (Source: Collier International)

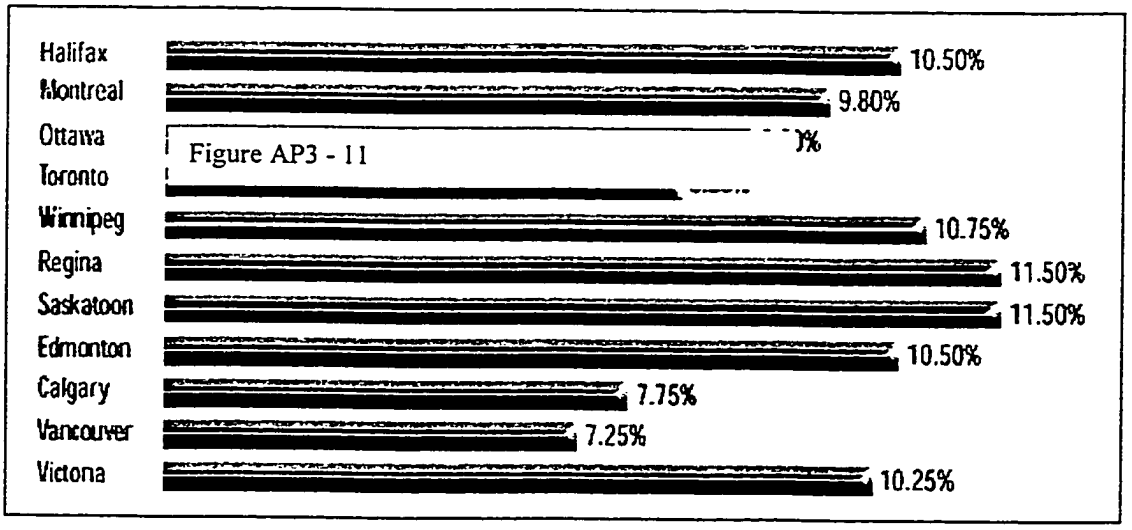

Figure AP3 - 14 Capitalized Rates in Central Business District (1997)
(Source: Collier International)

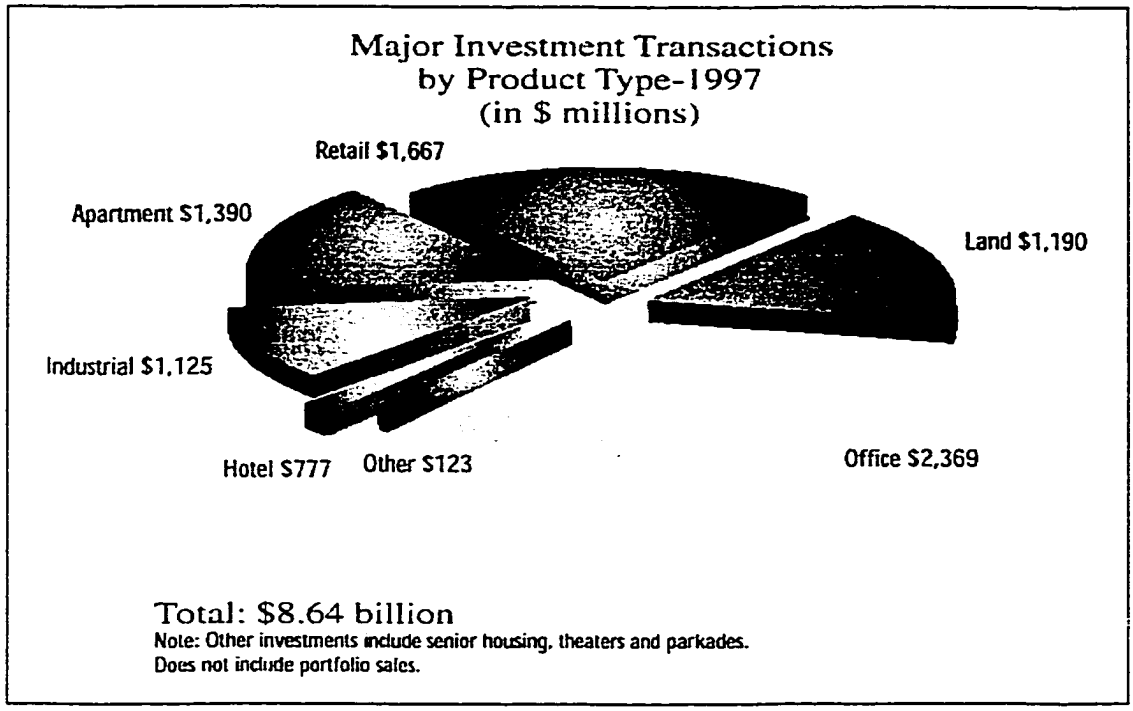

Figure AP3 - 15

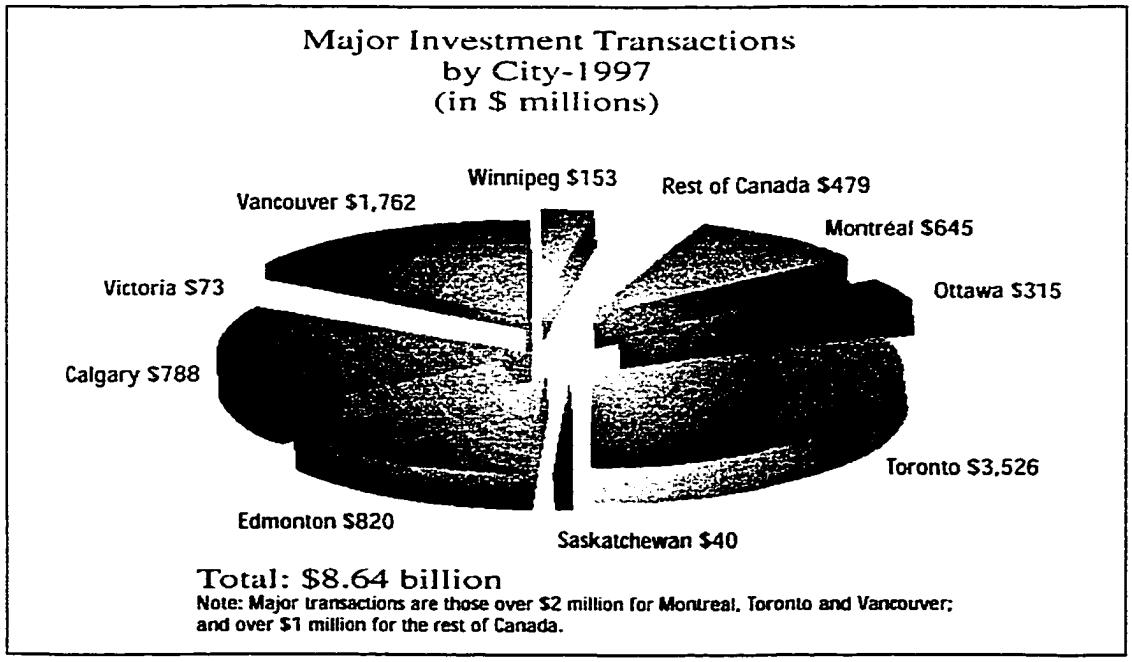

Figure AP3 - 16

Table AP3 - 1 Operating Costs of a New Class A Building from DPA Inc

Operating Cost (MONTREAL)				
Unit: $ / Sq. Ft.	1993	1994	1995	1996
Insurance	0.15	0.17	0.18	0.19
Tenant electricity	1.12	1.14	1.16	1.18
Building energy	1.12	1.14	1.16	1.18
Cleaning	1.19	1.05	1.05	1.05
Security	0.72	0.72	0.73	0.73
Elevators	0.30	0.31	0.31	0.32
Mechanical maintenance	0.50	0.50	0.52	0.53
Building Main / Salaries	1.03	1.03	1.05	1.07
Audit and Professional Fee	0.15	0.15	0.15	0.17
Management	1.00	1.02	1.04	1.06

Table AP3 - 2 Comparisons between Asking, Negotiated and Equilibrium Rental in 1994 DPA Inc. (MONTREAL)

MONTREAL Unit: $ / Sq. Ft.	Central Core	Midtown	Suburbs
Average Asking Rental rate			
Class A	15.44		
Class B	10.32	12.11	12.01
Class C	9.35	9.09	8.50
Estimated Negotiated Rental Rate			
Class A	12.00		
Class B	9.30	10.50	9.75
Class C	7.00	8.00	7.25
Estimated Equilibrium Rental Rate			
Class A	20.50		
Class B	15.50	13.50	12.00
Class C	11.50	10.00	9.00

Knowledge Requisition

The following content focuses on background knowledge and techniques, which are used in the present research. It explains terms and concepts that are necessary for the understanding of the research.

AP4 - 1 KNOWLEDGE OF REAL ESTATE (RE) FIELD

Real estate refers to land and buildings. A substantial percentage of the world's private, corporate, and public wealth consists of real estate. Usually, RE business is divided into residential, commercial and industrial categories. Office building is subcategorized in commercial real estate along with apartment buildings, shopping centers, and hotels, etc, which have similar income and expense item characteristics. The real estate field is a unique "kingdom", with a 'language' all its own. It has its own concepts, and uses different expressions to describe business activities and other circumstances. It is important to understand these basic underlying concepts and conventions, because they will help to explain the economic phenomenon in the RE world and enable the development of an LCC analysis system.

AP4-1-1 New Trend and Player in RE Industry Today

It should be noted that the commercial RE industry has undergone an incredible evolution. Following is a brief description of today's market trend:

1) **Increased demands by the owners of property** - Owners are demanding that traditional property management responsibilities become even more asset management driven, and they are demanding more service. Investors have become more careful concerning increase in property value, with a quick return on investment as the main goal.

2) **Increased competition, leading to lower fees** - At one time, owners held buildings for longer periods of time, expecting better margins of return on resource investment. Today's investment philosophy is purchase, increase value and sell.

3) **Change in product ownership** (REITs) - REIT refers to ***Real Estate Investment Trust***, the method of investing in real estate in a group, with certain tax advantages. This new approach, which is central to the decision-making process and portfolio posturing are professional property and asset managers, has been challenging current markets as shown in Table AP4 - 1. As REITs financing group, banks and insurance companies involved, they become leaders in RE business.

Table AP4 – 1 REITs Achievement

Real Estate Public Equity Financing ($ Millions)								
	1990	1991	1992	1993	1994	1995	1996	1997
R.E. Companies	63	648	592	525	577	43	756	3,474
REITs	0	0	0	35	33	48	679	2,005

AP4-1-2 Real Estate Terms

Like any other language, the RE field has its own language and rules, with special meanings, to express RE business matters and activities. It is difficult to find their real meaning in conventional dictionaries, and even in professional dictionaries such as the Building Contract Dictionary [12] and Construction Glossary [13]. To understand and interpret these sorts of "slang", use of this information is the first step to carrying out an LCC analysis in the RE field. The following lists some of "slang" that may have appeared throughout this project.

Transactions

Describes business or service activities that include:

- Selling or buying buildings
- Dealing with lease contract – lease signing, lease renewal, lease restructure, sublease, sublease renewal, lease negotiation, etc.
- Others: Build – to – suit, Relocation etc.

Existing Inventory

This is also called Space Available or Space Rentable. It usually refers to a city's total competition OB available space in renting condition in the market

Absorption

The net change in occupied space over a period of time (generally year to year). Positive absorption reflects an increase in occupied space in a market, while negative absorption reflects a decrease

Vacancy Rate

The percentage of non-occupied space in the total rentable space rate

Speculative Building

When a contractor builds a building without clients, confident they will find a tenant in the end

Owner – Occupied Building or **Owner user**

A building built and used by the owner

Build – to – Suit or **Design Build** or **Custom Design**

Usually, an Owner Company that undertakes the project for particular requirements. Basic requirements for many industrial users include: high ceilings, fire control (sprinkler) systems, heating/cooling systems, cross-dock loading, large outside storage and parking areas, and space for future expansion.

Net Operating Income (NOI)

NOI refers to Net Operating Income = Gross Scheduled Income less Vacancy and Credit loss less Operating Expenses

Capitalization Rate

An investor is most likely to use capitalization of income as the method of estimating property's value, expressed mathematically as:

Capitalization Rate = NOI / Present Value

Capitalization rate can be used as a predictor of the future value of a property. Example: Assuming a property generates NOI is $27,000 per year, and a new buyer requires a 9% rate of return (capitalization rate), then this property will estimate a resale price of $300,000.

Office Building Classification

Class A Building	Classification system; defined by BOMA International as the most prestigious buildings competing for premier office users with above average rental rates for the area along with high-quality standard finishes, state of the art systems, exceptional accessibility and a definite market presence
Class B Building	Defined by BOMA as buildings competing for a wide range of users with rents in the average range for the area. Building finishes are fair to good for the area and the systems are adequate, but the building does not compete with Class A at the same price
Class C Building	Defined by BOMA as buildings competing for tenant requiring functional space at rents below the average for the area

Many RE companies have their own system of categorizing building classes, such as: *AAA Building* or *Prestige Building*, that have the same standard as *Class A Building* by BOMA International

AP4-1-3 Rental Puzzle

When reading a RE market report, various rental names often lead to uncertainty and confusion. Some of them are shown in Figure AP4 - 1.

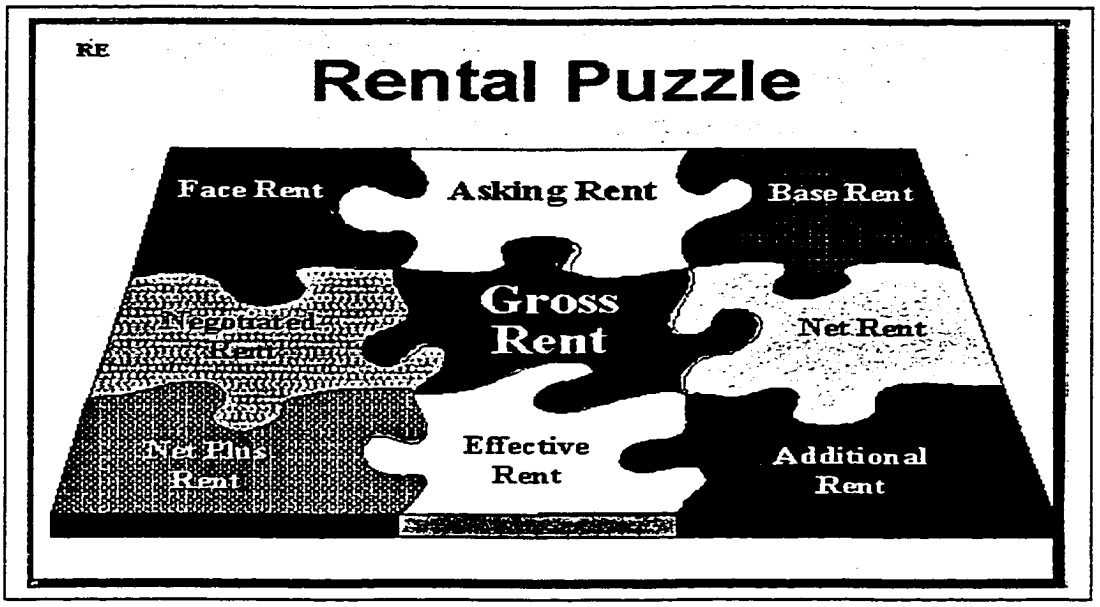

Figure AP4 - 1 Rental Puzzle

Rent Terms Definition

In the RE field, rental is usually considered consisting in two parts:

1) Liquid – negotiable
2) Fixed – not likely to change much at leasing period that indicates Operating and Maintenance costs, Taxes, Insurance, etc.

Today, at lease negotiation, property owners and leasing managers usually just deal with net rent, not gross rent.

Gross Rent

The net rent plus applicable taxes and operating costs.

Net Rent (negotiated rent)

It refers to income resources expected by the landlord. It can be the price after negotiation.

Asking Rent

It is also called Quoted Rent (without taxes and operating costs), which may be subject to negotiation. The average base rent for last space rented in a gross lease during the past year

Additional Rent

Payment for all operating costs, property taxes and utilities (energy)

Net effective rent

The rental rate minus all the inducements such as free rent and renovations.

Detailed Explanation

- ☛ Face Rent, Asking Rent and Base Rent are usually based upon the same standard
- ☛ Additional Rent and Net Plus Rent have the same meaning
- ☛ Table AP4 – 1 explains the relationship of these rents

For an individual building, more attention should be paid to rental strategy - inducement. Normally, for business purposes, there are various reductions in practice, especially in a market downside. When market demand is low, building owners and managers tightly control total expenses, and will also try anything to attract new tenants and retain current tenants.

Figure AP4 - 2 briefly illustrates various reductions in leasing agreement.

Figure AP4 - 3 presents a sample of Effective Rent calculation, which reflects the owner's actual income amounts.

Table AP4 – 1 Rent Calculation

Sample of Rent Structure			
	$ / SF	$ / SF	Total
Asking rent	15.00		
Net rent (Negotiated)			**13.75**
Additional rent including:			**7.75**
+ (1) Utilities (energy)		1.75	
+ (2) Operating Exp.		1.50	
+ (3) Taxes		4.50	
Subtotal		7.75	
Gross rent			**21.50**

Figure AP4 – 2 Leasing Strategy

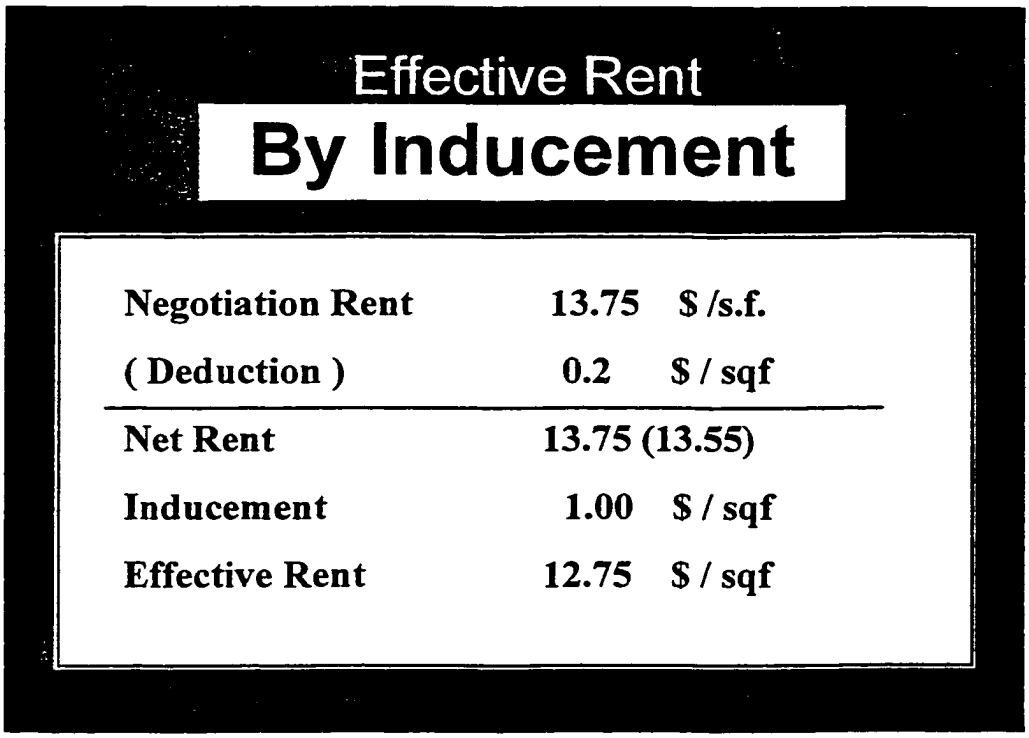

Figure 4 - 3 Effective Rent Calculation

AP4-1-4 Conceptions and Conventions

To have an overall knowledge of the RE business is very important to establish a current model for LCC analysis. The model must use such concepts and reflect directly RE business activity features.

Supply and Demand Equation

The principle of supply and demand affirms that increasing supply or decline in demand tends to affect adversely the price obtainable in the market. There is a point at which supply and demand are in balance, at least theoretically. At this point, market value tends to reflect cost of reproduction and replacement.

Figure AP4 – 5 describes the supply and demand relationship in the OB market. When market demand increases, the rental price rises. This pressure will keep going until new buildings join the market. After more and more new buildings enter into the existing

inventory, the market will go the other way causing rental prices to go down, and a new market balance is reached.

Factors affecting supply or demand for the OB market are population change, purchase power, price levels, wage rates, taxation, building codes and government controls.

Market Value

Value is the key word that links different segments of the RE business. Value plays an important part in all RE activity. Market value or value in exchange, reflects the actions of buyers, sellers, and investors in the market and typically represents the primary concern in an assessment of real property.

General Lease Period

Although a 5-year term with a 5-year renewal option is very common in new Class A buildings, the average lease term is usually ten years. It is unusual to find terms of more than 10 years lease.

Floor Space Measurement

Chapter 3 introduced the rule of thumb to measure floor space. Generally, a "Standard Method for Measuring Floor Area in Office Building" is established by BOMA International and has been the only method approved by the American National Standards Institute (ANSI Z65.1) since 1915. Another calculation method could be found throughout Internet directly at: http://www.officefinder.com/calc.htm

OB Market Frame

The office building market frame is shown in Figure AP4 – 4. The OB market is usually divided into two parts when conducting market analysis. One part is called competitive building. They attend Existing Inventory competition in market. Another is non-competitive building, usually they are government buildings or Build-to-Suit buildings. They do not participate in market competition.

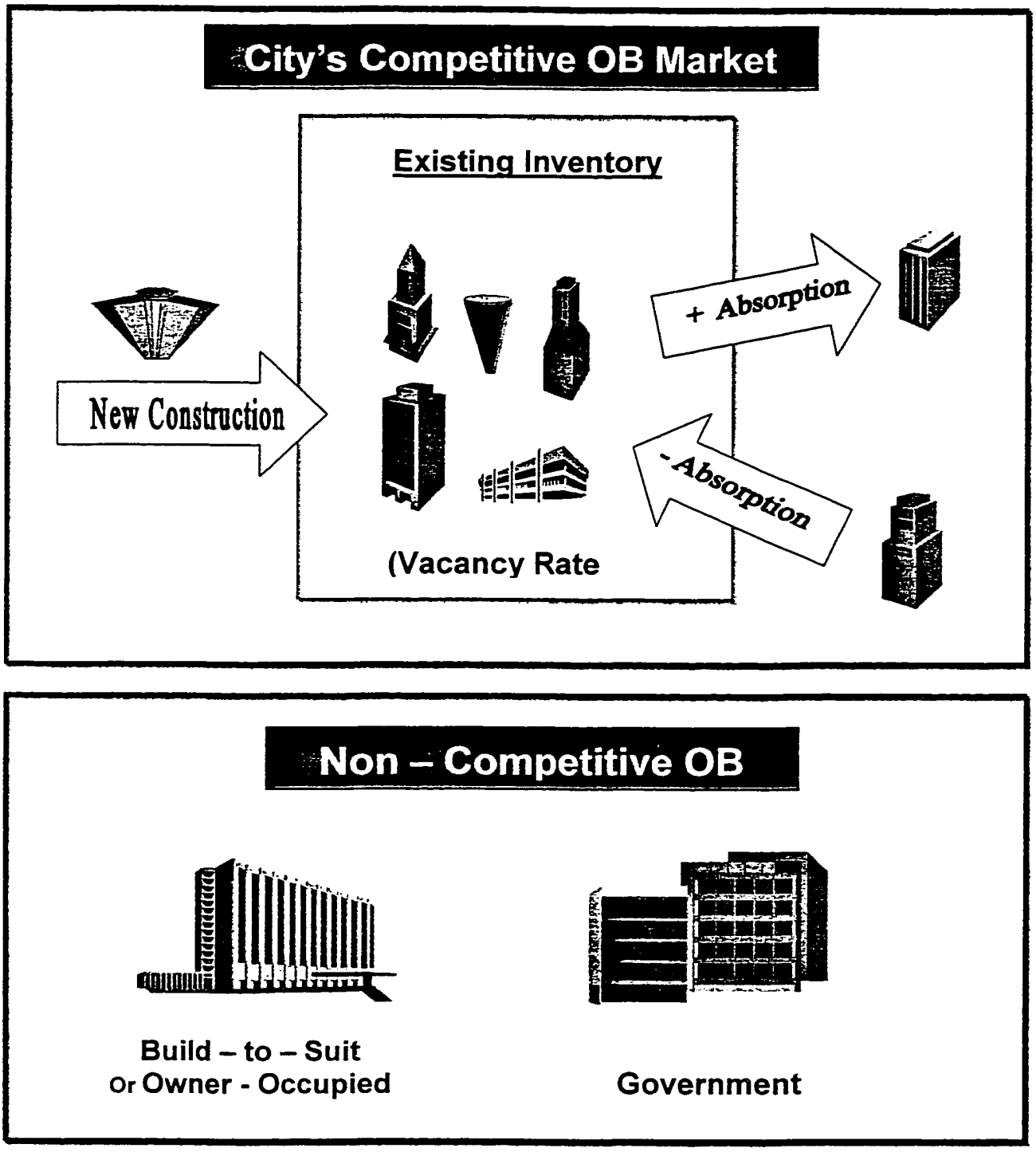

Figure AP4 – 4 OB Market Frame

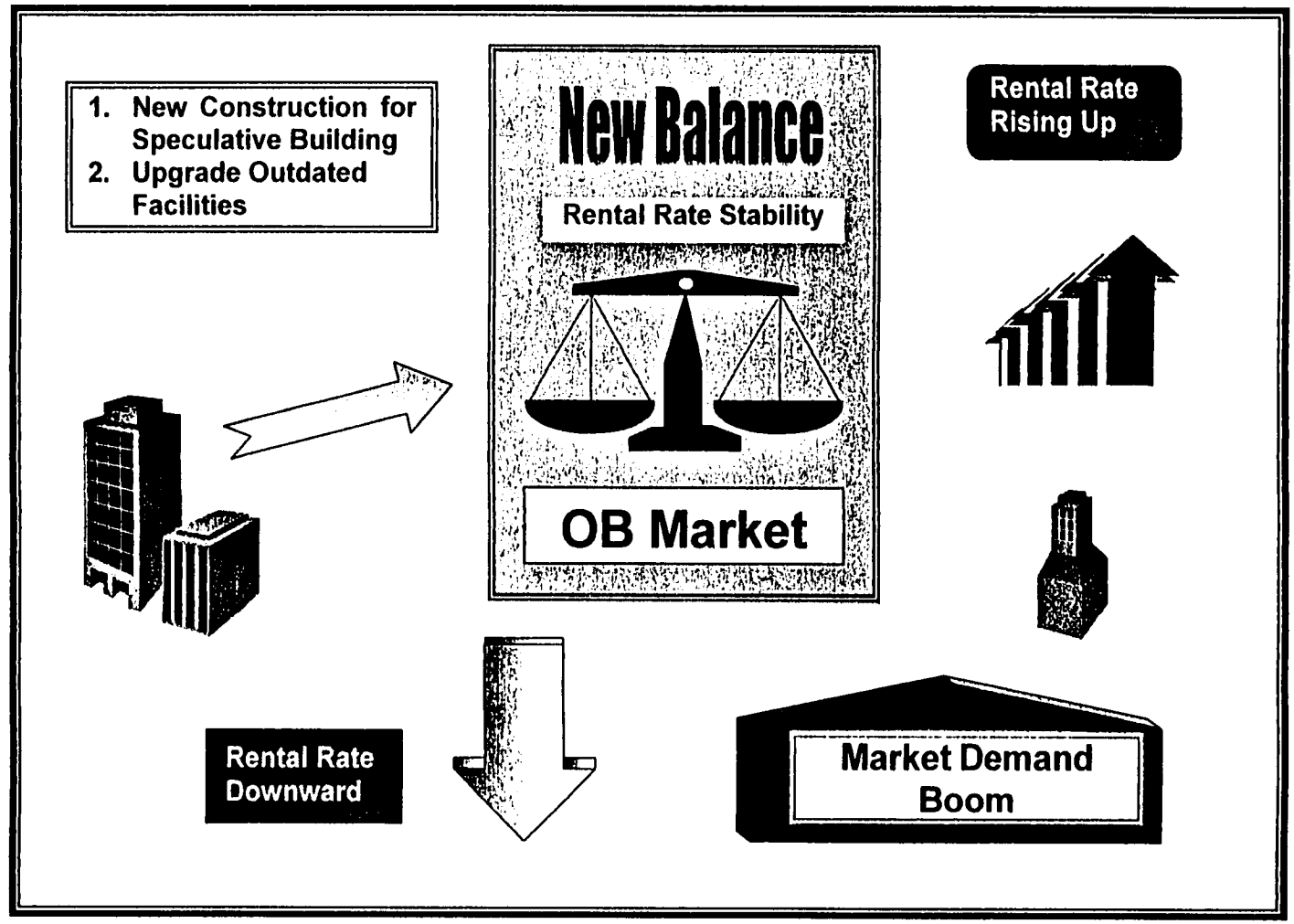

Figure AP4 – 5 Supply and Demand Relationships in the RE Market

AP4-1-5 Yield Rate Assumption For Ob Investment

For development of a speculative building, Development Yield can be referred to as the rate of return on actual development costs required by the developer, before leverage. Development Yield is one of the most important indexes for determining economic rent. The following introduces the procedures for estimating development yield rates for downtown Montreal office buildings.

Yield to Maturity of Canada Bonds Over 10 years	5.63% (Jan. 1998)
Yield Spread for New Buildings	+3.25%
Internal Rate of Return	**8.88%**

Long term Trend in Income

Land:	Basic Growth Rate: Inflation	2.0%
	Real Increase in Value Based upon Demographic Growth	
	+0.7% (factor of 3.0) + 2.1% = 0.43%	
Building:	Basic Growth Rate: Inflation	2%
	Yearly Depreciation	-2.0%

65% × 0% = 0.00%

Leasing Inducements: assumption of constant reinvestments (excluding major tenants)

75% × 25% × +2.0% = +0.37%

Summing them up: 0.43% + 0.37% = 0.8%

Overall Capitalization Rate (before amortization of leasing inducements)

8.88% - 0.8% = 8.08%

Reserve for Replacement of Leasing Inducements (excluding 25% major tenants) over 10 years at 3.34%

Made of the 10 year bond yield of	5.41%	
Minus the anticipated long-term rate of inflation of	2.00%	
	75% × 25% × 0.084 =	1.55%
Overall Capitalization Rate	1.55% + 8.08% =	9.64%
Development Profit (remuneration of the risk)	10%	0.96%
Development Yield		10.60%
	rounded	**10.50%**

AP4 - 2 KNOWLEDGE OF STATISTICS

Statistics is a discipline concerned with collecting, analyzing and interpreting data. Statistical methods have been used for a long time in fields as diverse as economics, genetics, meteorology and physics. With the development of modern facilities for collecting, storing and retrieving large amounts of statistical data, and with the explosive advancement of computer technology, statistics have become more important than ever before.

AP4-2-1 Regression Methods

The most common statistics technique applied in the RE business is regression methods, which are often used to predict present or future income or expense performance. There are number of existing regression methods applied in practice:

- Simple linear
- Exponential
- Polynomial
- Power
- Logarithmic

The data, which are sorted and analyzed, is the base of developing forecasting formula. The "better fit" with source data can generate reliable results. This is done by statistics

regression analysis and uses computer software such as database statistical analysis and spread sheet software.

AP4-2-2 Forecasting Techniques

Forecasting techniques can be divided into three general categories; extrapolative, causal, and qualitative.

- Extrapolative or time-series model simply extends the past into the future. The principle of this method presumes that predictions of the future can be based entirely on the historical behavior of a variable over time.
- Causal model is a more sophisticated forecasting tool. Single and multiple-variable linear-regression model is the most commonly used in RE analysis. It takes multi-impact factors into account in their model that estimates the relationship by choosing values for the parameters, the constant term, and regression coefficients.
- Qualitative techniques are those that rely on expert opinion or intuition as to future events. They may or may not take the past explicitly into consideration.

AP4-2-3 Meaning of R^2

It is noted that, in statistics terms, error does not mean mistake, it refers to variation. In other words, price is a function of its known explanatory attributes and its unidentified attributes. $\mathbf{R^2}$ (coefficient of determination) is the measure of the explanatory influence and 1 - R^2 is the measure of error, or the unexplained influences. An R^2 of 0.90 means that 90% of variation in price of the comparable is explained by the identified variables and that 10% is unexplained.

AP4 - 3 KNOWLEDGE OF COMPUTER APPLICATION

Today computers are in every corner of our society. There is no doubt about its accuracy, time efficiency, security, facility, and communication abilities, etc. A computer can to do many things that humans do not like to do. It goes without saying that computer technique is very useful and important in an LCC analysis, such as database establishment, cost performance simulation, cost forecasting, sensitivity study, numerical calculation and graphical demonstration.

The terms and concepts listed below, have been used in this research.

AP4-3-1 Database Management System

Database

Database is a collection of information regarding a certain topic. A database will help to organize this information in a logical manner for easy understanding.

Relational database

Relational database is a database that allows to group its data into one or more discrete tables that can be related to one another by using fields common to each related table.

Database management system (DBMS)

A database management system is an advanced type of database, and compares with another type of database - File Database. DBMS allows for the collecting, storage, searching, retrieving, adding and deleting of data.

Queries

A query is used to extract only certain information from a DBMS. A query can select groups of records that fulfill certain conditions. Queries can be used to select, change, add or delete records in DBMS.