ENGINEERING INVESTMENT DECISIONS

IN AN INFLATIONARY ENVIRONMENT

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ABSTRACT

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The objective of this paper is to examine the problem of engineering investment decisions under conditions of inflation. The text is divided into four chapters: an analysis of the nature and causes of inflation; a discussion of the significance of inflation throughout the life of engineering projects; the development of a methodology for the appraisal of a project in an inflationary environment; and a number of conclusions and recommendations for further study.

DEDICATION

EREV PESACH 5740

TO MY WIFE AND MY PARENTS WHOSE SUPPORT AND ENCOURAGEMENT MADE THIS PAPER A REALITY

ACKNOWLEDGEMENTS

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1

INTRODUCTION

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1.1 Introduction

There are a number of people who say that inflation, a man made condition, is similar to weather, a natural phenomenon. There is little that can be done to stop or change either one. Mankind, however, is able to control and minimize the impact of both problems on his activities.

Inflation and the economic system which causes it are part of a system for the production, distribution, and consumption of goods and services. It has become a topic of paramount importance in modern economics. Since the public produces and consumes the goods and the services of an economy, inflation is a problem that concerns not only economists, but every member of society. This paper is concerned with the problems associated with inflation and engineering investment decisions. Engineering investment decisions involve several important groups in our society and these decisions frequently result in major technological advances and economic undertakings. They form the basis for the allocation of many of the resources of the economy. The continued healthy growth of the economy, especially with respect to industrial, civil and building projects, is determined by these decisions.

The point of view taken in the text is generally that of the investor, developer, project manager, architect, or engineer. These are the persons who usually have the planning and control functions in a project. Engineering investment decisions, however, often involve, rely on, or are affected by contractors, suppliers, government agencies, and labour. These groups have a significant influence on a project as they can cause inflationary pressures at several stages during the life of an investment. This paper is therefore written with these groups in mind as well.

The major aspects of the inflation problem and engineering investment decisions are:

- how to minimize the impact of inflation on capital costs and future costs;

- how to predict, manage, and control future revenues and expenses under conditions of inflation; and

- how to incorporate inflation into the selection process for investment alternatives.

In order to accomplish these objectives the magnitude, significance, and causes of inflation must first be understood and appreciated. Then, techniques and policies to control, minimize, and eliminate the effects of inflation must be developed and implemented. This paper addresses these objectives in the following manner:

- an analysis of the nature and causes of inflation in Chapter 2;

- a discussion of the significance of inflation in engineering projects, with respect to all the phases and participants in the life of a project, in Chapter 3;
- the development of a methodology for the appraisal of a project in an inflationary environment in Chapter 4; and
- a summary of the conclusions and recommendations of this paper in Chapter 5.

This paper does not propose a comprehensive solution to the problem of inflation. Its main intent is to provide the reader with a good review of the problem of inflation with respect to engineering investment decisions and to provoke further discussion and investigation into this area.

CHAPTER 2

INFLATION AND ITS CAUSES

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2.1 Introduction

Inflation may be defined as a general rise in prices for commodities and factors of production (goods and services) that occurs in an economy. These price increases should not be in the form of a sudden spurt, but, a series of sustained price increases lasting at least a year. Although all such price increases, no matter how small, are by definition inflation, they are not all necessarily considered inflationary. The term inflation is employed to describe price increases that are considered detrimental to the economy or are a consequence of an unhealthy and unstable economic environment. The Western nations experienced low inflation rates in the years after the Korean War during the time of their most healthy economic growth. These price increases are not generally considered inflationary; they are believed to be part of the economic system by which consumers elicit from producers expanded and better goods and services, and are willing to pay more for it. These small price rises are called the 'normal rate of price increase' and are usually a sign of a healthy economy responding to the forces of supply and demand.

A large increase in the price of a commodity or factor of production is frequently offset by a corresponding decline in the price of another. Although the price of one item increases, inflation does not occur since the general price level remains constant due to the decrease in price of the other item. The second item costs less in response to a shift in its demand and supply function caused by the price change in the first item.

This chapter discusses the inflation problem with a description of the various types of inflation, a brief outline of the Western world's experiences with inflation, the present inflation situation in Canada and a detailed examination of several theories concerning the causes of inflation. If the problem and the causes of inflation are understood, then the persons involved in engineering investment decisions will be able to better forecast the inflation which may occur during the life of a particular investment.

2.2 Types of Inflation

The term inflation is employed when the detrimental effects of price increases are under consideration. Very low rates of price increase in a healthy economy are therefore not viewed as inflationary. Economists have recognized several types of harmful price increases [35, 38, 54,66].

2.2.1 Creeping Inflation

Creeping inflation is a condition that occurs when the level of prices rise at a relatively constant rate for a number of years above what is considered a normal rate of price increase. It is the type of inflation that most Western countries are presently experiencing and the type with which this paper is primarily concerned. The rate of increase does not necessarily remain constant for more tnan several years. Often there is an upward or downward adjustment in this average inflation rate as economic conditions change. An examination of Canada's inflation performance over the last twenty-five years indicates that there have been three distinct levels of inflation [5, 59, 60]. Figure 2.1 which presents Canada's inflation rates for this period, divides the past quarter century into three groups. There was a long period in the fifties and early sixties when inflation averaged only 1.5 percent. This is an extremely low rate of price increase and is considered acceptable in a healthy, growing economy. It is not coincidental that this was also the time of Canada's best economic performance during the past twenty-five years. From the mid-sixties to the early seventies the average inflation rate increased to 4.8 percent. This was mainly due to the spillover into Canada from the American deficit financing of the Vietnam war. Since 1973 grain crop failures in the Eastern countries and phenomenal increases in energy costs have resulted in another upward shift in the average inflation rate to about 8.9 percent.

Canada is therefore subject to a progressively worsening problem of creeping inflation. This situation results in the attraction of the resources of the economy away from the sectors producing real goods and services toward more speculative activities. Investors feel that these investments provide a better yield or hedge in an inflationary environment. Domestic savings are discouraged as even the small investor places his investments in commodities, collectibles, real estate, and gold. As capital flows to such non-productive areas there is a reduction in an economy's ability to respond to price increases

% INCREASE CONSUMER PRICE INDEX

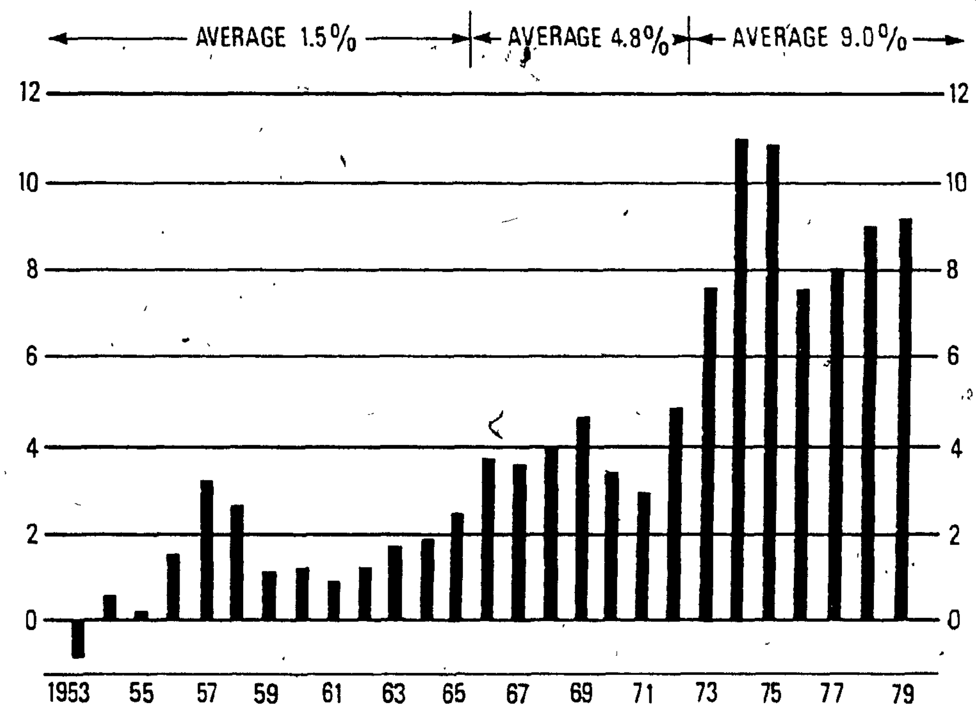


FIG. 2.1 INFLATION OVER THE PAST QUARTER CENTURY IN CANADA (STATISTICS CANADA)

with an expansion of output. Inventory accumulation and hoarding can further exacerbate the situation and further reduce the supply of goods and services in the market.

2.2.2 Chronic Inflation

Chronic inflation is a condition where high increases in the level of prices occur over a period of many years or decades. Inflation of more than 20 percent per year up to about 100 percent per year has drastic effects on an economy. Chronic inflation, however, is similar to creeping inflation since the rate of change remains relatively constant for extended periods. Hoarding is a must, home ownership and material possessions are the most valued of assets, money is lent and borrowed at astronomical interest rates and capital formation and investment decisions are modified to reflect this type of economy. Conditions of chronic inflation are presently occurring in several countries including Argentina, Brazil, and Israel [19].

2.2.3 Hyper-Inflation

Hyper-inflation is a situation where prices rise so rapidly as to destroy the efficiency of money; first as a store of value and finally as a standard of value and a medium of exchange. In a hyper-inflation situation, continuous rising prices set up the expectation of still further rises in the near future; so that, a scramble for goods sets in which results in a complete collapse of the currency. The main difference between hyper-inflation and the other types of inflation is that in a creeping or chronic inflation prices are subject to high rates of increases, but at relatively constant rates; while in a hyper-inflation the rates of increase themselves are subject to cumulative increases. Thus hyper-inflations are a chain reaction which are usually over quickly with drastic results. Hyper-inflation is usually a consequence of war, or the aftermath of war or revolution. Examples of hyper-inflations occurred in Germany after the First World War, in China just before the nationalist government was defeated and in Hungary after the Second World War.

2.3 Historical Background of Inflation

2.3.1 Before the Second World War

Inflation prior to the Second World War tended to occur during and immediately after wars, or revolutions, as governments financed war or revolution by resort to the printing press. These were often cases of hyper-inflation. Examples of such inflations include the inflation that occurred in France during the 1790's when the paper assignat fell to about one five-hundredth of its previous value and the inflation that followed the Revolutionary War in the United States when the paper continental currency fell to one-hundredth of its former value. Inflations resulted during periods when gold discoveries of a significant kind were made as when Spanish gold reached Europe from the New World. In other instances weak governments attempted to buy their way out of economic crisis by printing vast sums of money as happened in Germany in 1923 when prices increased 1,000,000,000,000 fold. In general these inflations had two important characteristics:

1. They occurred in response to a particular event, such as a war, revolution, gold discovery or an unmanageable economic crisis.

2. They lasted only as long as the event with which they were associated which was normally not very long. This is because these inflations were often examples of hyper-inflation which are quickly over with disastrous results.

2.3.2 After the Second World War

The Second World War was accompanied by a rapid world inflation. Wartime inflation continued into the post-war period, as part of the process of post-war reconstruction. Before this post-war inflation had time to unwind itself, the Korean War broke out and another war-generated inflation was precipitated. War and post-war pressures were over by 1953 and a new period of economic expansion began in which persistent inflation was not generally anticipated or feared.

2.3.3 1953-59

Governments in the industrialized countries were committed to policies of rapid growth and full employment. These policies were quite successful. Most European countries steadily approached full employment during the 1950's, and many achieved this objective by the mid-1950's. Meanwhile, growth rates continued at high levels in most countries; although the British and the American economies grew at markedly slower rates than the main European industrial countries. There were however disturbing signs that inflation was not going to disappear. Retail prices in the main industrial countries rose at an annual average rate of about 2-4% per annum between 1953 and 1959. At the time this was considered by some to be an above normal rate of price increase. Balance of payments problems became an increasing cause for concern in some countries, in addition to persistent small inflation.

2.3.4 1960-79

The pace of inflation quickened in the first half of the 1960's in many of the industrialized countries. Most European countries underwent price rises between 1960 and 1966 at a rate of about 3-5% per annum. North American inflation proceeded more slowly than in Europe during the early 1960's. The rate of inflation, however, accelerated in all the main industrial countries starting in 1967. It was by 1970 clear that a worldwide price and wage explosion was occurring which continued and accelerated. Table 2.1 presents the inflation rates for Canada and five major industrial countries for this period. Today we can only look with envy at the inflation of the fifties which many economists view as the normal rate of price increase for the period and thus, quite acceptable [29, 47, 64].

YEAR	UNITED STATES	CANADA	GREAT BRITAIN	JAPAN	GERMANY	FRANCE
1960	1.5	1.2	1.0	3.6	1.5	3.6
1961	1.1	0.9	3.4	5.4	2.3	3.4
1962	1.1	1.2	4.5	6.7	4.5	4.7
1963	1.2	1.7	2.5	7.7	3.0	4.8
1964	1.4	1.8	3.9	3.9	2.3	3.4
1965	1.6	2.4	4.6	6.5	3.4	2.6
1966	2.8	3.7	3.7	6.0	3.5	2.7
1967	2.8	3.6	2.4	4.0	1.5	2.7
1968	4.2	4.0	4.8	5.5	1.8	4.5
1969	5.0	4.6	5.2	5.1	2.6	6.4
1970	5.9	3.3	6.5	7.6	3.7	5.5
1971	4.3	2.9	9.5	6.3	5.3	5.5
1972	3.4	4.8	6.8	4.9	5.4	5.9
1973	6.2	7.5	8.4	12.0	7.0	7.5
1974	10.9	10.9	16.0	24.3	7.0	13.7
1975	9.2	10.8	24.2	11.9	5.9	11.7
1976	5.8	7.5	16.5	9.3	4.5	9.2
1977	6.5	8.0	15.9	8.1	3.9	9.5
1978	7.5	9.0	8.3	3.8	2.6	9.2
1979	11.3	9.2	13.5	3.6	4.1	10.7

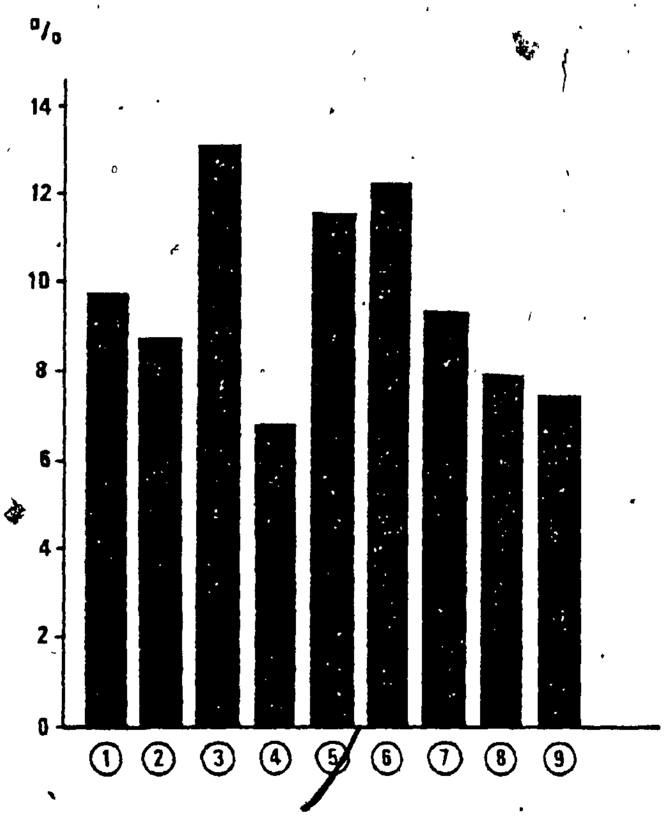
Table 2.1 Rates of Inflation in Six Major Industrial Countries 1960-1979

These rates of inflation are based on changes in the Consumer Price Index for each country. The Consumer Price Index measures the percentage change through time of a constant "basket" of goods and services, characteristic of each country, representing the purchases made by a particular population group in a specific time period. It is one of the many statistical indexes available from governments and international organizations and it is the most often quoted index for the general public. (International Financial Statistics, International Monetary Fund, Washington, D.C.)

2.4 Current Inflation in Canada

The inflation rates of Table 2.1 are the rates of inflation based on the Consumer Price Index for each country. These inflation rates represent only one aspect of inflation in an economy. Each area of economic activity operates under various pressures and influences; various sectors are often subject to different inflationary pressures. The Consumer Price Index itself is constructed with the weighted contribution of seven major groups. Figure 2.2 shows the components of the Consumer Price Index and their individual inflation rates [60]. The countries listed in Table 2.1 periodically publish statistics on their economic performance. Statistics Canada is responsible for this task in Canada. Three monthly publications by Statistics Canada are of particular interest since they contain a detailed breakdown of prices and inflation indexes. These publications are: Consumer Prices and Price Indexes, Industry Price Indexes, and Construction Price Statistics.

Two important observations may be made with an examination of a few selected indexes. Table 2.2 lists the cost indexes and the inflation statistics for the Consumer Price Index and five engineering oriented indexes [60, 61]. The cost data and the inflation rates are then presented graphically in Figures 2.3 and 2.4 to demonstrate the high degree of variation among the indexes. There is definitely some degree of correlation between the engineering indexes and the Consumer Price Index, but it appears that there are several other significant factors that determine the real price changes that are observed. It is evident that these engineering related indexes exhibit a significantly higher average



① ALL-ITEMS – 100% (WEIGHT IN INDEX)

② ALL-ITEMS EXCLUDING FOOD – 78.5%

③ FOOD – 21.5 %

④ HOUSING – 34.1%

⑤ CLOTHING – 10.1%

⑥ TRANSPORTATION – 15.8%

⑦ HEALTH AND PERSONAL CARE – 4.0%

⑧ RECREATION, READING AND EDUCATION – 8.3%

⑨ TOBACCO AND ALCOHOL – 6.2%

FIG. 2.2 PERCENTAGE CHANGE IN THE CONSUMER PRICE INDEX AND ITS MAJOR COMPONENTS – STATISTICS CANADA DECEMBER 1979

		1971	1972	1973	1974	1975	1976	1977	1978	1979
Consumer Price Index	Annual Index Value	100.0	104.8	112.7	125.0	138.5	148.9	160.8	175.2	191.2
	% Change during Year		4.8	7.5	10.9	10.8	7.5	8.0	9.0	9.1
Residential Building Price Index	Annual Index Value	100.0	110.1	123.2	134.7	144.0	160.5	175.5	192.0	211.4
	% Change during Year		10.1	11.9	9.3	6.9	11.5	9.3	9.4	10.1
Non-Residential Price Index	Annual Index Value	100.0	107.8	117.5	136.1	150.4	165.7	179.7	193.2	214.6
	% Change during Year		7.8	9.0	15.8	10.5	10.2	8.4	7.5	11.1
Highway Construction Price Index	Annual Index Value	100.0	105.1	118.3	158.7	177.5	185.1	198.2	214.4	229.7
	% Change during Year		5.1	12.6	34.2	11.8	4.3	7.1	8.2	7.1
Electric Utility Construction Price Index	Annual Index Value	100.0	104.4	114.1	137.5	154.2	163.1	173.9	186.8	211.3
	% Change during Year		4.4	9.3	20.5	12.1	5.8	6.6	7.4	13.1
Chemical and Petrochemical Price Index	Annual Index Value	100.0	105.9	113.6	134.2	158.9	172.9	186.4	201.1	220.2
	% Change during Year		5.9	7.3	18.1	18.4	8.8	7.8	7.8	9.5

Table 2.2 - Selected Statistics Canada Price Indexes, 1979 - 1979

Taken from Consumer Prices and Price Statistics (CAT 62-010) and Construction Price Statistics (CAT 62-007).

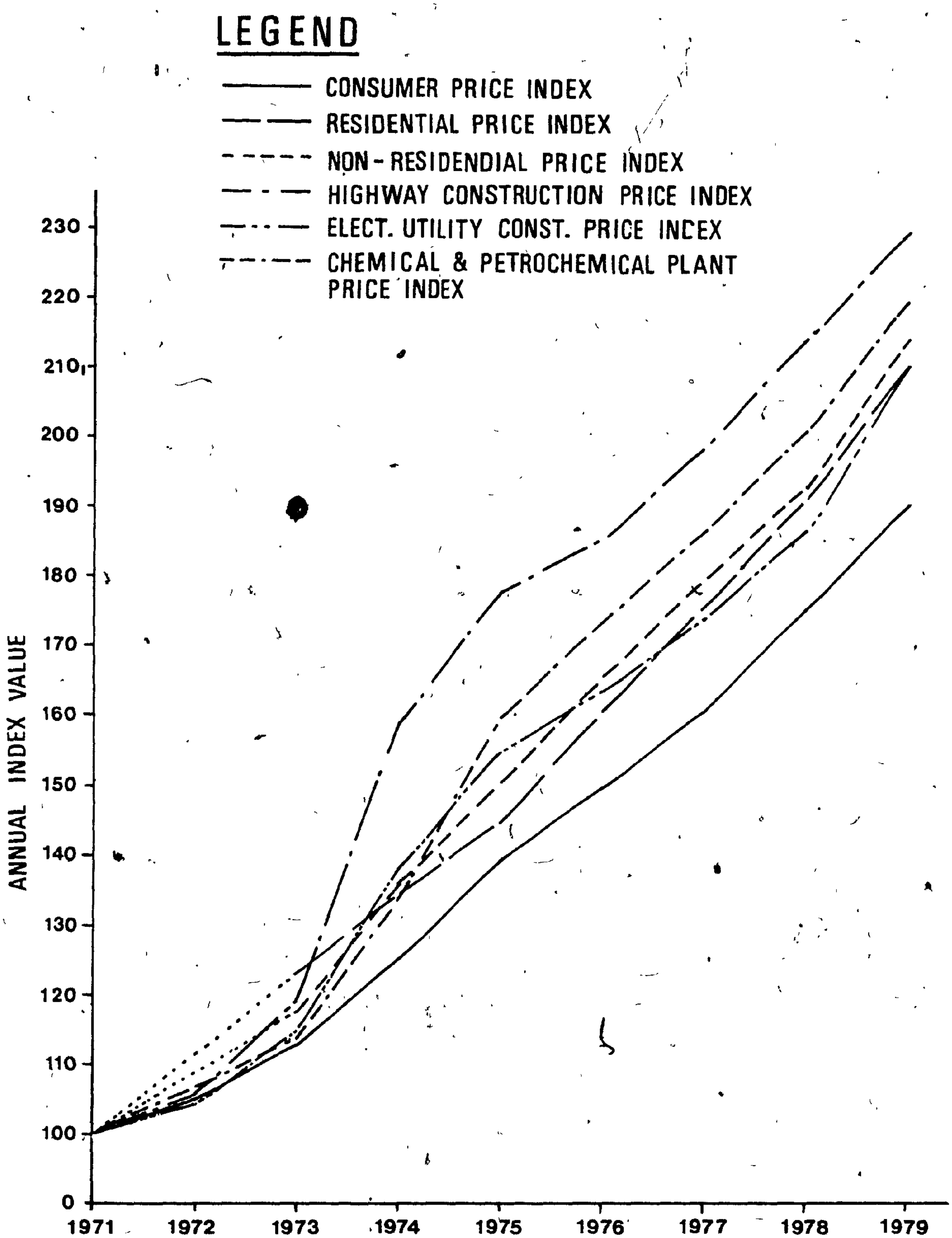


FIG. 2.3 GRAPHICAL REPRESENTATION OF SELECTED STATISTICS CANADA PRICE INDEXES 1971-1979

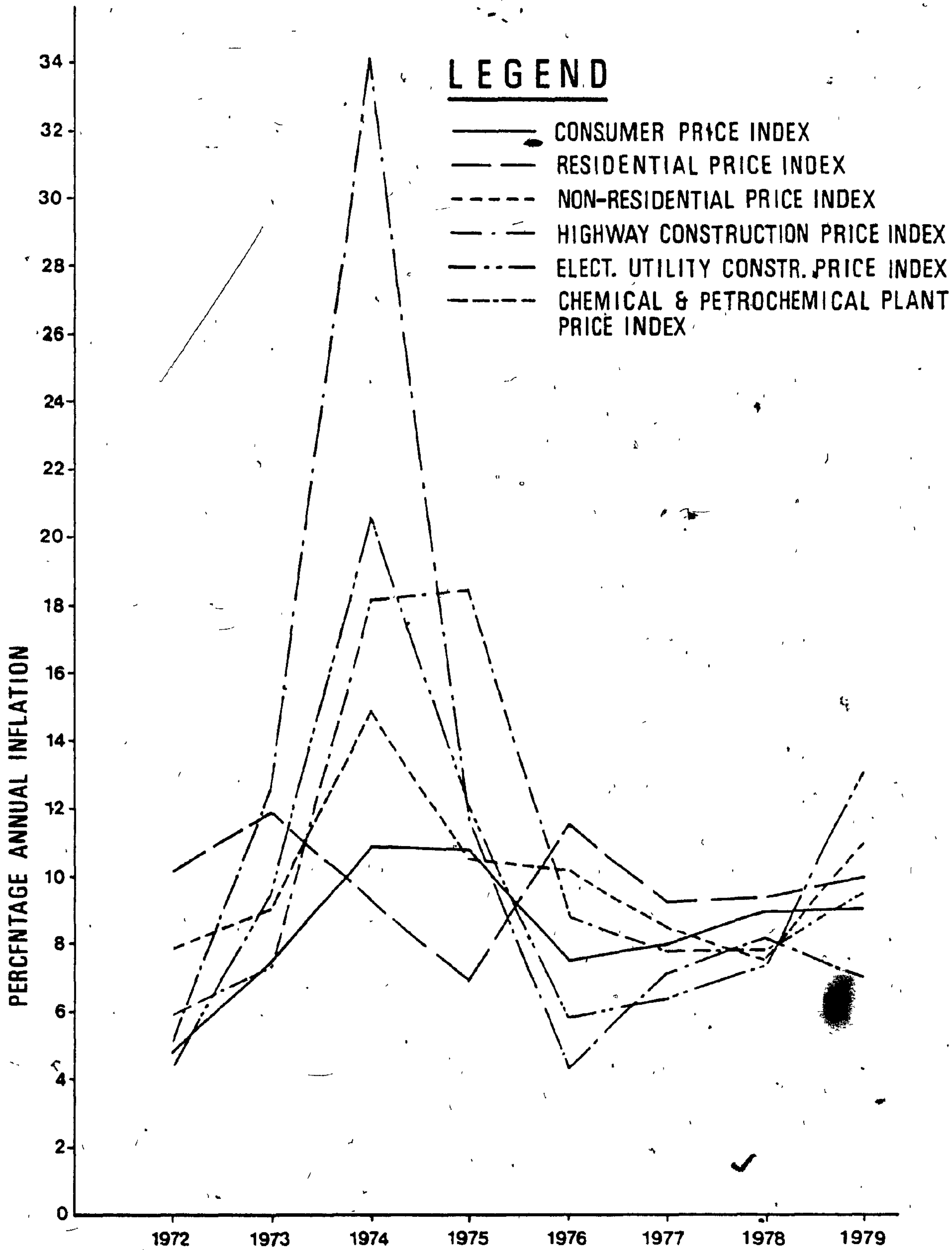


FIG. 2.4 INFLATION RATES FOR SELECTED STATISTICS CANADA PRICE INDEXES 1971-1979

rate of increase than the Consumer Price Index and that there are substantial fluctuations in the annual inflation rates over the years for certain cost indexes. This makes the task of relating specific indexes to a general price index even more difficult and results in more uncertainty in the prediction of future inflation for various cash flows in an engineering project. It is therefore even more essential for those involved in engineering investment decisions to understand, to consider the impact of, and to be able to predict inflation. The general causes of inflation are described in the next section. Specific engineering related aspects of inflation are discussed in Chapter 3.

2.5 The Causes of Inflation

There has been much debate among economists, government leaders and the public concerning the causes and solutions of the inflation experienced by North America, Western Europe and other industrialized nations. An understanding of the causes of inflation is essential to first controlling and then finding a solution to the problem. For the persons engaged in engineering investment decisions an appreciation of the causes of inflation is essential since they must predict the future inflation rates applicable to the various cash flows involved in an investment. When a special inflation causative mechanism can be identified, the effect of the particular inflation process can be attributed to the directly affected cash flows.

The general press often cites various causes for inflation. Although these causes are actually just symptoms of various inflation mechanisms it is useful to list some [30, 40]:

- the growth of the money supply relative to the Gross National Produce (G.N.P.);
- the effects of social welfare policy on the economy and capital formation;
- taxation policies required to support social policies;
- the existence of artificial controls on the economy that restrict market forces, thus causing inflation;
- changes in bank interest rates and international exchange rates;
- the distribution of wealth in society;
- the relation of unemployment to consumption;
- the relation of imports to exports - balance of trade and payments;
- speculation in the stock market and commodities;
- the effects of rising prices of imported raw materials and finished goods;

- low productivity in certain sectors of the economy;
- rising domestic and international energy costs;
- interruptions and interference with industrial output by legislation, government policy and labour disputes;
- government spending on non-productive programs;
- the failure to replace and modernize outdated industrial capacity.

Economists have identified several theories concerning the causes of inflation. Each item of the list just presented can be associated with one of the following theories:

1. demand-pull inflation
2. cost-push inflation
3. demand shift inflation
4. expectational inflation

The economy is subject to all of the above types of inflation to some degree. The following discussion concerning these various types of inflation, taken from several references [6, 20, 35, 38, 54, 58, 65, 66], discusses each inflation theory in detail.

2.5.1 Demand-Pull Inflation

The demand-pull theory states that changes in price levels are to be accounted for by disequilibria in the market caused by changes in aggregate demand for goods and services. Examples of demand pull inflation occurred several years ago in the steel industry and more recently in the cement industry.

A rise in aggregate demand at existing prices in a situation of near full employment creates an excess demand in many individual markets, and prices will be bid upward. The rise in demand for goods and services causes a rise in demand for factors of production; their prices are bid upward as well. Inflation in the prices of both consumer goods and factors or production is therefore caused by a rise in aggregate demand. This process of demand pull inflation is shown in Figure 2.5.

When demand increases from D_1 to D_2 the real national income increases from Y_1 to Y_2 because the existence of unemployment and unused capacity make possible an increase in supply at existing prices. When demand increases from D_2 to D_3 both prices and output rise because in spite of the presence of unemployment and idle capacity in the economy as a whole, in particular sectors 'bottlenecks' arise from shortages, imbalances and rising marginal costs. This type of inflation is sometimes called "bottlenecks" inflation to distinguish it from 'true' inflation which sets in when effective demand exceeds full employment, full capacity supply, as represented in the diagram by a move from D_4 to D_5 at Y_f.

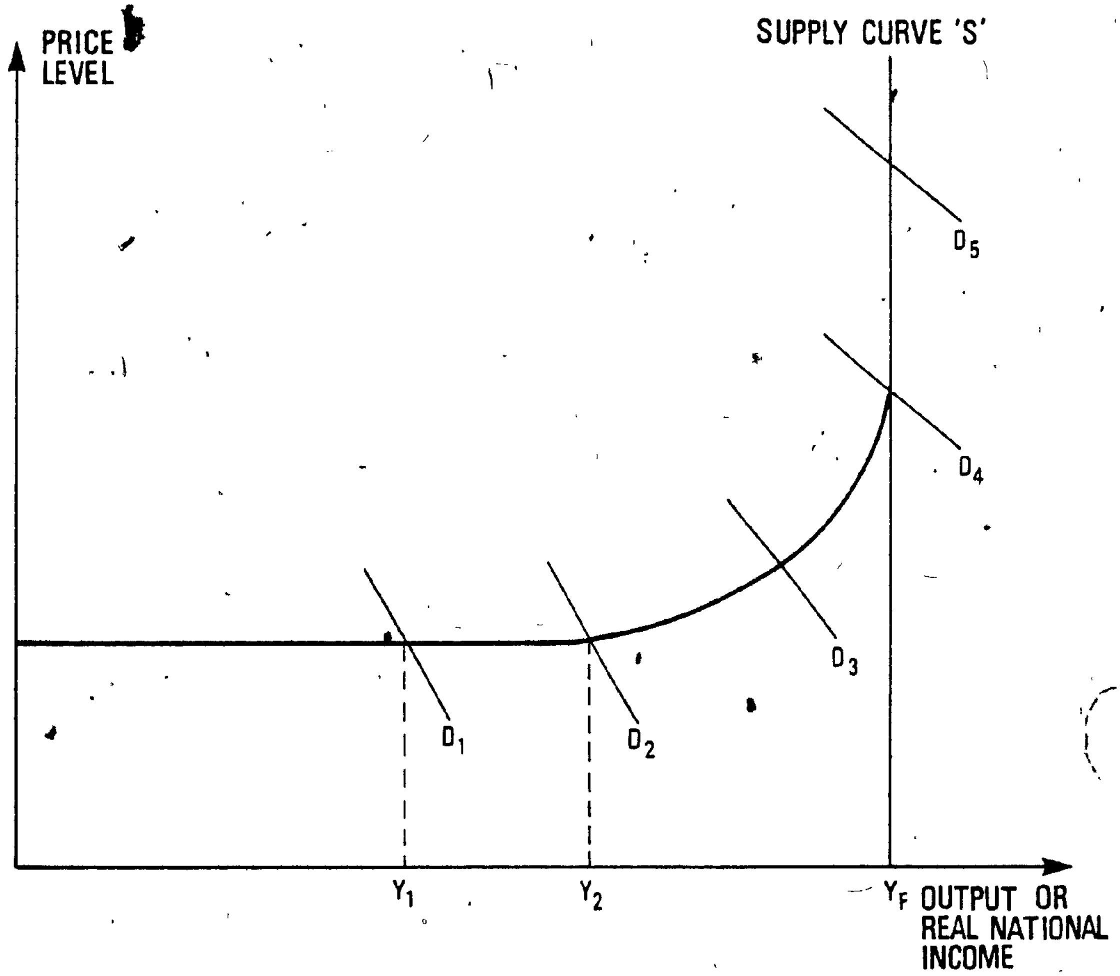


FIG. 2.5 DEMAND-PULL INFLATION. THE VERTICAL AXIS MEASURES THE PRICE LEVEL AND THE HORIZONTAL AXIS THE OUTPUT AND REAL INCOME. 'S' REPRESENTS THE SUPPLY CURVE OF GOODS AND SERVICES AT VARIOUS PRICE LEVELS AND INCOMES. REAL INCOME REFERS TO THE MONEY VALUE OF THE OUTPUT OF AN ECONOMY MEASURED IN BASE YEAR OR CONSTANT VALUE DOLLARS.

There is considerable disagreement among economists concerning the causes of demand-pull inflation. Two main streams of opinion exist about the economy and how to deal with the situation of excess demand. The two groups are the Monetarists and the Keynesians.

Monetarists believe that all inflations have monetary causes. An increase in money supply at a faster rate than the potential output is expanding is considered the necessary and sufficient condition for inflation. The economy is relatively self-regulating and monetary policy is the most effective method of reducing inflation.

On the other hand Keynesians believe that excess demand can be generated through either an increase in household expenditure or an increase in the money supply, both of which lead to more spending. Thus non-monetary factors, such as an investment boom caused by the opening up of new investment opportunities or a rise in consumer borrowing and spending, can cause substantial inflations. Keynesians agree with Monetarists that such inflations cannot continue indefinitely unless there is also a corresponding monetary expansion. However they feel that such an inflation can continue for an extended period even if there is no monetary expansion. Furthermore, the actual monetary expansion often occurs as a response of the banking system to the heavy monetary demand. Keynesians also believe that the economy cannot be relied on to produce a full employment situation if left to itself and that fiscal policy (taxes and expenditures) is a more effective tool than monetary policy (interest rates and money supply) in dealing with the problems of inflation and unemployment.

The Monetarists base their ideas on the Monetary Theory Model of the economy while the Keynesians employ the Income-Expenditure Model of the economy.

Monetary Theory and Inflation

A basic principle of the Monetary Theory is that inflation is caused by an excess of money in circulation. Modern Monetary Theory has its roots in the Traditional Quantity Theory of Money. This quantity theory was developed as part of classical economics which assumes that the equilibrium level of the national economy always occurs at full employment and that there is a constant velocity of circulation for money. The theory states that the monetary value of national production is the product of prices and national production. Changes in the money value of national income are proportional to changes in the money supply. Since the economy is assumed at full employment, further increases in output are impossible in the short term. Therefore any increase in the money supply will result in corresponding price increases as consumers have more money and demand more goods and services.

Modern Quantity Theory recognizes the frequent occurrence of unemployment at the equilibrium level and the possible variations in the velocity of money. The definition of the money supply has been expanded from just demand deposits and the amount of currency in the hands of the public, to include total privately held bank deposits (savings accounts, term deposits, etc.). Changes in the money supply and aggregate demand will mainly cause changes in prices in a full employment economy, and will cause changes in real income (output and employment) in an economy with unemployment and relatively rigid prices. Monetarists feel that the Central Bank's control of the money supply is the most effective factor in effecting changes in the national income to control inflation and unemployment.

The Keynesian Income-Expenditure Theory and Inflation

The Keynesian approach differs from the Monetarists approach in that it focuses attention on changes in the total expenditure flows and on their effects on income and prices. It assumes that for an economy to be in equilibrium with no pressure on prices, the total real expenditures must equal the total real income. The terms real expenditures and real income refer to monetary units as measured in a base year in constant dollars; as opposed to nominal or present day inflated dollars. The monetary value in constant dollars of the total demand for goods and services is the total real expenditure function.

The components of total real expenditure are: consumption expenditures (C), investment expenditures (I), government expenditures (G), and the difference between export income and import expenditures (X - M). This expenditure function may be expressed as $C + I + G + (X - M)$. The function relates the level of desired real expenditures to the level of real income. The real income is the money value in constant dollars of the total production of goods and services in the economy. When total expenditure exceeds what the economy can supply in terms of goods and services an inflationary gap exists as shown in Figure 2.6 and explained below.

This figure demonstrates how an inflationary gap can occur in the economy. The part of economic expenditure that is most sensitive to income is household consumption as represented by line C. Government expenditures, investments, exports, and imports are considered not as sensitive in the Keynesian model and are assumed to be relatively constant. The total expenditure function can therefore be represented by the line C + I + G + (X - M). The intersection of the total expenditure function with the forty-five degree line determines the equilibrium level of real national income, Y_E. When national income is at Y_E, the total amount of goods and services produced within the economy is equal to the total planned real expenditures. However, Y_E can represent an unfeasible level of output. If Y_F represents the absolute maximum level of output obtainable from the available resources of capital and labour, Y_F is the full employment level of national income. Y_F is thus an effective ceiling beyond which output cannot rise. When Y_E exceeds Y_F expenditures fall short of their real value. This situation exists when consumers desire to, and have the money to, purchase more goods and services than are available. The same amount of money is therefore spent on less and there is a consequent upward pressure on prices. This results in an inflationary gap in the economy of magnitude AB. The total expenditure

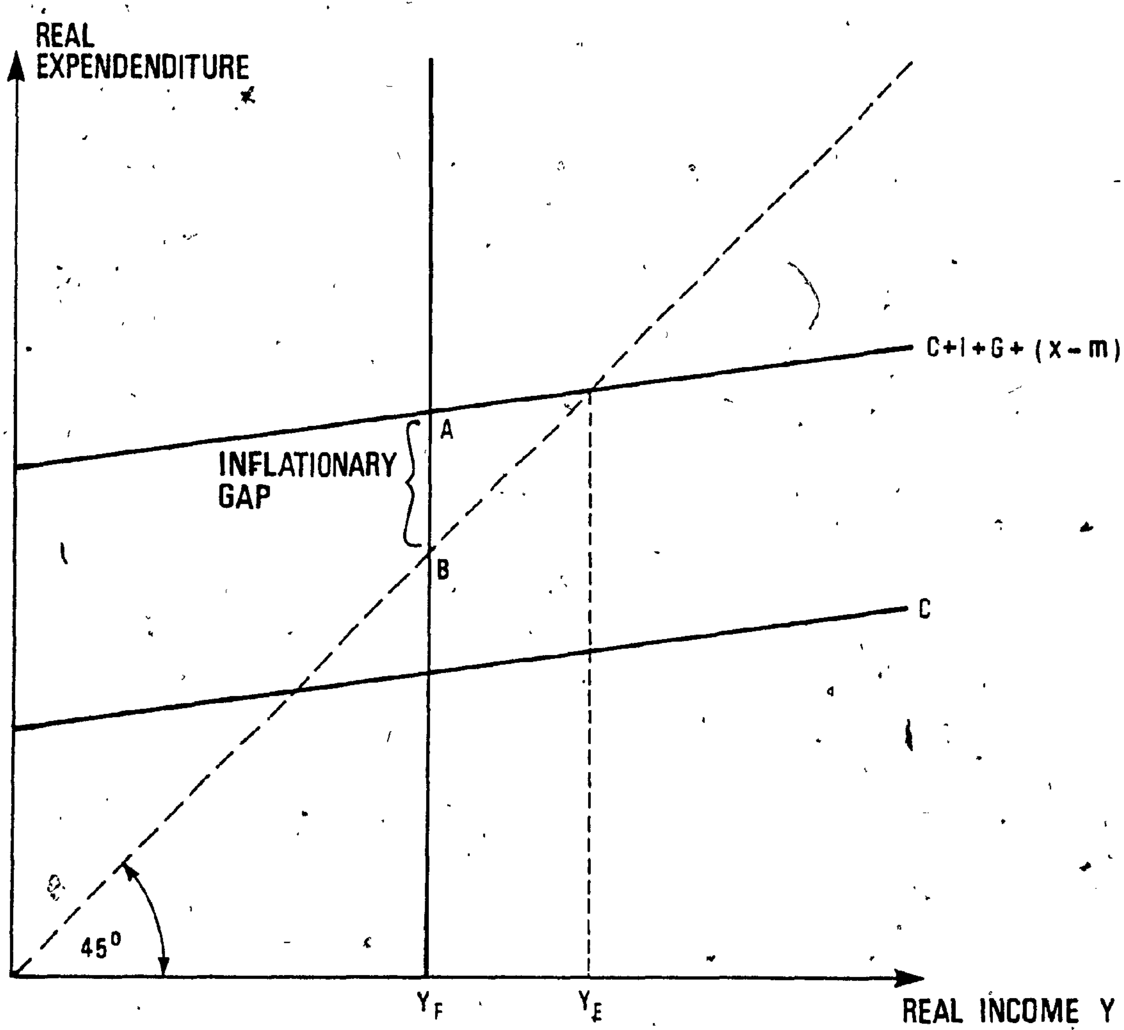


FIG. 2.6 AN INFLATIONARY GAP MODEL

function must be shifted downward to a level at which the desired real expenditures will meet the possible output. The Keynesians believe that an inflationary gap can be eliminated with the appropriate fiscal and monetary policies more effectively than with just monetary measures (54, 65).

The Keynesians agree that variation in the money supply exerts its influence mainly through impact on the components of total demand. An increase in the quantity of money causes a fall in interest rates, stimulates investments, and thereby increases output capacity. This type of action may be appropriate if a deflationary gap exists. A deflationary gap is a condition that exists when the total expenditure function is in equilibrium with the economy in a situation of less than full employment and output. However, during periods of depression and uncertain times investors take a bleak view of the future. A lower interest rate or increased availability of money is unlikely to exert enough of an influence on investment decisions. Similarly, contraction of money supply causes the rate of interest to rise and thus curtail expenditures. This cure for inflation may not work if investment optimism and consumer spending fails to be restrained enough by tighter money supply and higher interest rates. Total expenditures may not decrease and the inflationary gaps remain. For these reasons, the Keynesians place greater emphasis on fiscal policy rather than monetary policy. For example the Great Depression of the 1930's failed to be resolved with monetary measures, whereas the correct Keynesians fiscal policies may have revived the economy.

A combination of monetary and fiscal measures are thus appropriate when a condition of demand-pull inflation exists.

2.5.2 Cost-Push Inflation

The situation where prices are being pushed up above the rate of normal price increase because of rises in costs not themselves associated with excess demand is defined as cost-push inflation. The costs of production consist of wages and salaries, the cost of imported or local materials, profit, and the cost of capital. Cost-push inflation is caused when one or more of these components increases independent of the state of demand; the increased cost is then passed on to the consumer in the form of higher prices. The process of cost-push inflation is shown in Figure 2.7.

There are two types of curves in Figure 2.7. The original supply curve is S_o and the aggregate demand curve is D_o, yielding a full employment of Y_F. An increase in the price of one of the components of the cost of production, not counter-balanced by a corresponding increase in its productivity, causes the supply surve to rise to S_1. Price level rises to P_1 and output is reduced to Y_1. It is possible that the process will not stop at this point, for the increase in the price of one of the components could bring about a corresponding increase in the price of other components, thereby setting off a cumulative increase in prices, causing further reduction of output and employment. Expansionary monetary and fiscal policy alone, does not

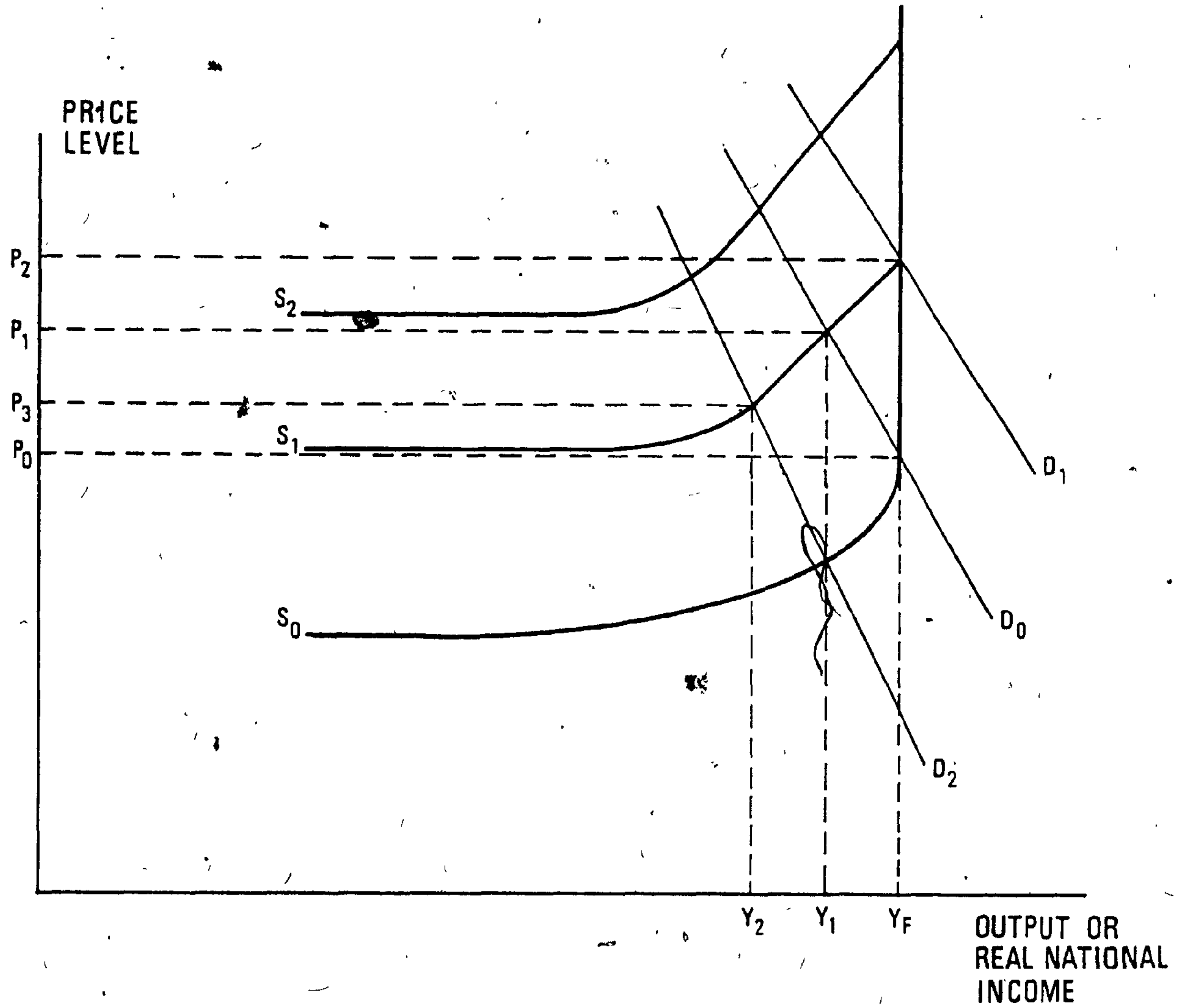


FIG. 2.7 COST-PUSH INFLATION

increase employment. If, as a result of expansionary policies, the demand rises to D_1, the price level would go up to P_2, and thereby stimulate the cumulative process of increasing costs. A contractionary monetary and fiscal policy does not arrest the price increase; it only worsens the unemployment situation. When the demand curve shifts to D_2, the output falls to Y_2 while the price level registers only a moderate decline. Futhermore, this type of inflationary pressure can result in another upward shift in the supply curve to S_2 and an increased problem at higher prices. The varying combination of rates of unemployment and inflation have been presented in the form of a series of trade off curves called Phillips curves [38, 54, 58, 65]. These curves demonstrate the relation between the average unemployment rate and the inflation over particular periods of years. These curves show that substantial increases in unemployment are required for even small decreases in the inflation rate. The only lasting solution to cost-push inflation is to remove or counteract the forces that paralyse the working of the free market.

The following types of cost-push inflation have been distinguished:

a) wage-push inflation

b) profit-push or price-push inflation

c) import-price push inflation

d) ignorance push inflation

e) inefficiency-push inflation

a) <u>Wage-Push Inflation</u>

Rises in costs that are associated with social and political origins, manifested by the power and actions of unions to increase wages has given rise to wage-push inflation. Powerful unions demand and obtain wage increases even when there is no excess demand for labour or increased productivity. In general, employers are forced to accede to these demands and pass on the increased wage costs to the consumer with higher prices.

The trade unions are able to resist downward movement of wages even in the presence of substantial unemployment, and to obtain wage increases in excess of productivity. There is also a tendency for wage increases justified by higher productivity in one sector of the economy, such as the auto industry, to spread to other sectors where no increase in productivity has occurred.

In demand-pull inflation, wages increase as the result of an excess demand for labour; the rise in wages is the result of increased demand causing higher prices. The concept of wage-push inflation is confined to increases in wages that are the cause, and not the result of higher prices. This type of inflation is not possible in an economy in which wage rates are determined by purely competitive market forces. In the absence of overall excess demand, the competition among the unemployed labour would be sufficient to keep the level down. What makes higher wages possible in the absence of overall excess demand is the existence of large trade unions. The monopoly power possessed by these unions makes it possible for them to obtain higher wages, even when unemployment is present, and no increase in productivity has occurred. The overwhelming power of construction labour unions is a major source of wage-push inflation in the construction industry. This increases the unit cost of production, raises the supply curve, and thereby causes prices to increase. In order for wage-push inflation to arise it is not necessary that the entire labour force be organized. As long as large trade unions exist, which are able to obtain wage increases in excess of productivity gains, these higher wages are likely to spread to the non-unionized sectors of the economy, and give rise to an economy-wide wage-push inflation.

If perfect competition prevails in an industry, then labour in a single firm cannot force the firm to increase wages without eventually driving it out of business. Since the firm's demand curve will be highly elastic, as it raises prices to offset higher wages, it is likely to lose its sales to its competitors. On the other hand, if all firms in the industry secure higher wages, all of them will raise prices to cover increased costs without fear of losing sales. However, in the modern Western societies, oligopolies are the norm in many sectors of the economy. These oligopolies are interdependent and dominate many industries and provide exceptional opportunities for unions to secure wage increases in excess of productivity gains, with the minimum loss of jobs. This is because the demand curves facing oligopolies are less elastic than those in competitive markets. Moreover, oligopolies are able to spend large sums on advertising, whose purpose is as much to make the consumer insensitive to higher prices as to make him buy more of a product.

b) <u>Profit-Push or Price-Push Inflation</u>

This type of inflation is also called the administered-price theory of inflation and it is similar to the wage-push theory except that enterprises rather than unions are the main cause.

The theory says that some firms or organizations, called sellers, have monopoly power and would like to raise prices but are restrained by fear of combines laws and adverse public opinion. Other sellers who operate in competitive conditions are restrained from raising prices by their competition. During wage negotiations sellers will grant wage increases and use them as an excuse to raise prices, often by more than is required to offset the rise in wage costs. This often happens in industries controlled by oligopolies.

When competitive conditions prevail in the economy, profit margins are kept at a level considered normal by the competing enterprises. Under these conditions profit-push is unlikely to be an element in the inflationary process. If overall demand increases above the level necessary for full employment, prices and profits naturally rise. This situation would belong to the category of demand-pull inflation. Therefore, when there is a high degree of competition in the economy, a cost-push inflation cannot arise as a result of increasing profit margins by the entrepreneurs. When a complete monopoly exists the entrepreneur sets a price that maximizes his profits for any given set of demand and cost conditions. At any other price, his profits decline. Therefore, the maximum profit motive ensures that profit-push does not act as a force generating inflation with monopolies.

Thus, an independent role is denied for profits only under conditions of pure competition and complete monopoly. This is not the case under conditions of oligopoly, where industries are dominated by a few large sellers: a situation that increasingly characterizes modern Western economies. In such industries, prices are determined by conventions, gentlemen's agreements, standard mark-ups and price-leadership. The goal of the firm is not so much to maximize profits, as to maximize revenue, to capture a larger share of the market, to grow and to gain stature in the industry. The firm may try to attain a certain "target" rate of return on invested capital, and if the firm decides to raise this "target" rate, then the profit-push could act as an autonomous force in generating inflation. The firm may also be using a price policy of charging a certain "mark-up" above its costs - "mark-up" being the percentage by which selling price exceeds variable costs, when the latter is defined to include charges for overhead costs and profits. The use of cost-plus contracts in engineering projects often contribute to inflation. Since, under conditions of oligopoly, competition among firms is characteristically in non-price terms, the overhead costs of firms are also likely to go up as more and more money is spent on promotion, selling gimmicks, advertisements, research and development, and product differentiation. This also leads to an increase in prices, even in the absence of excess overall effective demand.

The mechanics of the profit-push inflation are the same as those of the wage-push inflation. An increase in the mark-up leads to a rise in the supply curve, as shown in Figure 2.7 and to an increase in price; and with a given demand, to a reduction in output. The reduction in output acts as a deterrent on mark-up inflation. However, as more and more industries are drawn into the cycle of rising prices, they find their collective action ratified by the forces of the market. If one industry alone raises prices, it might lose its sales to other industries. When large segments of the economy resort to increasing prices, the relative prices in the economy remain unchanged. There is thus no change in total demand resulting from such collective action.

In most instances wage-push and profit-push inflations occur simultaneously and they often reinforce each other. This is sometimes referred to as profit-wage-push inflation.

The existence of oligopolies makes it possible for price increases to occur often in defiance of the laws of supply and demand just as the existence of powerful trade unions makes it possible for wage increases to occur even in the presence of substantial unemployment. It is the struggle between labour and business for higher shares of the total national product that sets off the wage-profit spiral of rising prices. Between them they want more than 100 percent of the total product. Since this is impossible, inflation controls what the actual shares should be.

The profit-wage-push inflation process works as follows: High profits increase labour's determination to wrest a larger share from business. If this were an isolated instance, business would be unwilling to grant the demanded wage increase. But if wage demands were being made in several sectors of the economy, business becomes more willing to grant the wage increases. This is because business is more confident of passing the wage increase to the consumer in the form of higher prices when such increases are already taking place all over the economy. The increased wage payments create enough additional purchasing power in the economy to buy up the former level of output at higher prices. Business will continue to employ the same labour force as before and produce the same rate of output. The increased prices, after a lag, may generate another round of wage and price increases. While enough purchasing power may be generated to buy the actual output at rising prices, there may still not be an overall excess demand. The primary solution to this kind of inflation must be the design of effective policy to wrest economic influence away from the double monopoly, and for strict governmental management of monetary policy (interest rates and money supply).

c) Import-Price Push Inflation

In a world where rising prices are universal, a country's price level would tend to go up simply because of the rise in the costs of the imported materials that enter into the production of domestic goods. The more dependent a country is on imports, the more powerful this factor is likely to be. Whereas imports of goods and services constitute a small percentage of the United States Gross National Product, they account for twenty-five percent of the Canadian Gross National Product [59]. This factor could account for the higher price increases often registered by Canada in comparison with the United States. The devaluation of the dollar also contributed substantially to some increases in domestic prices. High technology equipment which is often imported from Europe and Japan has risen in cost as the value of our dollar drops [34]. Imported oil is much more expensive than Canadian petroleum.

d) Ignorance-Push Inflation

A cost-push inflation may often be the result of consumer ignorance or insensitivity to high prices. Business is able to employ all the powerful media of communication and influence to create new wants in consumers as well as to make them insensitive to high prices.

An example of this kind of inflation is when consumers are convinced by advertising that a national brand name product is preferable to an equivalent less expensive non-label product. Thus consumers pay more for the same item.

The availability of easy credit even at high interest rates, which are often concealed from the gullible public, encourages this lack of sensitivity to high prices. Another factor of considerable importance is that high incomes have a natural tendency to encourage market imperfection. As the incomes of consumers increase it becomes progressively less worthwhile for them to search out bargains, and to compare prices. A third factor is the increasing proportion of women who enter the labour force. This gives them less time for careful shopping. The modern working-housewife therefore simply does not have the time to compare prices and quality, and make the best purchase possible. She also demands more services - better packaging, more processing of the product and so on. Producers offer confusing varieties of products, in not easily comparable sizes and this further compounds the lack of sensitiveness of the consumer to higher prices. Practices relating to promotion of sales such as 'cents-off' labels, over-priced 'large economy sizes', and advertised 'specials' on which no price reductions are made occur often. Promotional devices such as trading stamps, contests, coupons, give-aways, all add to costs and increase prices. The answer to ignorance-push inflation is better consumer education, and prohibition of practices that contribute to consumer deception. Ignorance-push inflation can occur in engineering projects as sales engineers promote various products and systems without permitting time for a systematic evaluation and choice by the project engineers.

e) <u>Inefficiency-Push Inflation</u>

The inefficient use of productive resources cause increasing prices and is called inefficiency-push inflation. The existence of large and lethargic oligopolies, the prolongation of the life of declining and inefficient industries under governmental protection all contribute to inefficiency-push inflation. A good example of this problem is the steel industry in Nova Scotia which is kept alive only with extensive government aid.

This factor is of special importance in Canada where a protected small domestic market encourages the use of outmoded technology and the production of small amounts of an infinite variety of products. The United States has a large domestic market and therefore is able to combine the economies of scale and the marketing advantages of product variety. The high standard of living in Canada and the exposure of Canadian consumers to products and advertising from the United States, have contributed to Canadian industries sacrificing the economies of scale in the interests of product variety especially in the area of consumer goods. The many small construction contractors are often an example of inefficiency-push inflation. This problem needs very careful study in order to devise schemes of encouraging the efficient use of Canadian resources.

2.5.3 Demand Shift Inflation

Demand shift inflation, also called structural rigidity inflation, exists in a situation where resources do not move quickly from one use to another and that wages can increase but not decrease. Under such conditions real adjustments occur very slowly when patterns of demand and cost change. Even though there may be no overall excessive demand in the economy and the cost-push elements are not powerful, inflation may occur, due to shifts in demand among the sectors of the economy. Shortages appear in a potentially expanding sector and prices rise because the slow movement of resources prevents the sector from expanding rapidly enough.

Wages and prices rise in the sectors where demand increases, but do not fall in sectors where demand declines. The increase in wages and prices that occurs in the sector where demand has increased is likely to result from increased profits or from the need to attract more labour. In a market economy, this type of behaviour of prices and wages is considered normal. It is the process by which market forces bring about that allocation of resources which conforms to the desires and wishes of consumers. In an efficiently functioning market economy this is counter-balanced by the fall in prices and wages that occurs in sectors which have witnessed a decline in demand.

However, in an economy suffering from structural rigidity contracting sectors keep factors of production employed because of their low mobility. The combination of business and trade unions result in a resistance to the downward movement of prices and wages. Since both prices and wages are rigid on the down side there is no deflation in the potentially contracting sectors of the economy. In fact often prices and wages may actually increase in these sectors of falling demand.

The high wages obtained in one sector of the economy lead to demands for increased wages in other sectors of the economy, regardless of the ability of these sectors to absorb higher wages. The process of adjustment of an economy with structural rigidity therefore causes inflation to occur.

2.5.4 Expectational Inflation

Expectational inflation or anticipated inflation is caused in an economy with a general assumption of a set of anticipated price and wage increases. These expectations can be generated by any of the above-mentioned causes of inflation. They can provide a major inflationary stimulus in themselves. The original causes may have been eliminated but the inflation psychology continues due to past expectations. Wage contracts often contain escalation clauses, contracts are made on a cost-plus basis, and interest rates rise in response to the anticipated inflation. Inflation persists under these conditions as each set of price increases leads to wage increases and to more anticipated cost rises.

2.6 Summary

The nature and the various types of inflation have been described in this chapter. It has outlined the history of inflation, Canada's present inflationary environment, and several theories relating to the causes of inflation. Inflation is a serious problem in engineering oriented projects. The persons concerned with engineering decisions therefore have a vital responsibility to determine, evaluate, control, and minimize inflation in their projects. The ensuing chapters are an effort to provide some of the necessary background to complete this task.

CHAPTER 3

THE SIGNIFICANCE OF INFLATION IN ENGINEERING PROJECTS

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3.1 Introduction

The previous chapter has reviewed the problem of inflation and outlined some theories concerning the causes of inflation in our economy. Economists have been discussing the causes and solutions of inflation for many years. The Investor, Owner, Project Manager, Architect, Engineer and the Contractor are concerned with the causes and effects of inflation and how to avoid or minimize its impact. Inflation becomes a major factor in many decisions. The information presented in Chapter 2 demonstrated how inflation in many sectors of the construction industry, urban real estate development, industrial plant and other engineering oriented projects has been above the general background inflation rate. There are some special reasons for this phenomena due to the particular characteristics of this sector of the economy. These causes add to the problem of inflation. This chapter describes how and why there has been such an escalation in costs. The chapter examines how inflation occurs during the life of a project and discusses the effects of inflation on the cash flow of a typical project.

3.2 The Project Cycle and Inflationary Pressure

The best method to understand where and how inflationary pressures are introduced into a project is to study the different activities and stages involved during a project. Inflationary pressures can increase the final cost and affect the viability of a project at every stage. From the financial viewpoint, that of the owner or investor, the project development cycle comprises four phases: the pre-investment phase, the investment phase, the operational phase and the disposal phase. The engineer, architect, project manager or contractor view a project differently. It is usually divided into these stages: conception, feasibility, design, procurement, construction, commissioning, operating and disposal. Some of these activities may occur in parallel or overlap. Figure 3.1 shows the project development cycle. In terms of actual capital expenditures, the greatest portion occurs during the construction stage. A review of the activities in the project cycle illustrates the sensitivity of each stage to inflationary pressures and how inflation can be effectively dealt with at all times. The most important observation is that the earlier inflation is identified and included, the better the ability to control and minimize its effects [8, 12, 15, 25, 67].

3.2.1 The Pre-investment Phase

The Pre-investment Phase - the conception stage of a project is the process of identifying investment opportunities and project ideas which are subject to further scrutiny if the propositions are provenviable. Market studies analyze proposed projects against the following basic criteria:

- the level of demand and supply for the product or service provided by the project;

FIGURE 3.1 THE PROJECT DEVELOPMENT CYCLE

PRE-INVESTMENT PHASE				INVESTMENT PHASE			OPERATIONAL PHASE		DISPOSAL
Conception-Identification of project ideas and investment opportunities	Pre-feasibility Studies - Preliminary selection stage	Feasibility studies of possible projects	Evaluation and decision stage for a project	Negotiating and contracting Procurement	Project design	Construction ....→	Commissioning or absorption	Income producing stage	Final project disposal

- the resources and factors of production required and available for the project, including natural resources, financial resources,technology and labour;
- the cost of these resources and factors of production;
- the general investment climate;
- the investment and fiscal policies of government;
- the industrial and development policies of government; and
- the possibility of utilizing or expanding existing facilities to produce the same item, to cut costs, attain economies of scale or to provide for easier integration or diversification.

Feasibility studies are prepared for projects that have been identified as possibly viable in one or more market studies. They provide a technical, economic and commercial base for an investment decision on a particular project. A feasibility study defines and analyzes the critical elements that relate to the production of a given product, or to the provision of a given service, together with alternative approaches to obtain the product or service. For industrial projects such as petrochemical, steel, pulp and paper, and manufacturing plants a feasibility study provides the required technical data for a project of a defined production capacity at a selected location, using a particular technology with a defined set of material inputs and product outputs. The financial data identify the investment andproduction costs and the sales revenue, yielding the return on investment. Specifically, the feasibility study examines the possible economic alternatives of:

a) Market and project capacity: demand and market study, sales and marketing, production programme, and plant capacity;

b) Material inputs;

c) Location and site;

d) Project engineering: technologies and equipment, and civil engineering works;

e) Overheads: factory, and administrative and sales;

f) Manpower: labour and staff;

g) Project implementation;

h) Financial analysis techniques: investment costs, project financing, production costs, and commercial profitability.

A feasibility study for a residential or commercial structure will contain a similar type of analysis.

Feasibility studies can be very time consuming, costly and involved. Often a less detailed study called a pre-feasibility study is conducted first. Pre-feasibility studies are done to determine whether:

a) The investment opportunity is so promising that an investment decision can be taken on the basis of the information elaborated at the pre-feasibility stage;

b) The project concept justifies a detailed analysis by a feasibility study;

c) Any aspects of the project are critical to its feasibility and necessitate in-depth investigation through functional or support studies such as market surveys, laboratory test, pilot plant tests;

d) The information is adequate to decide that the project idea is neither a viable proposition nor attractive enough for a particular investor or investor group.

When the feasibility studies are completed the proposed projects are evaluated against each other and other criteria set by the investors and the final decisions are made.

The impact of inflation on a project is most significant during pre-investment. Although only minimal expenditures occur during this phase it is evident from the description of pre-investment activities that it is the time when the key decisions whether to proceed, and how to proceed, with an investment are made. As just described the studies done during this period establish most of the technical, economic and commercial requirements and output for a project. The consequences of these engineering and investment decisions made during this period will last at least through the life of the investment and even beyond for the investor. Pre-investment activities involve a three stage process: the collection of relevant information and data, the preparation of projections over the life of the investment, and, the evaluation of this information to arrive at decisions. Since most of the major investment and engineering decisions are made during this period, this is the best time to utilize the proper techniques to evaluate projects, alter decisions and examine new ideas. Some of these techniques are discussed in Chapter 4. It is also the time when the most serious consequences will result from the failure to consider inflation, the underestimation of the effects of inflation or the use of improper techniques to arrive at engineering investment decisions.

The capital cost estimates and operating cash flow projections prepared during this phase are used as the basis during the design stage for the selection of materials, equipment, building systems, structural and architectural components, and all essential cost items of a project. They are then used during the construction stage for the actual committment and distribution of funds, and during the operational phase for the measurement, control and ofcash inflows and outflows. The faulty estimation of the effects of inflation will result in erroneous technical and economic decisions. This can affect the overall project detrimentally and result in expensive modifications or revenue losses later on.

Most projects are evaluated with either present worth techniques or internal rate of return criterion during the pre-investment stage. The entry of inflation into the analysis and the consideration of different inflation rates will often result in the acceptance of different project alternatives. The proper techniques for doing this will be discussed in Chapter 4.

Since decisions are made during this phase that affect the entire investment, consideration must be given to the forces that different types of inflation can exert on the cash flows. Demand - pull inflation can affect the viability of a project, since at almost all stages the project is frequently involved in a scramble for scarce resources such as energy, raw materials, construction materials, technology, equipment, skilled labour, and capital. Under such conditions even small changes in demand or supply can substantially affect costs. A current example is the energy situation. Slight increases in energy consumption or decreases in petroleum supplies, combined with international oil politics, have caused phenomenal increases in energy costs. The cost of diesel fuel in the United States has doubled in 1979 from fifty cents a gallon to over a dollar. In fact most organizations have underestimated the magnitude and the significance of energy costs. This results in higher inflations later on, as investors try to recover their lost revenue by passing on their mistakes in the form of increased prices. Since modifications are often involved, the price increases are usually even higher than if the original prices had included inflation.

Cost - push inflation must also be considered with reference to its possible effects on cash flow. The prime example is Wage - push inflation caused by the powerful construction unions that can escalate the cost of projects and cause delays if strikes occur. This is an especially serious problem during construction and start-up stages when projects are almost at the mercy of these unions.

The management and financial administration of a project, in terms of the overall expenditures and revenues for both the investor and the contractor, can also be inflationary. Longer construction periods mean higher financing costs to the owner, and more capital frozen in the form of retention (holdback), late payments, and in negotiations for contract price adjustments for the contractor.

Finally, there are many costs which are eventually passed on to the public which are not necessarily due to inflation but more the nature of the construction industry and the existing social and economic environment. These are considered as part of the pre-investment conditions for any proposed project. Quality control and quality assurance specifications add considerable time and money during the design phase, as well as the construction and operating phases. Environmental and safety requirements have resulted in enormous expenditures on non-productive elements. On the other hand, engineers, project managers, and contractors are frequently presented with inadequate or unclear specifications, work definitions, and drawings. The involvement of and regulation by governmental bureaucracies compounds this problem. Many projects are started, planned, and estimated with over optimistic and often unrealistic projections of time, cost, and revenue. The above problems result in uncertainty, delay, repeated work, conservative and uneconomic design. Contractors and design firms must absorb the considerable overheads and the costs of tenders that are not awarded. The diversity of projects incur additional costs as the necessary adjustments are made for each particular one. The cyclic and seasonal nature of the construction industry creates a major problem in the providing of year round stable employment of labour and machines. Consequently the cost of the nonproductive time is absorbed by a future project.

3.2.2. The Investment Phase

The Investment Phase - Once the go-ahead is given to a particular project substantial financial resources start being committed. The investment phase includes the design, procurement and construction stages.

The design stage includes the preparation of project plans and engineering designs including scheduling, site testing and surveying, the preparation of designs and blueprints, detailed engineering and architectural work and the final selection of materials, technology and equipment. There may also be a pre-design period wherein several proposed ideas or layouts are developed and compared before a particular scheme is finally selected. At this stage the opportunity exists to design and select systems that are resistant to inflationary pressures.

The procurement stage refers to the negotiating and contracting required to complete the project financing, the acquisition of materials, supplies, technology and equipment, the construction of the building and services and the obtaining of the necessary government permits. This work continues throughout the project since these activities must be started as early as the feasibility study. For example the contracts with the architects and engineer are usually signed during the pre-investment phase. It includes the signing of contracts between the investor on the one hand and the financial institutions, contractors, suppliers and government agencies on the other.

The construction stage involves site preparation, the construction of all the civil works and buildings and the installation and erection of all mechanical, electrical or process equipment in accordance with the established schedule. This is the most capital intensive stage of a project whether it is an industrial plant or a commercial building. It is essential that every element of cost is included in the planning for this stage.

The investment phase provides the opportunity for the utilization of both inflation avoidance and inflation control and minimization techniques. The design stage involves major decisions with regards to the selection of various systems and establishment of procedures and schedules. There exists, therefore, an ideal period to select and design those systems, procedures and schedules which are most resistant to inflationary pressures. The most effective approach during this stage is to select the alternatives which involve the least uncertainty about, and the most control over future construction and operating costs. The same inflation avoidance techniques can be used during the procurement stage in the drawing up of the terms and conditions of the various contracts that are signed. The selection of the type of contract can be an effective tool in this area.

It has been noted that the investment phase involves the major financial commitments for a project. These expenditures occur mainly during construction. Since every investment must follow the principle that time wasted equals money lost it is evident that delays or productivity problems, particularly during the construction phase, result in higher costs to the investor. These costs can be expected to be passed on in the form of higher prices for the products and services. As projects and individual tasks become more complicated and involved, labour efficiency diminishes. Site productivity has become a major area of concern. Futhermore, current projects require a high degree of interdependancy between the client, engineer, architect, project manager, and organized labour. The schedule and cost of such projects are highly sensitive to a disruption or delay by any of these groups. Thus bad scheduling, labour problems, delays in construction, deliveries, or startup even in one small area can quickly affect the entire project. The major tools available to manage and control these problem areas are proper and effective planning and scheduling. The performance of a project during the construction can only be as satisfactory as its engineering and management controls. All the various inflationary forces such as demand - pull or wage - push can be controlled and minimized [8, 11, 15, 17, 32, 48, 72].

3.2.3. The Operational Phase

The Operational Phase includes the commissioning and the income producing stages of an investment. By this time the major decisions and capital expenditures have been completed and the scope of change is limited and expensive. A major effort during this phase is directed toward controlling and minimizing the inflationary pressures now built into the project.

The Start-up stage includes the commissioning of a project and the training of its personnel. It is normally a brief but technically critical period during a project development. In the case of commercial or residential urban projects start-up usually just involves the training of custodial and maintenance staff and adjustments required for heating, ventilating, and air conditioning (HVAC) systems and elsewhere. Nonetheless, problems in these areas can result in serious difficulties due to extra costs and protests from tenants. The start-up stage for real estate developments is called the absorption period. This period spans the time when the first tenants move into a development to the time when it is considered fully rented. The training of skilled personnel and plant commissioning is much more critical in industrial situations. The initial period after the commencement of production can include problems in such matters as the application of production techniques, operation of equipment, labour and equipment productivity, and inexperienced supervisory staff or labour. The start-up stage links the construction stage with the operational stage.

The operational stage involves the regular operational, maintenance, and production activities during the operating life of an investment. It is concerned with the expenditures and revenues from the items produced, accommodation provided, or services given, and any associated problems. Energy, maintenance, labour, and materials are the major elements of cost, while sales or rent are the sources of revenue during this period.

It is hoped that the cash flow projections prepared for the operational phase are accurate and adequately account for the effects of inflation. Since the operational phase extends over the life of a project these effects of inflation are both cumulative and compounding. If operating costs and revenue projections are faulty, the economic justification of the entire project may be jeopardized. If such errors are only identified during the actual operational stage the remedial measures are often impossible or difficult and costly.

3.2.4 The Disposal Phase

Finally the disposal stage is concerned with the final disposition of a project at the end of its useful life. Its salvage value, if any, usually does not play an important role in the decision process since the discounted value of a cash inflow far into the future will be minimal. However, the feasibility of some projects of a medium life span, or real estate investments which usually have a substantial salvage value can be affected by this component. The influence of the salvage value will be enhanced when an inflated salvage value is considered.

3.3 Cash Flow During the Project Cycle and Inflation

It is important to examine the actual consequences of inflation on a project before various techniques are outlined for dealing with it. The project cycle can be expressed as a series of cash flows into and out of the project. The paramount factor that determines the viability of a project is its profitability. The assessment of the profitability of a project consists of the determination and evaluation of these cash inflows and outflows during the life of the investment.

3.3.1 Types of Cash Flow During a Project

The cash outflows during the life of an investment are categorized as follows [52]:

1. investment capital
2. working capital
3. annual fixed costs
4. variable costs
5. taxes

The cash inflows for a project are:

1. sales or rental income
2. scrap income or salvage value
3. working capital income

Of course the significance and size of cash flows for industrial projects are different from real estate developments but the viability of both is determined from the cash flows.

Investment capital includes all the financial resources required as a non-recurring fixed investment; the cost of which are allowed against profits over a period of years before taxation is calculated. They include:

1. buildings and civil works
2. mechanical, electrical, process and other moveable or stationary machinery or equipment.

The working capital consists of the money required to bridge the gap between expenses incurred and income received during the operational life of the investment. Working capital can be expressed as the current assets minus current liabilities or the permanent capital minus the fixed investments. Over the life of a successful investment the aggregate income exceeds expenses, recovering the working capital. Frequently the actual money used as starting working capital is recovered early. However, business operations still require working capital; whether self generated or externally supplied. Inflation can result in an increase in the working capital required to keep the investment operating. This may create cash flow problems for an investment.

Cash flow is especially important for industrial projects where raw materials have to be bought and paid before finished products are sold and income received. Considerable amounts of money are usually tied up in inventory and stockpiles. Thus, for an industrial project the working capital is often a large part of the permanent capital. It is only recovered at the end of a project when everything is sold.

The annual fixed costs include all the yearly expenses incurred by a project during the operational stage independent of what else happens. It is the major cash flow of an urban development and an important cash flow for industrial projects. These expenses include regular maintenance costs, repairs, taxes, insurance, overheads, and salaries.

Variable costs involve payments that are directly proportional to the production rates of an industrial project or occupancy rates of an urban development. It is most significant in industrial projects where materials are converted into finished products. These raw material costs are directly proportional to output. Some manpower and maintenance costs are also proportional to output and are considered variable costs.

Taxes represent payments to government and are calculated from the difference in annual cash inflows minus cash outflows subject to depreciation allowances on capital investment.

Sales and rental income are the most significant cash inflows of a project. Scrap income represents the money realized at the time of the final disposal of the assets of the project. This income is far off in the future and is usually relatively insignificant. Of course, the scrap income becomes important for investments with a short holding period and, or substantial salvage value. Working capital income is only the recovery of money laid out during the year to finance operations and is put back into the working capital for continuing operations.

3.3.2. Cash Flows, Profitability and Escalation

The profitability of a project for an investor is the rate of the return on his equity that the investment provides. Life cycle flows are projected and analyzed to determine whether the project has an acceptable level of profitability relative to the degree of risk. The contractors involved in a project are concerned with maintaining margins on the individual piece of work that is being done and thus their profitability. The main difference between the investor and the contractor involved in a project is that the owner or investor is interested in both the long term and short term profitability of his investment and the consequences of long and short term inflation while the individual contractor is more concerned with the effects of cost escalation on his profit during his relatively short term involvement in the project. It is the inflation of project construction costs during the capital intensive construction stage which is usually referred to as the cost escalation during a project.

The degree of cost escalation possible in a project can be observed with an examination of increases in expenditure of a project for a range of duration and escalation rates [25, 48, 55, 73]. Since the major expenditure of investment capital occurs during the construction phase of a project, increases during this period will seriously affect the profitability. The duration of most major construction projects is between one and five years. This duration is increasing as larger projects are undertaken. Escalation rates ranging between zero and thirty percent have been observed in certain projects. Total expenditure versus time curves, called S curves, can be prepared which indicate the rate of capital commitments over the duration of the investment phase of a project. A typical example of an S curve [48] is presented in Figure 3.2. The expenditures represented in Figure 3.2 have been escalated at constant annual rates, ranging between zero and thirty percent, for

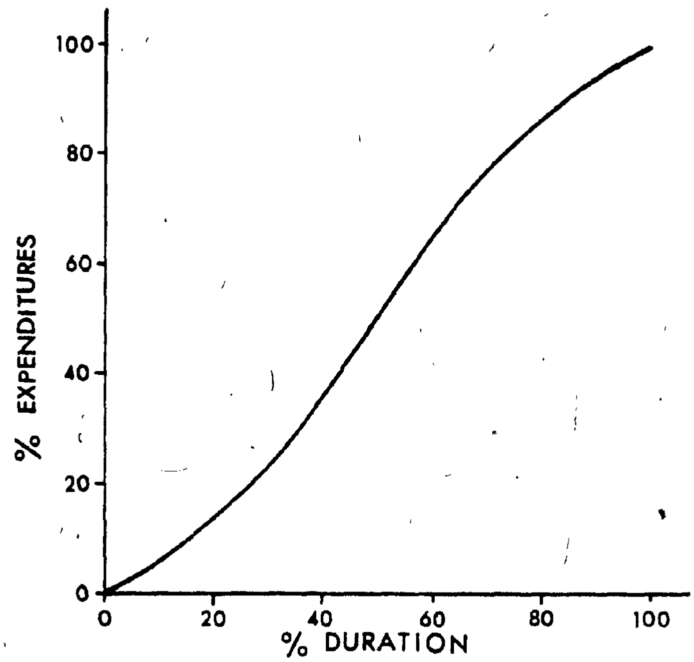

FIG. 3.2 EXPENDITURE CURVE FOR A TYPICAL PROJECT "A"

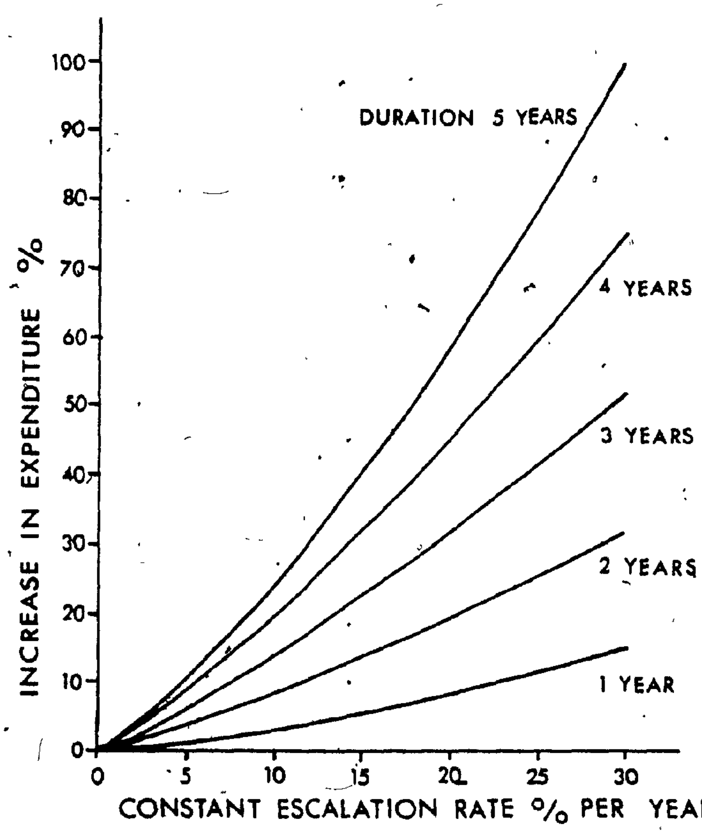

FIG. 3. 3 INCREASES IN EXPENDITURES FOR PROJECT "A" FOR DIFFERENT DURATIONS AND VARIOUS ESCALATION (INFLATION) RATES.

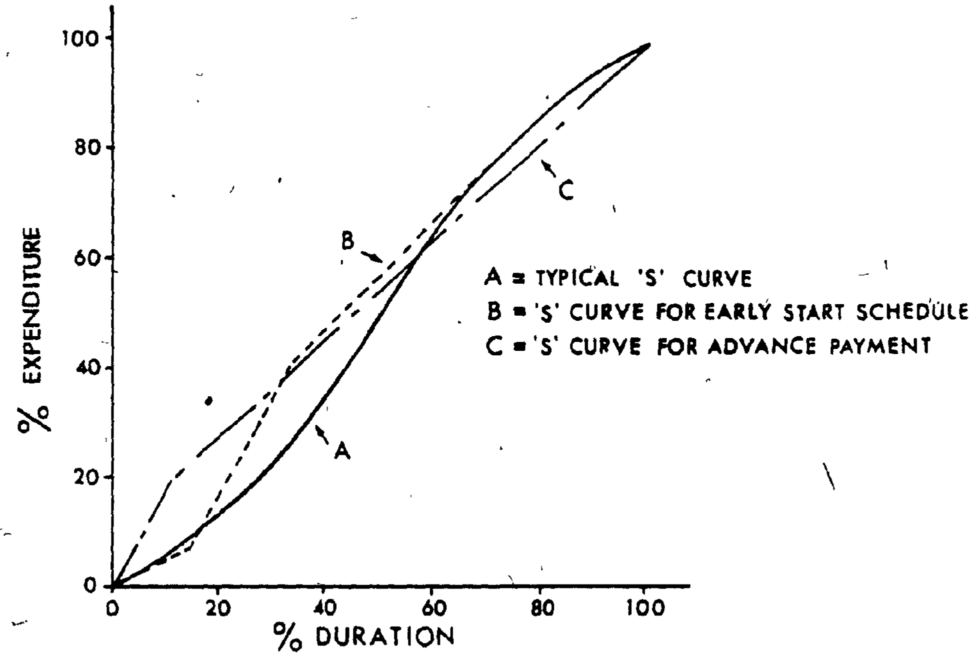

FIG. 3. 4 EXPENDITURE CURVES FOR THREE POSSIBLE PATTERNS OF EXPENDITURE A, B, C.

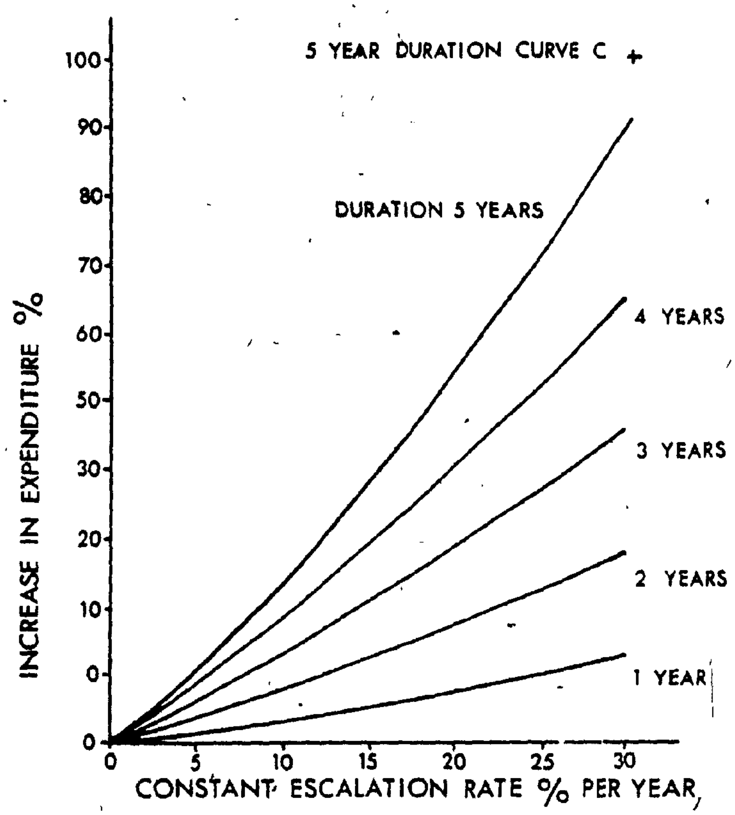

FIG. 3. 5 INCREASE IN EXPENDITURES FOR PROJECT 'B' FOR DIFFERENT DURATIONS AND VARIOUS ESCALATION (INFLATION) RATES

durations of one to five years. Although the data presented in Chapter 2 demonstrates that constant inflation rates do not exist in reality, averages can be established for certain cash flows and projects over several years. For this discussion a constant rate is therefore used to illustrate the effects of inflation on project expenditures. The new expenditures are presented in Figure 3.3 as percentage cost increases on the base date budgeted cost. It is obvious that the longer the duration of a project, the more it is influenced by changes in the rate of inflation. The capital cost of a five year project can be almost double the original budget. The additional capital investment required to finance this cost escalation can drastically alter the profitability of the investment.

The impact of inflation on capital expenditures also depends on the spending patterns over the period that the money is spent. Three possible expenditure curves for a project are shown in Figure 3.4. These expenditures have been escalated at different inflation rates and different durations and are presented in Figure 3.3 for A and Figure 3.5 for B. The escalated expenditure curves for C are so similar to curve A that Figure 3.3 may be used. The expenditure difference between curves A and B under the longest duration and highest escalation rates is about 13.5%. The expenditure difference for an average project of three years and up to twenty percent inflation is 4%. This relatively small difference in expenditure can make the difference between acceptance or rejection of an investment. Therefore the pattern of expenditures for a project must be accurately established with regards to the extra risk incurred by inflation.

It appears that given a constant and predictable inflation rate, that project costs will not differ substantially with the use of different scheduling and spending patterns, S curves. The use of early start schedules does allow a greater control over, and an earlier opportunity to minimize the impact of inflation. Early start schedules are even more effective in the case when inflation rates are not constant and cannot be predicted with great confidence, a condition that characterizes the present situation.

However the main area of concern and risk is in accurate prediction of the inflation rate,proper accounting for inflation in decisions, and in minimizing and avoiding the impact of inflation. For example referring to curve A in Figure 3.3 for escalation rates of 15% and 25% and five year duration the increase in expenditure over the base value at the start are 48% and 80% respectively, with a net difference of 32% between the two values. For a project of three years duration the net difference is 16%. Thus there is a high degree of uncertainty as to the capital investment required by the owner and the costs and revenues for the contractor. This results in a tendency for projects and contracts of shorter duration to reduce risk. This also results in a desire for higher profits and protective measures by investors and contractor for longer term projects due to the risk.

The construction phase involves the capital outlays to build the income producing facilities of a project. The previous section has demonstrated the effects of inflation on the cash flow during the construction phase.

However, since the investor is concerned with the overall performance of a project, the consequences of inflation on cash flow throughout the life of a project must be examined from conception, through feasibility, design, construction and operation. Since this time period extends over many years the effects of inflation constitute a major risk which must be included in the appraisal of a project.

Inflation can on occasion result in making an investment more profitable and desirable. If revenues increase faster than the general inflation rate while expenditures increase at a rate equal to or less than the general inflation rate then inflation can yield a net benefit to investors. The net income producing cash flows increase and the payback period can decrease in such a situation. Figure 3.6 shows the cumulative cash flow curve for an industrial type project during a non-inflationary situation and during high inflation. During the feasibility, design and construction phases the cash flows are negative since the investor does not see any financial return until the plant is commissioned. Throughout the operational phase income exceeds expenditures, cash flows are positive and the cumulative cash flow moves into a surplus. This project has a design - construction phase of about three years followed by ten years of operation. An examination of the two cash flow curves reveals the considerable effects of inflation. For example an assumption of an inflation rate of 20% for costs and 18% for revenues, will result in the cumulative cash flow of $23.98 million increasing to $114.64 million over the ten years. An investor faced with this situation must first determine if he is able to provide the extra capital required to complete the project [48].

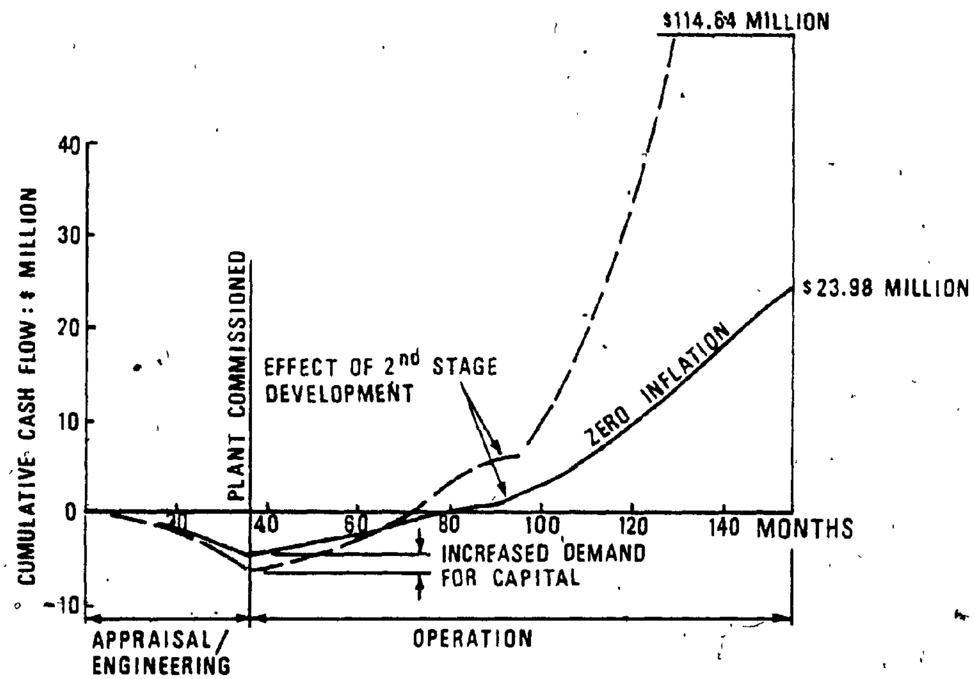

FIG. 3.6 CUMULATIVE CASH FLOW CURVES FOR AN INDUSTRIAL TYPE PROJECT IN A ZERO INFLATION SITUATION AND A 20% INFLATION SITUATION FOR EXPENSES AND 18% INFLATION FOR REVENUES. [48]

He must then evaluate the new cash flow situation to ascertain whether this investment still meets his objectives. Only then can he establish whether inflation still works to his advantage.

3.4. Summary

Thus, it is obvious that inflation plays a major role in every aspect of a project. This chapter had outlined how it can be a constant threat to the viability of a project, one that must be accounted for in the planning and appraisal of projects and a factor that must be controlled during the execution of a project. The following chapter will outline a methodology to address the problem of the planning and appraisal of projects in an inflationary environment. Since this activity occurs during the pre-investment phase, and since errors or misjudgements during this phase are most significant, it is the activity which must be dealt with first.

CHAPTER 4

THE APPRAISAL OF PROJECTS UNDER CONDITIONS OF INFLATION

CHAPTER 4

THE APPRAISAL OF PROJECTS UNDER CONDITIONS OF INFLATION

4.1 Introduction

The considerable impact of inflation on engineering projects was demonstrated in the previous chapter and must be accepted as a fact of life. This chapter is concerned with some of the techniques and methodology available to include the effects of inflation during the appraisal and evaluation stages of a project. The basic interest formulas for the time value of money are modified to include inflation. Suitable techniques for investment analysis are described along with different approaches that can be used with these methods. The difficulties in the selection of the appropriate discount rate and in the forecast of inflation rates for a project are reviewed. An introduction to cost indices for project planning, management, and control, is presented. Finally the important implications of taxation and depreciation are examined with respect to the problem of inflation.

4.2 Evaluation of Project Performance Under Inflation

There are several methods available for the evaluation of a project. Most employ the use of the project cash flows outlined in the previous chapter in their analysis. These techniques are divided into two types - simple methods which analyze projects without allowing for the time value of money, and discounting methods which use the time value of money as a basic factor in the appraisal of a project.

Simplified methods such as the payback period or return on equity do not account for the time value of money; they are suitable only in an initial stage for project evaluations that involve inflation. Net present worth and internal rate of return are two acceptable methods that use discounting techniques in the evaluation and comparison of project alternatives.

The net present worth method of evaluating project alternatives is considered the most straight-forward technique that employs the time value of money concept. The net present worth (NPW) of a project is defined as the value obtained by discounting, separately for each year, all the cash inflows and outflows throughout the life of the project at a fixed, predetermined interest rate. This interest rate is called the discount rate and is generally based on the cost of capital. Section 4.5 examines how the discount rate is affected by inflation. The net present worth does not have a physical significance in terms of a present cash flow, but it is an economic measure of the value of a particular project and it may be compared with the present worths of other possible alternatives.

The internal rate of return method uses the rate of return for a particular project as a basis for measuring its economic value. The internal rate of return (IRR) of a project is the discount rate at which the present worth of all the cash inflows is equal to the present worth of all the cash outflows. The internal rate of return of a project is calculated with the same discounting procedure and formulas as the net present worth. This internal rate of return is compared with a pre-determined minimum acceptable rate of return for the particular project.

Both methods have the capability to account for inflation and are extensively discussed in engineering economics and financial literature [2, 24, 46, 57, 71, 78]. This can be done through the modification of the basic interest formulas.

4.3 Development of Interest Formulas with Inflation

The net present worth and the internal rate of return methods both use interest formulas in discounting future cash flows. These formulas [24] are presented in Table 4-1 and will be modified to include inflation.

Several concepts must be explained before these inflation adjusted formulas are derived. First, all cash inflows and outflows must be measured in consistent units in order to perform an economic analysis. This is no problem under conditions of no inflation where future dollars are equivalent to present dollars. Inflation however, results in future dollars having less value than present dollars; the cash flows in an economic evaluation must therefore be accordingly adjusted. Thus two types of money must be distinguished. Current dollars refer to the actual cash flows occurring during a specific time period. Constant dollars represent cash flows described with respect to the purchasing power of a unit of money as represented at a specific point in time. Constant dollars have equal purchasing power at all times and are inflation corrected money. The interest formulas may now be modified to include inflation by carefully differentiating cash flows expressed in current dollars or constant dollars and developing expressions in consistent units. These expressions are

TABLE 4-1

Summary of Compound Interest Formulas without Inflation

	Concept	Discrete Compounding
1.	Compound amount of a single payment	$F = P(1+i)^N$
2.	Present worth of a single payment	$P = F\left[\frac{1}{(1+i)^N}\right]$
3.	Amount of an annuity	$F = A\left[\frac{(1+i)^N-1}{i}\right]$
4.	Periodic deposits to accumulate a future amount	$A = F\left[\frac{i}{(1+i)^N-1}\right]$
5.	Present worth of an annuity	$P = A\left[\frac{(1+i)^N-1}{i(1+i)^N}\right]$
6.	Capital recovery	$A = P\left[\frac{i(1+i)^N}{(1+i)^N-1}\right]$

F = future worth of a cash flow or flows
P = present worth of a cash flow or flows
A = amount of periodic cash flows
N = number of periods
i = interest rate per period

developed for the case of discrete intervals for compounding or discounting and at a discrete inflation rate.

First the following variables are defined:

i_j = real rate of compounding or discounting in the year j; $1 \leq j \leq N$

i_M = nominal rate of interest (market rate)

θ_j = discrete inflation rate in year; $1 \leq j \leq N$

F_{cu} = C_j = actual cash flow in current dollars in year j

F_{co} = future cash flow in constant dollars

P = present worth in constant dollars

A clear distinction between real interest rates and nominal or effective interest rates is essential. There is considerable confusion and vagueness in the available literature, especially in respect to the correct usage of these rates. Regardless of the criteria used to determine the minimum attractive rate of return for an investment, the interest rate is always quoted in nominal terms, that is actual current rates. This rate is a combination of three components:

(1) the interest rate for relatively risk-free investment in a non-inflationary situation;

(2) the risk premium to compensate investors for the uncertainty associated with the investment;

(3) an inflation premium that reflects the risk of inflation during the life of the investment.

The real rate of interest as defined and utilized herein does not include this inflation premium. The expressions presented in this section can be employed with either nominal or real interest rates and inflation. They are appropriate when constant inflation rates are under consideration. When differential and varying inflation rates are involved the basic expression for the equivalence between cash flows changes and a slightly different procedure is required.

Given an inflation rate "θ" and a discount rate "i" an equivalence between cash flows that occur at different times can be determined [1, 19, 22, 27, 51, 52, 68, 76]. In Table 4-2, all the cash flows at the start and end of each period are equivalent to the initial amount "P". The new amount at the end of each period has included the effects of the time value of money and inflation. Each cash flow increses the real purchasing power and takes account of the time value of money and inflation.

TABLE 4-2

Equivalent Cash Flows

Period	Amt at Start of Period	Interest During Period	Inflation During Period	Amt at end of Period
1	P	iP	$\theta(P+iP)$	$P(1+i)(1+\theta)$
2	$P(1+i)(1+\theta)$	$iP(1+i)(1+\theta)$	$\theta(1+i)P(1+i)(1+\theta)$	$P(1+i)^2(1+\theta)^2$

At the end of the jth period, a cash flow of $C_j = P(1+i)^j(1+\theta)^j$ is equivalent to a cash flow of $C_0 = P$ at time 0 at interest rate i, inflation rate θ. The cash flows reflect an investment that yields a real rate of return, i, plus maintaining the purchasing power of money.

Thus the fundamental relationship that expresses a future cash flow C_j in current dollars in terms of a present cash flow in constant dollars is:

$$P = \frac{C_j}{(1+i)^j(1+\theta)^j}$$

This expression can be modified to determine a "true" effective discount rate "i_B" that combines the real rate of interest and the inflation rate as follows:

$$P = \frac{C_j}{(1+i)^j(1+\theta)^j} = \frac{C_j}{((1+i)(1+\theta))^j} = \frac{C_j}{(1+i+\theta+i\theta)^j} = \frac{C_j}{(1+i_B)^j}$$

with $i_B = i+\theta+i\theta$

The effective discount rate, i_B, thus accounts for inflation and may be associated with existing market interest rates. The effective discount rate i_B can be used directly to find the present worth "P", in terms of a base currency of a future cash flow "F" in current dollars:

$$P = \frac{F_{cu}}{(1+i)^j(1+\theta)^j} = \frac{F_{cu}}{(1+i+\theta+i\theta)^j} = \frac{F_{cu}}{(1+i_B)^j}$$

Since in most situations it is the effective (or nominal) interest that is available, the real rate of return, i, must be determined. This can be done as follows:

$$i + \theta + i\theta = i_B \qquad \text{where } i_B \text{ is assumed a function of } i_M$$

$$i(1+\theta) + \theta = i_B \qquad \text{in general } i_B \geq i_M$$

$$i(1+\theta) = i_B - \theta$$

$$i = \frac{i_B - \theta}{1+\theta}$$

The future worth of cash flows can be determined with the same principles. In terms of then current dollars the future worth of a single present cash flow is:

$$F_{cu} = P(1+i_B)^j$$

The future worth in constant dollars is:

$$F_{co} = \frac{F_{cu}}{(1+\theta)^j} = \frac{P(1+i_B)^j}{(1+\theta)^j}$$

In terms of the real rate of interest, i:

$$F_{co} = \frac{P(1+i_B)^j}{(1+\theta)^j} = \frac{P(1+i+i\theta+\theta)^j}{(1+\theta)^j} = \frac{P[1+(1+i)(1+\theta)-1]^j}{(1+\theta)^j}$$

$$F_{co} = P(1+i)^j$$

These basic formulas for a single cash flow can be expanded to include all the expressions in Table 4-1 and obtain the present worths and future values of a series of cash flows occurring at given intervals.

If a series of "N" uniform end of period cash flows occur, each having a current dollar value of "A" then future worth in current dollars of these cash flows is equal to the sum of the individual future worths.

$$F_{cu} = A + A(1+i_B) + A(1+i_B)^2 + \ldots + A(1+i_B)^{N-1}$$

$$F_{cu} = A \left[\frac{(1+i_B)^N - 1}{i_B} \right]$$

This future worth in constant dollars is:

$$F_{co} = \frac{F_{cu}}{(1+\theta)^N} = \frac{A}{(1+\theta)^N} \left[\frac{(1+i_B)^N - 1}{i_B} \right]$$

In terms of the real interest rate, i:

$$i_B = i + i\theta + \theta = (1+\theta)(1+i) - 1$$

$$F_{co} = \frac{A}{(1+\theta)^N} \left[\frac{(1+i_B)^N - 1}{i_B} \right] = \frac{A}{(1+\theta)^N} \left[\frac{(1+\theta)^N(1+i)^N - 1}{(1+\theta)(1+i) - 1} \right]$$

A simple inversion of this formula provides the expression for the size of uniform end of period cash flows required to yield a future cash flow with a specific value in constant dollars.

The present worth of a series of "N" uniform end of period cash flow is:

$$P = \frac{F_{cu}}{(1+i_B)^N} = \frac{A}{(1+i_B)^N} \quad \frac{(1+i_B)^N-1}{i_B}$$

or in terms of the real interest rate, i:

$$P = \frac{A}{(1+i)^N(1+\theta)^N} \left[\frac{(1+\theta)^N(1+i)^N-1}{(1+\theta)(1+i)-1}\right]$$

A list of compound interest formulas are presented in Table 4-3.

The expressions derived in this section contain one main assumption that is simplistic; that is, all cash flows inflate at a rate equal to the general rate of inflation of an economy. The price statistics presented in Chapter 2 indicate the opposite. Different inflation rates apply to different cash flows. In fact, many of the available inflation indexes are composed of sub-indexes of labour and materials; with each sub-index experiencing a different rate of cost increase. A more accurate equivalence of cash flows may now be expressed as:

$$\frac{C_j}{(1+i)^j\,(1+\theta)^j} = \frac{C_o\,(1+\theta+\Delta\theta)^j}{(1+i)^j\,(1+\theta)^j}$$

with $\Delta\theta$ equal to the differential inflation rate for the particular cash flow under consideration. This differential inflation rate is largely independent of the general inflation rate present in the economy; it is usually a characteristic of the type of cash flow. Energy costs, for

TABLE 4-3

Summary of Compound Interest Formulas with Inflation

Concept	Effective Interest Rate and Discrete Compounding	Real Interest Rate and Discrete Compounding
1. a) Future worth in constant dollars of a single cash flow	$F_{co} = \frac{P(1+i_B)^N}{(1+\theta)^N}$	$F_{co} = P(1+i)^N$
b) Future worth in current dollars of a single cash flow	$F_{cu} = P(1+i_B)^N$	$F_{cu} = P(1+i)^N(1+\theta)^N$
2. Present worth of a future single cash flow in current dollars	$P = \frac{F_{cu}}{(1+i_B)^N}$	$P = \frac{F_{cu}}{(1+i)^N(1+\theta)^N}$
3. Future worth in constant dollars of uniform end of period cash flows	$F_{co} = \frac{A}{(1+\theta)^N}\left[\frac{(1+i_B)^N-1}{i_B}\right]$	$F_{co} = \frac{A}{(1+\theta)^N}\left[\frac{(1+\theta)^N(1+i)^N-1}{(1+\theta)(1+i)-1}\right]$
4. Amount of uniform end of period cash flows required to accumulate a future worth in constant dollars	$A = F_{co}\left[\frac{i_B(1+\theta)^N}{(1+i_B)^N-1}\right]$	$A = F_{co}\left[\frac{((1+\theta)(1+i)-1)(1+\theta)^N}{(1+\theta)^N(1+i)^N-1}\right]$
5. Present worth in constant dollars of uniform end of period cash flows	$P = \frac{A}{(1+i_B)^N}\left[\frac{(1+i_B)^N-1}{i_B}\right]$	$P = \frac{A}{(1+i)^N(1+\theta)^N}\left[\frac{(1+\theta)^N(1+i)^N-1}{(1+\theta)(1+i)-1}\right]$
6. Amount of uniform end of period cash flows required to recover a present cash flow	$A = P\left[\frac{i_B(1+i_B)^N}{(1+i_B)^N-1}\right]$	$A = P\left[\frac{((1+\theta)(1+i)-1)(1+i)^N(1+\theta)^N}{(1+\theta)^N(1+i)^N-1}\right]$

P = Present worth of a cash flow or flows in constant dollars

F_{co} = future worth of a cash flow or flows in constant dollars

F_{cu} = future worth of a cash flow or flows in current dollars

A = amount of periodic cash flows

N = number of periods

i = real interest rate per period

i_B = effective interest rate per period $\neq i_M$ market rate of interest

θ = inflation rate per period

example, have a high and positive differential inflation rate. The problem is further complicated when several different average inflation rates apply at various periods during the life of an investment.

A comprehensive economic evaluation under these circumstances requires that each cash flow be escalated at its particular inflation rates. Then every cash flow is discounted with the appropriate interest rate and inflation rate for each period. Although the formulas presented in this section can be modified, there is a limited scope for this type of analysis. The investment analysis procedure is too complex and tedious to undertake manually. Specially designed computer programs have made the problem more manageable and several different alternatives can be evaluated without much difficulty. These computer programs are designed to handle complex cash flows with varying interest rates, inflation rates, and risk factors. The input data base required for the above programs can, however, be quite extensive. This type of analysis is most suitable for long term or complex investment programs. Detailed breakdowns and projections of capital costs, life cycle cash flows, interest rates, inflation rates, and risk analysis are often necessary [52].

Many projects do not have the data for such an analysis; nor do they demand or have the resources for this level of examination. It is frequently more convenient and just as useful to proceed with an economic appraisal utilizing the discount formulas presented in this section; with a uniform average inflation rate and appropriate escalation rates for the cash flows. This method is employed for short term projects, relatively simple investment decisions, for projects with similar types of cash flows, and as an initial phase of a detailed evaluation. The examples in this paper demonstrate some of the practical applications of the interest formulas.

4.4 Practical Application of Inflation Adjusted Compound Interest Formulas

As long as the consistency of units is maintained the appraisal of any project may be completed with the aid of the formulas just presented. There are two general approaches that are used [13, 78]:

(1) to express all cash flows in terms of current dollars and combine the inflation rate with the real monetary interest rate to form a single effective discount rate for economic calculations, evaluations and comparison;

(2) to express all cash flows in terms of constant dollars and use the real monetary interest rate as a discount rate for economic calculations.

Both approaches will yield the same result for pre-tax evaluations as is shown in Table 4-4 which determines the present worth of a $10,000 investment that returns $3,000 at the end of the first year, $4,000 at the end of the second year and $5,000 at the end of the third year. The real monetary interest rate for this example is 10% per year and the inflation rate is 5% per year. The constant approach is a better method when the investor is unable to determine the effective discount rate under inflation and when the real discount rate is available. It is not suitable when

TABLE 4-4

Comparison Between Current Dollar and Constant Dollar Approaches for Investment Appraisal

Current Dollar Method $i = 10\%$ $\theta = 5\%$

Year "N"	Cash Flow in Current Dollars	Present Worth Discount Factor $\frac{1}{(1+\theta)^n(1+i)^n} = \frac{1}{(1+i_B)^n}$	Present Worth
0	-10,000	1.0000	-10,000.0
1	3,000	.8658	2,597.4
2	4,000	.7496	2,998.4
3	5,000	.6490	3,245.1
4	6,000	.5619	3,371.5
			+2,212.4

Constant Dollar Method

Year "N"	Cash Flow in Constant Dollars $1/(1+\theta)^n$	Present Worth Discount Factor $1/(1+i)^n$	Present Worth
0	-10,000	1.0000	-10,000.0
1	2,857.1	.9091	2,597.4
2	3,628.1	.8264	2,998.4
3	4,319.2	.7513	3,245.1
4	4,936.2	.6830	3,371.5
			+2,212.4

depreciation and taxation must be considered as is discussed in Section 4.6. The current dollar method, however, provides extra information since it includes in the analysis a projection of the actual cash flows over the life of the investment and it completely includes the effects of depreciation and taxation on these cash flows. This permits the investor to determine the actual financial requirements for a project. It is therefore more suitable when the effects of inflation on the discount rate are better known. The choice depends on the circumstances of the investment and the preference of the investor. Both approaches are frequently used with various combinations of inflation rates, real discount rates, and effective discount rates.

Once again, the main assumption implicit in this discussion is that all the cash flows are subject to the same uniform inflation rate. The formulas also assume that the effective discount rate i_B is a direct function of the real rate of interest and the inflation rate; it may be expressed as $i_B = i + i\theta + \theta$. The previous section has outlined when these assumptions are appropriate. The methods just presented are therefore limited in their applicability. Investments that require the consideration of non-uniform and differential inflation rates cannot be evaluated properly without some modifications in the methods described. Since various cash flows increase at different rates, no true equivalence of cash flows can be established using the general inflation rate for the project. A pure constant dollar analysis, for this type of investment, does not provide a valid measure of investment performance. This is because the constant dollar method assumes uniform inflation rates for all cash flows. The current dollar approach does not result in the correct decision as well. The purchasing power of current dollars, even when discounted with i_B, cannot be compared to the purchasing power of constant dollars due to the involvement of different inflation rates for cash flows and purchasing power. The investor therefore does not know whether he should postpone present usage of his money for future dollars of an undetermined value.

A two stage approach including the current dollar and the constant dollar method and incorporating differential inflation rates is proposed. The cash flows are first expressed in constant dollars; they are next inflated at their individual inflation rates. The investor now has more valid projections of the cash flows for the investment than if one uniform inflation rate is used. He can determine if the investment is desirable in terms of capital and cash flow requirements. The next step is to discount these cash flows to constant dollar cash flows using the overall inflation rate estimated for the period of the investment. The constant dollar cash flows are not the same as would be employed in a pure constant dollar analysis.* The constant dollar cash flows are then discounted with the time value of money rate, the real rate of interest appropriate for the

* In mathematical terms for situations where $\Delta\theta \neq 0$:

$$\frac{C_o \, (1+\theta+\Delta\theta)^j}{(1+\theta)^j} \neq C_o$$

investment. This method permits the investor to make comparisons among alternatives without worrying about the value of his units of measure; the constant dollars all have an equal purchasing power. This method is generally used with computer aided investment analysis programs [52] and it helps the investor arrive at what he hopes is the best decision.

4.5 Selection of the Discount Rate and Inflation Rate

The selection of the discount rate and the inflation rate used in the interest formulas is a major decision in the investment evaluation. Numerous guidelines and rules of thumb are used to select the discount rate. In general, the discount rate can be defined as the cost of capital for a project. For some projects, the cost of capital is determined by the monetary rate of interest of the long term borrowings required to finance the project. On the other hand there are more sophisticated concepts of the cost of capital [45] which are frequently used. These include:

(1) the rate of return required on new investments to maintain or increase earnings per share;

(2) the cost of debt capital minus tax savings;

(3) a weighted average of yield on debt capital and price to earnings ratio of the common stock of a company;

(4) the rate of return required on new investment in order that the market price of a company's common stock does not decline, thus enhancing or at least maintaining investors interest in the company.

However, regardless of how the discount rate is determined, it must be recognized that since cash flows, interest rates and the general outlook of the financial market is expressed in current dollars, that the cost of capital will include an inflation component to compensate for the decrease in the value of money. Thus the discount rate is composed of a constant dollar interest rate which remains relatively constant and an inflation responsive component. There is considerable controversy among economists concerning the relationship of inflation to interest rates and returns on investments.

The general assumption is that interest rates (market or effective) can be expressed as $(1 + i)(1 + \theta) - 1 = i + i\theta + \theta$. The value of i is of course different for risk free market investments (government bonds) and for risk venture capital investment. This is why the cost of capital or effective discount rate, i_B, is generally greater than the market rate, i_M. The formulas presented in this chapter which use the above expression for i_B can be used for risk free investments when $i_B = i_M$. It is crucial that the proper rate of interest is applied with either the constant dollar or the current dollar method of project evaluation. The current or market rate of interest i_B is appropriate with current dollar cash flow analysis. This is because the cash flows are to be discounted for both inflation and the time value of money. The real rate of interest [14, 36, 39, 42, 43, 46, 49, 52] must be used as the discount rate with a constant dollar analysis since inflated cash flows are not considered. If the effective or market rate of interest is mistakenly used then the cash flows are discounted twice for inflation.

The selection of real and effective discount rates is an arduous task in the present environment of high and fluctuating inflation rates. The real rate of interest is generally assumed to remain relatively constant for a particular type of project, while the effective rate of interest is supposed to respond closely to inflation. Market interest rates have, however, not risen adequately in response to inflation and real rates of interest have declined to low or even negative values. Table 4-5 examines this phenomena by adjusting the yield on long term Government of Canada Bonds for inflation on an annual basis and a five year moving average. The five year moving average smooths out very large price movements in any given year. This provides a better basis against which long term real rates of interest may be determined. These nominal and effective real interest rates are presented graphically in Figure 4-1. This makes meaningful economic analysis and decision extremely difficult. It must therefore be emphasized that the selection of the appropriate discount rates for an investment is a critical decision; one which involves the selection of a real discount rate for an investment, the inflation anticipated during the life of the investment, and general economic environment during the period.

The inflation rates used in the appraisal of a project are however just a projection and estimates of the future. Since the actual inflation rates can often vary considerably from the projection, the evaluation of a project should be conducted under a range of possible inflation rates and discount rates. The possible outcomes of the investment can be examined with respect to the probability of occurrence and a more reasonable and rational decision can be made.

TABLE 4-5

Yield on Long-Term Canada Bonds Adjusted for Inflation

Year	Canadian Govt. Long-term Bond Yields + 100%	Annual % Change in C.P.I. + 100%	Yield Adjusted with Annual Inflation Percent	5-Yr. Moving Avg. % Change in C.P.I. + 100%	Yield Adjusted with 5-Yr. Moving Avg. Percent
	(1)	(2)	(3) = [(1) ÷ (2)]x100-100	(4)	(5) = [(1) ÷ (4)]x100-100
1960	105.15	101.23	3.87	101.94	3.15
1961	105.03	100.94	4.05	101.83	3.14
1962	105.04	101.20	3.79	101.43	3.56
1963	105.07	101.71	3.30	101.24	3.78
1964	105.19	101.81	3.32	101.38	3.76
1065	105.23	102.42	2.74	101.62	3.55
1966	105.74	103.73	1.94	102.17	3.49
1967	105.93	103.59	2.26	102.65	3.20
1968	106.66	104.05	2.51	103.12	3.43
1969	107.59	104.56	2.90	103.67	3.78
1970	107.95	103.29	4.51	103.84	3.96
1971	107.15	102.88	4.15	103.67	3.36
1972	107.32	104.80	2.40	103.92	3.91
1973	107.12	107.54	-0.39	104.61	2.40
1974	109.23	110.91	-1.51	105.88	3.16
1975	109.44	110.80	-1.23	107.39	1.91
1976	109.51	107.51	1.86	108.31	1.11
1977	109.09	107.99	1.02	108.95	0.13
1978	109.57	108.96	0.56	109.23	0.31
1979	110.49	109.13	1.25	108.88	1.48

Average Adjusted Yield = 2.83%

SOURCES:
(i) Consumer Price Index
Statistics Canada Catalogue Nos. 62-002, 62,010.

(ii) Bond Yields
McLeod Young Weir Long-term Government of Canada Bond Index

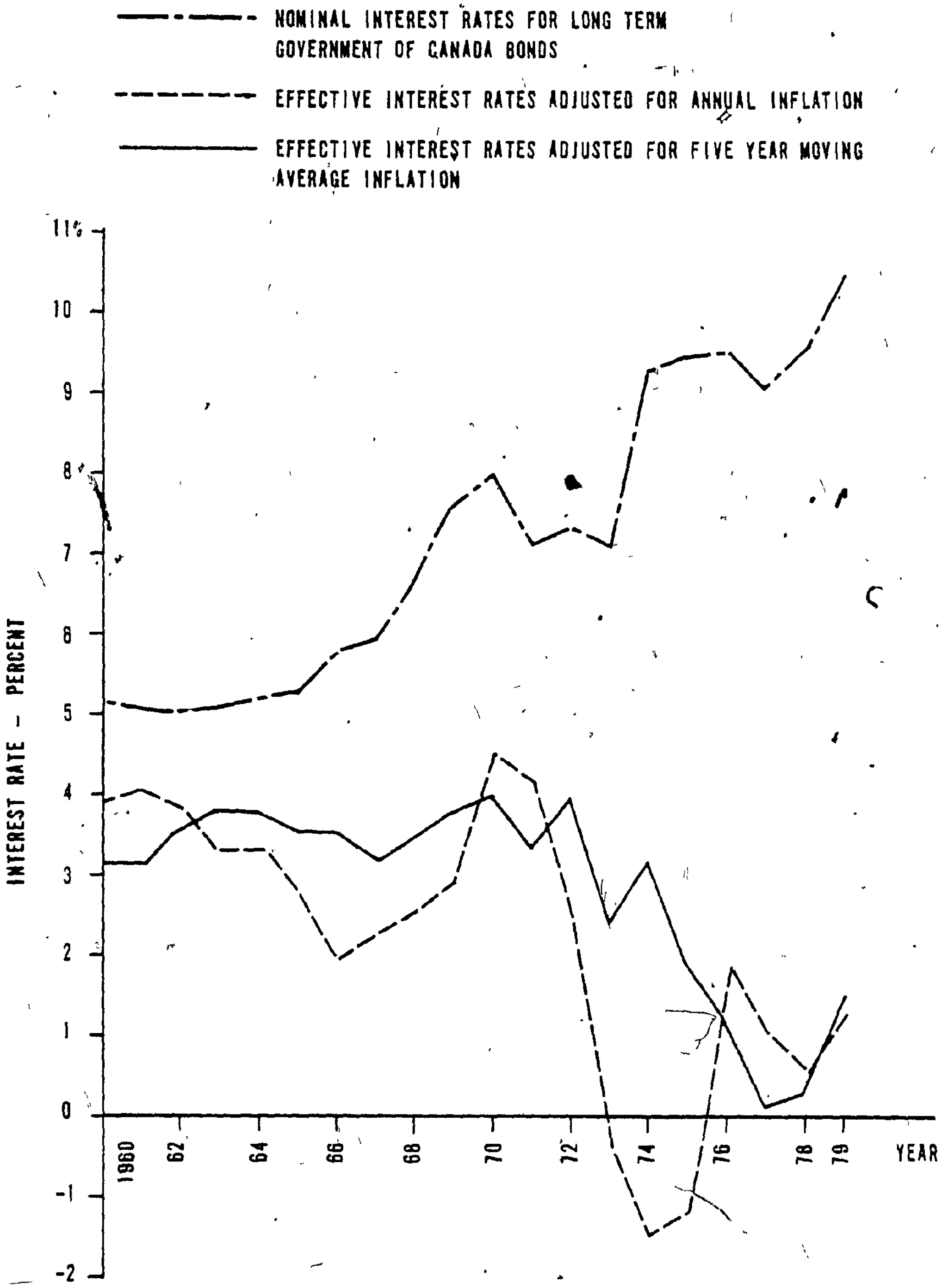

FIGURE 4.1 NOMINAL AND EFFECTIVE INTEREST RATES

4.6 Implications of Inflation for After Tax Investment Evaluation

Since most investment evaluations must be conducted on an after tax basis and with depreciation allowances, it is essential to develop the required methodology [46, 73, 77]. The basic tools are the discounting formulas and the present worth or internal rate of return methods into which are introduced taxation, depreciation and inflation.

Depreciation is the monetary allowance against income to account for the annual deterioration of the income producing assets of the investment. It allows for the recapture of the initial investment capital. The depreciation allowance reduces the annual income of an investment subject to taxes. Thus the larger the depreciation allowed, the less tax is paid and the more profitable the investment. Under present tax law, this depreciation allowance is based on the original cost of the asset. The depreciation allowance does not increase during an inflationary situation even though the replacement value of the capital assets and all the other cash inflows and outflows do increase. The tax benefit from "historical cost" depreciation is received in current dollars but is calculated and measured in terms of original investment dollars. The full benefit of depreciation is therefore not realized even though over the project life the sum of the yearly depreciation equals the original investment capital. This results in a steady shrinkage in the tax benefit of the depreciation allowance as gross profits inflate while depreciation does not.

The investor must select an appropriate method to evaluate an investment with depreciation and taxation considerations. Since the depreciation expense allowed does not change with inflation, the after tax cash flows do not inflate at the same rate as the general inflation rate. The constant dollar approach is therefore not suitable since it assumes that all the cash flows inflate at a rate equal to the general inflation. The current dollar method provides the correct technique for the required analysis. The current dollar approach expresses each cash flow in actual current dollars. The impact of depreciation and taxation can be fully included in the net after tax cash flows. The investment analysis is first conducted in current dollars including the depreciation allowances and taxation expenses to obtain current dollar after tax cash flows for each year. The after tax cash flows are adjusted to constant dollars and the present worth or internal rate of return is determined. The following example employs the internal rate of return method to measure the worth of an investment. It outlines the above procedure and demonstrates how after tax considerations are especially important under conditions of inflation.

An investment of \$10,000 is proposed which will yield an annual positive cash flow of \$3,500 for five years. The investment has no salvage value and a straight line depreciation of \$2,000 per year is used. The corporate tax rate is 50%. This investment is analyzed assuming no inflation and a 9% inflation rate. Table 4-6 provides the cash flows for the case of no inflation. The internal rate of return may be determined by solving for the interest rate in the expression for the present worth of the series of future benefits.

$$P = A \frac{(1+i)^N - 1}{i(1+i)^N} \quad \text{where } P = \$10,000 \text{ and } A = \$3,500$$

TABLE 4-6

Cash Flows for Proposed Investment with No Inflation

Year "N"	Pre-tax Cash Flow in Constant & Current Dollars	Depreciation Allowance	Taxable Income	Income Tax Paid @ 50%	After Tax Cash Flow in Constant Dollars
0	-10,000				
1	3,500	2,000	1,500	750	2,750
2	3,500	2,000	1,500	750	2,750
3	3,500	2,000	1,500	750	2,750
4	3,500	2,000	1,500	750	2,750
5	3,500	2,000	1,500	750	2,750

TABLE 4-7

Cash Flows for Proposed Investment with 9% Inflation

Year "N"	Pre-tax Cash Flow in Constant Dollars	Pre-Tax Cash Flow in Current Dollars $x\ (1 + \theta)^N$	Depreciation Allowance	Taxable Income	Income Tax Paid @ 50%	After Tax Cash Flow in Current Dollars
0	-10,000	-10,000				-10,000
1	3,500	3,815.0	2,000	1,815.0	907.5	2,907.5
2	3,500	4,158.4	2,000	2,158.4	1,079.2	3,079.2
3	3,500	4,532.6	2,000	2,532.6	1,266.3	3,266.3
4	3,500	4,940.5	2,000	2,940.5	1,470.3	3,470.2
5	3,500	5,385.2	2,000	3,385.2	1,692.6	3,692.6

Solving for i yields a before tax rate of return of 22% and an after tax rate of return of 11% for the case of no inflation.

The cash flows for the investment with 9% inflation are presented in Table 4-7. The before tax rate of return is still 22% since the pre-tax cash flows in constant dollars is still 3,500. However, in order to solve for the after tax rate of return, the after tax current dollar cash flows must be discounted by the inflation rate to constant dollar cash flows and solved for the unknown internal rate of return. This is presented in Table 4-8. The possible outcomes of this investment are summarized in Table 4-9. The before tax rate of return for both cases remains constant since the cash flows are fully responsive to inflation. However, in the after tax calculation there is a considerable decrease in the rate of return. Even though the actual cash flows respond to inflation, the depreciation allowance remains constant. Taxes increase and the real net profit in constant dollars decrease. As profit levels rise to higher taxation levels profits are reduced even further.

Two important conclusions may be observed from this example. The first is that inflation reduces the profitability of investments that involve tax considerations and depreciation. It is not as serious a factor for other types of investments where all cash flows are directly responsive to the inflation rate. The second conclusion is the obvious necessity of this type of methodology in an investment analysis in order to avoid some unfortunate surprises later.

TABLE 4-8

Adjustment of Current Dollar Cash Flows to Constant Dollar Cash flows and Determination of Internal Rate of Return

Year "N"	Current Dollar Cash Flow	Equivalent Constant Dollar Cash Flow $(1 + \theta)^{-N}$, $\theta = .09$	Present Worth @ 8%	Present Worth @ 9%	Present Worth @ 8.5%
0	-10,000	-10,000	-10,000	-10,000	-10,000
1	2,907.5	2,667.4	2,469.7	2,447.2	2,458.4
2	3,079.2	2,591.7	2,221.9	2,181.4	2,201.5
3	3,266.3	2,522.2	2,002.1	1,947.6	1,974.7
4	3,470.2	2,458.4	1,806.9	1,741.6	1,773.9
5	3,692.6	2,399.9	1,633.4	1,559.8	1,596.0
			+134	-122.4	+4.5

TABLE 4-9

Before and After Tax Rates of Return for an Investment Subject to a Zero Inflation Rate and a 9% Inflation Rate

Situation	Before Tax Rate of Return	After Tax Rate of Return
No Inflation	22%	11%
9% Inflation	22%	8.5%

4.7 Cost Indexes

Cost escalation indexes have been developed [4, 7, 41, 53] to monitor price increases of specific components and various sectors of the economy. These indexes are constructed by government and industry to provide a historical record of price changes, and can be utilized to monitor, manage, and control cost escalation during the life of a project [23, 26, 31, 48, 56, 62, 72]. Future cash flows, cost and price escalation and inflation rates can be estimated or forecast with the aid of these indexes and the statistical techniques outlined in Section 4.6.2. The utilization of the data provided by the indexes and the application of statistical analysis to them provide a rational estimate of the future cash flows for a project; this procedure also supplies appropriate inflation and escalation rates to incorporate in the project evaluation and planning.

The most often quoted index is the Consumer Price Index which was presented in Table 2-1. Although this index is not directly related to engineering activities it is usually employed when considering the appropriate inflation rate to be used for an investment. This is because the investment capital is provided by the general public who forego present consumption for future consumption. Thus the most relevant index to the public is one that relates the purchasing power of money over time; that is the Consumer Price Index. Other more engineering-oriented indexes which are employed for the analysis of individual cash flows are presented in Section 2.4 and Section 4.7.3.

4.7.1 The Development of a Cost Index

Each index is an average of a set of economic or cost factors believed to represent the wages, fringe benefits, productivity, cost of materials and general economic conditions required to produce a given product or service. Since each type of activity, product or sector of the economy differs, each type of index consists of different combinations of the above components and assigns different weights to these components. An index may be constructed in this manner for almost anything and to any desired level of detail. The index is a number that relates the average cost of these factors at any given time to a base reference year when the costs are assigned a base value of 100.

The indexes presented in this paper are generally available only several months after the fact. This is because they include a vast data base and there are delays in gathering and correlating all the information. The complexity of the problem is demonstrated if the flow of resources for a typical construction contract is examined. It is evident from Figure 4.2 that there are many levels of activity in the system where price changes are input [11]. The finished product is often processed at several stages with each stage contributing a component of labour cost and material cost. The construction of an accurate and reliable cost index for any item must account for these various inputs and assess the degree of cost contribution of each component toward the final product. The result is an index prepared at a given time with a set proportion of cost assigned to both labour

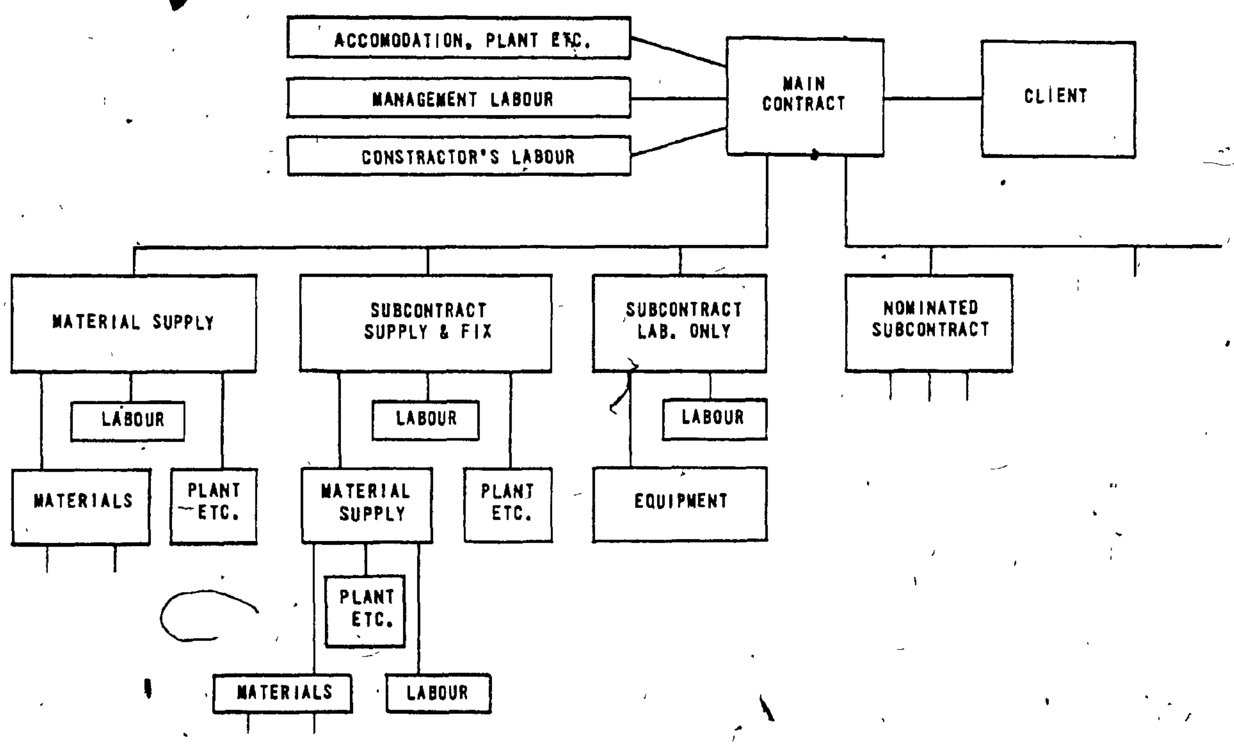

FIGURE 4.2

THE FLOW OF LABOUR AND MATERIAL RESOURCES IN A BUILDING CONTRACT [11] and material and a base value of 100. Changes in the index over time reflect price adjustments in the various weighted components of the index. The value of an index consisting of a material and labour component at any time is given by:

$$IV = \left[\frac{FL - BL}{BL}\right] L + \left[\frac{FM - BM}{BM}\right] M + 100$$

where IV = Index value at time "t"

FL = labour index value at final time "t"

BL = labour index value at base time

L = percentage of total base price for labour component

FM = material index value at final time "t"

BM = material index value at base time

M = percentage of total base price for material component

The indexes presented in this paper include two types - input and output indexes. Input indexes measure the cost performance of a component of a finished product. Statistics Canada prepares such indexes for different skilled labour, materials, goods and services. Output price indexes measure the cost performance of complete finished products or specified groups of goods and services. These indexes are prepared for residential and non-residential construction, consumer prices and many others. Both types of indexes are appropriate in specific applications.

Output price indexes are useful where the object is to monitor the price fluctuation of specific finished products in the economy. The main advantages of output indexes are that they are simple to use and that they measure the cost of a finished product. These costs incorporate productivity fluctuations and profit margin changes. The index formulation just presented is an output index. However, output indexes are only available for a limited number of products. These items are frequently not similar to the product being monitored. This may be due to major differences in the components of the product, the product itself or the technology used in production. All these factors are not generally reflected in an output index.

Input indexes are employed when detailed cost monitoring is required for the various labour and material cost components of a finished product. Thus input indexes can be prepared for both portions of the output index presented above. Monitoring the cost of components is an important and continuous activity during the life of an investment. Unfortunately input indexes do not make allowances for productivity changes. An attempt to use input indexes to measure price movements of the output of a sector of the economy will overestimate the extent that productivity has increased.

Therefore, output indexes are more suitable as an overall tool to monitor, manage, confirm and forecast overall cost escalation for the investor while input indexes are more effective as an operative instrument during the investment and operational phases of a project.

4.7.2 Forecasting Escalation Rates with Indexes

There are several mathematical and statistical forecasting models available which utilize the historical data contained in an index to predict future escalation and inflation rates. These techniques are extensively discussed [9, 16, 52, 74, 79] and include: multiple regression analysis, analysis of moving averages, time series analysis and exponential smoothing. Statistical forecasting techniques are useful when the investor is unable to employ some other more definite indicator of the future. These methods can be utilized, with the historical cost indexes providing input data, in order to obtain estimates of future inflation.

Some organizations are large enough or some projects are so extensive that specific cost indexes may be constructed and a detailed analysis is undertaken for specific areas. Of course the more detailed the analysis and the more custom made the index the more accuracy is expected from the predictions. On the other hand most projects and organizations do not have the resources to conduct this type of analysis. There is consequently a strong reliance on prediction of escalation based on published indexes and governmental and other published predictions. However, it must be recognized that when dealing with unknown future events the professional judgement and the experience of those making the forecasts may be the best and most important source of escalation predictions.

4.7.3 The Availability of Cost Indexes

Many different cost indexes are readily available from governmental and private organizations. Both the Canadian and American governments regularly publish reports on the performance of their economies. A few of the cost indexes prepared by Statistics Canada were presented in Section 2.4; many more are available [59, 60, 61]. These detailed indexes measure the changes in the cost of the labour and material components of different items incurring cash flows in a project. The United States Department of Commerce publishes a similar set of economic performance indexes in the Statistical Abstract of the United States; as do most other countries. Private and semi-private organizations regularly prepare and publish cost indexes that reflect their particular area of interest. Some of these indexes are very restricted in application and their general availability. Other indexes are suitable in diverse situations. These indexes are regularly updated and are sometimes issued together with others. For example, a comprehensive set of construction cost indexes is updated and published quarterly by the Engineering News Record [18]. A recent list of the indexes, with their source and composition, is presented in Table 4-10. The American Association of Cost Engineers (AACE) publishes the Cost Engineers' Notebook [3]. This publication contains a comprehensive list of available indexes, publishers, composition, accessibility, and suitability. Table 4-11 presents the list of indexes examined in the Cost Engineers' Notebook. The availability of cost indexes is therefore not a problem. However, the selection of an

Table 410 Builders' Construction Cost Indexes, Engineering New Record, Dec. 20, 1979

Builders' construction cost indexes

Name area & type	1974 AV	1975 AV	1976 AV	1977 AV	1978 AV	1979 Jan	Feb	Mar	Apr	May	June	July	Aug.	Sept.	Oct.	Nov	Dec	%chg. 78 79
GENERAL PURPOSE COST INDEXES																		
ENR 20-cities: Construction cost	188	206	223	240	258	267	268	269	269	269	278	284	286	290	291	292	292	+9.5
ENR 20-cities: Building cost	178	183	211	229	248	258	258	259	259	260	268	270	274	280	281	281	283	+10.1
U S Commerce Department	173	190	198	213	241	260	262	264	265	271	273	275	279	280	284p	—	—	+12.5
Boeckh: Denver bldgs	175	196	206	223	241	255	-	-	260	—		272	-	—	277	—	—	+11.2
Dodge bldg. cost	na	na	na	na	na			260	-	-		-	-	290	-		-	+13.8
Factory Mutual indus. bldg.	178	200	212	226	246	262			-	—	-	274	-	—	—	-	—	+9.5
Lee Saylor Inc labor/material	195	209	221	242	263			269	—		272	-		281	—		—	+6.4
Means: const cost	176	188	196	209	224	233	-	-	235	-	-	246	.	—	253		—	+9.5
CONTRACTOR PRICE INDEXES—BUILDING																		
Austin: central & eastern U.S., indus	176	187	198	208	228		-	243	-	—	252	-		259	-	—	—	+12.1
Fruin-Colnon: St. Louis industrial	183	202	236	234	258	273	276	278	280	284	285	287	288	289	290	292	-	+8.6
Geo A. Fuller	185	204	219	234	262	281		—	288			295	—	na	—	—		+10.3
Lee Saylor Inc subcontractor	186	167	182	209	241			252		-	264	—	-	277	—	—	—	+15.0
Turner: general	189	199	202	208	222	236	-	-	242	—	-	248	—	-	255	—	-	+10.9
Smith, Hinchman & Grylls: general*	176	186	199	213	229	236	237	238	238	239	245	248	250	252	253	254	—	+8.1
H F Campbell: 17 cities, mfg.	178	194	205	216	233	242	246	246	251	251	256	256	259	259	266	266	—	+9.5
VALUATION INDEXES																		
American Appraisal: 30-cities, indus	179	189	206	220	238	249	250	252	252	256	259	262	264	265	269	—	—	+8.8
Boeckh Index: 20-cities, comm'l & mfg†	171	189	205	221	238	250	-	251	-	256	—	263	—	265	—	269	—	+8.8
Marshall & Swift: industrial	169	184	196	209	231	246	—		252	-	—	260	--		268	—	—	+12.1
SPECIAL PURPOSE INDEXES																		
Nelson Refinery Cost: "inflation" index	182	200	215	223	244	254	255	256	257	-	—	—	—	—	—	—	—	+7.5
Chemical Engineering plant cost	151	186	175	186	201	210	211	212	213	216	216	218	219	222	224	—	—	+9.8
Port Authority of N Y & N J hangar cost	175	194	204	217	233	243	243	243	24[illegible]	244	254	257	268	269	269	—	—	+13.5

Base 1967 100

*Smith Hinchman & Grylls is an A E firm. †Adjusted for productivity. Prepared by Boeckh Publications div of American Appraisal Assoc Inc. p preliminary. na not available. from latest month to same period a year ago

American Appraisal Co., Inc., Milwaukee—This index represents a 30-cities average composite of four types of industrial buildings: wood frame, brick, concrete and steel. Established for valuation purposes, the index applies to structure only and does not include mechanical-trades installations. Indexes also are maintained for individual cities. Published monthly.

Austin Co., Cleveland—This contractor's building cost index reprices a typical one-story 116,760-sq-ft steel frame industrial building (240 x 480 ft with 40 x 60-ft column spacing) with concrete foundations and concrete floor on grade. It also includes a metal roof deck with insulation, concrete block sill walls with narrow bands of ventilating sash and field assembled curtain walls, fluorescent lighting, mechanical ventilation, sprinkler, plumbing and storm drainage. It is published on a quarterly basis.

Boeckh Building Cost, American Appraisal Co.—The index tabulated here is the average of 20 cities' averages for five commercial and factory building designs. City indexes are based on local surveys of materials prices and wages paid by contractors; they include overhead, sales taxes, compensation insurance, social security and allowance for profit. Published bimonthly.

H F Campbell Construction Co., Inc., Detroit—Price index, average for 17 cities based on materials and labor costs on five manufacturing buildings constructed by company in the Detroit area in 1960. Materials costs components are reduced to specific amounts of concrete, steel, masonry, glass, roofing, lumber and paving. Published monthly.

Chemical Engineering Plant Cost, McGraw-Hill, Inc., New York—Special purpose index published by Chemical Engineering, weighted by chemical process industry cost experience: equipment, machinery and supports 61%, installation labor 22%, buildings materials and labor 7% and engineering and supervision manpower, 10%. Labor productivity factored in. Equipment, etc. (61%) breaks down into seven subgroups. Published biweekly.

Dodge Building Cost, McGraw-Hill, Inc.—Compiled semiannually from questionnaires to 183 cities in the U.S. on latest wage and material prices affecting construction costs. Wages polled are for nine building crafts and common laborers. Material prices requested include brick, plaster, cement, lumber and structural steel. Ratios applies at the rate of 60% material, 40% labor to arrive at an index for each city.

Factory Mutual Engineering, Norwood, Mass.—A weighted aggregate cost index based on the wage rates of eight trades and on the costs of seven materials. These factors weights in the index derive from analysis of construction input to five typical industrial buildings ranging from a single-story steel-frame metal-clad warehouse to a multistory reinforced concrete building. The U.S. average reported here is the average of indexes computed for 23 cities. Published on a semiannual basis.

Fruin-Colnon Contracting Co., St. Louis—Five industrial buildings in St. Louis repriced with contractor's material and labor costs with periodic weighting adjustments for changes in materials and methods usage. Compiled monthly.

George A. Fuller Co., New York City—Contractor's price index based on a completed hotel, office building and factory broken out into selected trade classifications common to all three structures evaluated with current wage, tax and insurance rates and material prices for New York area. Contractor's overhead and profit excluded. Building designs change to reflect current practice. Compiled quarterly.

Marshall and Swift Publication Co., Los Angeles—A valuation cost index based on national average of three district indexes for eastern, central and western U.S. The basic indexes are divided further into five classes of construction: fireproofed steel frame, reinforced concrete frame, masonry, wood frame and steel buildings. Published quarterly.

R.S. Means Co., Inc., Duxbury, Mass.—**Composite building representing current design practice is the basis of quantity weightings assigned to 80 construction materials, 24 trades (labor), and nine types of construction equipment. Index tabulated here is average of indexes computed from local cost data for 30 largest U.S. cities. Published quarterly.**

The Oil & Gas Journal, Tulsa—Nelson Refinery Cost "Inflation" Index indicates present-dollar construction cost of duplicating a 1946 refinery without respect to changes in mechanical or process design, construction techniques or size. (Index converted to 1967 base in ENR tabulation.) The index is published monthly.

The Port Authority of New York and New Jersey, New York City—The hangar cost index is based on a hangar built at New York in 1940. The index includes 13 elements representing 76% of total structural and mechanical cost, excludes interior finish, mechanical trades and electrical work. Items used each repriced in place for labor and materials, include earthwork, concrete piles, other foundations and floors, structural concrete, metal doors and windows, masonry, structural steel, roofing and sheet metal work. It is compiled monthly.

Lee Saylor, Inc., Walnut Creek, Calif.—The firm compiles two indexes. The labor/material cost index weights labor and materials at 54% and 46%, respectively (weighting subject to change when labor-material input ratios change). Labor factor is based on quotes for nine classifications in 16 cities, the materials factor reflects 23 materials in 20 cities. The Lee Saylor Subcontractor price index expresses an unweighted composite of in-place unit prices most often quoted on specified basic quantities of 21 building construction materials. Both indexes are published quarterly.

Smith, Hinchman & Grylls, Inc., Detroit—Index expresses architect-engineer firm's projects' actual in-place prices using building materials costs, freight rates, skilled and unskilled labor rates and including labor efficiency and premiums, bidding competition, contractor profit margins and overhead. Figured with contractor overhead are taxes, duration of project, material-expediting and labor-procurement costs. It is published quarterly.

Turner Construction Co., Inc., New York City—This is a contractor's price index which reflects current experience on labor rates, materials prices, productivity of labor, efficiency of plant and management, competitive conditions and a forecast of price trends in major U.S. cities. It is published quarterly.

U.S. Bureau of Reclamation, Denver—Index for general property (buildings) in 18 western states including Alaska based on combined labor and materials costs furnished by contractors and the government. It is published quarterly.

U.S. Department of Commerce, Washington—Composite cost index represents the ratio of the annual value of new construction put-in-place in current dollars to comparable value of new construction in 1972 dollars (converted to 1967 base by ENR). In effect, this cost index uses construction put-in-place estimates by type of construction in order to weight appropriate special and general purpose construction cost or contractor price indexes. Sometimes two indexes are used, one for deflating another for extrapolating. Trend of the composite index is affected by shifts in the category mix of construction put-in-place as well as by trends of individual cost indexes used. This index is published monthly.

TABLE 4-11

List of Indexes in Cost Engineers' Notebook

Buildings

Index of the Cost of Industrial Building
Austin Building Cost Index (Industrial)
American Appraisal Company Construction Cost Index (Industrial)
Boeckh Building Cost Index (Industrial, Commercial, Apartments, Hotels, Residences and Office Buildings)
Marshall & Stevens Building Cost Index (Industrial)
Fruin-Colnon Building Cost Index (Industrial)
Fuller Building Cost Index (Composite of Industrial Hotels, and Office Buildings)
Smith Hinchman & Grylls Building Cost Index (Composite)
Turner Building Cost Index (Composite)
Department of Health, Education and Welfare Representative Construction Costs of Hill-Burton Hospitals and Related Heath Facilities
Dow Historical Local Cost Indexes (Various Types)
Campbell Manufacturing Building Cost Index (Industrial)
Engineering News-Record Building Cost Index

General Construction

Engineering News-Record Construction Cost Index
Department of Commerce Composite Cost Index
Engineering and Contract Record Cost Indexes (Canada)
Associated General Contractors Construction Cost Index - Constructograph (Wages, Materials & General Construction)
U.S. Army Engineer's Contract Unit Price Index (Heavy Construction)
Price Trends for Federal Aid Highway Construction

Plant Construction and Equipment

Chemical Engineering Plant Cost Index
Nelson Refinery Construction and Equipment Cost Indexes
Weber, Fick and Wilson Cost Indexes for Water Works Property
Handy-Whitman Index of Public Utility Construction Costs (Building, Gas Plant & Electric Light and Power)
Handy-Whitman Index of Water Utility Construction Costs (Water Works)
Bureau of Reclamation Construction Cost Trends (Power Plants, Irrigation and Hydropower Construction)
Marshall & Stevens Industrial Equipment Cost Index

TABLE 4-11 (Cont'd)

<u>Construction Materials</u>

Engineering News-Record Material Prices
(See also E-1.12, page 7, and E-1.21, page 7)

<u>Wages and Employment</u>

Bureau of Labor Statistics Employment and Earnings Statistics for the United States
Bureau of Labor Statistics Employment and Earnings Statistics for States and Areas
Engineering News-Record Wage Rate Indexes
Engineering News-Record Wage Rates
(See also E-1.12, page 7, and E-1.13, page 5)

<u>Construction Equipment</u>

Bureau of Labor Statistics Wholesale Price Index Construction Machinery and Equipment
Associated Equipment Distributor's Compilation of Averaged Rental Rates for Construction Equipment

<u>Commodity Prices</u>

Bureau of Labor Statistics Consumer Price Index (Goods and Services)
Bureau of Labor Statistics Wholesale Price Index (Various Commodities)
Bureau of Labor Statistics Steel Prices, Unit Costs, Profits and Foreign Competition

<u>Labor Output, Employment and Wages</u>

Bureau of Labor Statistics Indexes of Output per Manhour for Selected Industries
(See also E-1.15, page 1 and page 2)

<u>Plant Maintenance</u>

McGraw-Hill Factory Cost Index

<u>Transportation</u>

Department of Commerce Schedule of Annual Indexes for Carriers by Railroad appropriate index to be used with a particular type of cash flow is an area of great concern and significance.

4.8 Summary

The methodology and techniques presented in this chapter constitute a set of guidelines for the appraisal of projects under condition of inflation. An investment that is properly evaluated from its inception has a much better possibility of a successful outcome and no bad surprises.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions and Recommendations

Over the years countless authors have attempted to address the issue of inflation and society. This paper has discussed some aspects of this topic with a specific audience in mind, the persons concerned with engineering investment decisions. Engineering decisions have a prominent position in decisions regarding the distribution of our resources. Anything that affects the decision-making process or the outcomes must therefore be understood and controlled. The nature and significance of inflation has been examined with respect to the overall economic situation, engineering investment and engineering-oriented projects. The seriousness of both problems has been explained and cannot be overstated. A series of steps has been outlined which provides the reader with some of the basic tools required as part of a comprehensive effort to understand, control, and minimize inflation.

There are several other areas of activity that must be investigated; where new ideas must be developed to suit the present situation. The impact of inflation has been demonstrated to be especially significant during the pre-investment phase and the construction stage of a project. Concentrated effort is required in both research and practical areas, since the most important decisions and the major capital expenditures occur during these periods. This involves the establishment of inflation avoidance techniques, planning and scheduling procedures that properly incorporate the effect and the risk associated with inflation, and effective and manageable control systems. The accurate forecasting of cost escalation in a project and inflation in general is a difficult task during even the most stable economic environment. The present situation makes this task almost impossible unless more effort is directed to provide up to date cost information, and better, more sensitive, techniques and guidelines for forecasting and planning. An improved cost control system can be developed which will monitor, control, and minimize inflation during the construction stage. An overall inflation management program can be developed from this base to extend through all the phases of an investment. There are however several other areas of activity to be investigated, where new ideas must be developed to suit the present situation. This involves the establishment of inflation avoidance techniques not only during the appraisal stage, but also through the design, construction and operational phases of an investment. An effective or manageable control system can be developed to handle the problem of inflation through these phases. This program must apply to the management functions, accounting procedures, contractual arrangements and purchasing matters; as well as engineering functions, construction activities and operating procedures.

REFERENCES

REFERENCES

1. Alcott, F., "Present Value Analysis with Inflation", Transactions of the AACE, San Francisco, 1978.

2. Amadio, L.C., Life Cycle Costing, Transaction AACE, Cincinnati, 1979.

3. American Association of Cost Engineers, "Cost Engineers Notebook, Construction Statistic, Section E", AACE, 1972.

4. American Institute of Certified Public Accountants, "Reporting the Financial Effects of Price Level Changes", Accounting Research Study Number 6, 1963.

5. Bank of Montreal Business Review, "Perspective on Inflation", October 1979.

6. Bannock, G., Baxter, R.E., Rees, R., "Dictionary of Economics", Penguin Books, 1973.

7. Blackwell, W.B., "Indexation: A Theoretical Review and Empirical Perspective", Transactions of the AACE, Cincinnati, 1979.

8. Bonano, D.R., "Cost Escalation: Its Impact on Purchased Equipment", Chemical Engineering, July 1975.

9. Boor, J.H., "An Improved Method for Forecasting Escalation", Transactions of the Fifth International Cost Engineering Congress, Utrecht, 1978.

10. Briston, J.B., and Liversidge, J., "A Practical Approach to Business Investment Decisions", MacMillan, 1979.

11. Bromilow, F.J., "Problems of Price Escalation in Supply Management", The Building Economist, March 1977.

12. Buffet, W.E., "How Inflation Swindles the Equity Investor", Fortune, May 1977.

13. Canada, J.R., "Intermediate Economic Analysis for Management and Engineering", Prentice-Hall, 197 .

14. Carsberg, B., Hope, A., "Business Investment Decisions Under Inflation", Institute of Chartered Accountants in England and Wales, 1976.

15. Clark, F.D., "How to Assess Inflation of Plant Costs, Cost Control for Process Plants from the Owner's View", Chemical Engineering, July 1975.

16. Conduit, L.F., "A Method for Forecasting Escalation Rates of Utility Construction Expenditures", Proceedings of the American Gas Association - Edison Electric Institute Accounting Conference - 1977.

17. Cook, R.R., "Criteria for Analyzing Contingency and Escalation", Transaction of the AACE, San Francisco, 1978.

18. Engineering News Record, "Quarterly Cost Roundup".

19. Evans, G., "The Cost of Saving Regular Costs", Engineering Digest, September, 1978.

20. Fisher, W.H., "The Anatomy of Inflation 1955-1975", Scientific American, November 1971.

21. Flynn, T.D., "Why We Should Account for Inflation", Harvard Business Review, Sept. 1977.

22. Freidenfelds, J., and Kennedy, M., "Price Inflation and Long Term Present Worth Studies", Engineering Economist, Vol. 24, No.3.

23. Goodacre, P.E., "Payment of Increased Cost on U.K. Construction Project by Index Method", Transaction of AACE, Boston, 1076.

24. Grant, E.I., "Principles of Engineering Economy", 5th Edition, Ronald Press, 1972.

25. Haythorne, G.V., "Construction and Inflation", Information Canada, 1973.

26. Higgins, L.R., and Stidger, R.W., "Cost Reduction From A to Z", McGraw-Hill, 1970.

27. Holland, F.A. and Watson, F.A., "Putting Inflation into Profitability Studies", Chemical Engineering, February, 1977.

28. Holmes, R.L., "Inflation, Real Estate Yield and Current Market Aspirations", Real Estate Appraiser, July 1976.

29. International Monetary Fund, "International Financial Statistics, March 1980", I.M.F. Washington, D.C.

30. Jarvis, A.S., "Inflation and Capital Investment in the U.K.". Transactions of the Fifth International Cost Engineering Congres, Utrecht, 1978.

31. Jones, C.M.., "Contractors Selling Price Indexes, What Are They, How Can They be Used", Transactions of the AACE, Boston, 1976.

32. Jones, L.R., "Building Cost Escalation, Modern Cost Engineering", Chemical Engineering, July 1970.

33. Jelen, F.C., "Cost Optimization Engineering", McGraw-Hill 1970.

34. Kelly, M.G., "The Short Run Impact of Foreign Inflation on Canadian Prices", Information Canada, 1972.

35. Koipillai, C.J., "Myth of Inflation" second edition, University of Manitoba 1967.

36. LeRoy, S.F., "Interest Rates and the Inflation Premium", Federal Bank of Kansas City, Monthly Review, May 1973.

37. Lessard, D., and Modigliani, F., "Inflation and the Housing Market, Problems and Potential Solutions", Sloan Management Review, Fall 1975.

38. Lipsey, R.G., Sparks, G.R., Steiner, P.O., "Economics" 2nd edition, Harper and Tow, 1976.

39. McCollum, J.F., "Inflation and Interest Rates in Canada", Information Canada 1972.

40. McMahon, L.A., "Analysis of Factors that Cause Inflation", Transactions of the AACE, San Francisco, 1978.

41. Mendel, O.M., "Construction Price Indices", Transaction of the AACE, San Francisco, 1978.

42. Merrett, A.J., and Sykes, A., "The Finance and Analysis of Capital Projects", 2nd edition, Longmans, London 1973.

43. Merrett, A.J., and Sykes, A., "Capital Budgeting and Company Finance", 2nd edition, Longmans, London, 1973.

44. Mitchell, K., "Investment Appraisal in an Inflationary Situation", Accountant, March 2, 1977.

45. Moran, J.J., The Cost of Capital, Its Meaning, Determination and Use, Transaction AACE, Montreal, 1971.

46. Newman, D.G., "Engineering Economic Analysis", Engineering Press 1977.

47. OECD, "Main Economic Indicators", March 1980, OECD Paris.

48. Perry, J.G. and Thompson, P.A., "Construction Finance and Cost Escalation", Proceedings Institute of Civil Engineers, Part 1, November, 1977.

49. Pesando, J.E., "The Impact of Inflation on Financial Markets in Canada", C.D. Howe Research Institute, 1977.

50. Pilcher, R., "Appraisal and Control of Project Costs" McGraw Hill 1973.

51. Reisman, A., and Rao, A.K., "Discounted Cash Flow Analysis: Stochastie Extensions", Engineering Economy Division, Monograph Series No. 1, American Institute of Industrial Engineers, March 1973.

52. Rose, L.M., "Engineering Investment Division, Planning Under Uncertainty", Elsevier Scientific Publishing Co., 1976.

53. Rosen, L.S., "Current Value Accounting and Price Level Restatements", Canadian Institute of Chartered Accountants, Toronto, 1972.

54. Samuelson, P.A. "Economics", tenth edition, McGraw Hill 1976.

55. Savay, A., "Effects of Inflation and Escalation on Plant Costs", Chemical Engineering, July 1975.

56. Sinclair, J.M., "Project Cost Control in Periods of Severe Inflation", Transaction of the Fifth International Cost Engineering Congress, Utrech 1978.

57. Smith, G.W., "Engineering Economy: Analysis of Capital Expenditures", Iowa State University Press, 1975.

58. Solow, R.M., "What We Know and Don't Know About Inflation", Technology Review, January 1979.

59. Statistics Canada, "Canada Yearbook 1978-79.

60. Statistics Canada, "Consumer Prices and Price Statistics (catalogue 62-010), monthly.

61. Statistics Canada, "Construction Price Statistics (catalogue 62-007), monthly.

62. Stidger, H.C., "Inflation Management", John Wiley, 1976.

63. Stowe, P.A., Building Design Evaluation, Costs in Use, E & F Spon Ltd., London, 1967.

64. Thorne, H.C., "Impact of Inflation on International Ventures", AACE Bulletin, January 1978.

65. Trevithick, J.A., and Mulvey, C., "The Economics of Inflation", John Wiley, 1975.

66. Trevithick, J.A., "Inflation, A Guide to the Crises in Economics", Penguin Books, 1977.

67. United Nations Industrial Development Organization, "Manual for the Preparation of Industrial Feasibility Studies", Vienna, 1978.

68. Van Horne, J.C., "A Note on Biases in Capital Budgeting Introduced by Inflation", Journal of Financial and Quantitative Analysis, January 1971.

69. Von Furnstenberg, G.M. and Malkiel, B.G., "Financial Analysis in An Inflationary Environment", Journal of Finance, May 1977.

70. Wallich, H.C., "Investment Income During Inflation", Financial Analysis Journal, March 1978.

71. Warne, D.J., "Capital Budgeting Techniques", Transactions of the AACE, San Francisco, 1978.

72. Warszawski, A., "Construction Cost Control Under Inflationary Conditions", Transaction of the Fifth International Cost Engineering Congress, Utrecht, 1978.

73. Waters, R.C., and Bullock, R.L., "Inflation and Replacement Decisions", Engineering Economist, Vol. 21, No. 4.

74. Wehner, J.C., "A Model for Inflation Forecasting", Transactions of the AACE, Boston, 1976.

75. Wendt, P.F., "Inflation and the Real Estate Investor", The Appraisal Journal, July 1977.

76. Weston, J.F., and Brigham, E.F., "Managerial Finance", 6th edition, Dryden Press, 1978.

77. Westwick, C.A., and Shohet, P.S.D., "Investment Appraisal and Inflation", Institute of Chartered Accountants in England and Wales, 1976.

78. White, J.A., Agee, M.H. and Case, K.E., "Principles of Engineering Economic Analysis", John Wiley & Sons.

79. Wong, Y.C., "Practical Methods for Forecasting Material Escalation", Transaction of the AACE, Cincinnati 1979.

80. Woods, D.R., "Financial Decision Making in the Process Industry", Prentice Hall, 1974.

All the foregoing books, articles, etc. have been used for reference purposes in preparing this report, but not all are specifically identified therein.