Inflation

Prices of goods and services change over time -

> **inflation** is the increase in average prices over time
> **deflation** is the decrease in average prices over time.

Prices are likely to change over the life of an engineering project due to inflation or deflation - this chapter deals with how to take inflation into account when evaluating projects.

Measuring the Inflation Rate:

Consumer Price Index (CPI) relates the average price of a standard bundle of goods and services in a base period (now 1986) to the current price of the bundle.

- the base year (1986) index is set at 100
- the current year is measured with respect to 1986 - in 1994 the CPI was approximately $130 in 1995.

The most common way the national inflation rate in a particular year is measured is to find the % increase in the CPI over the year.

Engineers must compare dollars of constant purchasing power to make correct decisions.

- we use forecasts of inflation to estimate how prices in a project will change over time (usually an increase).

- we assume that estimates of inflation rates over the life of a project are available, and that the prices in a project change at that rate.

Real and Actual Dollars:

Real Dollars: dollars of constant purchasing power

- a.k.a. constant dollars

Actual Dollars: dollars at the time that cash flows occur.

- these are the ones in our pockets
- a.k.a. current or nominal dollars.

Example: *It is now January 1996. The W97 basic food plan at the residences is expected to cost $1000 one year from now. The $1000 is measured in actual dollars.*

If inflation is expected to be 2% over the year, the ***real*** *dollar amount (in today's dollars), is $1000/(1.02) = $980.39.*

Note that the $980.39 is the real dollar amount one year from now.

If we have an estimate of the inflation rate f per period over N periods we can convert actual dollars in period N to real dollars

A_N = actual dollars in year N
$R_{0,N}$ = real dollars equivalent to A_N relative to year 0, the base year.
f = the inflation rate/yr., assumed to be constant from year 0 to year N.

Then the conversion from actual dollars in year N to real dollars in year N relative to the base year 0 is:

$$R_{0,N} = \frac{A_N}{(1+f)^N}.$$

The base year (0) is usually omitted from the notation:

$$R_N = \frac{A_N}{(1+f)^N}.$$

This can conveniently be written as:

$R_N = A_N$ (P/F,f,N) (R_N is real dollars at time N and **NOT** a present worth)

Example: It is W96. The residence food plan in W98 is estimated at $1025. Inflation is expected to be 1.5% per year for the next 2 years. What is the real dollar cost of a food plan at that time?

N = 2, f = 1.5%, A_N= 1025.

$$R_N = \frac{A_N}{(1+f)^N} = \frac{1025}{(1+0.015)^2} = 994.93 \text{ or,}$$

$R_N = A_N$ (P/F,f,N) = 1025(P/F,1.5%,2) = 1025(0.97066) = 994.93

Note that the $994.93 is a real dollar amount in W98.

The Effect of Correctly Anticipated Inflation on Economic Analyses:

If we are able to correctly forecast inflation is has the effect of:

- increasing the actual MARR
- increasing the actual IRR

Lets look at each:

The effect of Inflation on the MARR:

The purchasing power of earnings from an investment depends on the **real** dollar value of the earnings.

If we wish to earn the **actual interest rate**, i, on a one year investment, and we invest \$$M$, the investment will yield \$$M(1+i)$ at the end of the year. If the inflation rate over the next year is f, the real value of our cash flow is \$$M\frac{1+i}{1+f}$.

The **real interest rate**, i' is the interest rate that would yield the same number of real dollars in the absence of inflation as the actual interest rate yields in the presence of inflation.

$$M(1+i') = M\left(\frac{1+i}{1+f}\right) \quad \text{or,}$$

$$i' = \frac{1+i}{1+f} - 1 \qquad \text{or,}\ \ i = i' + f + i'f$$

An investor who wishes to get a real rate of i’ and who expects inflation at a rate f will require an actual interest rate of i = i’ + f + i’f.

Implications for the MARR:

If investors expect inflation they will require higher actual rates of return on their investments then if no inflation was expected. i.e.

analogous to i = i’ + f + i’f,

$MARR_{ACTUAL} = MARR_{REAL} + f + MARR_{REAL}\, f$ or,

$MARR_{REAL} = (1 + MARR_{ACTUAL})/(1+f) - 1$

Example: As of March 8, 1996 Canada Trust offers a 4% interest rate for a 1 year GIC. If your require a real rate of return of 3% on your investments and you expect inflation to be 1.5% in the coming year, is a GIC a good investment for you?

First, the GIC provides 4% actual interest.

$$\begin{aligned}\text{Your } MARR_{ACTUAL} &= MARR_{REAL} + f + MARR_{REAL}\, f \\ &= 0.03 + 0.015 + (0.03)(0.015) \\ &= 0.04545, \text{ or } 4.545\%\end{aligned}$$

No, the GIC is not a good investment because it provides an actual interest rate less than your actual MARR.

Implications for IRR:

The effect of expected inflation on the actual IRR of a project is similar to the effect of inflation on the actual MARR.

Say we have a project with a first cost A_0 and actual cash flows $A_1, A_2, \ldots, A_T$

The **actual** IRR, IRR_A, can be found by solving for *i* in :

$PW(project) = 0$ or,

$$A_0 = \frac{A_1}{(1+i)} + \frac{A_2}{(1+i)^2} + \cdots + \frac{A_T}{(1+i)^T}.$$

An annual inflation rate *f* is expected over the *T* year life of the project.

In terms of *real* dollars (base year = now) the stream of actual cash flows can be written as $R_1(1+f), R_2(1+f)^2, \ldots, R_T(1+f)^T$

The expression which gives the actual internal rate of return can be rewritten as:

$$A_0 = \frac{R_1(1+f)}{(1+i)} + \frac{R_2(1+f)^2}{(1+i)^2} + \cdots + \frac{R_T(1+f)^T}{(1+i)^T}.$$

The **real IRR**, $IRR_{R'}$, is the rate of return obtained on the real dollar cash flows associated with the project. It is the solution for *i'* in:

$$A_0 = \frac{R_1}{(1+i')} + \frac{R_2}{(1+i')^2} + \ldots + \frac{R_T}{(1+i')^T}.$$

What is the relationship between the real IRR and the actual IRR?

$\frac{1}{1+i'} = \frac{1+f}{1+i}$ or, $i = i' + f + i'f$.

therefore:

$$\text{IRR}_A = \text{IRR}_R + f + \text{IRR}_R \, x \, f$$

$$\text{IRR}_R = \frac{1+\text{IRR}_A}{1+f} - 1$$

We see that the actual MARR and the actual IRR have, built in, adjustments to the real MARR or real IRR which accounts for inflation.

Example: A computer has a first cost of $3000 and brings about savings of $1700 in year 1 and $1800 in year 2 and will be salvaged at the end of 2 years for $500. Inflation is expected to be 5% per year and the real MARR is 12%. Based on an IRR analysis, should the project be undertaken?

Two approaches:

1. Convert the actual cash flows into real cash flows and find the real IRR directly. Compare to the real MARR

2. Use the actual cash flows to determine an actual IRR, convert to a real IRR and compare to the real MARR.

Approach 1: The actual cash flows are: -3000, 1700, 1800+500=2300

The real cash flows are:

$$-3000, \frac{1700}{(1+0.05)} \text{ and } \frac{2300}{(105)^2} = -3000,\ 1619.05 \text{ and } 2086.17$$

Now, to get the real IRR, solve for i in

$$-3000 + \frac{1619.05}{(1+i)} + \frac{2086.17}{(1+i)^2} = 0$$ Which gives a real IRR of 14.65%

Approach 2: solve for the value of i such that:

$-3000+\frac{1700}{(1+i)}+\frac{1800+500}{(1+i)^2}=0$ Which gives an actual IRR of 20.36%

Converting to a real IRR we get

$$IRR_{REAL}=\frac{1+IRR_{ACTUAL}}{(1+f)}-1$$
$$=\frac{1.2036}{1.05}-1=0.1463$$

Which (with a small rounding error) is the same as we obtained working with real cash flows.

Either method gives us the decision that since the real IRR exceeds the real MARR, we should proceed with the project.

Economic Evaluation With Inflation:

The engineer typically has been given an observed, or actual, MARR and projections of cash flows.

As we have seen, the actual MARR has, built in, two parts:
- the real MARR
- and an adjustment for anticipated inflation.

The projected cash flows are usually stated in real (current) dollars
- they **do not** include adjustments for inflation.

The challenge is to recognize that we have an **actual MARR, but real cash flows.**

There are two correct ways the analyst can proceed:

1. Work with real cash flows and find the real MARR using an estimate of f.

2. Adjust the real cash flows for inflation (i.e. get estimates of the actual cash flows using f) and apply the actual MARR.

Sources of forecasts over the short term (< 1 year) can be found in *The Globe and Mail, Report on Business.*

Longer term projects will necessitate longer term forecasts of inflation - these will be estimates and hence it would be wise to evaluate the project(s) over a range of possible inflation rates.

Example: Ken will get 10 $15 000 annual payments from a family trust starting one year from now. Inflation is expected to average 4% per year and Ken's real MARR is 8%. What is the present worth of the income from the trust?

Method 1: convert all dollars into real dollars and compute a present worth.
Method 2: convert to an actual MARR with the inflation rate and then take the PW

Method 1:

$$\text{PW(4th payment)} = \frac{15\,000\,(P/F,8\%,4)}{(1+f)^4} = 15000(P/F,8\%,4)(P/F,4\%,4)$$

$$= 9424.55$$

$$\text{PW(total)} = \sum_{i=1}^{10} \text{PW(ith payment)} = \$83\,655$$

Method 2: Find the actual MARR:

$$\begin{aligned} MARR_{ACTUAL} &= MARR_{REAL} + f + MARR_{REAL}\, f \\ &= 0.08 + 0.04 + (0.04)(0.08) \\ &= 0.1232 \text{ or } 12.32\% \end{aligned}$$

$$\begin{aligned} \text{PW(total)} &= 15\,000\,(P/A, MARR_{ACTUAL}, 10) \\ &= \$83\,655 \end{aligned}$$

Example: Sonar warning devices cost $220 000 to purchase and install for trucks (they warn of a truck backing up) Savings per year (in today's dollars) are expected to be $50 000 due to less congestion at loading docks and $30 000 per year (in today's dollars) due to reduced damages. The actual MARR is 18% and the life of the sonar systems is 4 years. The expected scrap value of the systems is $20 000 (in today's dollars). Inflation is expected to be 6% over the life of the project.

a) What is the real dollar MARR?

$$MARR_R = \frac{(1 + MARR_A)}{(1 + f)} - 1 = \frac{118}{106} - 1 = 0.1132 \text{ or } 11.32\%$$

b) what is the real rate of return?

PW(project) = 0 = -220 000 + 80 000(P/A, i,4) + 20 000(P/F,i,4)

Int rate	PW(project)
19%	1.0602
19.5%	-1.1156

The real IRR is 19.25%
This exceeds the real MARR

c) what is the actual IRR?

The actual IRR can be found either from actual cash flows or from b)

From b) : $IRR_A = IRR_R + f + IRR_R \; x \, f$

$= 0.1925 + 0.06 + 0.1925(0.06)$

$= 0.264$ or 26.4%

Summary

Concept of Inflation/deflation

Measuring the inflation rate - the CPI

Converting between Real and Actual Dollars

Adjustments to the MARR and IRR due to inflation:

$$MARR_{ACTUAL} = MARR_{REAL} + f + MARR_{REAL}\ f$$

$$IRR_A = IRR_R + f + IRR_R \times f$$

Economic evaluation with inflation:

1. Work with real cash flows and find the real MARR using an estimate of f.

2. Adjust the real cash flows for inflation (i.e. get estimates of the actual cash flows using f) and apply the actual MARR.