11.1. Asphalt and Concrete Pavements

A local government faces the classic dilemma of choosing between a design with high first cost and longer life and one with a lower first cost but shorter life: concrete versus asphalt pavements for an access road. The projected first cost per square yard of roadway is $21.00 for the concrete pavement and $17.80 for the asphalt.

Either pavement would have to be resurfaced eventually with asphalt, but at different times. The best information is that the concrete base was to be resurfaced every 27 years, and the asphalt base every 17 years. Annual maintenance costs for either roadway will be $8000.

(a) Assuming a 10% real discount rate, how much cheaper would the more expensive material have to become to be competitive on this job?
(b) At what rate or interest are the two costs equal?
(c) Which solution would you recommend if (1) the national government pays 50% of the initial costs but none of the maintenance or replacement costs (a typical kind of subsidy) or (2) the local government sells municipal bonds that, because of tax advantages, only have to pay 6% real interest?

a) Since concrete and asphalt road beds have different life spans, they cannot be compared over one life span each. They can be considered over multiple life spans, repeating the projects until a common multiple of years is reached. Practically, this can be done by finding close multiples around 30 or more years, since the present values of sums further in the future are insignificant. The calculations may be quickly performed by considering the difference between the two cash flows. Choosing 3 life spans for asphalt and 2 for concrete (51 and 54 years respectively) gives sufficiently close projects lives.

Figure 1 gives the cash flow of the costs and savings of initially choosing concrete over asphalt, in terms of dollars per square yard. The initial extra cost of the concrete is $21 - $17.8 = $3.2. Note that by focusing on the incremental difference of one alternative over the other, rather than on each separately, there are fewer and simpler calculations.
For concrete to be as inexpensive as asphalt, the cost of concrete must be reduced by $0.37 per square yard. At $20.63 per square yard, NPV=0, and both materials have equivalent costs over time.

**b)** The costs are equal at \( r = 9.2\% \)

**c)** If the national government pays one half of the initial cost of the road:

\[
\text{NPV} = -0.37 + \frac{3.2}{2} = 1.23/\text{yd}^2
\]

So choose concrete.

If the discount rate is 6\%, \( \text{NPV} = 2.03/\text{yd}^2 \)

So choose concrete.
12.10. Start-Up

Your friend the entrepreneur has just started a new business. Your advice is needed on the discount rate to be used to evaluate new opportunities. Looking through the financial records, you find that your friend could already

- insulate the building for $40,000, which would save 5600 gal/yr of fuel, currently valued at $1/gal.
- pay off $80,000 borrowed at a rate of 12% on the balance.
- pay $20,000 for an annuity paying $3200/yr for 30 years.
- lend to another entrepreneur who guarantees to double a $30,000 investment in 5 years.

Your friend has $60,000 in cash for investment. Estimating inflation at 4% a year, what is your friend’s minimum discount rate for a $20,000 investment? a $60,000 investment?

An important observation at the outset is that the four alternatives available to your friend bear similar risk. Even lending to another entrepreneur is stated to be guaranteed to return $30,000 in 5 years. On this premise, the returns from the 4 alternatives are comparable. If the four alternatives did not bear the same risk, a direct comparison would not have been possible since investments of higher risk generally have higher returns. This is implied in ASA p. 229: “the discount rate should be the lowest acceptable rate of return to any investor.”

All \( r_1, r_2, r_3, r_4 \) here are net of inflation, if we think with inflation, just add 4% to all these rates.

1. To assess the investment on building insulation requires that your friend picks an appropriate time horizon as well. Say this is infinite. Then the return of this investment is found by equalizing $40,000 with a perpetuity of (5600)gal/yr ($1)/gal = $5,600 $/year:

\[
40,000 - \frac{5,600}{r_1} = 0 \Rightarrow r_1 = 0.14 = 14\%
\]

As calculated above, the return on the first alternative does not include inflation.

2. The second alternative has a return of 12% with inflation, so \( r_2 = 8\% \).

3. \( r_3 = \frac{3200}{20000} - 1 - 4\% = 12\% \)

4. As for \( r_4 \), it can be determined from

\[
-30,000 + (2)(30,000) \frac{1}{(1+r_4)^5} = 0 \Rightarrow r_4 = 14.9\%
\]

Since the 60,000 received in 5 years from now are inflated, the ex-inflation

\[
r_4 = 14.9\% - 4\% = 10.9\% \approx 11\%
\]
Therefore, if your friend’s budget is only $20,000 the discount rate at which investment opportunities of this risk should be valued is 14%, since he/she can use additional money to insulate the building.

If the budget is $60,000, then we can assume your friend will use the first $40,000 for the building and the next $20,000 (<$80,000) for pay for the annuity. So the discount rate is \[
\frac{20000 \cdot 12\% + 40000 \cdot 14\%}{60000} = 13.33\% .
\]