Lecture 10: Replacement Analysis

Replacement analysis is concerned with the question, when is it time to replace an existing piece of equipment with a new one? The answer to this is not necessarily ``When the old one wears out.'' It is possible, after all, to keep a 1957 Chevy running up to the present day, if you're prepared to spend enough time and money on it. Conversely, it may be worth replacing an IBM XT with a Pentium well before the former breaks down.

We therefore distinguish between the *physical life* of an asset and its *economic life*. The physical life will sometimes be well-defined, though in some cases, like the 1957 Chevy, we have to set an arbitrary limit on how long we're prepared to keep an obsolete asset in service. The economic life is the time after which we save money by replacing the asset. Thus, the physical life is always greater than or equal to the economic life.

The most effective way to think about the replacement interval is to consider the equivalent uniform annual cost of the asset over its life, taking various different durations for its life. The EUAC is usually made up of two factors: the initial cost of the asset, spread out over its life (the `capital recovery' annuity); and the annual cost of repairs and maintenance. The capital recovery should include a deduction for the salvage value of the asset, if any. The annual cost of repairs should, if appropriate, include a contribution representing the cost of correcting any defects in the product resulting from the use of an outmoded machine.

The first factor will go down as we consider longer lifetimes, while the second will usually go up. The sum of the two will therefore (usually) have a minimum value. This minimum value is the minimum EUAC, and in most cases this will correspond to the economic life of the asset.

In many cases, we consider replacing an existing asset (the `defender') with another asset (the `challenger'). The simplest case, however, occurs when we are considering getting rid of an asset and not replacing it. Examples might include a video game machine at a corner store, or a piece of equipment that allows a company to service a particular small section of their customer base -- for example, a machine for processing Cibachrome film at a photo shop. In this simplest case, we calculate the present worth of the asset and the cash flows associated with it for a range of possible lifetimes. If any of these present worths are positive, we should retain the asset; otherwise we should get rid of it.

A more commonly occurring case is that in which we plan to replace the asset with another, identical asset. This is most likely to apply in a field where technology is changing relatively slowly -- a fork-lift truck might be an example.

In this case, we first look at the challenger, and calculate its EUAC for a range of lifetimes, so as to find the minimum EUAC. Since the defender is identical to the challenger, it will have the same minimum EUAC, and hence the same optimum lifetime. If its current age is less than the optimum lifetime, it should be retained, while if its current age is exactly equal to the optimum, it should be replaced.

The only case requiring comment occurs when the defender is past its optimum lifetime. You'd think this would mean we should retire it at once, but that may not be the best thing to do. For example, we may just have passed a `peak' year in operating expenses, or the salvage value may just have dropped dramatically. To determine the right choice, we should now calculate the equivalent annual cost of retaining the defender for 1, 2, ... more years, up to the end of its physical life. If any of these costs is less than the EUAC of the challenger, we should retain the defender.

The third, and most common, case, is that in which the challenger is not identical to the defender -- for example, if we are considering when to replace a 486 by a Pentium. We begin, as before, by calculating the optimum lifespan and EUAC for the challenger. Now we calculate the cost of keeping the defender one more year. If this cost is less than the challenger's EUAC, we can keep the defender for at least another year. If the cost of keeping the defender one more year is *greater* than the EUAC of the challenger, you'd perhaps think that we should retire it at once, but this may not be the best choice. Instead, we should first calculate the equivalent annual cost of keeping the defender *two* more years...then three, four, ... up to its physical life. If all of these EUAC's are greater than the optimum EUAC of the challenger, we should replace the defender.

In the most general case, we would like to plan a strategy for evolving our company's technology over a series of hardware generations. The first set of difficulties associated with this are in anticipating what hardware will become available in the future, and at what cost. However, even supposing this information can be estimated, quite a lot of computation is involved. The basic difficulty is that the optimum lifetime of the next-generation challenger cannot be calculated without comparing it with its potential successors; and their lifetimes in turn cannot be calculated without looking at the *next* generation...

Dynamic programming offers some powerful tools for dealing with this problem, but it is beyond the scope of this course.

Leaving the general case aside, the problems we have examined are computationally rather simple. The major pitfalls lie in obtaining careful estimates of the inputs to the calculation. For example, in calculating salvage costs, it is important to include the cost of preparing the asset for re-sale; this may include cleaning, repair, crating and shipping. Again, in estimating the cost of bringing in a challenger, the cost of installation, debugging, and re-training should be considered. Most importantly, the assumptions made in course of your analysis should be documented in detail, so that others have a basis on which to accept or challenge your conclusions.

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