CHAPTER IX

THE REPLACEMENT OF EQUIPMENT

GENERAL PRINCIPLES

1.1. Factors in Replacement

The replacement of existing equipment is only a special case of the problem of investment choice. But its relative simplicity and its great practical importance justify a specific study. In this field, economic theory has moreover recently been enriched through fundamental advances thanks to the efforts of Mr. Desrousseaux and his team.

In the rest of this chapter we shall assume that a well-defined productive operation must be carried out by one piece of equipment. The size and the nature of the operation are of little importance: it could just as well be a matter of providing electricity from a power-station, as the assembling of parts by a mechanical tool. The only assumption is the qualitative and quantitative constancy over time of the service provided. Practical application will moreover accommodate approximations which will be the more valid the slower the rate at which production changes.

In a moment we shall analyse briefly the main elements of the problem. The general method of solution due to Desrousseaux will be presented in outline. Then we shall describe the method of Mr. George Terborgh, which provides a remarkably simple analytical solution. Finally the results obtained will be compared with the realities of current industrial practice.

The replacement of a machine is an expensive operation. Schematically, it can be justified for three main reasons which in practice are inextricably bound up together: physical destruction, wear and tear and obsolescence.

(1) The first case relates to ‘all or nothing’ machines or those subject to irrepairable breakdown. This is obviously the case when the cost of repair exceeds the purchase price of a new unit. Thus an electronic tube burns out, and a car can be reduced to a pile of scrap in an accident. Under this assumption there is in fact no economic choice properly speaking. We must point out, however, that statistical analysis of experimental survival
rates is the basis for policies towards quality control (reliability). We shall leave aside these probabilistic models which lie outside the framework of this book and we shall try with Terborgh to define precisely wear and tear and obsolescence.

(2) *Wear and tear* becomes the reason for scrapping a machine when the necessary costs of maintenance exceed a certain threshold.

Let us denote by $E(s, t)$ the operating costs at time $t$ of a machine bought at time $s(t \geq s)$. To be precise, we are here concerned with a running cost that includes costs of manpower, raw materials, power, maintenance, etc. *but excludes all amortisation costs*. The age of the machine is therefore:

$$u = t - s.$$  

(IX.1)

Symmetrically, we shall call $R(s, t)$ the revenue resulting from the system under consideration during year $t$ (it is useless here to postulate the constancy of $R$). The wear and tear $U$ of the equipment is defined by the equation:

$$U(s, t) = [R(s, s) - E(s, s)] - [R(s, t) - E(s, t)] = [R(s, s) - R(s, t)] + [E(s, t) - E(s, s)].$$  

(IX.2)

In other words, wear and tear is measured by the decline in gross profit that is considered to be due to progressive ageing of the equipment. The standard of reference is provided by a new machine. In general $R(s, s)$ is greater than $R(s, t)$ and $E(s, t)$ is greater than $E(s, s)$. Once the equipment is installed, wear and tear increases, as a rule, with age and the amount of work done. In fact, it is erratic. If maintenance is preventive, wear and tear — as defined — increases during the periods when the plant is being overhauled. It thus depends on maintenance policy, which is itself a function of the chosen date of scrapping. Mathematically:

$$E = E(s, t, d).$$  

(IX.3)

When the decision has been taken to withdraw a machine in the near future, upkeep is reduced as a result.

If the amount of work done does not change, we have:

$$U(s, t) = E(s, t) - E(s, s).$$  

(IX.4)

(3) *Obsolescence* is one of the most characteristic phenomena of our