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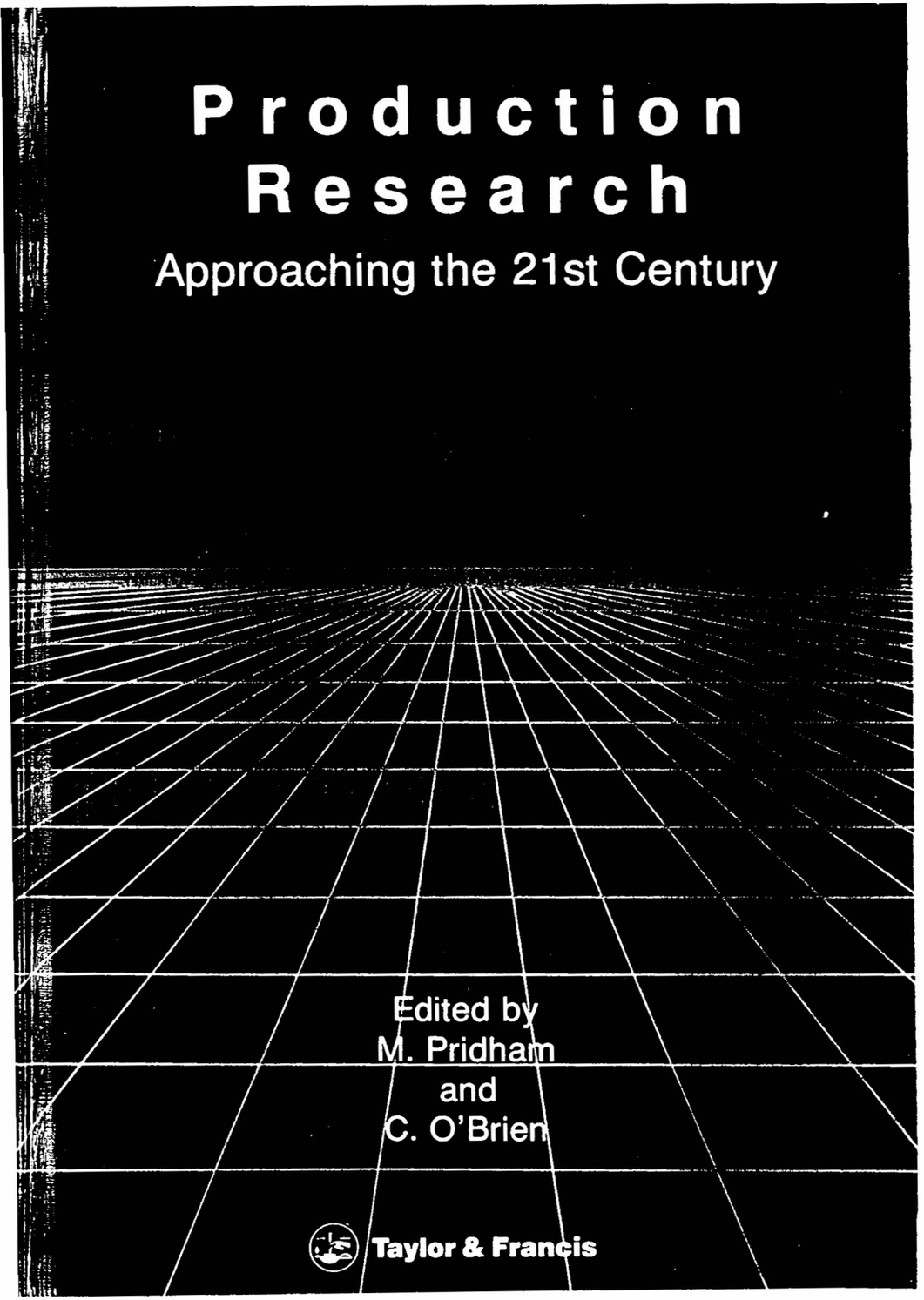

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Evaluation of flexible capital investments—with consequences for decisions and suppliers

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Abstract

Capital-back is a method for evaluating capital investments, especially taking into account the different investment proposals' abilities to meet radical changes, if for instance, the market of the product produced by the machinery suddenly drops. Capital-back implies that every investment is divided into one flexible part and one inflexible part. The requirement for the flexible part is the normal discount rate. The remaining surplus goes to the inflexible part of the investment. The Capital-back method also invites an analysis of who is most eligible for owning and administering the flexible part of the capital investment.

Introduction

The environment of companies today is much more dynamic than it used to be; this manifests itself in a higher degree of uncertainty on the market, shorter product life cycles and a higher demand for customization. Flexibility in manufacturing is therefore of substantial significance as a means of strategic advantage for companies in the manufacturing industry.

Certain types of machinery are better prerequisited than others to meet the demands for flexibility. Especially well equipped are, for example, Flexible Manufacturing Systems (FMS) and industrial robots. These advantages must be taken into account in the capital budgeting process. With the Capital-back method the ability to handle the most radical changes is evaluated.

By way of introduction, the significance of flexibility will be discussed. Flexibility is a wide concept and here its relationship to Capital-back will be illustrated. Capital-back itself and its characteristics will then be described through a comparison with the Pay-back method. Conclusions will also be drawn concerning Capital-back and its consequences for decision making in companies as well as the opportunities it creates for suppliers of flexible machinery, such as robots. Finally, a deeper study of the Capital-back method is carried out concerning sensitivity to the rates of interest, the lifespan of the machinery, and an evaluation of the results is done.

Flexibility of the machinery

Flexibility related to the design of the products and the flow of goods is well analysed. Several authors (Gerwin, 1983; Browne *et al.*, 1984) have discussed and made definitions of flexibility in the manufacturing process. These definitions have one major shortcoming: the analysis is only executed in two dimensions, the product dimension and the material flow dimension. This classification does not consider the possibilities of re-using the equipment in different manufacturing processes. A method which takes this prospect into account already at the acquisition stage implies that the flexibility is evaluated as well as analysed.

Flexibility concerning investment analysis of the manufacturing process is given three dimensions: (1) material flow, (2) products, and (3) machinery.

Capital-back (CB) is a method for evaluating the flexibility of the machinery. Flexibility of machinery means having the possibility of using the machinery for other purposes than originally intended, either inside the company or in some other manufacturing process outside the company.

CB implies that every investment proposal is split into two parts, one flexible and one inflexible. It is true that the different parts constitute one and the same investment, but from the point of uncertainty they are quite different. The inflexible part of the investment is denominated 'The Risky Investment'.

One part of the investment (G_f) is flexible enough to be used for some other purposes. This may happen if, for example, the market expectations are not fulfilled, or if the machinery becomes obsolete due to a radical change in the manufacturing process. Examples of this type of equipment are robots, CNC machines or parts of FMS. Due to the flexibility and hence lower degree of uncertainty a lower interest rate is acceptable for the capital invested in this type of equipment.

The rest of the investment constitutes those parts that are dedicated for a specific manufacturing process or product. These parts are inflexible and belong to the part of the investment called the risky investment (G_r). The parts belonging to the risky investment cannot be used to produce other products in other manufacturing processes. The residual value is zero irrespective of how long the set-up has been used. Examples of this type of component are fixtures and gripping appliances that are intended for a specific product. Included as part of the capital investment are also expenditures for projection and design as well as for the physical installation. These expenditures are usually not possible to re-utilize if the project fails and are hence a part of the risky investment.

The total investment (G) is the sum of the flexible part of the investment and the risky investment, $G = G_f + G_r$. This categorization of the parts that constitute the capital investment into one flexible part and one risky is in itself an important distinction. One possibility is to stop here and specify a measurement of profitability together with the size of the flexible investment or the risky investment.

Capital-back and Pay-back

With the Capital-back method (Nilsson and Nordahl, 1988; Persson, 1988) we advance further and the profitability and the flexibility are weighted to form a single measurement.

The need of a new method depends on, for example, the high Pay-back demands in the manufacturing industry. The object of Capital-back (CB) is to release flexible investments of the unreasonably high demands of a short Pay-back (PB) period, requested due to a high degree of uncertainty and short-term planning. The PB demands are especially high for rationalization investments where, for example, robots are of current interest. According to Hayes and Garvin (1982), 25% of the American companies had a demand for a PB period no longer than three years. Ten

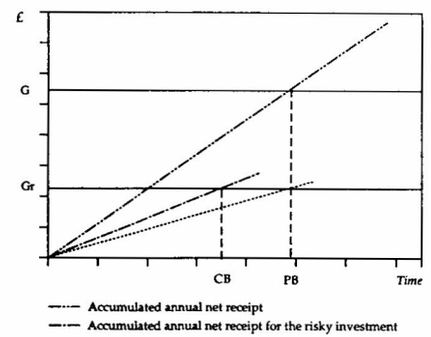

Figure 1. A comparison between Capital-back and Pay-back.

years earlier only 20% of the companies had this demand. PB demands in the Swedish industry range from 2·7–3·1 years (Yard, 1987). According to Yard its not quite clear if consideration has been given to the rate of interest or to the inflation. This means that taking these into consideration the possible interval in Swedish companies is a PB period somewhere between 2·4–4·3 years (Yard, 1987). Through our own research we have found PB demands as low as two years to be frequent.

PB emphasizes short-term planning; above all the method captures the liquidity aspect and the uncertainty. For flexible investments, like for instance, a robot unit excluding gripping appliances, etc. it can lead to the wrong investment decision if the uncertainty is focused by the high requirements for profitability. The advantage of CB is that it takes into consideration the uncertainty of the custom-made part and the requirement for profitability for the flexible part.

Calculation of the CB period thus implies that the flexibility and the profitability are weighted to form one single measurement. CB presents the PB period for the risky investment, while the flexible part of the investment generates a yield as high as the discount rate. The CB period can, alternatively, be described as the time it takes to consolidate the invested capital; this is the reasoning behind the CB concept. It is further understood that the flexible part of the investment is already consolidated through its flexibility.

CB is described in Figure 1. The horizontal lines show the capital investment, the lower line is the risky investment (G_r) and the upper line (G) is the total investment, $G = G_f + G_r$. The difference between the lines is thus the flexible part of the investment (G_f). The two lines proceeding from the origin, show how the accumulated annual net receipt for PB and CB grows as a function of time. The lines are straight due to the restriction that the annual net receipt is constant with time. The steeper curve is the accumulated annual net receipt for the total investment (a) in pounds (£). This amount accumulates with time and when it intercepts the upper line G, the PB period is reached.

When using CB, a cost for the flexible part of the investment is calculated. This cost reduces the accumulated annual net receipt thus levelling the line. When the lower line in the figure intercepts the risky investment, G_r, the CB period has been reached. The cost for the flexible part includes both depreciation and rate of interest. This can be calculated in different ways. The choice of calculation method affects the result. The most natural method to use in capital budgeting is the annuity method which provides a constant annual cost during the lifespan of the installation. If the interest rate is (i)% and the expected lifespan is (n) years the annual cost for the flexible part of the investment, according to the annuity method, is $G_f * \text{ann}$ (n years, i%). When this amount is reduced from the annual net receipt, the

difference is: $a - G_f * \text{ann}$ (n years, i%). This difference is then calculated as the annual net receipt of the risky investment and accumulated in the same way as in the PB method.

In analytical terms, CB is calculated by analogy with PB, i.e. the investment divided by the annual net receipt:

$$\text{CB} = G_r/(a - G_f * \text{ann}\ (n \text{ years}, i\%)).$$

From the formula it may be concluded that the gradient of the line decreases as the interest rate increases. The interest rate that will generate a CB period equal to the PB period is of special significance. This is illustrated with the dotted line in Figure 1. At this rate of interest the rate of return on the risky investment is as high as the rate of return on the flexible part of the investment. (This calculation presupposes that the lifespan of the risky investment is as long as the lifespan of the flexible part of the investment).

The CB method is an especially valuable aid if the CB period is shorter than the PB period. If this is not the case the profitability for the risky investment is lower than for the flexible one.

The described calculation of the CB period is valid only if the annual net receipt is equal every year. If the annual net receipts vary, they have to be added together until the sum equals the amount invested in the risky part. Also this is analogical to the PB method.

The CB condition for the investment is then:

$$G_r = \sum_{x=1}^{\text{CB}} (a_x - G_f * \text{ann}\,(n \text{ years}, i\%))$$

where a_x = annual net receipt year X (£), n = the lifespan of the flexible part (years), i = the discount rate of the company (%).

Consequences for decisions and suppliers

Consequences for the decision-making

Using the CB method will affect the investment process as well as the crucial decisions being made. CB presupposes that the components that constitute the capital investment are divided into one flexible part and one inflexible part. The process of dividing the components will force the decision makers to analyse as well as evaluate the flexibility of the different investment proposals. This process in itself is therefore important.

The rate of change in the manufacturing industry is constantly increasing. New models and new products are superseding each other at a rapid pace. This means that flexibility in the manufacturing process is, or ought to be, a strategic goal for companies in the manufacturing industry. CB is an excellent aid to incorporate the strategic importance of flexibility in the capital budgeting process. The CB method illuminates the importance of flexibility and promotes flexible investment-alternatives. Traditional capital budgeting techniques do not take flexibility into consideration but regard the flexible and the risky parts of the capital investment as equally uncertain.

Neither CB, nor any other capital budgeting technique gives any information about the degree of uncertainty that prevails *if* the inflexible, or risky, investment becomes obsolete. Neither will it tell anything about *when* the investment will be obsolete.

Financing and consequences for suppliers

Dividing the investment into one flexible part and one risky part will also have consequences for the financing of the capital investment. The risky investment will be regarded in the same way as the total investment is today. The company will buy the machinery and take all the risks. The flexible part on the other hand can be treated differently depending upon the nature of the company that is investing.

One possibility is that the company in a traditional manner invests in the flexible part as well as in the risky part of the investment. In this case the CB method will be a relevant capital budgeting technique to use when evaluating the proposal. Since the method assumes alternative uses for the flexible part, it is more consequent to consider the flexible part as a potential resource for all the different workshops in the company. Larger companies could buy the flexible part of investments on a company-wide basis. Proceedings such as this, with central administration, are already a reality in some companies today.

In reality different machinery has different degrees of flexibility. When CB is used the possibility exists to differentiate the rent according to the degree of flexibility. Doing this guides the different subdivisions toward more flexible machinery. Using CB will give the management an opportunity to release the right 'signals' early in the capital budgeting process. The subdivisions will accordingly receive an incentive to invest in flexible machinery.

An interesting alternative way to finance the investment is that the supplier of the flexible parts directly grants a lease of these parts. The supplier has a better knowledge of the market and is best fitted to find new users for the flexible machinery. The advantages of this procedure are greatest for smaller companies, lacking the possibility to find new users for the flexible machinery within their own company. The supplier's leasing firm will in this case take over the function of the central administration found in the larger company.

When working under uncertainty, an external leasing procedure such as the one described is favourable, especially for smaller companies. If the leasing procedure is used then CB is reduced to a PB calculation. The investment is the risky part and the flexible part is taken on lease thus charging the annual receipt with the rent.

Deeper analysis of the Capital-back method

The CB period is influenced by four factors:

(1) the flexible share of the investment,
(2) the level of the discount rate,
(3) the profitability of the total investment (measured with for instance the Internal Rate of Return (IRR) or the PB period),
(4) the lifespan of the flexible part of the investment.

There is no room to carry out a total analysis here, but we will illustrate how the different parameters influence the outcome. The flexible part of the investment has been chosen as main parameter. The effect on the CB period is then analysed for different levels of discount rate and profitability, and lifespan.

The discount rate level

In order to select discount rates we will proceed from earlier research. Those studies carried out in Swedish companies show that the average discount rate is 20% with no consideration given to taxation. The variation, however, is high. Yard (1987) found that the minimum discount rates varied between 10% and 30% and that the maximum rates amounted to 50%. Tell (1978) also found discount rates slightly

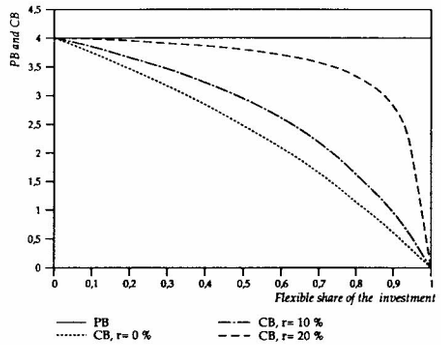

Figure 2. The CB period as a function of the flexible share of the investment. The discount rate is 0%, 10% and 20%. The PB period is four years and the lifespan of the flexible part is ten years.

below 20%. Neither could establish if the discount rates were real or nominal. According to Gitman and Forrester (1977) the discount rates in American companies were lower, in several cases between 10% and 15%. Hayes and Garvin (1982) mean that it is considerably higher.

With these results as a starting point the influence of the discount rate on the CB period is analysed for discount rates between 10% and 20%. In order to save space the total analysis is only carried out for a PB period of four years. This analysis is supplemented with a schematic description of what will happen if the PB period is shortened to two years. The extreme value of the zero per cent discount rate is also displayed for comparison. In the analysis it is presupposed that the annual net receipt is equal every year.

Figure 2 shows CB as a function of the share of flexibility in the total investment under the following restrictions:

— The lifespan of the flexible part of the investment is ten years.
— The profitability is expressed as the PB period, which is four years.
— The discount rate varies between zero and 20%.

The figure reveals that:

(1) The CB curves are decreasing which means that the CB period decreases when the share of flexibility increases. This is valid as long as the IRR is higher than the discount rate. When the share of flexibility approaches 100%, the CB period approaches zero.
(2) The CB period increases as the discount rate increases, which has been established earlier.

Now we will make a closer study of the curves starting with the discount rate of 20%. The CB period is here close to the PB period, which is four years. The significance of this is that the IRR is very close to the discount rate, in this case slightly above 20%. The share of flexibility has to be 70% or more in order to show significantly different periods for PB and CB.

If the discount rate is 10%, the CB period decreases more smoothly and the difference between PB and CB is more significant, even if the share of flexibility is low. This is representative of the CB method. A low discount rate generates a low annual cost for the flexible part of the investment. Thus the share of annual net receipt that goes to the risky investment increases. The CB period is then improved, i.e. becomes shorter.

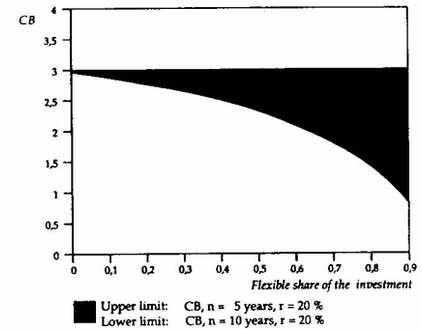

Figure 3. The CB period as a function of the flexible share of the investment. The lifespan of the investment is varied between five years (upper limit) and ten years (lower limit). The discount rate is 20% and the PB period is three years.

Profitability of the total investment

In Figure 2 the PB period is four years. If the PB period becomes any shorter, then the CB period becomes less dependent upon the level of the discount rate. This is due to a high IRR and the fact that the annuity method has been chosen to calculate the annual cost.

If the IRR is high, then the annual net receipt is high and, accordingly, the amount that goes to the risky investment. For instance, an investment with a PB period of two years has a very high profitability. If the lifespan of the total investment is ten years, IRR is close to 50%. If the demand for profitability of the flexible part of the investment is 20% then the remaining part of the IRR will be added on to the risky investment. This means that if the IRR is very high, then it does not matter much how high the discount rate is.

The result is also influenced by the annuity method. When using the annuity method the total cost of capital is distributed with an equal annual cost every year during the lifespan of the investment. This implies that the depreciation is lower during the first years. For instance if the lifespan of the investment is ten years, the first year's depreciation is 3·9% with a discount rate of 20%. CB is also compatible with other depreciation and rate of interest models. Those alternatives will, however, not be covered here.

The lifespan of the flexible part

The lifespan of the risky investment and the flexible part do not have to be equal. It is, for instance, possible that the lifespan of a robot is longer than that of manipulators and fixtures (Björkman and Ekdahl-Svensson, 1986). This will influence the IRR. If the flexible part of the investment consists of components with different expected lifespans, then the calculations will be affected too. In order not to complicate the analysis we will assume that all the parts of the investment have the same lifespan.

The dark field in Figure 3 shows the CB period for different lifespans of the flexible part of the investment. With a lifespan of five years, the CB period is very close to the PB period that is three years. This is dependent upon the fact that the discount rate and the IRR are very close to each other. In this example the IRR for the total investment is slightly below 20%. If the lifespan is longer, then the

Table 1. PB, CB and profitability, a comparison.

	PB (years)	CB (years)		Flexible share	Lifespan (years)	Internal rate of return (%)
		$r = 20\%$	$r = 10\%$			
A	4	3·61	2·20	0·7	10	21
B	3	2·67	2·46	0·3	10	30

IRR is higher. Consequently, the CB period is shorter. The lower limit reveals the CB period if the lifespan of the installation is ten years. The CB period is considerably shortened when the flexible share of the investment is increased.

Capital-back and priorities

An important factor is how the method orders the different investment proposals. We will look at the preferences when using CB compared to the preferences when using the IRR or PB. In Table 1 two different investment proposals, A and B, are compared. The profitability and the flexible share of the proposals are chosen in order to change the priorities when the discount rate is reduced from 20% to 10%. The flexible share of proposal A is high but it has a low IRR, 21%. This makes alternative A sensitive to the discount rate. Alternative B on the contrary has a low flexible share but a high IRR. This means that alternative B, is not so sensitive to changes in the discount rate.

For the competing investment proposals in Table 1 the CB recommendations are:

— A company with a high requirement for profitability, i.e. willing to take risks, will prefer proposal B. B has a high profitability, IRR 30%, and a high risk, 70% inflexible share.
— A company with a low requirement for profitability, i.e. risk-averse, will prefer proposal A. A has a low profitability, IRR 21%, and a low risk, 70% flexible share.

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PART V

HUMAN FACTORS ISSUES IN PRODUCTION