# Payback Without Apology*

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**Abstract**

When interest rates are uncertain, the net-present-value threshold required to justify an irreversible investment is increasing in the length of a project's payback period. Thus, slow-payback projects should face a higher hurdle than fast-payback projects, just as investment folklore suggests. This result suggests that the widely disparaged use of payback for capital budgeting purposes can be an intuitive response to correctly perceived costs and benefits.



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# Payback Without Apology

## 1 Introduction

One of the simplest project-evaluation methods is the payback period — the expected length of time for an investment to return its initial cost. According to this method, the investment is viable if and only if payback is sufficiently fast. However, simplicity has its costs: the payback method ignores both the time value of money and any cashflows that occur subsequent to payback. By contrast, net-present-value (NPV) provides a decision rule that is consistent with the maximisation of shareholder value, so this method has received greater theoretical acceptance.

Given this consensus, one of the more perplexing, and most criticized, aspects of corporate investment practice is the apparent preference for short-term projects with a fast payback. Without exception, surveys of capital budgeting practice highlight the continuing popularity of payback. For the US, Gilbert and Reichert (1995), Gitman and Forrester (1977), Oblak and Helm (1980), Stanley and Block (1984) and Visscher and Stansfield (1997) find that between 40% and 90% of U.S. firms use payback as a capital budgeting technique while Jog and Srivastava (1995), Kester et al (1999), Patterson (1989), and Shao and Shao (1993) report similar findings for firms in Asia, Canada, Europe, and Oceania. Longitudinal studies over 17-year periods for the U.S. (Gitman and Vendenberg, 2000) and the U.K. (Pike, 1996) also find little evidence of declining usage over time. Such myopic behaviour has traditionally been condemned by academic writers because, in calculating NPV, cashflows that occur in the more distant future are automatically discounted most heavily via the compounding mechanism. To then further penalize projects with a high proportion of such cashflows seems inconsistent with an efficient allocation of investment funds.

In this paper, we offer a value-maximising justification for the use of payback.[1] In the next section, we develop a very simple model of optimal capital budgeting in a world with uncertain interest rates and dynamic and irreversible investment opportunities, and show that slow-payback projects must pass a more stringent test than otherwise-equivalent fast-payback projects. Section 3 discusses some implications and limitations of this result, while Section 4 provides some brief concluding remarks.

## 2 Payback and the optimal investment rule in a dynamic world

To make our analysis as transparent and intuitive as possible, we use a minimalist model of investment under uncertainty. In brief, we analyse the investment timing choice of a firm facing uncertain future interest rates and show that the NPV threshold required to justify investment

[1] Other authors to advance explanations for payback include Chaney (1989), Cornell (1999), Narayanan (1985a,b), Shleifer and Vishny (1990), Stein (1988), Thakor (1990, 1993), and Weingartner (1969). With the exception of Cornell, all these depend on deviations from first-best value maximisation.

is an increasing function of the length of payback period.

Consider an investment project that incurs a sunk cost $I$ and generates constant expected real cashflows $X$ for $T$ years after launching. In general, the present value of these expected cashflows is obtained by discounting each of them at a term-specific rate that includes a premium for systematic risk.[2] However, to avoid equilibrium asset pricing complexities that are of second-order importance for capital budgeting decisions , we assume (i) that the risk of these cashflows is entirely idiosyncratic and (ii) that the yield curve is flat. As a result, all cashflows are discounted at the riskless interest rate common to all maturities.

With these assumptions, investment today (at time 0) yields the project NPV

$$N_0 = \int_0^T X \exp(-rt)dt - I = X\left(\frac{1-\exp(-rT)}{r}\right) - I, \tag{1}$$

where $r$ is the current riskless interest rate. If the project is 'now-or-never' or is fully reversible (so that the future is in effect certain), then the standard textbook case applies: investment is justified if and only if $N_0 \geq 0$ and payback per se is irrelevant. However, as discussed in detail by Dixit and Pindyck (1994), most projects are at least partially irreversible and have some degree of timing flexibility. To capture the essence of this idea, we assume the firm has a simple dynamic choice: either invest now (at time 0) or delay investment until some future time $s$.[3] Investment today necessitates the firm giving up the opportunity to invest at time $s$, so the cost of this sacrifice must be incorporated in the investment decision. Letting $N^*$ denote the time 0 value of this opportunity cost, investment today is justified if and only if $N_0 \geq N^*$.

If time $s$ interest rates are uncertain, then delay of investment has value because of the potential for a lower discount rate.[4] We assume a simple binomial structure: the time $s$ interest rate either equals $r_d < r$ with probability $p$ or it equals $r_u > r$ with probability $1-p$. As a result, the possible payoffs to time $s$ investment are

$$\begin{aligned} N_s(r_d) &= X\left(\frac{1-\exp(-r_dT)}{r_d}\right) - I, \\ N_s(r_u) &= X\left(\frac{1-\exp(-r_uT)}{r_u}\right) - I. \end{aligned}$$

To capture the principal implications of interest rate uncertainty in a simple way, we assume $N_s(r_d) > 0 > N_s(r_u)$, i.e., investment is profitable at date $s$ if the interest rate is low, but not otherwise.[5] Thus, if the firm delays until time $s$, investment commences at that date if the interest rate turns out to be low, but the project is abandoned if the interest rate is high.

[2]See, for example, Rubinstein (1974).

[3]This simple timing decision is similar to that analyzed by Abel et al. (1996). Extending the model to incorporate multiple delay dates and an optimal stopping rule, as in McDonald and Siegel (1986) or Boyle and Guthrie (2003b), would complicate the analysis without affecting the results. We discuss this point in more detail in Section 3.

[4]Most studies of the investment timing problem focus on the case where a positive value of $N^*$ emanates from shocks to future expected cashflows. However, as Ingersoll and Ross (1992) point out, interest rate uncertainty (shocks to expected returns) is an even more ubiquitous phenomenon.

[5]If both payoffs are positive, then waiting simply generates a payoff of $N_0$ $s$ years later, so time 0 investment is trivially optimal.

In this setup, investment today sacrifices a potentially higher payoff $N_s(r_d)$ at time $s$. Thus, $N^*$ is simply the expected present value of this foregone payoff:

$$N^* = p\exp(-rs)N_s(r_d). \tag{2}$$

We wish to determine the effect, if any, of a change in payback on the investment threshold $N^*$ for a project with given net-present-value $N_0$. If, for example, a longer payback period leads to greater $N^*$, then the level of $N_0$ required to justify investment is greater for long-payback projects.

To model an increase in the length of payback period, we 'stretch' the project's expected cashflows out over a longer life (i.e., greater $T$), where, to isolate any payback effect, the resulting fall in each annual cashflow leaves $N_0$ unchanged. From (1), this satisfies [6]

$$0 = \frac{\partial X}{\partial T}\left(\frac{1-\exp(-rT)}{r}\right) + X\exp(-rT),$$

so that

$$\frac{\partial X}{\partial T} = \frac{-rX\exp(-rT)}{1-\exp(-rT)}. \tag{3}$$

The effect of longer payback on $N^*$ and the optimal decision rule can then be determined by differentiating (2) with respect to $T$. Using the chain rule, this yields[7]

$$\begin{aligned}\frac{\partial N^*}{\partial T} &= p\exp(-rs)\left(\frac{\partial N_s}{\partial X}\frac{\partial X}{\partial T} + \frac{\partial N_s}{\partial T}\right)\\ &= p\exp(-rs)\left(\frac{\partial X}{\partial T}\left(\frac{1-\exp(-r_dT)}{r_d}\right) + X\exp(-r_dT)\right).\end{aligned} \tag{4}$$

After substituting in (3), this becomes

$$\begin{aligned}\frac{\partial N^*}{\partial T} &= p\exp(-rs)\left(\frac{-rX\exp(-rT)}{1-\exp(-rT)}\left(\frac{1-\exp(-r_dT)}{r_d}\right) + X\exp(-r_dT)\right)\\ &= \frac{p\exp(-rs)(1-\exp(-r_dT))X}{r_dT}\Big(f(r_dT) - f(rT)\Big),\end{aligned}$$

where

$$f(z) = \frac{z\exp(-z)}{1-\exp(-z)}.$$

From Abramowitz and Stegun (1970, p. 70), we know that $\exp(-z) > 1 - z$ for all $z > 0$, so

$$f'(z) = \frac{\exp(-z)(1-z-\exp(-z))}{(1-\exp(-z))^2} < 0.$$

$f$ is thus a strictly decreasing function of $z$ for all $z > 0$, so that $f(r_dT) > f(rT)$ and $\frac{\partial N^*}{\partial T}$ is strictly positive, i.e., longer payback increases the NPV threshold required to justify investment. That is, projects that return their investment cost only over a long period of time must offer an 'NPV-premium' relative to their shorter-term counterparts.

[6]The right-side of the first equation below uses the product rule of differential calculus. For a simple discussion of this rule, see Watsham and Parrimore (1997, pp. 90–91).

[7]See Watsham and Parrimore (1997, p. 91).

This result runs counter to the prescriptions appearing in modern accounting and finance textbooks, but is consistent with investment folklore that short payback is beneficial. In fact, it is a simple manifestation of a general property: when interest rates are uncertain, the incentive to wait is greater for long-term than for short-term projects, so the former must pass a stricter test in order to justify investment. To see why, note that flexibility in investment timing is valuable because it offers the opportunity to obtain a greater payoff in the future without the risk of receiving a negative payoff (since in that case investment does not proceed). With risky interest rates, this opportunity is most valuable for slow-payback projects: unexpectedly low interest rates have a greater positive impact on the present value of long-dated cashflows, so there is a stronger incentive to delay long-term projects. Consequently, the opportunity cost of investing now is greater for long-term projects, thereby motivating a bias towards short-term projects.

As the above explanation suggests, this result is a straightforward combination of the theories of bond pricing, option pricing, and capital budgeting. From bond pricing theory, we know that the value of long-dated cashflows is more sensitive to discount rate shocks, and hence, for a given interest rate distribution, more volatile.[8] From option pricing theory, we know that greater volatility makes options more valuable and hence more difficult to justify exercising. From capital budgeting theory, we know that the choice of project investment date is akin to determining an optimal exercise policy for a call option. Our contribution in this paper is to combine these insights in order to clarify the potential contribution of payback to value-maximising investment decisions.

Although the particular mechanism described above is new, we are not the first to point out a link between payback and the value of waiting to invest. Boyle and Guthrie (1997), McDonald (2000), and Wambach (2000) all recognise that shorter payback can be associated with a lower waiting value, but arrive at this conclusion via a very different route to this paper. In their models, interest rates are fixed, but long-payback projects are assumed to have high expected cashflow growth which, in turn, gives rise to a high value of waiting. By contrast, our story emphasizes the importance of uncertain interest rates, in keeping with the traditional practitioner risk-based justification for payback. Our analysis thus formalizes and clarifies the traditional explanation. Furthermore, uncertainty about interest rates is common to all real-world projects, whereas high cashflow growth is by no means a guaranteed indicator of long payback, so our story seems likely to apply in a much wider variety of situations.[9]

[8]The concept of duration is commonly used to measure the interest rate sensitivity of a bond. For an application of duration to capital budgeting, see Rhys and Tippet (1996).

[9]Boyle and Guthrie (2003a) establish a link between project value and the immediacy of cashflows in the presence of uncertain interest rates, but do not address the form of the optimal investment rule or its link to payback.

# 3 Implications and Limitations

The principal implication of our analysis is that a seemingly puzzling aspect of capital budgeting practice has a value-maximizing justification. In particular, our story provides support for decision rules that (i) require projects with a positive NPV to also have a sufficiently short payback period or (ii) use a higher discount rate for long-term projects than for short-term projects. Although such procedures will not in general replicate the optimal rule, they do represent an intuitive response to correctly perceived costs and benefits.

We stress that this result should not be interpreted as implying a blanket preference for short-payback projects, regardless of NPV. In general, there is a trade-off between payback and NPV; shorter payback encourages investment, but not if it comes at the expense of too much NPV. The point of our analysis is not that shorter payback is always preferred, but rather that it lowers the NPV necessary to justify investment.

An alternative way of expressing our result is that the required yield on any project is an increasing function of payback period. This interpretation is helpful for comparing our story with that of Cornell (1999). He considers a mean-variance world where all future expected cashflows are discounted at a constant rate $\rho$ which contains a premium for systematic risk. Cornell's argument is that (i) most systematic variation in asset returns is due to time-varying expected returns and (ii) expected return fluctuations have a greater effect on the returns to long-term assets because of the compounding effect. Consequently, long-term investments have greater systematic risk and thus their cashflows should rationally be discounted at a higher rate. That is

$$\rho = r + g(\text{Payback}), \quad g' > 0,$$

where $g(\cdot)$ is the risk premium. In our story, the analogous equation is

$$\rho = r + h(\text{Payback}), \quad h' > 0,$$

where $h(\cdot)$ is the "delay" premium. The difference between these two equations is straightforward. In both models, the discount rate $\rho$ is the opportunity cost of the capital used to finance investment. In Cornell's model, the opportunity cost of investment today is the expected return on another investment of equivalent systematic risk. The shorter a project's payback period, the lower its systematic risk and hence, given risk-averse investors, the lower the cost of capital. In our model, systematic risk is zero, but investment today means forgoing the opportunity to make the same investment at a future date, so the cost of capital must reflect this sacrifice. The shorter a project's payback period, the smaller the sacrifice and hence the lower the opportunity cost of capital. In contrast to Cornell, our story applies even when interest rate shocks are unsystematic.

The primary objective of our analysis is prescriptive, insofar as it provides a justification for why firms should use payback. However, it also has some descriptive implications that can be compared with actual capital budgeting practice. In particular, our model predicts that payback should be used in conjunction with NPV or some other discounted cashflow method rather than in isolation, and that its use should be observed primarily in firms with investments that have significant waiting value. As it turns out, both of these phenomena are empirically observable. Survey research indicates that firms that use the payback calculation primarily do so in conjunction with discounted cashflow methods. For example, Stanley and Block (1984) find that 5% of respondents use payback as their primary evaluation method, but 38% use it as an ancillary technique. Oblak and Helms (1980) find the corresponding percentages to be 10% and 62% respectively. Other more recent studies report similar findings.[10] Moreover, payback seem to be more extensively used in firms with significant business or financial risk, i.e., those with projects that are likely to have high values of waiting. For example, Binder and Chaput (1996) and Schall and Sundem (1980) find that the use of payback is positively associated with the level of economic uncertainty. Similarly, Poterba and Summers (1995) report that U.S. CEOs cite a credible government commitment to long-term tax stability as a significant factor in discouraging myopic investment decisions.

One feature of our model that may seem somewhat restrictive is the assumption that firms can delay investment only once and only until a fixed future date $s$. However, this seems unlikely to alter the role we have proposed for payback. To see this, suppose that firms have the choice of investing or delaying at every date, so today's invest-delay decision is made in the knowledge that the same decision will be available (assuming delay is chosen today) at the next date. Consequently, investment today incurs the costs of (i) forgoing the opportunity to make the same investment again at the next date if economic conditions turn out to be better at that date and (ii) forgoing the opportunity to delay investment again at the next date if economic conditions turn out to be worse. In our model, by contrast, only cost (i) exists because there is no option to delay again at time $s$. Our payback principle therefore reflects the greater upside potential of long-payback projects. But such projects also have greater downside potential and so have a higher cost (ii) as well. Thus, inclusion of multiple delay dates in our model would, if anything, accentuate the link between payback and the value of waiting.

Finally, we emphasize the obvious point that payback is useful (at least in the way we envisage) only to the extent that the value of waiting is significant. As some authors (see, for example, Pindyck, 1993; Milne and Whalley, 2000; and Boyle and Guthrie, 2003b) have pointed out, various outside factors can substantially reduce this value. If these factors turn out to have practical relevance, then our case for payback is weakened.

## 4 Concluding Remarks

One of the first things students are taught about capital budgeting is that project value depends only on the total discounted value of expected cashflows. The timing of cashflows matters to the extent that it affects this total discounted value, but not otherwise. Thus, project evaluation

[10]See Jog and Srivastava (1995) for Canadian evidence.

methods that hold long-term projects to a higher standard than short-term projects are deficient mechanisms for maximizing firm value. Their only redeeming feature, it is said, is that they may provide some crude adjustment for liquidity and/or risk differences and thus yield some indirect information about firm value (see, for example, Brigham et al. 1999, pp. 426–29; and Ross et al. 1991, pp. 199–203). Nevertheless, surveys of capital budgeting practice indicate a bias against long-term projects, perhaps reflecting the often-expressed practitioner belief that "short-term" is strongly correlated with "low risk".

In this paper, we have shown that there may be some justification for firms to favour short-term investments, and that this justification is not too far removed from the traditional view that long-term investments are riskier. Such projects are more sensitive to interest rate fluctuations and hence have more to gain from waiting to acquire more information about their true value. Thus, the dynamic opportunity cost of investment is greater for projects with long payback, so value-maximisation requires that the investment payoff needed to justify investment be an increasing function of payback.

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