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# Observability and the Payback Criterion*

The payback criterion continues to be widely used in industry, although there is little support for it among the academicians. This paper attempts to find an economic rationale for it by using an incentive model with asymmetric information. It argues that when the managers possess private information regarding projects selected for implementation, it is in their interest to choose, ceteris paribus, projects that pay back faster. Since manager's wages depend on output (because their productivity is unknown), by choosing projects that pay back fast they hope to improve their reputations.

## I. Introduction

Among the enigmas of corporate finance theory that have received little attention is the puzzling use of the payback method as a capital budgeting tool. Although the payback method has many drawbacks, it is widely used in industry (see Klammer 1972; Fremgren 1973; Schall, Sundem, and Geijsback 1978).[1] Gordon (1955) attempted to explain this anomaly by observing that the inverse of the payback period is an approximation for the internal rate of return. But as Sarnat and Levy (1969) point out, the accuracy of the approximation depends on the life of the project and its IRR. For low values of IRR the inverse of payback is a very poor approximation. Moreover, it is difficult to believe that corporations that use complex and sophisticated technologies need a rule of thumb to approximate something as simple to compute as the IRR. In fact, empirical evidence shows that most firms compute both the IRR and the payback period (see Schall

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1. It has been found that payback is rarely used as a primary capital budgeting method. It is used as a secondary criterion to a discounted cash-flow method such as NPV (net present value) or IRR (internal rate of return).

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et al. 1978). Therefore the rule-of-thumb explanation does not seem to be very satisfactory. The rationale for the use of payback for project analysis must lie elsewhere.

Managers who use the payback method apparently prefer projects with quick returns. This implies that they prefer, ceteris paribus, a dollar today to a dollar tomorrow, over and above the conventional "impatience" for current consumption; if this were not the case the managers could use any discounted cash flow technique to take into account the conventional time preference for money. This paper provides an economic rationale for this additional time preference, which is inexplicable under perfect market conditions. The explanation is based on the separation of ownership and control in organizations and the inability of the owners to observe the actions of the manager. The firm is modeled as consisting of stockholders and a manager who is employed to run it. The output of the firm depends on the ability of the manager, which is unknown to all (including the manager), the state of nature, and decisions made by the manager. The market for labor is competitive; so after paying the manager the firm cannot make positive expected profits. The manager can make decisions that result in quicker returns or alternatively, slower returns. In either case, the NPV is the same. (It is important to keep the NPV constant in order to analyze the manager's preference for payback.) The stockholders cannot observe the manager's decisions or infer it from the output. Hence the manager hopes that if he selects the quick-return project, the stockholders may attribute the extra dollars to his ability and pay him higher wages not only in that period but also in subsequent periods, since his pay is based on current and past performances. He hopes to enhance his reputation early, and, since his wages in subsequent periods are based on his reputation (for managerial ability), he can capitalize on his reputation for a longer period of time. In equilibrium, the stockholders will expect the manager to choose the quicker-return project and will evaluate him on that basis. In reality, then, the manager does not gain by choosing the project with the quicker return, but because of stockholders' expectations, he loses if he fails to select the quick-return project.

Section II describes the basic model used to derive an optimal wage schedule for the manager. In order to illustrate the central idea of this paper, the model is kept simple by assuming an additive production function and normal distribution of the random noise. In Section III it is shown that given the optimal wage schedule derived in the previous section, the equilibrium project choice is, ceteris paribus, the one with quicker returns. In Section IV the same result is proved under conditions more general than in Section III. Section V concludes the paper.

## II. The Model

In this section a simple model is used to characterize the optimal wage schedule of the manager.[2] This model illustrates the basic idea and provides the economic intuition. A more general model is provided in Section IV.

Consider an all-equity firm run by a professional manager. Let the market consist of a large number of such identical firms. All these firms produce the same consumption good using one factor of production—the labor supplied by the manager. Firms and managers are assumed to live for a finite number of periods, $T$. The output of the firm in period $t$ depends on the manager's ability, $n$, and a random disturbance term $e_t$, and is given by the equation

$$y_t = n + e_t. \tag{1}$$

When a manager is first hired his ability $n$ is not know with certainty to either the stockholders or the manager himself. Based on some information that is common knowledge, the stockholders and the manager hold the same prior beliefs about $n$. The information on which the prior is based may be the education of the manager, if he has no previous job experience, or may be the output produced by the manager in previous jobs. The important thing to note is that this information is available to all participants in the market and that all of them have the same prior distribution of $n$. In particular, it is assumed that this prior distribution of $n$ is normal with mean $m_0$ and precision $h_0$.[3] The $e_t$'s are assumed to be distributed independently and normally with mean zero and precision $r$.

It is assumed that the managers are risk averse, with their utility for intertemporal consumption $C^T \equiv (C_1, C_2, \ldots, C_T)$ given by

$$U(C^T) \equiv \sum_{t=1}^{T} b^t u(C_t), \quad b \leq 1. \tag{2}$$

As can be seen from equation (2), the manager has no disutility for labor. This assumption eliminates all moral-hazard problems of the usual type. It is also assumed that the risks arising from the uncertainty in output, and hence the perceived ability, cannot be insured except through the wage contract offered by the stockholder. As in Harris and Holmstrom (1982), stockholders are assumed to be risk neutral. This assumption helps to keep the mathematics simple. It is also a reasonable approximation when the stockholders are well diversified, so

2. The model is borrowed from Harris and Holmstrom (1982). Most of this section is based on their paper.

3. The regularity conditions $|m_0| < \infty$ and $h_0 > 0$, are assumed to be satisfied.

that the fortunes of one of their firms have only negligible impact on their wealth. The manager is precluded from borrowing or saving.

The firms and the managers enter into a series of binding 1-period contracts.[4] At the end of each period the manager can leave the firm or the firm can fire him. The stockholders, after they have paid the manager's wage, cannot derive positive expected profits in any period since the labor market is competitive and since there are no other factors of production.

Prior beliefs are updated—that is, the posterior distribution of $n$ is computed—on the basis of all the outputs produced by the manager to date. Consider the posterior distribution of $n$ at time $t$ when outputs $y_1$, $y_2, \ldots, y_t$ have been observed. From (1) we know that $(y_1, y_2, \ldots, y_t)$ is a random sample from a normal distribution with mean $n$ and precision $r$. Since the prior beliefs of $n$ are assumed to be normal with mean $m_0$ and precision $h_0$, the posterior distribution of $n$ at time $t$ is normal with mean $m_t$ and precision $h_t$ given by (see DeGroot 1970)

$$m_t = \frac{h_0 m_0 + r(y_1 + y_2 + \ldots + y_t)}{h_0 + tr} \tag{3}$$

$$h_t = h_0 + tr. \tag{4}$$

The equations above may be written in recursive form as

$$m_{t+1} = \frac{h_t m_t + r y_{t+1}}{h_t + r} \tag{5}$$

$$h_{t+1} = h_t + r. \tag{6}$$

Note the following points: ($a$) The expected output in period $t$ is the same as $m_{t-1}$, the mean perceived ability of the manager in period $t - 1$. ($b$) The precision $h_t$ develops deterministically over time, independent of the output, while the mean $m_t$ follows a random walk with declining variance. ($c$) The history $y^t = (y_1, y_2, \ldots, y_t)$ is equivalent to the history $m^t \equiv (m_0, m_1, \ldots, m_t)$; that is, if one is known, the other can be computed.

The manager is hired in period 0. He comes in with expected ability $m_0$ and precision $h_0$. On the basis of these parameters of the distribution of his ability, he is offered an initial wage of $w_0$, which is paid in period 0. After the first period output $y_1$ is observed, the mean ability and the precision are updated to $m_1$ and $h_1$, respectively. Then the manager is offered a new contract that pays a wage of $w_1$ in period 1, and so on.

4. Assuming long-term contracts will result in a wage policy where the manager's wage is different from his mean perceived ability (see Harris and Holmstrom 1982; Holmstrom and Costa 1984). But, as shown in App. B, even under such a wage policy the central result of this paper holds.

In order to derive the optimal wage contract, we need to define what a wage policy is.

DEFINITION: A *wage policy d* is defined as a sequence of wage payments $\{w_t(m^t)\}_{t=0}^{T-1}$, where $w_t(m^t)$ is the wage offered in period $t$ given the history $m^t$ up to period $t$. (Recall the equivalence between histories $y^t$ and $m^t$.)

The optimal wage policy can be obtained by solving the following optimization program:

$$\max_{d} E_0 \left[ \sum_{t=0}^{T-1} b^t \, u(w_t) \right]$$

$$\text{s.t. } E_s \left[ \sum_{t=s}^{T-1} b^{t-s} \, (m_t - w_t) \right] = 0, \quad \forall m^s \equiv (m_1, m_2, \ldots, m_s), \qquad (7)$$

$$s = 0, 1, 2, \ldots, T - 1.$$

That is, the optimal wage contract maximizes the manager's expected utility subject to constraint (7).[5] The subscript on the expectation operator indicates the time period in which the expectation is taken. The left-hand side of (7) is the expected profits of the shareholders. It cannot be positive since the labor market is competitive. It cannot be negative since that would violate individual rationality. The following proposition gives the optimal wage policy.

PROPOSITION 1: The optimal wage policy is given by $w_t(m^t) = m_t$, $t = 0, 1, 2, \ldots, T - 1$. That is, in every period the manager is paid his mean perceived ability, given the history up to that period.

PROOF: It is easily verified that the policy above is the only feasible one. Hence it is optimal. Q.E.D.

Note that the optimal wage policy is noncontingent. Wages in any period depend only on the current output and all past outputs.

## III. Payback Criterion under Asymmetric Information

To show that the economic rationale for the use of payback lies in the fact that managers have an additional time preference for money, it is necessary to compare the manager's preferences between projects that are identical in all respects except in their payback periods.

Consider the following project:

$$y_t = n + e_t + D_t(z), \quad t = 1, 2, 3. \qquad (8)$$

The project produces cash flows for 3 periods. As before, $n$ is the manager's ability and $e_t$'s are random terms independently and nor-

5. It can be easily shown that (7) implies that, given the available information in any period $s$, the stockholders want their expected *next*-period profits to be zero.

mally distributed with mean zero and precision $r$. The project's cash flows depend on the manager's ability, a random state of nature, and decisions taken by the manager; $z \in Z$ represents an element of his decision set $Z$; and $D_t: Z \rightarrow R^1$ are functions that represent the cash-flow outcomes of the managerial decision. The decision $z$ is taken at time zero.

Let $Z = \{A, B\}$; that is, the manager can take decision A or B. Let

$$\begin{aligned} D_t(A) &= 1, \quad t = 1 \\ &= 0, \quad t = 2 \\ &= 0, \quad t = 3 \\ D_t(B) &= 0, \quad t = 1 \\ &= 1, \quad t = 2 \\ &= 0, \quad t = 3. \end{aligned}$$

In other words, decision A provides an extra dollar in period 1 while decision B provides an extra dollar in period 2. The third period cash flows are unaffected by the decision. This is the simplest set of outcomes of managerial decisions that can be used to study the reason for the manager's additional time preference. In Section IV, more general sets of outcomes are explored.

From now on it is assumed that the discount factor $b$ for both the manager and the stockholders is one. This enables us to concentrate on the preference of the manager for the timing of the cash flows beyond the preferences generated by the conventional time value of money. With this assumption it is easy to see that decisions A and B result in cash flows that have the same risk and the same NPV (NPV being the sum of the certainty equivalents in each period). However, A yields a quicker payback than B. Hence, if there is any preference for one set of cashflows or the other it must arise because of the difference in their payback periods.[6]

In order to highlight the effect of asymmetric information on the managerial decision, first consider the managerial decision under full information, that is, under the assumption that all the stockholders know the manager's decision.

If the manager's decision is A, the stockholders will evaluate his performance by the following set of equations:

$$\begin{aligned} y_1^A - 1 &= n + e_1 \\ y_t^A &= n + e_t, \quad t = 2, 3. \end{aligned} \tag{9}$$

6. When we talk about payback or NPV in this model, we are considering cash flows before the manager is paid. Conventionally, such payments as wages are included in the operating expenses and hence, are part of the cash flows used in evaluating projects. Here we cannot do that, as the manager's wage is based on all observed outputs. But this method of computing payback period on NPV (using prewage cash flows) does not induce any preference for one project over the other when all information is common knowledge. Only when there is asymmetric information between the manager and the stockholders does a preference result for the quicker payback project.

If the manager's decision is B, the stockholders will evaluate his performance by

$$y_t^{\mathrm{B}} = n + e_t, \quad t = 1, 3$$
$$y_2^{\mathrm{B}} - 1 = n + e_2; \tag{10}$$

$y_t^{\mathrm{A}}$ and $y_t^{\mathrm{B}}$ represent outputs under decisions A and B, respectively. From (9) and (10) it is obvious that $y_1^{\mathrm{A}} - 1 = y_1^{\mathrm{B}}$, $y_2^{\mathrm{A}} = y_2^{\mathrm{B}} - 1$, and $y_3^{\mathrm{A}} = y_3^{\mathrm{B}}$. Therefore, the mean perceived ability of the manager $m_t$, $t = 1, 2$, will be the same irrespective of the manager's decision. Hence, by proposition 1, the wage policy is independent of the manager's decision. The following proposition summarizes this argument.

PROPOSITION 2: Under full information, the manager is indifferent between decision A and decision B.

In other words, as long as the NPV is the same, the manager is indifferent between cash flow patterns resulting from decisions A and B. The stockholders are also indifferent between these two decisions. This result is in conformity with the conventional result that NPV is the optimal capital-budgeting criterion.

Next, consider the situation where only the manager knows the decision that he has taken. The stockholders can observe only the output. Since the stockholders are interested in maximizing their expected net profits (expected gross profits − expected wages), they would like the manager to make the decision that results in higher profits to them. In other words, they would like the manager to make the decision that would minimize his expected total wages since the total gross expected profits are the same for both decisions. However, since they cannot observe the manager's decision, they cannot control it directly. They can influence his decision only by providing him with suitable incentives. They are also constrained by the competitive labor market: they have to pay the manager his mean perceived ability (proposition 1). Therefore, the stockholder's problem is to choose a wage schedule that would meet the requirements of the competitive labor market and provide the manager an incentive to make the decision that would minimize the expected wage bill (or maximize the expected net profits). To be more specific, if the stockholders desire the manager to make decision A, they would select a wage policy according to the following optimization program:[7]

PROGRAM A:

$$\underset{\{w_t(y^t)\}}{\mathrm{Min}}\; E_0\left[\sum_{t=0}^{2} w_t(y^t) \,|\, \mathrm{A}\right],$$

7. This line of reasoning was suggested by the referee.

such that

$$E_0\left\{\sum_{t=0}^{2} u[w_t(y^t)]|A\right\} \geq E_0\left\{\sum_{t=0}^{2} u[w_t(y^t)]|B\right\}, \quad \text{for all } y^t. \tag{11}$$

$$E_s\left\{\sum_{t=s}^{2} u[w_t(y^t)]|A\right\} = E_s\left\{\sum_{t=s}^{2} u[m_t(y^t)]|A\right\}, \text{ for all } y^t, \tag{12}$$

$$\text{for } s = 0, 1, 2.$$

All expectations are conditional on the manager's decision. Equation (11) is the incentive constraint: the optimal wage policy should ensure that the manager's expected utility is maximized if he makes decision A. Equation (12) represents the competitive labor market constraint: in each period the manager's wages must be equal to his mean perceived ability.

On the other hand, if the stockholders want the manager to implement decision B, they would select the wage policy according to program B, which is obtained by interchanging A and B in program A. Since the stockholders want to minimize the expected wage bill, they would want to choose the program whose solution results in lower expected total wages. In order to find out the decision the stockholders would prefer, we need the results of the following lemmas.

LEMMA 1: Let $m_t(s_e, s_m)$ represent the manager's perceived ability when he has taken decision $s_m$ and the stockholders are evaluating him on the basis that he has taken decision $s_e$, where $s_e, s_m \in \{A, B\}$.[8] Then, $m_1(\cdot, A) > m_1(\cdot, B)$ and $m_2(\cdot, A) = m_2(\cdot, B)$.

PROOF: If $s_e = A$, the manager will be evaluated according to the following equations: $y_1 - 1 = n + e_1$, $y_2 = n + e_t$, $t = 2, 3$. From equation (5), therefore,

$$m_1(A, s_m) = \frac{h_0 m_0 + [y_1(s_m) - 1]r}{h_0 + r}, \tag{13}$$

$$m_2(A, s_m) = \frac{h_0 m_0 + [y_1(s_m) + y_2(s_m) - 1]r}{h_0 + 2r}, \tag{14}$$

where $y_t(s_m)$ is the output in period $t$, $t = 1, 2$, as a function of the manager's decision $s_m$. Clearly, $m_1(A, A) > m_1(A, B)$ and $m_2(A, A) = m_2(A, B)$.

If, on the other hand, $s_e = B$, the manager will be evaluated according to the following equations: $y_1 = n + e_1$, $y_2 - 1 = n + e_2$, and $y_3 = n + e_3$.

8. This notation makes the dependence of the mean perceived ability on the manager's decision and the stockholder's basis of evaluation explicit. In specifying program A(B) or program A'(B') this dependence has been somewhat suppressed to avoid cumbersome notation. In program A(B) or A'(B'), the stockholders' basis of evaluation is A(B) and all the expectations are conditional on the manager's decision.

Using (5) again we get

$$m_1(\mathrm{B}, s_m) = \frac{h_0 m_0 + y_1(s_m)r}{h_0 + r} \tag{15}$$

$$m_2(\mathrm{B}, s_m) = \frac{h_0 m_0 + [y_1(s_m) + y_2(s_m) - 1]r}{h_0 + 2r}. \tag{16}$$

As before, $m_1(\mathrm{B}, \mathrm{A}) > m_1(\mathrm{B}, \mathrm{B})$ and $m_2(\mathrm{B}, \mathrm{A}) = m_2(\mathrm{B}, \mathrm{B})$. Q.E.D.

LEMMA 2: $m_1(\mathrm{A}, \cdot) < m_1(\mathrm{B}, \cdot)$ and $m_2(\mathrm{A}, \cdot) = m_2(\mathrm{B}, \cdot)$.

PROOF: From (13) and (15), $m_1(\mathrm{A}, s_m) < m_1(\mathrm{B}, s_m)$. From (14) and (16), $m_2(\mathrm{A}, s_m) = m_2(\mathrm{B}, s_m)$. Q.E.D.

From lemmas 1 and 2, the next proposition follows.

PROPOSITION 3: The stockholders would choose program A. In other words, they would prefer the manager to implement decision A.

PROOF: Consider the following programs:

PROGRAM A′:

$$\underset{[w_t(y^t)]}{\mathrm{Min}}\, E_0\left[\sum_{t=0}^{2} w_t(y^t)\,|\,\mathrm{A}\right],$$

such that

$$E_s\left\{\sum_{t=s}^{2} u[w_t(y^t)]|\mathrm{A}\right\} = E_s\left\{\sum_{t=s}^{2} u[m_t(y^t)]|\mathrm{A}\right\},$$

for all $y^t$, and for $s = 0, 1, 2$.

PROGRAM B′:

$$\underset{[w_t(y^t)]}{\mathrm{Min}}\, E_0\left[\sum_{t=0}^{2} w_t(y^t)\,|\,\mathrm{B}\right],$$

such that

$$E_s\left\{\sum_{t=s}^{2} u[w_t(y^t)]|\mathrm{B}\right\} = E_s\left\{\sum_{t=s}^{2} u[m_t(y^t)]|\mathrm{B}\right\},$$

for all $y^t$, and for $s = 0, 1, 2$. Programs A′ and B′ are obtained by removing the incentive constraints from programs A and B, respectively. The optimal solutions to programs A′ and B′ are given by propostion 1, which states that the wage in any period will be the mean perceived ability in that period: $m_t(\mathrm{A}, \mathrm{A})$ for program A′ and $m_t(\mathrm{B}, \mathrm{B})$ for program B′. From lemma 1 it follows that the optimal solution to A′ is a feasible solution to program A; that is, it also satisfies the incentive constraint (11). Hence it is optimal for program A. From lemma 2 it is clear that the optimal solution to program A′ is strictly less than that of program B′. Thus, solution of program A = solution of program A′ < solution of program B′ ≤ solution of program B. Q.E.D.

Therefore, in equilibrium, the cash flow pattern with a quicker return, that is, lower payback period, is chosen. The intuition behind the preference for a quicker return is simple. Choice of such a cash flow presumably enhances the manager's reputation earlier; that is, he hopes to achieve a higher reputation early. And since the effects of this reputation lingers on (because his wages are dependent on past performance), he is able to enjoy the benefits for many periods into the future. All this can happen only if the stockholders are fooled. But they are not, as they know how the manager will behave and make allowances for it when evaluating his performance. Nevertheless, the manager is forced to act in the way he is expected to act, since any deviation would only make him worse off. To see this, suppose he takes decision B. The stockholders are evaluating him on the basis that he has taken decision A, and when they see the first period returns fall short of their expectations, they attribute the poor performance to the manager's (in)ability: his reputation is ruined and his wage is lowered. The manager is of course compensated in the second period when the stockholders realize an unexpected bonus, which they attribute to the manager's ability. This restores his damaged reputation and for the purpose of future wages he is back on even keel. But the damage done in the earlier period cannot be rectified. Therefore even though the manager does not realize any actual gains by taking decision A, he is forced to take it. Similarly, stockholders always evaluate him on the basis of decision A, for they stand to lose if they evaluate him on a different basis.

Recently Holmstrom and Costa (1984) have suggested that risk-averse managers might wish to avoid projects that result in the revision of their (unknown) ability. With updating, the mean perceived ability follows a random path with nondecreasing expected value (Holmstrom and Costa 1984, eq. [12]). Since the expected value of the mean perceived ability is nondecreasing, there is value to learning or updating. However, since the mean perceived ability follows a random path, there are costs to learning for a risk-averse manager. Thus, depending on the degree of his risk aversion, the manager may prefer no updating at all. Holmstrom and Costa conjecture that this possible aversion to updating may lead managers to choose projects that yield all their cash flows in later periods. One reason the manager in our model does not have such incentives is simple: the updating process is the same, irrespective of whether he takes decision A or B. This is because both projects have the same risk ($\varepsilon_t$). Also, there is an important difference between our models regarding the decision set of the manager. In our model, the only decision the manager has to make is the project choice at the beginning of the first period. In the Holmstrom-Costa model he has to make similar decisions at the beginning of each period—in other words, they are considering a series of projects. If in the Holmstrom-Costa model (example 1) the manager's only decision is to accept or reject the project in its entirety (as against doing so in each period), then his incentive to reject is reduced dramatically. If he rejects, he gets nothing in the second period, while if he accepts, he expects to get his first period wage. Third, the unobservability of the project choice by the market reduces the manager's incentive for choosing projects with later cash flows. If the market cannot observe the project choice, they do not know whether poor returns are a result of the manager's (in)ability or due to the fact that he has chosen a project with later cash flows. This will lead to unfavorable updating of the manager's ability. This is the primary reason why managers scramble to show quick results.

## IV. Generalization and Extensions

In the last section, in order to illustrate the conditions under which corporate managers will choose projects with lower payback periods, it was assumed that the production function $y$ was additive in its components $n$ and $e_t$ and that the random term $e_t$ was distributed normally. These assumptions were made for expositional reasons. In this section, it will be shown that a wide variety of production functions and distributions will reproduce the results obtained in the last section.

Before deriving the sufficient conditions that the production function and the distribution of $e_t$ have to satisfy in order to produce the result that a dollar today is worth more than a dollar tomorrow, a few terms need to be defined.

Let $x \in R^m$ be the observations from a distribution with an unknown parameter $P$. Let $f(x|p)$ be the conditional density of probability mass function on $R^m$ when $P$ takes on a particular value $p$.

DEFINITION:[9] Observation $x$ is *more favorable* than observation $y$ if for every nondegenerate[10] prior distribution $G$ of $p$, $G(.|x)$ stochastically dominates $G(.|y)$ in the strict first-order sense, namely, $G(p|x) \leq G(p|y)$ for all $p$, and $G(p|x) < G(p|y)$ for some $p$.

DEFINITION: Let $x$, $y \in R$. Let $p$ and $p'$ be two realizations of the unknown parameter $P$ with $p' > p$. Then the densities $[f(.|p)]$ have the strict monotone likelihood ratio property (MLRP) if for every $x > y$

$$\frac{f(x|p)}{f(x|p')} < \frac{f(y|p)}{f(y|p')}. \tag{17}$$

The next lemma is useful in proving the central result of this section. This lemma states the conditions under which "more is better." The proof is given in Milgrom (1981).

9. The terminology is borrowed from Milgrom (1981).

10. A distribution is *degenerate* if it assigns probability one to a single point. If not, it is *nondegenerate*.

Lemma 3: The family of densities $[f(.|p)]$ has the strict MLRP if and only if $x > y$ implies that $x$ is more favorable than $y$.

Now we turn to the central result of this section. Let $y_t = y(n, e_t)$, $t = 1, 2, \ldots, T$, be the production function. As before, $n$ is the ability of the manager, which is unknown to himself as well as the stockholders. Let $e_t$ be independent realizations of the random variable $e$. Let $p \in R^m$ be the parameter vector of the distribution of $e$. The distribution of $e$ and the parameter $p$ are assumed to be public knowledge. Therefore, the outputs $y_t$, $t = 1, 2, \ldots, T$, may be considered independent realizations of the random variable $(Y|n, p)$. Decisions A and B are defined as before.

Proposition 4:

i) Let $y$ be a monotonically increasing function of $n$, for any given value of $e_t$, $t = 1, 2, \ldots, T$.

Suppose the family of distributions of the random variables $[(Y|n, p), n \in R]$, with probability mass functions or densities $[f(y|n, p), n \in R]$ has the following properties:

ii) A sufficient statistic for $n$ of fixed dimension (independent of the number of observations) of the form $\Sigma_{i=1}^{t} y_i$.

iii) Strict MLRP with respect to the sufficient statistic $\Sigma_{i=1}^{t} y_i$ in the following sense:

Let $(y_1, \ldots, y_t)$ and $(y_1', \ldots, y_t')$ be two sets of observations. Let $\bar{y}_t = \Sigma_{i=1}^{t} y_i$ and $\bar{y}_t' = \Sigma_{i=1}^{t} y_i'$. Then, for every $\bar{y}_t > \bar{y}_t'$ and $n' > n$,

$$\frac{f(\bar{y}_t|n, p)}{f(\bar{y}_t|n', p)} < \frac{f(\bar{y}_t'|n, p)}{f(\bar{y}_t'|n', p)}, \quad t = 1, 2, \ldots, T - 1.$$

Then, the equilibrium project choice will be A.

Proof. See Appendix A.

It is easy to see that the MLRP condition is also a necessary one. The condition about the sufficient statistic is not a necessary one, and it is fairly easy to construct examples to show this.[11]

A number of well-known distributions satisfy conditions ii and iii in the proposition above. Some examples, other than the normal distribution, are the Bernoulli distribution, the Poisson distribution, the exponential distribution, and the negative binomial distribution.

It had been assumed so far that decision A yielded an additional dollar in period 1 and decision B in period 2. All the results above will still hold if decision A yielded the additional dollar in period $t$ and decision B yielded the additional dollar in period $t + s$. By renumber-

11. Consider the production function $y_t = n + e_t$, where $e_t$ is uniformly distributed over $(-n, 0)$. The conjugate family of distributions for samples from a uniform distribution is the Pareto family. It can be shown that, even though the sufficient statistic in this example does not satisfy condition ii of proposition 4, the manager will still choose the project with the lower payback period.

ing the time scale (with period $t - 1$ as period 0), it can be shown that an extra dollar in period $t$ is preferred to an extra dollar in period $t + 1$. It is also clear that this argument is transitive over time. Hence an extra dollar in period $t$ is preferred to an extra dollar in period $t + s$.

The only difference between decisions $D_t(\mathrm{A})$ and $D_t(\mathrm{B})$ was the timing of the extra dollar. This can be generalized to some extent. Suppose $D_t(\mathrm{A})$ and $D_t(\mathrm{B})$ are defined as below.

$$\sum_{t=1}^{T} D_t(\mathrm{A}) = \sum_{t=1}^{T} D_t(\mathrm{B})$$

$$\sum_{t=1}^{s} D_t(\mathrm{A}) \geq \sum_{t=1}^{s} D_t(\mathrm{B}),\ \forall\, s < T,$$

with strict inequality for some $s < T$.

The first equation assures that the NPV of the two decisions is the same. It is clear that decision A is preferred to B. This is again because by taking decision A the manager can be assured that his mean perceived ability, and hence his wage, in each period will be at least as high as would result from decision B.

## V. Conclusions

The object of the paper was to investigate whether there is any economic rationale for the use of payback criterion as a capital-budgeting technique. It was found that when ownership and control of a firm are separated the manager of the firm has an incentive to make decisions that yield cash flows earlier in time, when the owners cannot observe the decisions.

While this paper clarifies an important issue concerning payback, namely, the preference for quicker returns, it does not address the other issues. For example, how is the cutoff date determined by the firms? What factors are involved in its determination? Also, the paper rationalizes the use of the payback criterion only in firms where ownership and control are in different hands. Presumably, some owner-managed firms also use payback. My theory does not explain this.

## Appendix A

### Proof of Proposition 4

Because the production function is not additive, the optimization program for the wage policy given in Section II must be rewritten as follows:

$$\max_{d} E_0\left[\sum_{t=0}^{T-1} b^t\, u(w_t)\right]$$

subject to

$$E_s\left[\sum_{t=s}^{T-1} b^{t-s}(y_{t+1} - w_t)\right] = 0, \forall\, y^s \equiv (y_1, y_2, \ldots, y_s),$$
$$\text{and } s = 0, 1, 2, \ldots, T-1 \tag{A1}$$

It will be shown that, given conditions i–iii, the manager is strictly better off taking decision A if the stockholders evaluate him on the basis of decision B. Once this is shown, following the line of the proof for lemmas 1 and 2 and proposition 3 it is easy to show that A is the equilibrium project choice.

In period 1, decision A results in higher cash flow than decision B. As the stockholders are using decision B as their basis, the higher cash flow is attributed to the manager's ability. By condition iii and lemma 3, the posterior distribution of $n$ in period 1 when decision A is taken, $G_A(n|y_1^A)$, dominates the posterior distribution of $n$ in period 1 when decision B is taken, $G_B(n|y_1^B)$, in the strict first-order sense of stochastic dominance.

Let us denote by $M(y_2|\bar{y}_1|e_2)$ the cumulative distribution function of the second-period output $y_2$ as assessed by stockholders, given the cumulative output $\bar{y}_1$ up to and including period 1 and the random disturbance term $e_2$. The only uncertainty involved in this distribution is due to $n$. If the manager takes decision $i$, $i$ = A, B, we denote this distribution function by $M(y_2|\bar{y}_1^i, e_2)$. Note that by condition ii, the distribution function $M$ will be the same irrespective of the decision taken. For any realization $y_2^*$ of the random variable $y_2$, we have

$$\begin{aligned} M[y_2^*|\bar{y}_1^A, e_2] &= pr[y_2 \leq y_2^*|\bar{y}_1^A, e_2] \\ &= pr[y(n, e_2) \leq y_2^*|\bar{y}_1^A, e_2] \\ &= pr[n \leq n^*|\bar{y}_1^A, e_2], \end{aligned}$$

by condition i, where $y(n^*, e_2) = y_2^*$

$$< pr[n \leq n^*|\bar{y}_1^B, e_2],$$

since $G_A(n|\bar{y}_1^A)$ stochastically dominates $G_B(n|\bar{y}_1^B)$ in the strict first-order sense (with strict inequality for some $n$),

$$\begin{aligned} &= pr[y(n, e_2) \leq y_2^*|\bar{y}_1^B, e_2] \\ &= M[y_2^*|\bar{y}_1^B, e_2]. \end{aligned}$$

Therefore, $M[y_2|\bar{y}_1^A, e_2]$ stochastically dominates $M[y_2|\bar{y}_1^B, e_2]$ in the strict first-order sense of stochastic dominance for all realizations of $e_2$. This implies that $E(y_2|\bar{y}_1^A, e_2) > E(y_2|\bar{y}_1^B, e_2)$ for all realizations of $e_2$. Hence, $E(y_2|\bar{y}_1^A) > E(y_2|\bar{y}_1^B)$. Since $\bar{y}_2^A = \bar{y}_2^B$, $G_A(n|\bar{y}_2^A) = G_B(n|\bar{y}_2^B)$. Hence $E(y_3|\bar{y}_2^A) = E(y_3|\bar{y}_2^B)$.

From the proof of proposition 1 it is clear that the wage policy $w_t = E(y_{t+1}|\bar{y}_t)$ is optimal for the general production function $y_t = y(n, e_t)$ where $e_t$'s are independently and identically distributed according to some distribution function. As before, let $w_t^A$ and $w_t^B$ the wages in period $t$ if the manager takes decision A and decision B, respectively. Then, clearly, $w_1^A > w_1^B$ and $w_2^A = w_2^B$. Hence the manager is strictly better off taking decision A.

## Appendix B

### Proof That the Manager Prefers Project A Even When Firms Are Committed to Long-Term Contracts

When firms are required to offer long-term contracts to their managers (who are not bound by them), program A gets modified. Instead of equation (12), we have the following constraints:

$$E_s\left\{\sum_{t=s}^{2} u[w_t(y^t)]|\mathrm{A}\right\} \geq E_s\left\{\sum_{t=s}^{2} u[m_t(y^t)]|\mathrm{A}\right\}, \tag{B1}$$

for all $y^t$ and for $s = 0, 1, 2$.

$$E_0\left\{\sum_{t=0}^{2} u[w_t(y^t)]|\mathrm{A}\right\} = E_0\left\{\sum_{t=0}^{2} u[m_t(y^t)]|\mathrm{A}\right\}. \tag{B2}$$

Equation (B1) states that the firm cannot make positive expected profits in any period. This is different from (12), which implies that the firm should make zero expected profits every period. Equation (B2) is required to make the contract efficient. Programs B, A′, and B′ are also accordingly modified. From Harris and Holmstrom (1982), the optimal wage contract for program A′ or B′ is

$$w_t = \max_{0 \leq s \leq t}[m_s - z_s(h_s)]. \tag{B3}$$

Since $h_s$ moves deterministically over time, $z_s$ is independent of the manager's decision. Lemmas 1 and 2 still hold. From lemma 2 and (B3) it follows that the manager's wage in any period $t$ under program B′ is at least as great as that under program A′ under all histories $y^t$, while it is strictly greater on a set of positive measure. From lemma 1 it follows that the optimal wage contract for program A′ is also feasible, and hence optimal, for program A. The rest of the proof follows that of proposition 3.

## References


DeGroot, M. H. 1970. Optimal Statistical Decisions. New York: McGraw-Hill.

Fremgren, J. A. 1973. Capital budgeting practices: A survey. *Management Accounting* 54:19–25.

Gordon, M. J. 1955. The payoff period and the rate of profit. *Journal of Business* 28:253–60.

Harris, M., and Holmstrom, B. 1982. A theory of wage dynamics. *Review of Economic Studies* 49:315–33.

Holmstrom, B., and Costa, J. R. 1984. Managerial incentives and capital management. Working paper. New Haven, Conn.: Yale University.

Klammer, T. 1972. Empirical evidence of the adoption of sophisticated capital budgeting techniques. *Journal of Business* 45:387–97.

Milgrom, P. R. 1981. Good news and bad news: Representation theorems and applications. *Bell Journal of Economics* 12:380–91.

Sarnat, M., and Levy, H. 1969. The relationship of rules of thumb to the internal rate of return: A restatement and generalization. *Journal of Finance* 24:479–89.

Schall, L. D.; Sundem, G. L.; and Geijsback, W. R., Jr. 1978. Survey and analysis of capital budgeting methods. *Journal of Finance* 33:281–87.