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Carlo Alberto Magni

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University of Modena and Reggio Emilia
Address: Viale Berengario 51, 41121 Modena, Italy,
email: carloalberto.magni@unimore.it

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Abstract

This note deals with the case of a principal (e.g., a firm's board of directors) which delegates execution of an economic activity to a business unit (or a subsidiary firm) managed by a manager. It is assumed that the manager has no control over the cash flows injected into the unit or withdrawn from it: such decisions are made by the principal. The principal aims at measuring the manager's performance in a given interval of time. Neither the Net Present Value (NPV) nor its companion Net Terminal Value (NTV) are appropriate measures for this purpose, because they depend on the cash flows injected and withdrawn by the principal. We introduce the manager's profitability index (MPI), which is invariant under changes in the cash flows, so neutralizing the effect on value creation of the principal's decisions. We also break down the project's NTV into two components, which measure the manager's contribution and the principal's contribution to value creation.

Keywords. Finance, economic performance, profitability index, Return On Investment, manager.

*University of Modena and Reggio Emilia, Department of Economics, viale Berengario 51, 41100 Modena, Italy, tel. +39-059-2056777, fax +39-059-2056937, E-mail: magni@unimo.it. Webpage: <http://morespace.unimore.it/carloalbertomagni/>

1 Introduction

This note deals with investment decisions in decentralized organizations: we analyze the case of a principal, such as the board of directors of a company, which delegates the execution of an economic activity to an agent, represented by a new business unit (or a subsidiary firm) which is managed by a manager (or a management team). The principal retains the right of periodically withdrawing funds from or investing additional funds into the business unit. In such a way, the overall business unit's performance depends on (i) the investment policy followed by the business unit's management, and (ii) the principal's decisions about injections and withdrawals of funds. We aim at measuring the economic efficiency of the business unit and, therefore, the manager's performance. We extrapolate it from the overall performance, offsetting the contribution of the principal to value creation.

In management science and operations research, the use of the net present value (NPV) for assessing economic performance is ubiquitous (Gallo and Peccati, 1993; Naim, 1996; Herroelen et al. 1997; Van der Laan, 2003; Giri and Dohi, 2004; Borgonovo and Peccati, 2004, 2006; Herroelen and Leus 2005; Borgonovo, Gatti and Peccati 2010; Wieseman 2010; Pasqual, Padilla and Jadotte, 2013). By far, it is the evaluation tool which is most used by firms in real-life applications (Remer and Nyeto, 1995a, 1995b; Slagmulder et al., 1995; Graham and Harvey, 2001; Sandahl and Sjögren, 2003). An investment's NPV measures the investors' wealth increase and, in a complete market, it equals the increase in firm value. For ex post performance, the NPV might be, in principle, replaced by its companion net terminal value (NTV): the latter is computed as the compounded value of the cash flows and, therefore, it measures the value added by the business unit at a given terminal date. Being only a multiple of the NPV, the NTV has the same sign of the NPV, so ex post economic performance is interchangeably captured either by the (hindsight) NPV or the NTV: if they are positive, value is created; if they are negative, value is destroyed.

However, given our economic setting, the NPV (or NTV) is not appropriate for measuring the economic efficiency of a business unit and the managers' per-

formance, for it depends on the principal's contributions and distributions in and out of the business unit. For example, suppose a subsidiary firm is incorporated by the principal and its management is endowed with \$100. Assume the management manages the endowment in such a way that a return of \$20 is earned after one period. Suppose the principal liquidates the subsidiary firm at the end of the period, so that \$100+\$20 is the final distribution. With an assumed 10% cost of capital, the NPV is $-100 + 120/1.1 = 9.09$. Consider now another subsidiary firm which is endowed with \$200 and guarantees a return of \$40 at the end of the period. The operating efficiency of the two units is the same, since $20/100 = 40/200 = 20\%$, but the second firm's NPV is twice the NPV of the first firm: $-200 + 240/1.1 = 18.18$. That is, the NPV (NTV) is proportional to the investment scale, regardless of the manager's skills. Likewise, considering a multi-period interval, the interim cash flows affect the NPV (NTV) regardless of the manager's performance skills.

Therefore, an appropriate measure capable of isolating the management's performance from the overall economic performance of a business unit should only depend on the investment policy decisions made by the manager. It is then necessary to extrapolate a metric which is independent of the contribution/distribution policy followed by the principal.

This paper just aims at

(i) assessing the operating efficiency of the business unit and, therefore, measuring the manager's capability of adding value for the company;

(ii) measuring the principal's contribution to economic performance, that is, assessing the principal's capability of injecting and withdrawing funds at the "right" times.

To pursue these aims, we make use of the notion of Profitability Index (PI), a widely known evaluation tool in real-life applications (Berk and DeMarzo 2011; Brealey, Myers and Allen 2011; Ross, Westerfield and Jordan 2011). In particular, we show that the cash flow contributions can be neutralized by focussing on the Return On Investment (ROI) earned by the business unit and by assuming a zero-contribution policy in the interim periods (i.e., no interim cash flows are added

to or subtracted from the unit). This will result in a *manager's profitability index* (MPI), which is only affected by the management's investment decisions. The manager's performance, in absolute amount, is given by the product of the MPI and the initial endowment; subtracting the latter form the overall economic performance, one captures the principal's contribution to wealth creation.

The remainder of the note is structured as follows. In section 2 we introduce the setting and the working assumptions. In section 3 we show how economic performance can be attributed to manager and principal, via the profitability-index notion. Some concluding remarks end the note.

2 Preliminary notions

We study the following problem: a principal (e.g., a firm's board of directors) entrusts a manager or a management team an initial endowment of $f_0 > 0$ to be used for managing a new business unit or a new subsidiary firm (henceforth, often called "unit"). The principal periodically makes a decision on the amount of cash flow that is additionally contributed in the unit or withdrawn from the unit for distributions to shareholders (or for other investment purposes within the firm). Let $f_t, t = 1, 2, \ldots, n-1$ denote the cash flows from the point of view of the unit: they represent contributions if $f_t > 0$ (cash flows from the firm to the unit) or distributions if $f_t < 0$ (cash flows from the unit to the firm). At time n, the principal closes off the unit and withdraws the project's residual value f_n; n is also the evaluation date, when the business unit's ex post performance is assessed for the operating interval $[0, n]$. To this end, we assume that the project is benchmarked against a similar asset traded in the capital markets, and that the benchmark rate of return is ϱ_t. We assume that the benchmark return is constant, unless otherwise stated: $\varrho_t := \varrho \; \forall t = 1, 2, \ldots, n$. Economic performance is measured by the value added, which is the value over and above the value that investors would have obtained if they had invested in the benchmark at the rate ϱ. This is the cutoff rate which signals value creation or destruction. The value added to the firm is also called Net Terminal Value (NTV), which is just the

(hindsight) Net Present Value compounded to time n:

$$NTV = \sum_{t=0}^{n} F_t(1+\varrho)^{n-t} = (1+\varrho)^n \cdot \sum_{t=0}^{n} F_t(1+\varrho)^{-t} = (1+\varrho)^n \cdot NPV$$

where $F_t := -f_t$ are the cash flows from the point of view of the principal.

The book value of the business unit's assets, as recorded in the historic balance sheet, is B_t, with $B_0 = f_0$, which is periodically increased (decreased) by the net operating profit recorded in the unit's income statement and increased (decreased) by the contributions (distributions) made by the principal. Letting x_t denote the net operating profit,

$$B_t = B_{t-1} + x_t + f_t \qquad t = 1, 2, \ldots, n-1. \tag{1}$$

B_t represents the capital invested in the business unit at time t (beginning of period $[t, t+1]$. At time n, the business unit is liquidated, so $B_n = 0$, which means $f_n = -B_{n-1} - x_n$.

Denoting as $\Delta B_t := B_t - B_{t-1}$ the change in capital, one can conveniently split it into two shares:

$$\Delta B_t = x_t + f_t. \tag{2}$$

The latter expresses a natural attribution for the change in the invested capital: it depends partly on the management's policy (which affects x_t) and partly on the principal's decisions (which affect f_t). Therefore, both x_t and f_t affect the investment base in each period, but while x_t is a direct result of the efficiency of the investment policy of the business unit's management, f_t depends on the exogenous decisions of the principal.

3 ROI and manager's profitability index

The overall unit's performance, as measured by the NTV, is the result of three drivers: (i) the initial endowment, (ii) the contributions/distributions in and out of the unit and (iii) the investment policy. The first two drivers summarize the investment base, which varies, period by period, as the principal withdraws funds from the unit or injects additional funds into it; these drivers depend on decisions

made by the principal. The third driver depends on decisions of the manager and, therefore, on how well the manager has employed the available funds. We aim at isolating the manager's performance from the overall performance. It is then evident that NTV is not an appropriate measure for assessing the operating efficiency of the unit (as well as the manager's performance), because it is the result of the joint effect of both principal and manager's decisions. One needs offset the initial investment (f_0) and the interim cash flows (f_t, $t < n$). We accomplish this task into two steps: first, we offset the interim cash flows, and then we offset the initial endowment.

3.1 Neutralizing interim cash flows

To neutralize the interim cash flows, we make the assumptions that the manager's investment policy is not affected by the magnitude of the cash flows deposited or withdrawn by the principal. We then measure what the performance would have been under the assumption of a *buy-and-hold* strategy, that is, assuming that the principal did not deposit nor withdraw any funds in the interim periods.

To assess the business unit's efficiency and, therefore, the management's performance, we consider eq. (2). As noted, the role of the manager in increasing the capital is given by x_t: essentially, the manager employs an amount of capital equal to B_{t-1} and gets a return of x_t. Hence, the ratio of x_t to B_{t-1} represents the degree of efficiency at which the capital is invested in a given period: this is the well-known Return On Investment (ROI), which we denote as $ROI_t := x_t/B_{t-1}$. Under the buy-and-hold assumption no interim cash flows exist, so the change in invested capital is just $\Delta B_t = x_t$, which implies $B_t = B_{t-1}+x_t = B_{t-1}(1+ROI_t)$. The business unit's ending value E_n is then a function of the ROIs:

$$E_n = B_0 \cdot (1 + ROI_1)(1 + ROI_2) \cdot \ldots \cdot (1 + ROI_n). \tag{3}$$

The resulting economic performance is measured by what we call the *manager's net terminal value* ($MNTV$):

$$MNTV = E_n - f_0(1 + \varrho)^n;$$

it measures the value over and above the amount that the principal would have received if it had invested f_0 at the benchmark return ϱ.

As the overall performance of the business unit is measured by $NTV = \sum_{t=0}^{n} F_t(1+\varrho)^{n-t}$, we get the principal's contribution by subtracting $MNTV$. We call it the principal's NTV ($PNTV$):

$$PNTV = \sum_{t=1}^{n} F_t(1+\varrho)^{n-t} - E_n$$

so that

$$NTV = MNTV + PNTV.$$

$PNTV$ quantifies the role of the principal in creating value, $MNTV$ represents the contribution of the manager to value creation, *given the initial endowment of* f_0. From (1),

$$B_{n-1} = \sum_{t=0}^{n-1} f_t \cdot \prod_{h=t+1}^{n-1} (1+ROI_h).$$

Also, $F_n = -f_n = B_{n-1} + x_t$ which implies

$$F_n = B_{n-1} \cdot (1+ROI_n) = \sum_{t=0}^{n-1} f_t \cdot \prod_{h=t+1}^{n} (1+ROI_h). \tag{4}$$

Therefore,

$$PNTV = \sum_{t=1}^{n-1} F_t(1+\varrho)^{n-t} + \sum_{t=0}^{n-1} f_t \cdot \prod_{h=t+1}^{n} (1+ROI_h) - E_n.$$

As $B_0 = f_0$, eq. (3) becomes $E_n = f_0 \cdot \prod_{t=1}^{n}(1+ROI_t)$, whence

$$PNTV = \sum_{t=1}^{n-1} F_t(1+\varrho)^{n-t} + \sum_{t=0}^{n-1} f_t \cdot \prod_{h=t+1}^{n} (1+ROI_h) - f_0 \cdot \prod_{t=1}^{n}(1+ROI_t)$$

whence

$$PNTV = \sum_{t=1}^{n-1} F_t\Big((1+\varrho)^{n-t} - (1+ROI)^{t,n}\Big) \tag{5}$$

where $(1+ROI)^{t,n} := \prod_{h=t+1}^{n}(1+ROI_h)$. Accordingly, the $MNTV$ can be reframed as

$$MNTV = F_0\Big((1+\varrho)^{n} - (1+ROI)^{0,n}\Big). \tag{6}$$

We have then decomposed the business unit's NTV into two shares, where the role of the the ROIs (and, therefore, the management's contribution) is highlighted. In particular, it is clear that $PNTV$ depends on the manager's capability of effectively managing funds (expressed by the ROIs) as well as on the interim cash flows, whereas $MNTV$ depends on the former but not on the latter. Therefore, $MNTV$ offsets the policy of interim contributions and withdrawals made by the principal.

3.2 Neutralizing the initial endowment

The $MNTV$ still depends on the initial endowment, which is a principal's decision. We then divide by f_0, so finding the excess return per unit of invested capital:

$$\pi_m = \frac{MNTV}{f_0} = \prod_{t=1}^{n}(1 + ROI_t) - (1 + \varrho)^n.$$

Note that $\partial\pi_m/\partial f_t = 0$ for all $t = 0, 1, 2, \ldots, n$, so π_m is indeed independent of the principal's policy of deposits/withdrawals.

It is worth noting that π_m is just the (compounded value of the) profitability index of the asset $(-f_0, 0, \ldots 0, E_n)$, which is the cash-flow stream generated under the assumption of a buy-and-hold strategy:

$$\frac{-f_0 + \frac{E_n}{(1+\varrho)^n}}{f_0} \cdot (1 + \varrho)^n = \frac{f_0 \cdot (1 + ROI)^{0,n} - f_0(1 + \varrho)^n}{f_0} = \pi_m.$$

We call π_m the *manager's profitability index* (MPI).

Note that, to assess the manager's performance, we have derived a *relative* measure of worth, not an *absolute* measure of worth. The $MNTV$ is an absolute measure of worth and it informs about the contribution of the manager to value added, *given the initial contribution* f_0. The latter amount has not to do with the manager's performance, so $MNTV$ informs about the manager's skill of amplifying the initial investment base: $MNTV = f_0 \cdot \pi_m$. The first factor is determined by the principal's decision on the investment scale, so the manager's performance is to be assessed on a *per-dollar* basis. Conversely, the principal's contribution to value is determined by an absolute amount of money, the $PNTV$.

Note that it may well occur that $MNTV > 0$ and $PNTV < 0$, which means that, notwithstanding the operating efficiency of the unit is positive, the principal has not been able to profit from the management' skills, following a suboptimal contribution policy (i.e., overall, cash flows have been deposited or withdrawn at the "wrong" times).

More generally, if one allows for time-variant benchmark rates of return, the compounding factor $(1+\varrho)^{n-t}$ can be replaced by the $(1+\varrho)^{t,n} := \prod_{h=t+1}^{n}(1+\varrho_h)$, so we have proved the following result.

Proposition 1. *Consider a business unit, managed by an agent, and let F_t, $t = 0, 1, \ldots, n-1$ be the capital injections and withdrawals made by the principal. The operating efficiency of the unit (and, therefore, the manager's performance) is measured by the Manager's Profitability Index (MPI):*

$$\pi_m = \frac{MNTV}{f_0} = \prod_{t=1}^{n}(1 + ROI_t) - \prod_{t=1}^{n}(1 + \varrho_t); \tag{7}$$

the MPI is a function of the business unit's ROIs (as well as the benchmark rate ϱ_t) and expresses the profitability index of the cash-flow stream $(F_0, 0, \ldots, 0, E_n)$ which would result by a buy-and-hold strategy. It offsets the contribution policy of the principal and only takes account of the investment policy of the business unit's management. Value is created (i.e., the unit has outperformed the benchmark) if and only if $\pi_m > 0$. Further, the NTV of the given cash-flow vector can be decomposed into manager's and principal's component:

$$NTV = \overbrace{\sum_{t=1}^{n-1} F_t\Big((1+\varrho)^{t,n} - (1+ROI)^{t,n}\Big)}^{principal\ NTV} + \overbrace{F_0\Big((1+\varrho)^{0,n} - (1+ROI)^{0,n}\Big)}^{manager's\ NTV}. \tag{8}$$

Equation (8) enables the analyst to interpret the NTV as an n-tuple of excess returns obtained by withdrawing funds from an asset and injecting them in another asset. To better understand this interpretation, we explicitly distinguish between contributions and distributions: let $T^+ = \{t \in \mathbb{N} \text{ such that } f_t > 0\}$ be the set of dates where the principal contributes capital into the unit and

$T^- = \{t \in \mathbb{N} \text{ such that } f_t < 0\}$ the set of dates where the principal withdraws funds from the unit. Then, (8) can be written as

$$NTV = \sum_{t \in T^+} f_t \Big((1 + ROI)^{t,n} - (1 + \varrho)^{t,n} \Big) - \sum_{t \in T^-} f_t \Big((1 + \varrho)^{t,n} - (1 + ROI)^{t,n} \Big).$$

The above equality informs that the NTV is just equal to the value added that would be obtained by alternatively taking long and short positions on the business unit and on the benchmark asset. In particular, when $t \in T^+$, $f_t[(1 + ROI)^{t,n} - (1 + \varrho)^{t,n}]$ is the result of a long position on the unit and a short position on the asset; that is, the principal borrows f_t at the borrowing rates ϱ_h and invests it at the rates ROI_h, $h = t + 1, \ldots, n$. When $t \in T^-$, the opposite occurs: $f_t[(1 + \varrho)^{t,n} - (1 + ROI)^{t,n}]$ can be interpreted as the result of a long position on the benchmark and a short position on the business unit; that is, the principal borrows f_t at the borrowing rates ROI_h and invests it at the investment rates ϱ_h, $h = t + 1, \ldots, n$.

Let $ROI_{0,n} = \prod_{t=1}^{n} (1 + ROI)^{t,n} - 1$ expresses the overall *manager's rate of return* in the interval $[0, n]$. While the MPI is essential in capturing economic efficiency, the manager' rate of return $ROI_{0,n}$ is sufficient to rank different business units or managers if (i) the benchmark rate is time-invariant, or (ii) the benchmark rate is time-variant and equal across units. In these cases, maximization of π_m is equal to maximization of $ROI_{0,n}$.

Note that the MPI also has a cardinal value, as it is capable of quantifying the relative performance and, therefore, the managers' skills: the ratio π_m^j / π_m^k tells us by how much manager j has outperformed manager k. For example, $\pi_m^j / \pi_m^k = 2$ means that manager j has performed twice as good as manager k.

4 Concluding remarks

The Net Present Value (NPV) is the main evaluation tool for industrial investments. It expresses the investors' wealth increase and is a function of the project's cash flows and the cost of capital, which is a benchmark return against which the economic performance of an investment (or a portfolio of investments) is evaluated. In a decentralized organization where the execution of an economic activity

project is entrusted to a business unit (or a subsidiary firm) which is managed by a manager (or management team), there often arises the need of ex post auditing. This means that the operating efficiency of the business unit is assessed, which is expression of its management's skills. If the manager has no control over the cash flows injected and withdrawn, the Net Present Value (NPV) or its companion Net Terminal Value (NTV) cannot be the appropriate metrics for such an analysis. The reason is that the overall economic performance is measured by the NTV and the NTV just depends on injections and withdrawals, whose amounts depend on the principal's decisions. Therefore, a different metric is to be used for assessing a manager's skill in managing the unit. To this end, one must offset the interim cash flows and the initial contribution and supplies a measure of worth on a per-dollar basis.

We introduce the *manager's profitability index* (MPI), which is just a relative measure of worth. Being a function of the business unit's ROIs and being invariant under changes in the cash flows, it expresses the economic efficiency of the unit and, therefore, measures the manager's performance. The positive sign of MPI signals value creation (performance is over the benchmark), whereas a negative sign signals value destruction (performance is under the benchmark). Various managers can be ranked via their MPIs and the ratio of two MPIs detects the relative skill of a manager with respect to another one in a given time interval.

The NTV is broken down into two shares: the manager's NTV, which quantifies the wealth increase due to the management's skills (given the initial endowment) and the principal's NTV, which measures the role of the contribution/distribution policy in creating value.

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