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# ROI and profitability index: A note on managerial performance

Carlo Alberto Magni\*

## 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 It is assumed that the manager has no control over the cash flows injected into the unit or withdrawn from it: such decisions are made by the principal.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Terminal Value (*NTV*) are appropriate measures for this purpose, because they depend on the cash flows injected and withdrawn by the principal.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.

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# 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 from 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  $f_t, t = 1, 2, \dots, n - 1$  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  $\varrho_t$ . We assume that the benchmark return is constant, unless otherwise stated:  $\varrho_t := \varrho \forall t = 1, 2, \dots, n$ . 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  $\varrho$ . 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,

$$B_t = B_{t-1} + x_t + f_t \quad t = 1, 2, \dots, n-1. \quad (1)$$

$B_t$  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:

$$\Delta B_t = x_t + f_t. \quad (2)$$

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:

$$E_n = B_0 \cdot (1 + ROI_1)(1 + ROI_2) \cdot \dots \cdot (1 + ROI_n). \quad (3)$$

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  $\varrho$ .

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

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

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

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

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

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



We have then decomposed the business unit's  $NTV$  into two shares, where the role of 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  $t = 0, 1, 2, \dots, n$ , so  $\pi_m$  is indeed independent of the principal's policy of deposits/withdrawals.

It is worth noting that  $\pi_m$  is just the (compounded value of the) profitability index of the asset  $(-f_0, 0, \dots, 0, E_n)$ , 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  $\pi_m$  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  $F_t$ ,  $t = 0, 1, \dots, n-1$  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):*

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

the MPI is a function of the business unit's ROIs (as well as the benchmark rate  $\varrho_t$ ) and expresses the profitability index of the cash-flow stream  $(F_0, 0, \dots, 0, E_n)$  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:

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

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

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

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  $\varrho_h$  and invests it at the rates  $ROI_h$ ,  $h = t + 1, \dots, n$ . 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  $\varrho_h$ ,  $h = t + 1, \dots, n$ .

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's 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  $\pi_m$  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  $\pi_m^j / \pi_m^k$  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.

## References

- Borgonovo, E., Gatti, S., Peccati, L. 2010. What drives value creation in investment projects? An application of sensitivity analysis to project finance transactions. *European Journal of Operational Research*, 205(1) (August), 227–236.

- Borgonovo, E., Peccati, L. 2004. Sensitivity analysis in investment project evaluation. *International Journal of Production Economics*, 90, 17–25.
- Borgonovo, E., Peccati, L. 2006. The importance of assumptions in investment evaluation. *International Journal of Production Economics*, 101, 298-311.
- Giri, B.C., Dohi, T. 2004. Optimal lot sizing for an unreliable production system based on net present value approach. *International Journal of Production Economics*, 92, 157-167.
- Graham, J., Harvey, C. 2001. The theory and practice of corporate finance: Evidence from the field. *Journal of Financial Economics*, 60, 187-243.
- Herroelen, W.S., Leus, R. 2005. Project scheduling under uncertainty: Survey and research potentials, *European Journal of Operational Research* 165(2), 289-306.
- Herroelen, W.S., Van Dommelen, P., Demeulemeester, E.L. 1997. Project network models with discounted cash flows A guided tour through recent developments, *European Journal of Operational Research* 100(1), 97-121.
- Lindblom, T., Sjögren, S. 2009. Increasing goal congruence in project evaluation by introducing a strict market depreciation schedule. *International Journal of Production Economics* 121(2) (October), 519–532.
- Pasqual, J., Padilla, E., Jadotte, E. 2013. Technical note: Equivalence of different profitability criteria with the net present value. *International Journal of Production Economics*, 142(1) (March), 205–210.
- Remer, D.S., Nieto, A.P. 1995. A compendium and comparison of 25 project evaluation techniques. Part 1: Net present value and rate of return methods. *International Journal of Production Economics*, 42, 79–96.
- Sandahl, G., Sjögren, S. 2003. Capital budgeting methods among Swedens largest groups of companies. The state of the art and a comparison with earlier studies. *International Journal of Production Economics*, 84, 51–69.

- Slagmulder, R., Bruggeman, W., van Wassenhove, L., 1995. An empirical study of capital budgeting practices for strategic investments in CIM technologies. *International Journal of Production Economics* 40, 121–152.
- van der Laan, E. 2003. An NPV and AC analysis of a stochastic inventory system with joint manufacturing and remanufacturing. *International Journal of Production Economics*, 81-82, 317–331.
- Wiesemann, D., Kuhn D., Rustem B. 2010. Maximizing the net present value of a project under uncertainty. *European Journal of Operational Research*, 202(2) (April), 356–367.