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Performance Evaluation and Corporate Income Taxes in a Sequential Delegation Setting

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Abstract. We consider a setting where a firm delegates an investment decision and, subsequently, a sales decision to a privately informed manager. For both decisions corporate income taxes have real effects. We show that compensating the manager based on pre-tax residual income can ensure after-tax NPV-maximization ("goal congruence") for each decision problem in isolation. However, this metric fails if both decisions are nontrivial, since it requires asset-specific hurdle rates and hence precludes asset aggregation. After-tax residual income metrics (e.g., EVA) allow the firm to consistently apply its after-tax cost of capital as the hurdle rate to its aggregate asset base. We show that existing tax depreciation schedules may explain why firms in practice use more accelerated depreciation schedules than those suggested by previous studies. Our findings also rationalize the widespread use of "dirty surplus" accounting for windfall gains and losses for managerial retention purposes.

Keywords: capital budgeting, income taxes, residual income (EVA), hurdle rates

JEL Classification: M41, D82, G31, G34

Corporate income taxes are an important factor for managerial decision-making.[1] At the same time, tax considerations have been notably absent from the delegation and incentives literature. A possible explanation for this omission is that taxes are often merely seen as a "scaling" variable, similar to price levels. However, for a variety of managerial decisions, such as capital investments, taxes clearly have real effects. Hence, there appears to be a gap in the literature as to how taxes affect decision-making and managerial compensation. The present paper addresses this issue.

The decision-relevance of taxes mainly arises from an attendant intertemporal displacement of cash flows. We therefore develop a multi-period model where the firm first faces an investment decision and then a subsequent sales decision: how should the output from the investment project, if undertaken, be split over cash sales and (risky) credit sales? For both decisions, taxes have real effects. The firm bears the full pre-tax cost of the investment upfront and benefits from the depreciation tax shield only later. Receivables are taxed by the IRS with their nominal (gross) value when the credit sales are made, regardless of time value of money or default risk considerations.[2]

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By integrating investment and sales decisions, we are able to address several important accounting issues, such as revenue recognition and aggregation of qualitatively different assets—specifically, PP&E, receivables, and deferred taxes. Moreover, since the optimal sales decision will generally depend on updated revenue information received after the investment is made, our model is inherently dynamic. Earlier studies on delegated investment decisions with multi-period returns, in contrast, have confined attention to settings in which no information is revealed and no decisions are made after the investment is undertaken.[3]

We ask how the firm can delegate both investment and sales decisions to a better informed manager while ensuring the manager internalizes the shareholders' objective, which is to maximize the after-tax net present value. Residual income, the amount by which income exceeds the opportunity cost of capital, is a natural candidate for a performance measure in such a multi-period setting. Traditionally, residual income has been derived based on pre-tax operating income. More recently, a growing number of firms have adopted "economic value added" (EVA) as a particular form of after-tax residual income. EVA proponents argue that only an after-tax metric is suitable from an equity valuation perspective. In the contracting setting analyzed here, pre-tax performance evaluation can never outperform after-tax evaluation. Yet we identify conditions under which the two are outcome-equivalent and others under which after-tax residual income is strictly preferred.[4]

When facing the investment or the sales decision in isolation, we show that goal congruence can be achieved with either pre-tax or after-tax residual income. However, if both decision problems are jointly present, and the firm confines itself to using only one capital charge rate for all assets, then only the after-tax metric attains goal congruence. Hence, pre-tax residual income can align managers' objectives with those of shareholders for a particular decision, yet this metric ultimately fails because it requires asset-specific hurdle rates and therefore precludes asset aggregation. Given the importance of aggregation for accounting, we view this as a useful insight into the relative merits of alternative performance metrics.

When implementing after-tax residual income, firms have to decide how to account for taxes. We first consider cash accounting for taxes in that no deferred tax assets or liabilities are recorded. Goal congruence then requires a specific form of intertemporal matching. First, the total after-tax investment return is decomposed into its after-tax operating cash flow and depreciation tax shield components. The after-tax operating cash flow is then matched period-by-period with the effective after-tax net investment cost, which equals the initial cash outlay less the present value of the depreciation tax shield. We characterize the optimal internal depreciation policy and show that tax depreciation and internal depreciation are complements. Given that most companies use accelerated tax depreciation, this may explain why internal depreciation on average is more accelerated than earlier studies have suggested in the absence of taxes.[5]

If both investment and sales decisions are delegated to the manager, these two control problems become intertwined: the investment returns over time are endogenously determined by the sales plan which, in turn, is contingent on the resolution of some residual demand uncertainty. We show that after-tax residual income achieves goal congruence if the central office values receivables at their fair after-tax value and commits to asset valuation rules for PP&E that are contingent upon the demand realization. This is consistent with the widespread use of flexible accounting rules in performance evaluation—most notably the "dirty surplus" accounting for windfall losses in the case of uncontrollable events that adversely affect the profitability of an asset.

While EVA-adopting firms often revert to cash accounting for taxes (Young and O'Byrne, 2001), we also consider more GAAP-consistent accounting methods. The goal is to identify a set of "minimally invasive" adjustments to GAAP that allow for goal congruence.[6] We find that goal congruence remains attainable if the firm retains some flexibility by fine-tuning the capitalization factor for deferred taxes.[7]

Our analysis suppresses explicit agency cost considerations by assuming the firm wants the manager to maximize the after-tax net present value. Instead, we allow for the manager's time preferences to differ from those of the shareholders, either because of the manager's restricted access to capital markets or the possibility of internal restructurings (or managerial turnover). Previous literature has shown that the insights obtained from such "goal congruence" models are robust in that they qualitatively carry over to optimal contracting settings with moral hazard and adverse selection.[8]

Furthermore, our approach allows us to provide a purely tax-based explanation of the well-documented empirical finding that firms' hurdle rates tend to exceed their after-tax cost of capital (e.g., Poterba and Summers, 1995). Existing explanations of this finding are based on informational rents (Antle and Eppen, 1985), private benefits of control (Lambert, 2001; Baldenius, 2003), or financing constraints. We show that, if compensation is based on pre-tax residual income, then in order to have the manager internalize the tax consequences of his actions, the hurdle rate has to exceed the after-tax cost of capital. A key empirical implication of our model is therefore that firms using pre-tax residual income should on average have higher capital charge rates than comparable firms employing after-tax metrics such as EVA.

The paper is organized as follows. Section 1 lays out the basic capital budgeting model with after-tax residual income as the performance measure. Section 2 adds credit sales (and hence accounts receivable) to the analysis. Section 3 addresses pre-tax residual income as the performance metric. In Section 4, we consider alternative capitalization rules for deferred taxes. Section 5 concludes.

1. Investments in Capital Assets

We consider a firm that consists of a central office, acting in the interest of shareholders, and a self-interested manager. The manager has private information regarding the profitability of an investment project that becomes available at date 0 (the beginning of period 1). For the sake of illustration, think of the investment object as a plant with a useful life of T periods. The investment decision is denoted by the indicator variable $I \in \{0, 1\}$. If $I = 1$, the firm incurs a cash outlay of b and the plant generates x_i units of output in period i, at marginal costs normalized to zero.

Units produced in period i are sold at date i (the end of period i) at pre-tax revenues of $\phi_i(x_i)\theta$. As in Reichelstein (1997) and Rogerson (1997), we assume that at date 0 only the manager knows the time-invariant variable θ, which scales revenues in each period. The remaining "base revenue" component in period i, $\phi_i(x_i) \geq 0$, is commonly known and (for now) assumed to be deterministic.[9] All revenues from period-i sales are collected instantaneously. (Note that in this base setting one could simply set $\phi_i(x_i) \equiv x_i$; however, the additional generality will be helpful later in the analysis when we consider credit sales.) The sequence of events is depicted in Figure 1.

We explicitly incorporate the fact that the firm pays income taxes. Let the marginal tax rate be denoted by t. The depreciation rates employed by the IRS for taxation are represented by the vector $\boldsymbol{\delta} = (\delta_1, \ldots, \delta_T)$, where $\sum_i \delta_i = 1$.[10] Taxes paid in period i are

$$T_i = t[\phi_i(x_i)\theta - \delta_i b].$$

In the presence of taxes, any investment project has two return components: the after-tax operating cash flow, $(1-t)\phi_i(x_i)\theta$, and the depreciation tax shield, $t\delta_i b$. The resulting after-tax net present value then equals

$$\begin{aligned} NPV(\theta) &= \sum_{i=1}^{T} \gamma^i [(1-t)\phi_i(x_i)\theta + t\delta_i b] - b \\ &\equiv (1-t)\boldsymbol{\Gamma}\boldsymbol{\Phi}\theta + t\boldsymbol{\Gamma}\boldsymbol{\delta} b - b. \end{aligned} \tag{1}$$

Here, $\boldsymbol{\Gamma} = (\gamma, \ldots, \gamma^T)$ is a row vector with $\gamma = 1/(1+r)$, where r is the firm's after-tax cost of capital, and $\boldsymbol{\Phi} = (\phi_1(x_1), \ldots, \phi_T(x_T))$.[11]

If the central office knew θ, it would invest whenever $\theta \geq \theta^*$, where θ^* denotes the first-best profitability cut-off given by $NPV(\theta^*) = 0$. However, since only the manager knows θ, the central office delegates the investment decision to him and compensates him based on residual income, $RI_i(\theta|\cdot)$, which, in turn, is a function of the underlying profitability parameter, θ, and a set of accounting rules. We confine attention to residual income-based compensation schemes as this performance metric is widely used and has desirable properties in multi-period delegation settings.

As noted in the Introduction, we suppress explicit moral hazard considerations and instead assume that the manager's time preferences may differ from those of the

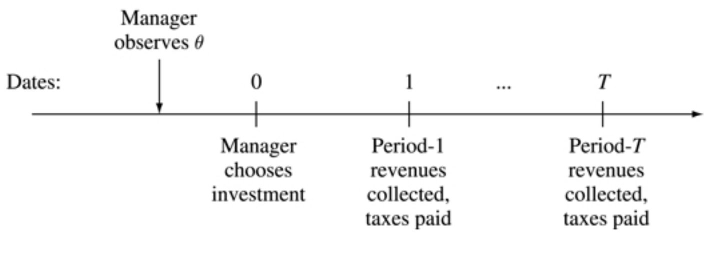

Figure 1. Timeline with investment decisions only.

shareholders. This may be caused by the manager's restricted ability to borrow or lend or by a truncated planning horizon (e.g., due to anticipated intrafirm reorganizations or managerial turnover). In particular, the manager is assumed to attach strictly positive weights $\mathbf{u} = (u_1, \ldots, u_T)$, unknown to the central office, to the sequence of performance measures so that his date-0 objective function is to maximize $\sum_{i=1}^{T} u_i RI_i(\theta| \cdot)$.[12]

An incentive scheme is said to induce "goal congruence" if the manager, for any $\mathbf{u}$, is strictly better off investing if $\theta > \theta^*$, and vice versa. Formally:

Definition 1 *Goal congruence is obtained if and only if the following holds*:

$$\sum_{i=1}^{T} u_i RI_i(\theta| \cdot)\left\{ \begin{matrix} > \\ < \end{matrix} \right\}0, \quad \textit{if } NPV(\theta)\left\{ \begin{matrix} > \\ < \end{matrix} \right\}0, \quad \textit{for any } \mathbf{u} = (u_1, \ldots, u_T).$$

As shown in earlier studies, unknown time preferences on the part of the manager create a need for matching investment costs with benefits, so as to ensure the manager internalizes the shareholders' objective in each period.

It is useful at this stage to review the scope of our analysis. Our search for goal congruent incentive schemes is confined to performance measures that linearly aggregate accounting variables frequently used for performance evaluation. In this section these are revenues, taxes, depreciation and book value of PP&E; later we also consider accounts receivable and deferred taxes. In particular, we ignore "forcing" contracts that depend on information to become available at some future date (e.g., the realization of revenue uncertainty in Section 2). Clearly, there are alternative contractual solutions that can achieve goal congruence outside the class of schemes considered here.

We first consider cash accounting for taxes. This appears consistent with the practice of most EVA-adopting firms (Young and O'Byrne, 2001). This particular form of residual income, denoted RI_t^c, is derived by subtracting from pre-tax operating cash flow (i) taxes paid, T_i, (ii) internal depreciation as represented by the vector of depreciation percentages $\mathbf{d} = (d_1, \ldots, d_T)$ with $\sum_i d_i = 1$, and (iii) a capital charge based on a hurdle rate of ρ that is applied to the previous period's ending net book value. Hence,

$$RI_i^c(\theta|\mathbf{d}, \rho) = \phi_i(x_i)\theta - T_i - d_i b - \rho\left[1 - \sum_{j=0}^{i-1} d_j\right] b, \tag{2}$$

where the superscript "c" denotes cash accounting for taxes. Throughout the paper, we adopt the convention that $d_0 = 0$. It is instructive first to lump together depreciation and capital charges and to refer to the resulting vector $\mathbf{z} = (z_1, \ldots, z_T)$ as an "intertemporal cost allocation." As first noted in Rogerson (1997, Proposition 2), there is a one-to-one correspondence between $\mathbf{z}$ and $\mathbf{d}$. For any collection of a tidy depreciation schedule and a capital charge rate, $(\mathbf{d}, \rho)$, there exists a corresponding intertemporal cost allocation, $\mathbf{z}$, such that the following holds:

$$z_i = d_i + \rho\left[1 - \sum_{j=0}^{i-1} d_j\right], \quad \sum_i d_i = 1. \tag{3}$$

Consider the following intertemporal cost allocation:

$$z_i^c = \frac{\phi_i(x_i)}{\mathbf{\Gamma}\boldsymbol{\Phi}}(1 - t\mathbf{\Gamma}\boldsymbol{\delta}) + t\delta_i. \tag{4}$$

Straightforward algebra establishes that this intertemporal cost allocation ensures that RI_i^c is proportional to the shareholders' objective for any period i:

$$\begin{aligned} RI_i^c(\theta \mid \mathbf{z}^c) &= (1-t)\phi_i(x_i)\theta + t\delta_i b - \left[\frac{\phi_i(x_i)}{\mathbf{\Gamma}\boldsymbol{\Phi}}(1 - t\mathbf{\Gamma}\boldsymbol{\delta}) + t\delta_i\right]b \\ &= \frac{\phi_i(x_i)}{\mathbf{\Gamma}\boldsymbol{\Phi}}[(1-t)\mathbf{\Gamma}\boldsymbol{\Phi}\theta - (1 - t\mathbf{\Gamma}\boldsymbol{\delta})b] \\ &= \frac{\phi_i(x_i)}{\mathbf{\Gamma}\boldsymbol{\Phi}} NPV(\theta). \end{aligned}$$

As a consequence, the manager makes the desired investment decision for any $\mathbf{u}$. This leads to our first result (the proof resembles that of Proposition 3 in Reichelstein, 1997 and is hence omitted).

Proposition 1 *After-tax residual income with cash accounting for taxes,* $RI_i^c(\theta|\cdot)$, *achieves goal congruence if* $(\mathbf{d^c}, \rho^c)$ *correspond to (according to (3)) the intertemporal cost allocation in (4). In particular,* $\rho^c = r$ *holds.*

Using arguments found in Rogerson (1997) and Reichelstein (1997), one can show that the above incentive scheme is indeed the unique solution (up to a normalizing constant) to achieve goal congruence within the class of linear performance measures depending on revenues, taxes paid in cash, depreciation and net book value. Thus, the hurdle rate has to equal r.

The intertemporal cost allocation in (4) generalizes the so-called relative benefit cost allocation.[13] It is therefore instructive to compare the two schemes in more detail to better understand the impact of income taxes. In the absence of taxes, the investment cost allocated to period i simply amounts to $v\phi_i(x_i)$ for some time-invariant scalar

$$v = \frac{b}{\sum_{j=1}^{T} \gamma^j \phi_j(x_j)}.$$

The cost allocation scheme in (4), in contrast, has an affine structure in that it effectively separates the total investment return into its after-tax-operating-cash-flow and depreciation-tax-shield components. In the first step, the central office subtracts the present value of the depreciation tax shield from the initial cash outlay, which yields an "effective after-tax net investment cost" of $(1 - t\boldsymbol{\Gamma\delta})b$. This amount is then matched with the after-tax operating cash flow in each period. This separation of the two return streams is key to achieving goal congruence, because only the after-tax operating cash flow depends on the manager's private information parameter, θ, whereas the depreciation tax shield does not.[14]

In the absence of taxes, the relative benefit depreciation schedule implies annuity (decelerated) depreciation for projects with uniform operating cash flows. That is, $d_i = (1 + r)d_{i-1}$, if $t = 0$ and $\phi_i(x_i) = \phi_j(x_j)$ for all i, j. This is clearly at odds with firm practice. As Lambert (2001) and Glover (2002) note, companies overwhelmingly use straight-line (or even more accelerated) depreciation internally. Our analysis may help explain this puzzle. The intertemporal cost allocation in (4) suggests that tax depreciation and internal depreciation for performance measurement are linked. To investigate this linkage more formally, we look at the special case where $T = 2$, so that $d_2 = 1 - d_1$. In this case, d_1 is a compact measure of more or less accelerated depreciation.

Corollary 1 *If taxes are accounted for on a cash basis and $T = 2$, then d_1^c is increasing in δ_1.*[15]

To see why tax and managerial depreciation are complements, suppose that δ_1 increases by an amount k. The manager then should invest more often (i.e., θ^* decreases), due to an increase of $(\gamma - \gamma^2)tkb$ in the present value of the depreciation tax shield. If the internal depreciation schedule were held constant, then a project that was marginally profitable initially (and hence showed a marginally positive RI_2) may now result in $RI_2 < 0$, since the period-2 depreciation tax shield decreases by tkb. To ensure proper intertemporal matching, d_1^c must be raised. We will revisit this linkage between tax and managerial depreciation below for the case of capitalized deferred taxes.

To summarize, our analysis identifies an additional force that helps explain why companies in practice employ depreciation schedules that are more accelerated than suggested by prior studies for settings without taxes. The vast majority of firms use accelerated tax depreciation. By Corollary 1, therefore, internal depreciation on average also tends to be more accelerated.

2. Investment and Credit Sales Decisions

In the previous analysis, all sales revenues were collected instantaneously, and, as in Rogerson (1997) and Reichelstein (1997), the investment return pattern over time was assumed exogenous. To simultaneously relax both these assumptions, we now allow the firm to engage in credit sales. This is also of interest from a tax-planning perspective, as the IRS treatment of accounts receivable deviates from "fair value" principles.

Of the x_1 units of period-1 output, x_{11} units are sold on a cash basis (collected instantaneously), while the remaining x_{12} units are sold on a credit basis. A proportion p of the resulting receivables is collected in period 2, while the remaining fraction of $(1-p)$ is subject to default.[16] To add a non-trivial sales planning problem, we assume that, after the investment has been made, an additional (possibly multi-dimensional) random variable, ε, is realized that potentially affects all base revenue functions

$$(\phi_1(x_{11} \mid \varepsilon), \phi_{12}(x_{12} \mid \varepsilon), \phi_2(x_2 \mid \varepsilon), \ldots, \phi_T(x_T \mid \varepsilon)),$$

and thereby also the optimal ratio of cash versus credit sales in period 1. Let

$$R_1^{nom} \equiv \phi_{12}(x_{12}|\varepsilon)\theta$$

denote the nominal (gross) receivables from credit sales at the end of period 1.

The current US tax code discourages credit sales in that the IRS ignores the default risk and the time value of money by taxing the nominal receivables R_1^{nom} in period 1. The IRS then grants the firm a (non-compounded) tax refund in period 2 when the defaults occur. Hence, the tax bills for the respective periods are:

$$T_1 = t[\phi_1(x_{11}|\varepsilon)\theta + R_1^{nom} - \delta_1 b],$$
$$T_2 = t[\phi_2(x_2|\varepsilon)\theta - (1-p)R_1^{nom} - \delta_2 b],$$

while, as before, $T_i = t[\phi_i(x_i|\varepsilon)\theta - \delta_i b]$ for $i > 2$. The expected date-1 after-tax present value of the receivables equals $\gamma\Delta R_1^{nom}$, where $\Delta \equiv p + t(1-p)$. The optimal sales decision now depends on ε and is determined by:

$$x_{11}^*(\varepsilon) \in \arg\max_{x_{11} \in [0,x_1]} \{(1-t)\phi_1(x_{11}|\varepsilon) + (\gamma\Delta - t)\phi_{12}(x_1 - x_{11}|\varepsilon)\}, \tag{5}$$

and $x_{12}^*(\varepsilon) \equiv x_1 - x_{11}^*(\varepsilon)$.[17]

The realization of ε in general also affects the profitability of the investment project. The *ex-post* after-tax net present value of the project, for any ε, equals

$$\begin{aligned} NPV(\theta, \varepsilon) = {} & \gamma[(1-t)\phi_1(x_{11}^*(\varepsilon)|\varepsilon) - t\phi_{12}(x_{12}^*(\varepsilon)|\varepsilon)]\theta + \gamma^2\Delta\phi_{12}(x_{12}^*(\varepsilon)|\varepsilon)\theta \\ & + \sum_{i=2}^{T} \gamma^i (1-t)\phi_i(x_i|\varepsilon)\phi - (1 - t\boldsymbol{\Gamma\delta})b, \end{aligned} \tag{6}$$

provided the sales decision is made optimally. Let $NPV(\theta) = E_\varepsilon[NPV(\theta, \varepsilon)]$ denote the *ex-ante* after-tax net present value with $E_\varepsilon[\cdot]$ as the expectation operator with regard to ε. As before we denote by θ^* the first-best profitability cut-off, such that $NPV(\theta^*) = 0$. For future reference, we define a new function,

$$f(\varepsilon) \equiv NPV(\theta, \varepsilon) - NPV(\theta), \tag{7}$$

that captures the profitability implications of a particular realization of ε. For instance, $f(\varepsilon) < 0$ implies a poor realization of ε (a windfall loss), and vice versa.

We now consider more flexible accounting rules. In particular, we allow the firm to engage in "dirty surplus asset write-offs" in case of windfall losses. Upon observing ε, for performance evaluation purposes the firm may revalue the plant at an initial outlay of β different from the actual outlay b. Unlike under US GAAP, any windfall gains/losses are recorded directly in the divisional balance sheet without "flowing through" the income statement. They only indirectly affect the manager's performance metrics via the resulting changes in depreciation and capital charges. (Note that tax depreciation remains based on b.)

In this generalized setting, the firm has two assets on its balance sheet: PP&E and accounts receivable. Consistent with firm practice, we impose the aggregation requirement that the firm employs only one uniform capital charge rate to both assets for the purpose of computing residual income. The latter can then be written as follows (suppressing the arguments in $\phi_i(\cdot)$):

$$RI_1^c(\theta, \varepsilon|\mathbf{d}, \rho, R_1, \beta) = [(1-t)\phi_1 - t\phi_{12}]\theta + t\delta_1 b + R_1 - d_1\beta - \rho\beta, \tag{8}$$

$$\begin{aligned} RI_2^c(\theta, \varepsilon|\mathbf{d}, \rho, R_1, \beta) = {} & [(1-t)\phi_2 + \Delta\phi_{12}]\theta + t\delta_2 b - R_1 - d_2\beta \\ & - \rho[R_1 + (1-d_1)\beta], \end{aligned} \tag{9}$$

$$\begin{aligned} RI_i^c(\theta, \varepsilon|\mathbf{d}, \rho, \beta) = {} & (1-t)\phi_i\theta + t\delta_i b - d_i\beta \\ & - \rho\left[1 - \sum_{j=0}^{i-1} d_j\right]\beta, \quad \text{for } i > 2, \end{aligned} \tag{10}$$

where R_1 is the value assigned to accounts receivable at the end of period 1.

To capture the intuition that the manager is not just better informed about the permanent profitability parameter θ, but also learns faster about the short-term market conditions, we assume the manager observes the realization of ε after investing, but before making the sales decision. The central office, in contrast, does not observe ε until the end of period 1. Hence, the manager has more timely demand information, and we assume that this timeliness is essential in that the sales decision has to be made before the central office observes ε. As a consequence, this decision also needs to be delegated to the manager.[18] See Figure 2 for the sequence of events.

Goal congruence now becomes a more demanding concept: the manager should have incentives to make the efficient investment decision and, subsequently, also to make the efficient sales decision. Moreover, we allow the manager to quit after observing ε, assuming that the shareholders want to retain him provided he has made

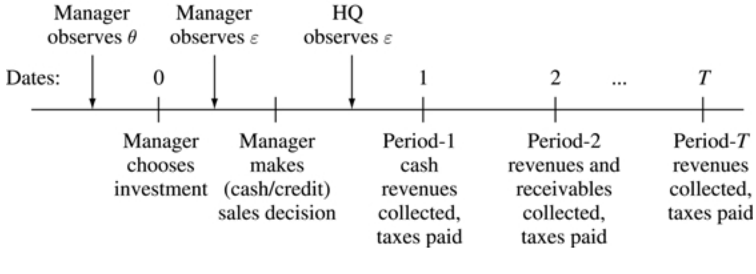

Figure 2. Timeline with investment and sales decisions.

all decisions in their best interest. Using backwards induction, we therefore require

$$x_{11}^*(\varepsilon) \in \arg\max_{x_{11}} \sum_{i=1}^{T} u_i RI_i(\theta, \varepsilon | \cdot), \quad \text{for any } (\mathbf{u}, \theta, \varepsilon), \tag{11}$$

$$\sum_{i=1}^{T} u_i RI_i(\theta, \varepsilon | \cdot) > 0, \quad \text{for any } (\mathbf{u}, \theta > \theta^*, \varepsilon), \tag{12}$$

$$\sum_{i=1}^{T} u_i E_\varepsilon[RI_i(\theta, \varepsilon | \cdot)] \left\{ \begin{matrix} > \\ < \end{matrix} \right\} 0, \quad \text{if } NPV(\theta) \left\{ \begin{matrix} > \\ < \end{matrix} \right\} 0, \quad \text{for any } (\mathbf{u}, \theta), \tag{13}$$

where (11) captures the sales problem, (12) the retention problem, and (13) the investment problem. The need, *ex-post*, to shield the manager from downside risk due to an unfavorable realization of ε, together with the requirement that the manager have proper incentives to invest (only) in positive-*ex-ante*-NPV projects, implies that, in each period, he has to be worse off investing if $\theta < \theta^*$, and better off investing if $\theta > \theta^*$, for any realization of ε. Formally:[19]

Lemma 1 *The requirements (12) and (13) together imply that, and are implied by,*

$$RI_i(\theta, \varepsilon | \cdot) \left\{ \begin{matrix} > \\ < \end{matrix} \right\} 0, \quad \textit{if } NPV(\theta) \left\{ \begin{matrix} > \\ < \end{matrix} \right\} 0, \quad \textit{for any } (i, \theta, \varepsilon). \tag{14}$$

Proof: Proofs are found in the Appendix. ■

The preceding discussion is summarized in the following definition.

Definition 2 *Sequential goal congruence is obtained if and only if the requirements in (11) and (14) are met, and if asset aggregation is feasible in that one uniform capital charge rate, ρ, can be applied to all assets.*

We now show that sequential goal congruence is attainable, if the central office can commit to asset valuation rules referred to here as "ε-contingent". In particular, we allow the accounting variables $(R_1^c(\cdot|\varepsilon), \beta^c(\varepsilon), z_i^c(\varepsilon))$ to be conditioned on the realization of ε. Consider the following internal asset valuation rules:

$$R_1^c(\cdot|\varepsilon) = \gamma \Delta R_1^{nom}, \tag{15}$$

$$\beta^c(\varepsilon) = b + \frac{f(\varepsilon)}{1 - t\boldsymbol{\Gamma\delta}}, \tag{16}$$

$$z_i^c(\varepsilon) = \frac{\bar{\phi}_i(\varepsilon)}{\boldsymbol{\Gamma}\bar{\boldsymbol{\Phi}}}(1 - t\boldsymbol{\Gamma\delta}) + t\delta_i \frac{b}{\beta^c(\varepsilon)}, \tag{17}$$

where $\bar{\phi}_1(\varepsilon) \equiv \phi_1(x^*_{11}(\varepsilon)|\varepsilon) + (\gamma\Delta - t)/(1-t)\ \phi_{12}(x^*_{12}(\varepsilon)|\varepsilon), \bar{\phi}_i(\varepsilon) \equiv \phi_i(x_i|\varepsilon)$, for $i \geq 2$, and $\bar{\boldsymbol{\Phi}} \equiv (\bar{\phi}_1(\varepsilon), \ldots, \bar{\phi}_T(\varepsilon))$.

Our next result shows that the above asset valuation rules succeed in aligning the manager's objectives with those of the shareholders.[20]

Proposition 2 *Suppose only the manager observes ε before the sales decision has to be made, and the firm uses cash accounting for taxes. Then after-tax residual income, $RI^c_i(\theta, \varepsilon|\cdot)$, based on the ε-contingent accounting rules in (15)–(17) achieves sequential goal congruence. In particular, $\rho^c = r$ holds.*

The asset valuation rules in (15)–(17) can be interpreted as follows. Receivables are valued at their fair after-tax value at date 1, according to (15). As a consequence, RI_1 is the only performance measure to be affected by the credit sales, which ensures that the manager's sales decision is independent of his time preferences.[21] This is also reflected in the intertemporal cost allocation in (17). Moreover, the plant is revalued from b to $\beta(\varepsilon)$ according to (16), based on the adjustment function, $f(\varepsilon)$. This adjustment function, however, has to be properly scaled since the realization of ε only affects the after-tax operating cash flow and not the depreciation tax shield. Lastly, since the total cost charge for PP&E in period i equals $[z^c_i(\varepsilon)\beta^c(\varepsilon)]$, whereas the depreciation tax shield amount is based on b (and not $\beta^c(\varepsilon)$), an adjustment factor of $b/\beta^c(\varepsilon)$ is required for the depreciation tax shield component of $z^c_i(\varepsilon)$.

Proposition 2 demonstrates that after-tax residual income has strong aggregation properties. For properly chosen asset valuation and revenue recognition rules, setting the capital charge rate equal to the after-tax cost of capital induces the manager to make the desired investment and sales decisions and to remain with the firm even for unfavorable (uncontrollable) demand shocks.

A key element of the contingent accounting rules is the revaluation rule for PP&E given in (16).[22] Note that $f(\varepsilon) < 0$ implies a windfall loss. Suppose the manager has adopted the first-best investment policy, that is, invest whenever $\theta \geq \theta^*$. The revaluation rule in (16) then ensures that the project will contribute a non-negative amount to his compensation in each period even for poor realizations of ε, provided the sales plan is chosen optimally. Put differently, the project's cash outlay is readjusted for internal control purposes, such that a project that was profitable in expectation over all ε always contributes positively to the manager's performance measure; that is $RI^c_i(\theta^*, \varepsilon|\cdot) \equiv 0$ holds for all ε in any period i.

While the above solution is consistent with the widespread use of dirty surplus accounting for windfall losses, we note that it is somewhat extreme in two ways. First, if ε is drawn from a continuous distribution and all base revenue functions are monotonic in ε, then asset revaluations will occur with probability 1. Second, upward and downward asset revaluations occur with (roughly) equal probability in this model. A more descriptive outcome would arise if ε were drawn from a discrete set where, with some strictly positive probability, an "intermediate" demand scenario obtains, conditional on which the assets are not revalued, that is, $f(\varepsilon) = 0$ for some ε.[23]

Asset revaluations are frequently observed in practice. Contingent depreciation schedules, $(d_1(\varepsilon), \ldots, d_T(\varepsilon))$, on the other hand, seem less common. However, given our assumptions that (i) the manager cannot commit to stay on the job after observing ε, and (ii) ε can affect the base revenue functions $\phi_i(x_i|\varepsilon)$ in an arbitrary fashion, this additional degree of freedom is crucial for sequential goal congruence to be attainable. To better understand the role of flexible valuation rules for PP&E, we briefly (and informally) discuss the significance of assumptions (i) and (ii). If only (i) holds, while ε simply scales all revenue functions in that, for all i, $\phi_i(x_i|\varepsilon) = \phi_i(x_i)g(\varepsilon)$ holds, for some commonly known function $g: \Re^n \to \Re_+$, then sequential goal congruence only requires that $\beta(\varepsilon)$ depends on ε. Thus, if ε captures demand uncertainty that permanently affects the market price for the plant's output, then the depreciation schedule can be fixed *ex ante*. If the manager can commit to stay for all T periods (i.e., assumption (i) does not hold), then neither the book value b nor the depreciation schedule need to be adjusted upon realization of ε. The initial depreciation schedule then only needs to ensure that $E_\varepsilon[RI_i(\theta, \varepsilon|\cdot)]$ has the same sign as $E_\varepsilon[NPV(\theta, \varepsilon)]$ for all i.

3. Pre-Tax Performance Evaluation

Firm practice varies with regard to the use of pre-tax versus after-tax performance metrics. Residual income as traditionally used by, e.g., General Electric was computed on a pre-tax basis, whereas EVA proponents have recently argued that a stronger link to firm value is established by subtracting corporate income taxes.[24] As noted in the Introduction, the maintained assumption in the literature is that only after-tax performance measures can sensitize a manager to the tax consequences of his actions. This line of reasoning, however, ignores that the firm has other instruments (e.g., properly adjusted depreciation or revenue recognition rules) at its disposal to induce goal congruence. In particular, one would expect the capital charge rate under pre-tax residual income to exceed the after-tax cost of capital, r.[25]

Assume for now that aggregation of PP&E and receivables is feasible for the purpose of computing capital charges. Allowing for the possibility of internal asset revaluations from b to β, pre-tax residual income (suppressing the arguments in $\phi_i(\cdot)$) equals:

$$RI_1^p(\theta, \varepsilon|\mathbf{d}, \rho, R_1, \beta) = \phi_1\theta + R_1 - d_1\beta - \rho\beta, \tag{18}$$

$$RI_2^p(\theta, \varepsilon|\mathbf{d}, \rho, R_1, \beta) = [\phi_2 + p\phi_{12}]\theta - R_1 - d_2\beta - \rho[R_1 + (1 - d_1)\beta], \tag{19}$$

$$RI_i^p(\theta, \varepsilon|\mathbf{d}, \rho, \beta) = \phi_i\theta - d_i\beta - \rho\left[1 - \sum_{j=0}^{i-1} d_j\right]\beta, \quad \text{for } i > 2. \tag{20}$$

As before, we first ignore credit sales and base-revenue uncertainty and focus solely on investments in capital assets. Applying similar arguments as above, the following intertemporal cost allocation is readily shown to ensure goal congruence:

$$z_i^p = \frac{\phi_i(x_i)}{(1-t)\boldsymbol{\Gamma\Phi}}(1 - t\boldsymbol{\Gamma\delta}). \tag{21}$$

Breaking down this intertemporal cost allocation into depreciation and capital charges shows that the hurdle rate indeed has to exceed the after-tax cost of capital.

Lemma 2 *Suppose the firm only faces an investment decision, i.e.,* $\phi_{12}(\cdot|\varepsilon) \equiv 0$. *Pre-tax residual income,* $RI_i^p(\theta, \varepsilon|\cdot)$, *then achieves goal congruence if* $(\mathbf{d^p}, \rho^p)$ *correspond to (according to (3)) the intertemporal cost allocation in (21). In particular,* $\rho^p > r$.

Now consider the complementary scenario where the manager only faces a sales planning problem, but no (or only a trivial) investment problem. We capture this by setting $b = 0$. Our next result characterizes the accounting rules, $(R_1^p(\cdot), \rho^p)$, that ensure the manager implements the optimal sales plan as given in (5).

Lemma 3 *Suppose the investment decision is degenerate in that* $b = 0$. *The manager will make the first-best sales decision, as given in (5), under pre-tax residual income if*:

$$R_1^p(\cdot|\varepsilon) = \frac{\gamma\Delta - t}{1-t} R_1^{nom}, \tag{22}$$

$$\rho^p = \frac{p(1-t) + t}{p(1-t) - rt} r > r. \tag{23}$$

Lemmas 2 and 3 are qualitatively consistent: for each decision problem viewed in isolation, goal congruence is attainable even under pre-tax performance evaluation. That is, there is no loss to the firm from using a pre-tax measure. Confirming our earlier intuition, the capital charge rate in both cases exceeds the after-tax cost of capital, r.

A natural question now is how the optimal hurdle rates identified in Lemmas 2 and 3 compare with the corresponding pre-tax cost of capital, $r/(1-t)$. Closer inspection of Lemma 3 shows that $\rho^p > r/(1-t)$ must hold unambiguously for the manager to have the correct sales incentives, because the IRS ignores the time value of money when taxing credit sales. On the other hand, the hurdle rate for PP&E in Lemma 2 can be shown to be greater or less than $r/(1-t)$, depending on how accelerated the IRS depreciation is relative to the intertemporal pattern of investment returns.[26] This suggests that there may not be a single hurdle rate that allows for asset aggregation under pre-tax performance evaluation. Our next result confirms this intuition.

Proposition 3 *If both investment and sales decisions are delegated to the manager, then pre-tax residual income,* $RI_i^p(\theta, \varepsilon|\cdot)$, *does not achieve sequential goal congruence.*

Pre-tax residual income fails from an incentive perspective because it precludes asset aggregation. Since aggregation is of such key importance to accounting, we view this as a useful result from a normative standpoint. While corporate controllers at times devise depreciation or revenue recognition rules that are specifically tailored to certain transactions, they generally apply only one uniform hurdle rate to all assets within a given division. To make this possible, Proposition 3 shows that the performance measure has to explicitly subtract taxes, as does, for instance, EVA. On the other hand, Lemmas 2 and 3 show that pre-tax residual income can align the incentives of managers and shareholders as long as the decisions in question are qualitatively similar: either the manager only makes investment decisions (and the investment projects have roughly similar intertemporal cash return patterns and tax depreciation schedules), or he only makes credit/cash sales decisions (and the default risk does not vary too much).

4. Deferred Tax Accounting

Our analysis of after-tax performance metrics in Section 2 has used the actual cash payments to the IRS as the relevant tax expense for the purpose of performance evaluation. Since both depreciation and bad debt expenses represent temporary differences in income, however, the matching principle in its classical form suggests that the tax expense be calculated based on GAAP pre-tax income. In this section, we investigate the consequences of adopting GAAP rules also for the performance measurement system. This may result in cost savings since GAAP numbers are readily available from the external reporting system (see note 6).

Recording the accrual, rather than cash, tax expense gives rise to deferred tax assets (or liabilities) on the balance sheet. Currently, GAAP requires firms to record deferred tax assets and liabilities at their nominal value, ignoring present value considerations. This approach was investigated and criticized in the valuation literature (e.g., Gunther and Sansing, 2000; Amir et al., 2001). To analyze alternative approaches to deferred tax accounting, let η_p denote the portion of the PP&E-related deferred taxes that is capitalized. Similarly, η_r is the capitalization factor for deferred taxes arising from accounts receivable. Hence, $\eta_i = 0, i \in \{p, r\}$, describes cash accounting for taxes, whereas current GAAP prescribes $\eta_i = 1$. To keep the notation tractable, we restrict the analysis to the case of $T = 2$ in this section.

In Section 2, it was shown that receivables should be valued at their fair after-tax value, $R_1^c(\cdot|\varepsilon)$, taking into account the time value of money and the default risk. While the IRS disregards both these factors when taxing receivables, current GAAP requires firms to record receivables at their expected (but nominal) collection value:

$$R_1^{GAAP}(\cdot|\varepsilon) = pR_1^{nom} = p\phi_{12}(x_{12}|\varepsilon)\theta. \tag{24}$$

The associated deferred tax asset therefore solely values the default risk:

$$D_1^r = t(1-p)R_1^{nom}. \tag{25}$$

For any internal depreciation schedule, $(d_1, 1-d_1)$, and any possible revaluation of the plant for performance evaluation, β, PP&E-related deferred taxes amount to[27]

$$D_1^p = t(d_1\beta - \delta_1 b). \tag{26}$$

Note that the latter is often a deferred tax liability, e.g., if $d_1 < \delta_1$ and $\beta = b$. The total net book value of assets at the end of period 1 then comprises the GAAP receivables, the net book value of PP&E, and the capitalized portion of the deferred tax assets.

Based on the above asset valuation rules, period-1 net income equals

$$NI_1 = (1-t)[\phi_1(x_1|\varepsilon)\theta + R_1^{GAAP} - d_1\beta] - (1-\eta_r)D_1^r - (1-\eta_p)D_1^p, \tag{27}$$

and the after-tax residual income is $RI_1 = NI_1 - \rho\beta$. Similarly, for period 2:

$$NI_2 = (1-t)[\phi_2(x_2|\varepsilon)\theta - R_1^{GAAP} - (1-d_1)\beta] + (1-\eta_r)D_1^r + (1-\eta_p)D_1^p,$$

and the corresponding after-tax residual income equals

$$RI_2 = NI_2 - \rho[R_1^{GAAP} + (1-d_1)\beta + \eta_p D_1^p + \eta_r D_1^r].$$

Note that in this $T = 2$ case, capitalized deferred taxes always fully reverse in period 2.

We begin with the simplest case, ignoring credit sales and additional demand uncertainty; that is, $x_{11} = x_1, \varepsilon$ is a singleton and, thus, $\beta(\varepsilon) \equiv b$. Following similar steps as in Section 1, it follows that for any capitalization factor, η_p, there exists a depreciation schedule, $\mathbf{d}^*(\eta_p)$, that induces goal congruence. The following result is a straightforward generalization of Proposition 1 and hence is stated without formal proof.

Proposition 1′ *In the absence of credit sales, for any deferred tax capitalization factor for PP&E, η_p, there exists a corresponding depreciation schedule given by*

$$d_1^*(\eta_p) = \frac{1}{1 - t\eta_p}\left[\frac{\phi_1(x_1)}{\boldsymbol{\Gamma\Phi}}(1 - t\boldsymbol{\Gamma\delta}) + t\delta_1(1-\eta_p) - r\right] \tag{28}$$

and $d_2^*(\eta_p) = 1 - d_1^*(\eta_p)$, such that residual income achieves goal congruence. Furthermore, $\rho = r$.

Proposition 1′ demonstrates that the firm has a degree of freedom: for a variety of asset deprecation methods (e.g., those used for external reporting) there generally exists a value of η_p that induces goal congruence.

We now revisit our earlier comparative statics result of Corollary 1 where the implicit assumption was that $\eta_p = 0$. For general capitalization factors, we find that δ_1 and d_1 need no longer be complements. If δ_1 increases, then (27) implies that for high capitalization factors ($\eta_p \to 1$) the manager will benefit from the attendant increase in the present value of the depreciation tax shield only in period 2. Hence, to make the manager internalize the fact that θ^* decreases as δ_1 increases, and to ensure proper matching of investment costs and total returns, d_1 needs to be lowered. This argument is formalized in the next Corollary, which follows from direct differentiation of (28).

Corollary 1′ *Under the conditions in Proposition 1, $d_1^*(\cdot)$ is increasing in δ_1 if, and only if, $\eta_p < \hat{\eta}_p \equiv [1 + r\phi_1(x_1)/(\phi_1(x_1) + \phi_2(x_2))]^{-1}$.*

To study the linkage between tax and internal depreciation empirically, Corollary 1′ demonstrates that this question needs to be addressed jointly with that of how companies capitalize deferred taxes for performance evaluation.[28] We note, however, that one of the most commonly used adjustments to GAAP among EVA-adopting firms amounts to "undoing" deferred taxes, i.e., these firms revert to cash accounting for taxes.

We now turn to the complementary case: the firm faces a trivial investment decision ($b = 0$) at date 0, but has to allocate its output between cash and credit sales, contingent upon the realization of ε.

Lemma 4 *Suppose the firm faces a trivial investment problem in that $b = 0$. If receivables are recorded at their GAAP value as given in (24), then the manager will make the first-best sales decision if, and only if, $\eta_r^* = \gamma[1 - rp/(t(1-p))] < 1$.*

Unlike for capital assets, there is no degree of freedom when accounting for receivables. This asymmetry arises from the fact that GAAP allows for a variety of depreciation schedules while it imposes fairly rigid requirements for accounts receivable. Hence, the central office needs to fine-tune the capitalization rate for the latter, η_r, so as to ensure goal congruence. An immediate corollary of Lemma 4 is that goal congruence cannot be obtained by adopting current GAAP rules for all assets including deferred taxes, since this would require $\eta_r = 1$.[29]

To conclude this section, we address the complete setting with delegated investment and sales decisions, adding the aggregation requirement that a uniform capitalization factor be applied to all deferred tax items.

Proposition 4 *Suppose (i) investment and sales decisions are delegated to the manager, (ii) PP&E, accounts receivable and income tax expenses are valued based on GAAP rules, and (iii) the deferred taxes in (25) and (26) are capitalized at the same rate, $\eta_r = \eta_p = \eta$. Then residual income achieves sequential goal congruence if:*

$$\begin{aligned}
\rho^* &= r,\\
\eta^* &= \eta_r^* = \gamma\left[1 - \frac{rp}{t(1-p)}\right],\\
\beta^*(\varepsilon) &= b + \frac{f(\varepsilon)}{1 - t\boldsymbol{\Gamma\delta}},\\
d_1^*(\eta^*|\varepsilon) &= \frac{1}{1 - t\eta^*}\left[\frac{\bar{\phi}_1(\varepsilon)}{\boldsymbol{\Gamma\bar{\Phi}}}(1 - t\boldsymbol{\Gamma\delta}) + t\delta_1(1-\eta^*)\frac{b}{\beta^*(\varepsilon)} - r\right],
\end{aligned}$$

where $\bar{\phi}_i(\varepsilon)$ and the vector $\bar{\boldsymbol{\Phi}}$ are as defined in connection with (17).

Following the arguments in connection with Proposition 2, the fact that additional revenue information will become available subsequent to investing requires the central office to commit to ε-contingent asset valuation rules. Receivables become the constraining factor from the perspective of valuing deferred taxes in that they eliminate any degrees of freedom in choosing the suitable capitalization factor, η.

5. Summary and Conclusion

This paper makes several contributions to the literature. First, we show that firm owners can sensitize their managers to the tax consequences of their actions even under pre-tax residual income. However, this requires computing asset-specific hurdle rates which renders such a system unsuitable for divisions carrying qualitatively different assets on their balance sheet. After-tax residual income, in contrast, allows the firm to consistently apply its after-tax cost of capital as the hurdle rate to the aggregate value of a variety of assets such as PP&E, receivables and deferred taxes. Second, we demonstrate that the recent call for more decelerated depreciation for investment projects with uniform operating cash flows (e.g., Young and O'Byrne, 2001) may be misguided for managers who are compensated based on EVA-type metrics. The overwhelming majority of firms employ accelerated tax depreciation; by Corollary 1, the internal depreciation for performance evaluation should therefore also be more accelerated.

Third we show that goal congruence in a sequential delegation setting with investment and subsequent sales decisions requires contingent accounting rules. This rationalizes the widespread use of "dirty surplus" accounting for windfall gains or losses for retention purposes when demand shocks occur that are viewed as outside the manager's control.[30] Lastly, we characterize the "minimally invasive" adjustments to GAAP procedures required for goal congruence to be attainable. This is important from a practical standpoint as firms often appear reluctant to implement internal control systems that greatly differ from their external reporting practice.

The related literature cited in the Introduction has shown that, by calibrating accounting rules so as to have the NPV consequences of any given decision reflected in residual income in each period, the shareholders can ensure that a manager with unknown time preferences will always act in their best interest. This may suggest that there should be one accounting instrument (e.g., depreciation, accounts receivable, finished goods inventory) for each decision that has to be fine-tuned to the specifics of that particular decision.[31] However, in a pure capital budgeting model without subsequent operating decisions, Bareket (2002) has shown that the firm needs two accounting instruments (depreciation and revenue recognition), if it wants the manager to select the *highest*-NPV project from a pool of competing projects, rather than just pick any *positive*-NPV project. Moreover, in many situations of interest, the cash flows resulting from a decision made at time t will be affected by future decisions, as is the case in our model. Rational managers will anticipate this interaction and could thereby "game" an overly rigid accounting system. To prevent this, and at the same time to ensure the manager can be retained in case of an unfavorable (exogenous) random shock, the above accounting choices cannot be made independent of one another.

Why do many firms in practice use pre-tax residual income, despite the fact that this metric, by design of our model, is dominated by after-tax residual income? A factor that is missing in our analysis is compensation risk. Bonus plans based on pre-tax metrics shield the manager from tax-related compensation risk (Dhaliwal et al., 2000). The incremental risk premium required under after-tax performance evaluation then needs to be traded off against the improved aggregation properties demonstrated in this paper. Our model also abstracts from any explicit agency considerations with the consequence that first-best investment and sales decisions can be implemented. As argued in the Introduction, this approach appears reasonable given that the insights gained from such "goal congruence" settings tend to carry over to agency settings. Obviously, adding explicit agency costs such as informational rents would impact the optimal hurdle rates. For instance, the deviations from the after-tax cost of capital under pre-tax performance evaluation would be exacerbated in the presence of adverse selection problems. The exact nature of the interplay between agency-related and tax-related distortions in hurdle rates is an interesting avenue for future research.

Appendix

Proof of Lemma 1: The part of the Lemma which claims that (14) implies both (12) and (13) is obvious. Hence, we only need to show the reverse, namely that (12) and (13), taken together, imply (14). First, note that (13) implies that

$$E_\varepsilon[RI_i(\theta^*, \varepsilon | \cdot)] = 0 \quad \text{for any } i,$$

has to hold for the manager to internalize the first-best cut-off, θ^*, for any unknown time preferences **u**. This, together with the fact that (12) implies $RI_i(\theta, \varepsilon | \cdot) > 0$ for any $(\theta > \theta^*, i, \varepsilon)$, yields

$$\lim_{\delta \to 0} RI_i(\theta^* + \delta, \varepsilon | \cdot) = 0 \text{ for any } (i, \varepsilon).$$

This in turn implies (14) because, all else equal, $RI_i(\cdot, \varepsilon | \cdot)$ is monotonically increasing in θ. ■

Proof of Proposition 2: We first show that, given the investment decision at date 0 was made optimally, i.e., $I(\theta) = 1$ if, and only if, $\theta \geq \theta^*$, where $E_\varepsilon[NPV(\theta^*, \varepsilon)] = 0$, then valuing receivables at $R_1^c(\cdot | \varepsilon) = \gamma \Delta R_1^{nom} = \gamma \Delta \phi_{12}(x_1 - x_{11} | \varepsilon)\theta$ will induce the manager to make the efficient sales decision. Suppose the manager does not quit (we will verify later that this is indeed the case). Goal congruence requires that the manager will implement the solution to the problem in (5). The first-order condition corresponding to this first-best solution is

$$(1-t)\phi_1'(x_{11}|\varepsilon) - (\gamma\Delta - t)\phi_{12}'(x_1 - x_{11}|\varepsilon) = 0.$$

The manager, compensated based on residual income with cash accounting for taxes, chooses the sales plan, x_{11}, so as to maximize $u_1 RI_1^c(\cdot) + u_2 RI_2^c(\cdot)$, where the performance measures are given in (8)–(10). The corresponding first-order condition for the manager's problem is

$$\begin{aligned} u_1 &\left[[(1-t)\phi_1'(x_{11}|\varepsilon) + t\phi_{12}'(x_1 - x_{11}|\varepsilon)]\theta + \frac{\partial R_1}{\partial x_{11}} \right] \\ &+ u_2 \left[-\Delta\phi_{12}'(x_1 - x_{11}|\varepsilon)\theta - (1+\rho)\frac{\partial R_1}{\partial x_{11}} \right] = 0. \end{aligned}$$

For this to hold at $x_{11} = x_{11}^*(\varepsilon)$ for any (u_1, u_2), both terms in square brackets need to be 0 at $x_{11}^*(\varepsilon)$. This is indeed the case if $\rho = r$ and if the receivables are valued at $R_1^c(\cdot|\varepsilon) = \gamma\Delta R_1^{nom} = \gamma\Delta\phi_{12}(x_1 - x_{11}|\varepsilon)\theta$, as postulated in (15).

Provided the receivables are chosen as in (15) and the plant is revalued according to (16), then residual income in each year will be proportional to the firm's *ex-ante* objective function, i.e., $NPV(\theta) = E_\varepsilon[NPV(\theta, \varepsilon)]$. We demonstrate this for period 1 (for brevity, we suppress the arguments of the base revenue functions, $\phi_i(\cdot)$):

$$\begin{aligned} RI_1^c(\theta, \varepsilon|\mathbf{z}^c(\varepsilon), R_1^c(\varepsilon), \beta^c(\varepsilon)) &= [(1-t)\phi_1 - t\phi_{12}]\theta + t\delta_1 b + R_1^c - z_1^c\beta^c(\varepsilon) \\ &= [(1-t)\phi_1 - t\phi_{12}]\theta + t\delta_1 b + \gamma\Delta\phi_{12}\theta \\ &\quad - \left[\frac{\bar{\phi}_1(\varepsilon)}{\mathbf{\Gamma}\bar{\boldsymbol{\Phi}}}(1 - t\mathbf{\Gamma}\boldsymbol{\delta}) + t\delta_1 \frac{b}{\beta^c(\varepsilon)} \right] \beta^c(\varepsilon) \\ &= (1-t)\left[\phi_1 + \frac{\gamma\Delta - t}{1-t}\phi_{12} \right]\theta - \frac{\bar{\phi}_1(\varepsilon)}{\mathbf{\Gamma}\bar{\boldsymbol{\Phi}}}(1 - t\mathbf{\Gamma}\boldsymbol{\delta})\beta^c(\varepsilon) \\ &= \frac{\bar{\phi}_1(\varepsilon)}{\mathbf{\Gamma}\bar{\boldsymbol{\Phi}}}[(1-t)\mathbf{\Gamma}\bar{\boldsymbol{\Phi}}\theta - (1 - t\mathbf{\Gamma}\boldsymbol{\delta})b - f(\varepsilon)] \\ &= \frac{\bar{\phi}_1(\varepsilon)}{\mathbf{\Gamma}\bar{\boldsymbol{\Phi}}}[NPV(\theta, \varepsilon) - (NPV(\theta, \varepsilon) - NPV(\theta))] \\ &= \frac{\bar{\phi}_1(\varepsilon)}{\mathbf{\Gamma}\bar{\boldsymbol{\Phi}}} NPV(\theta). \end{aligned}$$

Thus, even for poor realizations of ε the manager will stay on the job provided the investment was made efficiently. The same arguments apply to $RI_i^c, i = 2, \ldots, T$, which completes the proof of Proposition 2. ■

Proof of Lemma 2: If the firm only faces the investment problem, that is, $x_{12} \equiv 0$, then pre-tax residual income in any period i equals:

$$RI_i^p = \phi_i(x_i)\theta - d_i^p b - \rho^p \left[1 - \sum_{j=0}^{i-1} d_j^p\right] b,$$

where $d_0^p = 0$ and the variables characterizing the accounting system, $(d_1^p, \ldots, d_T^p, \rho^p)$, correspond to the intertemporal cost allocation method in (21). (To show that $(z_1^p, \ldots, z_T^p)$ given in (21) achieve goal congruence, simply use these cost allocation amounts for the residual income formulae above to show that $RI_i^p(\cdot)$ is proportional to the after-tax NPV for any i.)

The capital charge rate ρ^p that corresponds to $\{z_i^p\}$, according to (3), for general planning horizons of T periods is given by (e.g., Rogerson, 1997, p. 786):

$$\sum_{i=1}^{T} (1 + \rho^p)^{-i} z_i^p = 1,$$

provided clean surplus holds. Using (21), this implies

$$\boldsymbol{\Gamma}^p \mathbf{z}_t^p = \frac{\sum_{i=1}^{T} \gamma^{p^i} \phi_i(x_i)}{(1-t)\boldsymbol{\Gamma\Phi}} (1 - t\boldsymbol{\Gamma\delta}) = 1,$$

where $\gamma^p \equiv (1 + \rho^p)^{-1}$ and $\boldsymbol{\Gamma}^p \equiv (\gamma^p, \gamma^{p^2}, \ldots, \gamma^{p^T})$. The previous equation can be rewritten as

$$\boldsymbol{\Gamma}^p \boldsymbol{\Phi} = (1-t)\frac{\boldsymbol{\Gamma\Phi}}{1 - t\boldsymbol{\Gamma\delta}}. \tag{29}$$

For $t = 0$, pre-tax and after-tax residual income values coincide, and we know that the capital charge rate then has to equal r. To show that the capital charge rate, ρ^p, which solves (29) exceeds r for $t > 0$, we only need to show that the right-hand side of (29) is decreasing in t:

$$\begin{aligned}
\frac{\partial}{\partial t}[\text{RHS of}(29)] &= -\frac{\boldsymbol{\Gamma\Phi}}{1 - t\boldsymbol{\Gamma\delta}} + (1-t)\frac{(\boldsymbol{\Gamma\Phi})(\boldsymbol{\Gamma\delta})}{(1 - t\boldsymbol{\Gamma\delta})^2} \\
&= \frac{1}{(1 - t\boldsymbol{\Gamma\delta})^2}[-(\boldsymbol{\Gamma\Phi})(1 - t\boldsymbol{\Gamma\delta}) + (1-t)(\boldsymbol{\Gamma\Phi})(\boldsymbol{\Gamma\delta})] \\
&= -\frac{\boldsymbol{\Gamma\Phi}}{(1 - t\boldsymbol{\Gamma\delta})^2}[1 - \boldsymbol{\Gamma\delta}] \\
&< 0.
\end{aligned}$$

Hence, $\rho^p > r$ for $t > 0$. ■

Proof of Lemma 3: If the firm only faces the sales planning problem, that is, $b = 0$, then pre-tax residual income in the two periods, for any ε, equals:

$$RI_1^p = \phi_1(x_1|\varepsilon)\theta + R_1(x_1 - x_{11}|\varepsilon)$$
$$RI_2^p = [\phi_2(x_2|\varepsilon) + p\phi_{12}(x_1 - x_{11}|\varepsilon)]\theta - (1+\rho)R_1(x_1 - x_{11}|\varepsilon).$$

The manager will then choose $x_{11}(\varepsilon)$ so as to maximize $\{u_1 RI_1^p + u_2 RI_2^p\}$. This implies the necessary first-order condition

$$u_1[\phi_1'(x_{11}(\varepsilon)|\varepsilon)\theta - R_1'(x_1 - x_{11}(\varepsilon)|\varepsilon)] + u_2[-p\phi_{12}'(x_1 - x_{11}(\varepsilon)|\varepsilon)\theta + (1+\rho)R_1'(x_1 - x_{11}(\varepsilon)|\varepsilon)] = 0, \quad (30)$$

where $R_1'(x_1 - x_{11}(\varepsilon)|\varepsilon)$ denotes the partial derivative $\partial R_1/\partial x_{12}$.

For goal congruence to be obtained, (30) has to hold for $x_{11}(\varepsilon) \equiv x_{11}^*(\varepsilon)$ for any (u_1, u_2), since the manager's time preferences are unknown to the central office. (Recall that the first-best value of $x_{11}^*(\varepsilon)$ maximizes (5).) Hence, for this two-degree polynomial to equal zero for any (u_1, u_2), both coefficients have to be zero, that is

$$\phi_1'(x_{11}^*(\varepsilon)|\varepsilon)\theta - R_1'(x_1 - x_{11}^*(\varepsilon)|\varepsilon) = 0 \quad (31)$$

$$-p\phi_{12}'(x_1 - x_{11}^*(\varepsilon)|\varepsilon)\theta + (1+\rho)R_1'(x_1 - x_{11}^*(\varepsilon)|\varepsilon) = 0 \quad (32)$$

both have to hold simultaneously.

From (5), we know that

$$(1-t)\phi_1'(x_{11}^*(\varepsilon)|\varepsilon) = [\gamma\Delta - t]\phi_{12}'(x_1 - x_{11}^*(\varepsilon)|\varepsilon),$$

where $\Delta \equiv p + t(1-p)$. Using this for (31), we find that

$$R_1(x_{12}|\varepsilon) = \frac{\gamma\Delta - t}{1-t} R_1^{nom}.$$

Using the latter for (32) yields

$$\rho^p = \frac{p(1-t)+t}{p(1-t)-rt} r.$$

For some non-zero credit sales to be optimal, $\gamma\Delta > t$ has to hold (see note 17). Hence the denominator in this last equation is positive. This implies that $\rho^p > r$. ■

Proof of Proposition 3: Without loss of generality, we conduct this proof for the case of $T = 2$. With pre-tax residual income values $(RI_1^p(\cdot), RI_2^p(\cdot))$ as defined in (18)–

(20), the manager will maximize:

$$u_1[\phi_1(x_{11}|\varepsilon)\theta + R_1^p(\cdot|\varepsilon) - z_1^p(\varepsilon)\beta^p(\varepsilon)]$$
$$+ u_2[(\phi_2(x_2|\varepsilon) + p\phi_{12}(x_{12}|\varepsilon))\theta - (1+\rho^p(\varepsilon))R_1^p(\cdot|\varepsilon) - z_2^p(\varepsilon)\beta^p(\varepsilon)],$$

where the collection of the accounting variables $(\{z_t^p(\varepsilon)\}, \beta^p(\varepsilon), \rho^p(\varepsilon))$ expresses the notion that the capital rate and asset valuation rules for PP&E, in addition to accounts receivable, may also be contingent on ε.

Following the same steps as in the proof of Lemma 3, it follows that, in order to provide the manager with incentives to implement the first-best sales plan, the following has to hold:

$$R_1^p(\cdot|\varepsilon) = \frac{\gamma\Delta - t}{1-t} R_1^{nom},$$
$$\rho^p(\varepsilon) \equiv \rho^p = \frac{p(1-t)+t}{p(1-t) - rt} r. \tag{33}$$

Hence, the capital charge rate will not depend on ε; only the accounts receivable will. We also note for future reference that ρ^p is independent of the tax depreciation schedule, as given by δ_1.

At the same time, the manager must also be provided with incentives to implement the first-best investment policy, i.e., to invest if, and only if, $\theta \geq \theta^*$, where the latter is given by $NPV(\theta^*) = 0$. It is straightforward to show that the intertemporal cost allocation must then satisfy

$$z_i^p(\varepsilon) = \frac{\bar{\phi}_i(\varepsilon)}{(1-t)\mathbf{\Gamma}\bar{\boldsymbol{\Phi}}}[1 - t\mathbf{\Gamma}\boldsymbol{\delta}].$$

Since $t\mathbf{\Gamma}\boldsymbol{\delta} = t\gamma^2(1 + r\delta_1)$, it is apparent that the present value of the depreciation tax shield is increasing in the period-1 tax depreciation rate, δ_1. As a consequence, $dz_i^p/d\delta_1 < 0$ for $i = 1, 2$. From the mapping in (3), it then follows that $d\rho^p/d\delta_1 < 0$ also has to hold, which contradicts our above finding in (33) that ρ^p must be independent of δ_1 in order to create proper incentives for revenue maximization. Hence, there is no capital charge rate, ρ^p, that achieves goal congruence if applied uniformly to both assets. ■

Proof of Lemma 4: The central office solves for the optimal $x_{11}^*(\varepsilon)$ by taking the necessary first-order condition of equation (5) with respect to x_{11}:

$$(1-t)\phi_1'(x_{11}^*(\varepsilon)|\varepsilon) = (\gamma\Delta - t)\phi_{12}'(x_1 - x_{11}^*(\varepsilon)|\varepsilon). \tag{34}$$

The manager, on the other hand, maximizes his payoff, which equals

$$u_1[(1-t)\theta[\phi_1(x_{11}|\varepsilon) + \phi_{12}(x_{12}|\varepsilon)(p - (1-\eta_r)t(1-p))]]$$
$$+ u_2[(1-t)\phi_2(x_2|\varepsilon)\theta + (1-\eta_r)\phi_{12}(x_{12}|\varepsilon)\theta t(1-p)$$
$$- \rho\phi_{12}(x_{12}|\varepsilon)\theta(p + \eta_r t(1-p))].$$

The necessary first-order condition with respect to x_{11} implies:

$$(1-t)\phi_1'(x_{11}|\varepsilon) = \phi_{12}'(x_{12}|\varepsilon)\left[p(1-t) - (1-\eta_r)t(1-p) + \frac{u_2}{u_1}(1-\eta_r)t(1-p) - \rho\frac{u_2}{u_1}(p+\eta_r t(1-p))\right].$$

For goal congruence to obtain, the manager must find it in his best interest to choose the desired $x_{11}^*(\varepsilon)$ regardless of his time preferences, (u_1, u_2). For this to hold, two conditions need to be satisfied: first,

$$(1-\eta_r)t(1-p) = \rho[p+\eta_r t(1-p)],$$

and, second, the manager internalizes the shareholders' intertemporal trade-off:

$$(1-\eta_r)t(1-p) = (1-\gamma)[p+t(1-p)].$$

Solving these two conditions simultaneously with respect to ρ and η_r yields $\rho = r$ and $\eta_r = \gamma[1 - rp/(t(1-p))]$. ■

Proof of Proposition 4: We omit the part that shows the manager will always make the first-best sales decision, given the investment was undertaken, since the arguments are identical to those in the proof of Lemma 4. Instead, we take it as given that the manager chooses $x_{11}^*(\varepsilon)$, for any ε, and solely focus on the delegated investment decision.

Under the valuation rules in Proposition 4, after-tax residual income in period 1 equals (again, we suppress the functional arguments to save on notation):

$$\begin{aligned}
RI_1(\cdot) &= (1-t)[\phi_1\theta + R_1^{GAAP} - d_1^*\beta^*] - (1-\eta^*)(D_1^r + D_1^p) - \rho^*\beta^* \\
&= (1-t)[(\phi_1 + p\phi_{12})\theta - d_1^*\beta^*] - \left[1-\gamma+\gamma\frac{rp}{t(1-p)}\right]t(1-p)\phi_{12}\theta \\
&\quad - (1-\eta^*)t(d_1^*\beta^* - \delta_1 b) - \rho^*\beta^* \\
&= (1-t)[\phi_1\theta - d_1^*\beta^*] + [(1-t)p - t(1-p) + \gamma t(1-p) - \gamma rp]\phi_{12}\theta \\
&\quad - (1-\eta^*)t(d_1^*\beta^* - \delta_1 b) - \rho^*\beta^* \\
&= (1-t)\left[\phi_1 + \frac{\gamma\Delta - t}{1-t}\phi_{12}\right]\theta - (1-\eta^* t)d_1^*\beta^* + (1-\eta^*)t\delta_1 b - \rho^*\beta^* \\
&= (1-t)\bar{\phi}_1\theta - \left[\frac{\bar{\phi}_1}{\boldsymbol{\Gamma}\bar{\boldsymbol{\Phi}}}(1-t\boldsymbol{\Gamma}\boldsymbol{\delta}) + (1-\eta^*)t\delta_1\frac{b}{\beta^*} - r\right]\beta^* + (1-\eta^*)t\delta_1 b - r\beta^* \\
&= \frac{\bar{\phi}_1}{\boldsymbol{\Gamma}\bar{\boldsymbol{\Phi}}}NPV(\theta).
\end{aligned}$$

Thus, $RI_1(\cdot)$ is proportional to the shareholders' objective, and the same can be shown for $RI_2(\cdot)$. This completes the proof of Proposition 4. ■

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Notes

1. See Scholes et al. (2002) on tax considerations in decision-making.
2. See Section 166 of the Internal Revenue Code on "specific charge-offs."
3. In particular, see Rogerson (1997), Reichelstein (1997), Wei (2000), and Bareket (2002). Lambert (2001), in his appraisal of this literature, calls for "more dynamic" models where the future pattern of cash flows is not perfectly known at the outset. This is the case in our model.
4. There is an extensive empirical literature on taxes and managerial compensation, see the references in Dhaliwal et al. (2000). In particular, Newman (1989) finds that capital-intensive firms are more likely to pay bonuses based on after-tax earnings and argues that "it is more important that managers of capital intensive firms take tax rates into account when making capital investment decisions" (p. 759).
5. Solomons (1965), Reichelstein (1997), and Rogerson (1997) discuss "annuity" depreciation as a specific form of decelerated depreciation that induces goal congruence for uniform cash flows in the absence of taxes. Young and O'Byrne (2001) refer to this method as "sinking-fund" depreciation.
6. Haspeslagh et al. (2001, p. 70) address the issue of complexity arising from accounting adjustments in connection with "value-based management" metrics: "Successful companies kept the technical aspects of value-based management simple. To derive its measure of economic profit, Dow made very few changes to its accounting system, focusing on simplicity and ease of use. For instance, it applied one standard tax rate across all units. Cadbury has changed nothing at all in its accounting practices. Both companies felt that a major overhaul of their accounting systems would create two sets of accounts running in parallel, potentially a very confusing situation. They also feared that employees would view anything beyond minor tinkering as management manipulating the numbers."
7. Note that current GAAP requires full capitalization of deferred taxes. Guenther and Sansing (2000) and Amir et al. (2001) study the valuation consequences of deferred taxes. In his discussion of Amir et al. (2001), Lundholm (2001) conjectures that aggregation may be the key to identifying the "best" accounting system. Our analysis lends support to this view.
8. This was shown by Dutta and Reichelstein (1999, 2002).
9. As an example, the central office can often assess a plant's practical capacity over time, whereas the expected unit contribution margin of its output is likely to be known only to the manager.
10. All vectors are column vectors, unless otherwise indicated.
11. The firm in our model always expects to utilize its entire future depreciation tax shield, and this tax shield is commonly known. We thus ignore the possibility of firm-wide net operating losses or valuation allowances for deferred tax assets. See DeAngelo and Masulis (1980) for the valuation implications of such events. Firms with expiring NOLs or firms subject to AMT often revert to straight-line tax depreciation. The percentage of such firms in the economy, however, is relatively small. We also ignore any linkage between the firm's cost of capital, r, and the tax environment as given by $(t, \boldsymbol{\delta})$. In a more general model, one would expect these variables to interact.
12. Technically speaking, $\mathbf{u}$ can vary freely in some open neighborhood in $\Re^T_+$. The weight on the performance measure in period i can be interpreted as $u_i = \hat{\gamma}^i \alpha_i$, where $\hat{\gamma}$ is the manager's personal discount factor and $\alpha_i > 0$ is the bonus coefficient (which is assumed exogenous) in period i. The

manager's time preferences coincide with those of the shareholders for $u_i = \gamma^i$, whereas the manager will behave "myopically" if $(u_i/u_{i-1}) < \gamma$ for all i.

13. If $t \to 0$, then $\{z_i^c\}$ converges to the relative benefit intertemporal cost allocation, as in Reichelstein (1997) or Rogerson (1997).
14. In the terminology of Feltham and Ohlson (1995), the capital asset in our model shows characteristics of an operating asset (the anticipated future after-tax operating cash flows) and of a financial asset (the present value of the depreciation tax shield). In our model, only the operating asset is subject to informational asymmetries; in Section 2 the returns from this asset will also be subject to uncertainty.
15. A formal proof of Corollary 1 is omitted. It immediately follows from the fact that $d_1^c = z_1^c - \rho$ with $\rho = r$. Differentiating d_1^c with respect to δ_1 then yields the result.
16. All results would qualitatively go through if there were multiple periods in which credit sales occur, or if these credit sales were to be collected in periods that are more than one year ahead.
17. We implicitly assume that $\gamma\Delta > t$, that both $\phi_{1i}(\cdot)$ are positive, increasing and concave, and that $\phi'_{1i}(0)$ is sufficiently high for $i = 1, 2$. This ensures that the firm will always want to set $0 < x_{11}^*(\varepsilon) < x_1$.
18. As noted above, we do not consider "forcing contracts" by which the central office, upon observing ε at the end of period 1, could punish the manager severely if he has made a suboptimal sales decision.
19. To see why the manager's option to quit complicates the delegation problem, consider an investment project that, in expectation over all ε, was marginally profitable (i.e., $\theta - \theta^* > 0$, but "small"). If the central office sticks to accounting rules that resulted in marginally positive residual income values *in expectation*, then the actual performance measures would in fact be negative in each period for poor realizations of ε. The manager would then quit, thereby violating the above retention requirement. See also the Harvard case study on "Vyaderm Pharmaceuticals" (HBS #9–101–019).
20. Other goal congruent solutions are conceivable where the plant is not revalued. But then the firm would have to violate the requirement that $\sum_i d_i = 1$. Note that in the above solution $\beta(\varepsilon)$ is indeed fully depreciated. Ohlson (1999) addresses windfall gains and losses in a valuation framework.
21. The revenue recognition method in (15) is consistent with that advocated in Dutta and Reichelstein (1999). In this model, however, the objective is to shield a risk-averse agent from unnecessary risk.
22. Baldenius and Reichelstein (2000) and Dutta and Zhang (2002) show that the lower-of-cost-or-market rule, by which working capital is revalued in case of poor market conditions, is an effective contractual tool to induce managers to sell off obsolete units in finished goods inventory.
23. For example, let $\varepsilon \in \{L, M, H\}$, where H is a low-probability event resulting in exceptionally strong market conditions, whereas L is only slightly less favorable than M, but significantly more likely to occur than H. Now suppose that $f(\varepsilon = M) = 0$; hence, $\beta^c(M) = b$. For this knife-edge case, our model would predict (i) a strictly positive probability of no-revaluations (for $\varepsilon = M$, *ex post*), (ii) only a small probability of upwards revaluations (for $\varepsilon = H$), and (iii) a higher probability of moderate downward revaluations (for $\varepsilon = L$).
24. Previous studies have shown that, of all firms employing earnings-based bonus schemes, between 39% and 69% use pre-tax earnings as opposed to after-tax earnings; see Dhailwal et al. (2000) and the references cited therein.
25. Scholes et al. (2002, p. 95) address the required pre-tax rates of return in centralized firms as a function of alternative depreciation schedules. We use similar ideas in our delegation setting.
26. For reasonably liberal tax depreciation schedules, e.g., those that match depreciation with undiscounted investment returns so that $\delta_1 = \phi_1(\cdot)/[\phi_1(\cdot) + \phi_2(\cdot)]$ in the $T = 2$ case, one can show that $r < \rho^p < r/(1 - t)$. *A fortiori*, this also holds for more accelerated tax depreciation schedules.
27. In most cases, GAAP does not prescribe a specific depreciation schedule. Otherwise (e.g., straight line depreciation prescribed for goodwill amortization prior to SFAS 142), we would have to make a similar adjustment for PP&E.
28. Also by straightforward differentiation of (28), one can show that $d_1^*(\cdot)$ increases in the capitalization factor η_p whenever $\phi_1(x_1)$ is sufficiently large relative to $\phi_2(x_2)$, and vice versa. The intuition for this can be gained from the expression for period-1 net income in (27): if $\phi_1(x_1) \gg \phi_2(x_2)$, then $d_1^*(\cdot)$ tends to be high, as well. As a consequence, $D_1^p > 0$, by (26). That is, the firm records a deferred tax asset (not a liability). Thus, as η_p increases for $D_1^p > 0$, period-1 residual income increases, while this effect

reverses in period 2. To offset this intertemporal cost shifting (recall that the first-best cutoff, θ^*, is independent of η_p), the central office raises d_1.

29. If one restricts the firm to record deferred tax assets (or liabilities) for internal purposes at less than their nominal value, then, for sufficiently high p, there may not be any feasible goal congruent solution. This is readily seen from the term for η_r^* in Lemma 4: if $p > t/(t+r)$ then η_r must be negative. Moreover, $\eta_r^* \rightarrow -\infty$, as $p \rightarrow 1$, since the capitalized deferred tax asset $(\eta_r^* D_1^r)$ is the sole instrument that the central office can use to "close the gap" between the GAAP receivables, $R_1^{GAAP}(\cdot)$, and the after-tax fair value, $R_1^c(\cdot)$. As $p \rightarrow 1$, however, $D_1^r \rightarrow 0$, and hence $|\eta_r^*|$ has to become very large.
30. Our findings complement those in Ohlson (1999) who shows that transitory earnings should be excluded from a manager's performance measure to make the latter more informative about his effort. This requires that transitory earnings be unaffected by managerial effort and uninformative about future profitability. In our model, in contrast, the windfall gains and losses to be excluded from the performance metrics in general are informative about future profitability. Instead, the need for dirty surplus accounting in our model arises from an interplay of *ex-post* retention problems and *ex-ante* investment problems.
31. Rogerson (1997) and Reichelstein (1997) have shown in the absence of taxes that residual income with relative benefit depreciation and the hurdle set equal to the cost of capital is the unique goal congruent solution, up to a normalizing constant. This finding carries over to our setting with after-tax residual income where the tax expense serves as an additional accounting "dial." Under pre-tax residual income, this dial is not used at all, which eliminates the degree of freedom. This in turn precludes asset aggregation.

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