



# Should Intangibles Be Measured: What Are the Economic Trade-Offs?

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Received 11 December 2002; accepted 19 May 2003

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## ABSTRACT

We investigate whether a firm's intangible investments should be measured and separated from operating expenses. We find that the information extracted from accounting reports of investments and earnings is different when intangibles are measured and identified separately from operating expenses than when intangibles are left commingled with operating expenses. This difference in the market's information causes a change in the behavior of market prices, inducing changes in the firm's investments and cash flows. Thus, from a *real effects* perspective, measuring intangibles is not unambiguously desirable. We identify the conditions under which providing information on intangibles may be desirable. This study also shows the inadequacy of statistical associations between accounting numbers and prices as a basis for evaluating the desirability of measuring intangible investments. We show that the measurement of intangibles alters the very distribution of cash flows about which the measurement regime is seeking to provide information.

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\*University of Minnesota; †University of Chicago. We appreciate the helpful comments of David Aboody, Ray Ball (the editor), Tim Baldenius, Qi Chen, Sidney Davidson, Jennifer Francis, Frank Gigler, Milt Harris, Jack Hughes, Karim Jamal, Jing Liu, Per Olsson, Shiva Rajgopal, Stefan Reichelstein, Jack Simms, Michael Smith, Sri Sridharan, Andy Spero, Mohan Venkatachalam, Ram Venkataraman, and an anonymous referee. This paper has also benefited from the comments of workshop participants at Alberta, Duke, Houston, Minnesota, Stanford, UCLA, and the 2002 Chicago-Minnesota Theory Conference held at Chicago. Sapra and Venugopalan gratefully acknowledge financial support from the University of Chicago, Graduate School of Business.

## 1. Introduction

The last decade has witnessed an explosive growth in intangible investments. Currently, it is believed that such investments frequently constitute the most valuable assets of firms. Despite the enormity and value of these assets, the appropriate accounting treatment of intangibles remains an unsettled issue, with ongoing debate in the Financial Accounting Standards Board (FASB), the academic literature, and the popular press. Critics of current accounting practice argue that “R&D outlays generate some of the most prized economic assets in the economy, and that accountants’ refusal to recognize these expenditures as assets seriously impairs the credibility and relevance of financial reporting” (Healy, Myers, and Howe [2002, p. 678]). Lev and Zarowin [1999] argue that nonrecognition of intangibles on the balance sheet has caused a significant decline in the relevance and usefulness of accounting reports. In a 1996 symposium on “Financial Accounting and Reporting of Intangible Assets,” organized by the Securities and Exchange Commission (SEC), many speakers expressed the view that enhanced disclosure of intangible investments is highly desirable. In the popular press there are concerns that “arcane” accounting rules devised for a brick-and-mortar economy may be ill-suited to an economy in which many firms derive their competitive advantage from investments in intangibles.

Most of the debate regarding the accounting treatment of intangibles has centered on whether expenditures on intangibles should be reported in the income statement or in the balance sheet. Under current accounting rules, R&D outlays are disclosed as a line item in the income statement but are not allowed to be capitalized on the balance sheet. However, many other intangible investments are not even identified in the financial statements. For example, investments that create brand value, increase customer base, enhance a firm’s information technology, or improve product and process design are not distinguished from operating expenditures. Thus, there is a more primitive question that must precede the issue of whether intangibles should be reported in the income statement or the balance sheet: Should expenditures on intangibles be measured and reported separately, or left unmeasured and commingled with operating expenditures? In this paper we investigate this more primitive *informational* question and ignore issues regarding the balance sheet or income statement disclosure of intangibles. If expenditures on intangibles are not measured and identified separately, they are accounted for in the same way as operating expenditures because they remain commingled with such expenses. Hence, we refer to this disclosure regime as the “expensing regime.” If intangibles are measured and identified separately, there is the additional issue of whether these expenditures should be capitalized and reported on the balance sheet or reported as a line-item expense on the income statement. We do not distinguish between these two accounting treatments and refer to both forms of disclosure as the “intangibles measurement regime.”

It appears that the FASB's reluctance to account for intangibles separately from operating expenditures is due to two concerns: (1) impairment of the reliability of reported accounting numbers because of errors associated with measuring intangibles, and (2) expansion of opportunities for earnings management by unscrupulous managers. Our model incorporates FASB's concerns by assuming that the measurement of intangibles is necessarily noisy. We model three sources of noise and show that each of these sources of noise plays an important role in determining whether intangibles should be measured and reported. The first kind of noise arises from random errors in discriminating between operating expenses and expenditures on intangible investments. The boundaries between operating expenditures and intangible investments are often so fuzzy that separation of the two would require many subjective judgments by accountants and auditors. For example, what portion of product design and product engineering costs should be treated as operating expenses and what portion should be reported as intangible investments? What proportion of an employee's time is devoted to normal production, what proportion to process and product development, and what proportion to human capital development? Even the best intentioned accountant would make random errors in sorting through this maze. A second source of noise arises from the difficulty of discriminating between productive and unproductive components of expenditures on intangibles. Not all expenditures on intangibles are productive; some random unforeseeable component is inevitably unproductive and wasteful. This is most apparent in R&D but is likely true of all kinds of intangibles. We think it is unlikely that accountants can accurately discriminate between the productive and unproductive components of intangibles at each point in time. This inaccuracy would precipitate random errors in accounting reports. We think a third source of noise arises because the measurement of intangibles (and the implicit claim that they are assets) induces error in the measurement of tangible investments. Attempts to classify the totality of investments into tangible and intangible is prone to manipulation and classification errors.

Informationally, the noise associated with measuring intangibles is a *major* difference between the intangibles measurement regime and the expensing regime. The expensing treatment is relatively free of noise because it requires no measurement of intangibles at all. Any outlay that is not clearly in the nature of tangible investments is immediately charged to the income statement as an expense.

It may appear that even a crude estimate of intangibles would be better than providing no information on intangibles. Although true in a game against nature, this claim is false in a situation where intangibles are purposefully chosen to optimize some well-specified objective function. In such situations, noisy estimates of intangibles contain no information on the intangibles themselves and are ignored by the market. What does change as a result of intangibles measurement is the structure and information content of the reported operating earnings of the firm. The separation of

intangibles removes the contamination of earnings caused by the unobservability of intangibles in an expensing regime but introduces random errors because of the shifting of transactions among operating expenses, intangible investments, and tangible investments. This is akin to a noisy accrual process. Given noisy accruals, a firm's cash flows acquire information content incremental to the information contained in the reported operating income. Thus, in the intangibles measurement regime both reported operating earnings and reported net cash flow have information content. Together, they convey strictly more information to the market about the firm's true operating earnings than the reports in an expensing regime. However, in this process, some information about the firm's tangible investments is lost.

Because observed net cash flow acquires information content in the intangibles measurement regime, capital market prices assign positive weights to both earnings and cash flows. We show that a positive weight on earnings stimulates investment, but a positive weight on net cash flow deters investment. This deterrence arises from a subtle endogenous informational cost. When the capital market cannot perfectly observe the firm's investments, it is forced to anticipate those investments and incorporate these anticipations into its pricing rule. Given these anticipations, higher net cash flow signals good news and induces upward revisions in the market's assessed distribution of future earnings, causing an increase in the market price of the firm. This *informational* factor makes the firm reluctant to take unobservable actions, such as investment in intangibles, that decrease current cash flows, even though the decrease is more than offset by expected increases in future cash flows. The incentive to cut back investments from first-best levels to increase current cash flow is fully anticipated by the market and built into its pricing rule. Thus, there is no deception, but the firm is trapped in a bad equilibrium.

Such informational costs are also present in the expensing regime because the firm's intangible investments are unobservable in this regime, too. The observability of tangible investments in the expensing regime partially alleviates this cost. But, more important, we show that the informational cost in the expensing regime is *independent* of noise in accounting measurements and is determined solely by the technological parameters that govern the *relative* weight on intangibles in the tangibles-intangibles mix that constitutes the firm's capital stock. On the other hand, the informational cost in the intangibles measurement regime depends critically on the extent of noise in the earnings report caused by random misclassifications of operating expenses and intangible investments. As this noise increases, the equilibrium price in the capital market assigns relatively less weight to the firm's earnings report and more weight to the firm's observed cash flow, causing an increase in the informational cost to investment. This shift in the assigned weights on earnings and cash flow deters investment in intangibles, which in turn reduces the firm's incentives to invest in tangibles.

Our main result is that separate disclosure of intangibles is preferred if and only if intangibles can be measured with sufficient precision and the firm's technology is such that the relative weight on intangibles in the firm's capital stock is sufficiently high. In all other cases, immediate expensing of intangibles is preferred. This result is consistent with the FASB's intuition that there is a trade-off between reliability and relevance that must be taken into account in the determination of accounting standards. Our analysis makes this trade-off precise, albeit in a stylized setting, and underscores the importance of the *real* effects of accounting in understanding the nature of the trade-off. Our analysis also identifies a hitherto ignored aspect of disclosure. The totality of information about the firm's current earnings that is revealed to the capital market is insufficient to rank disclosure policies; *how* that information is conveyed to the capital market is also important. Information about earnings that is conveyed through cash flows comes with hidden costs. These costs can be decreased by accruals, provided the accruals are appropriately designed and relatively free of noise.

Empirically, it has been found that stock prices correlate better with accounting income and book values when intangibles are estimated, capitalized, and amortized than when they are expensed (Lev and Sougiannis [1996], Aboody and Lev [1998]). The policy implication of these findings is summarized by Lev and Zarowin [1999], who explicitly state, "Accounting standards which improve the alignment of reported book value with the firm's intrinsic value (usually proxied by market value) and/or improve the prediction of earnings should be preferred over standards which do not" (p. 378). This value-relevance approach to accounting policy suggests that the measurement and capitalization of intangibles is unambiguously preferred to the expensing of intangibles. Our approach, and our conclusions, differs sharply from this value-relevance approach. Statistical associations and alignments do not by themselves identify economic consequences. If the statistical associations between accounting reports and stock prices change depending on the accounting treatment of intangibles but nothing else in the economy changes, such as capital market prices and firms' investments and cash flows, these statistical associations are of purely academic interest and must surely lack policy significance. We believe that accounting policy on intangibles is better guided by a clear identification of changes in economic decisions, and their consequences, that are caused by a change in the accounting treatment of intangibles. We *assume* that intangible investments are value relevant and show that the value relevance of intangibles, the magnitude and growth of these investments, or their profitability do not by themselves imply that measurement and disclosure of intangibles is the preferred accounting policy.

The results in our paper depend on explicit differences in the information content of accounting reports, disclosed to the capital market, because of the accounting treatment of intangibles. We study how these informational differences induce the firm's investments to change. The firm is assumed to choose its investments in tangibles and intangibles to maximize its price in

the capital market. The price in the capital market is endogenously determined and depends on inferences made by traders from publicly observed accounting reports and from prior knowledge of the firm's technology and expectations of profitability. The beliefs of traders are rational, in the sense that these beliefs are consistent with the firm's equilibrium choices, even when these choices are not fully observed, and all assessed distributions of future cash flows coincide with the distributions realized in equilibrium. This extreme rationality (market efficiency) rules out, by fiat, any form of mispricing in the capital market. However, rational pricing does not imply that firms' incentives for investment are unaffected. Informational differences caused by the accounting treatment of intangibles induces a change in the behavior of market prices, which in turn induces changes in the firm's investments and cash flows. These *real* effects have clear implications for accounting policy. We find that from such a real effects perspective, the measurement and disclosure of intangibles is *not* unambiguously preferred to expensing. We identify conditions under which such measurements are desirable and conditions under which expensing is the preferred accounting treatment.

Stein [1989] and Kanodia and Mukherji [1996] are important antecedents to this paper. Stein shows how managers acquire an incentive to borrow at unfavorable terms from the future to inflate current earnings when such borrowings cannot be observed by the capital market. The notion of informational cost is implicit in Stein's analysis but is more fully developed in Kanodia and Mukherji, who use it to show why it is fundamentally important for accounting to separate investments from operating cash flows.<sup>1</sup> Our analysis also exploits the results in Kanodia and Lee [1998], who showed how interim earnings reports that precede a firm's final cash flows provide discipline for the firm's investment decisions, via the pricing of the firm in the capital market. Kanodia [1980] first formulated the real effects of accounting by developing a general model of how accounting disclosures and firms' decisions are interrelated through the pricing of firms in the capital market.

The remainder of the paper is organized as follows. Section 2 describes the model and the assumptions underlying our analysis. In sections 3, 4, and 5, we characterize equilibrium investments and market prices for each of three informational regimes: the regime where full information is available, the regime where intangibles are expensed, and the regime where intangibles are measured and disclosed. In section 6, we construct welfare comparisons and develop the implications of our analysis for accounting policy. Section 7 provides some insights suggested by our analysis regarding the interpretation of empirical findings concerning the capitalization of intangibles. Finally, in section 8 we indicate some limitations to our analysis and describe possible extensions. Proofs of formal propositions are contained in the appendix.

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<sup>1</sup> Dutta and Reichelstein [2003] investigate a similar issue in an agency setting.

## 2. *The Model*

Consider a firm that needs both tangible and intangible investments to produce future returns. Let  $K$  denote the firm's tangible investments and  $N + \tilde{\gamma}$  denote the firm's expenditures on intangible investments. We assume that the expenditures required to build intangible investments are uncertain, in the sense that some random component of these expenditures turns out to be wasteful and unproductive. For example, inevitably only some of the numerous R&D projects undertaken by a firm will be successful; hence, ex ante the cost of achieving an innovation is a random variable. We capture this real-world feature by the additive term  $\tilde{\gamma}$ , which represents the random unproductive component of expenditures on intangible investments, whereas  $N$  represents the productive component. Tangible investments and productive intangible investments combine to form the firm's capital stock,  $q(K, N)$ . The future returns to investment are determined by the firm's capital stock rather than directly by its tangible and intangible investments. We assume:

- A1.  $q_K > 0$ .
- A2.  $q_N > 0$ .
- A3.  $q_{KN} > 0$ .
- A4.  $q_{KK} < 0$ ,  $q_{NN} < 0$ ,  $q_{KK} \cdot q_{NN} - q_{KN}^2 > 0$ .

Assumption A3 implies that the marginal effect of each investment on the firm's capital stock is increasing in the magnitude of the other investment. This specification captures the idea that tangible and intangible investments complement each other. Assumption A4 is a standard concavity assumption. Though many of our results are established more generally, to obtain closed-form solutions, we assume a Cobb Douglas-like technology:

$$q(K, N) = K^\alpha N^\beta, \quad \alpha > 0, \beta > 0, \alpha + \beta < 1. \quad (1)$$

The specification in (1) satisfies assumptions A1 through A4;  $\alpha + \beta < 1$  guarantees strict concavity.

There are three dates in the economy: dates 0, 1, and 2. The firm acquires its tangible and intangible investments,  $K$  and  $N$ , at date 0. The returns,  $\tilde{x}_1$ ,  $\tilde{x}_2$ , to these investments are stochastic and are realized at dates 1 and 2, respectively. We assume that  $(\tilde{x}_1, \tilde{x}_2)$  is joint normally distributed with:

$$E(\tilde{x}_1) = E(\tilde{x}_2) = q(K, N)\mu,$$

where  $\mu > 0$  is a known constant, describing the expected per period return per unit of the firm's capital stock,

$$\text{Var}(\tilde{x}_1) = \sigma_x^2,$$

and

$$\text{Cov}(\tilde{x}_1, \tilde{x}_2) = \rho > 0.$$

A positive covariance implies there is some persistence, or growth component, in returns, making current returns informative about future returns to the investment undertaken.

We assume that the firm's manager makes all decisions in the best interests of the firm's current shareholders. However, current shareholders do not hold the firm until all of the returns to the firm's investments have been realized. At some interim date, there is a change in ownership, and current shareholders are replaced by a new generation of shareholders. Specifically, we assume that current shareholders sell their shares inelastically in a competitive capital market at date 1, after realization of  $\tilde{x}_1$  but before the realization of  $\tilde{x}_2$ . Thus, although there is no source of conflict between the firm's manager and current shareholders, there is a conflict of interest between current and prospective shareholders. This specification allows us to abstract away from contracting issues and focus entirely on conflicts that are mediated by capital market prices, accounting measurements, and disclosures.

We assume that all current and prospective shareholders are risk neutral. Thus, the date 1 equilibrium price in the capital market is:

$$\tilde{P} = \underbrace{\tilde{x}_1 - K - N - \tilde{\gamma}}_{\text{cash assets at date 1}} + \underbrace{E(\tilde{x}_2 | \text{information})}_{\text{expectation of future cash flows}}$$

that is, the price in the capital market is the firm's cash assets at date 1 plus the expectation of its future cash flows. The firm's current shareholders consume  $\tilde{P}$ , obtaining their entire return through market prices while future shareholders consume the firm's net cash flows less the price they pay to acquire the firm.

The accounting system provides a report on the firm's investments, earnings and net cash flows before the transfer of ownership occurs. We analyze three disclosure regimes: the full information regime, an expensing regime where intangibles are not measured, and an intangibles measurement regime. The primitive variables describing the state of the firm at date 1 are: (1) the firm's investment in tangibles  $K$ , (2) the firm's productive intangibles investment  $N$ , (3) the total expenditure on intangibles  $N + \gamma$ , and (4) the date 1 true operating profits  $x_1$ . The true operating profit of the firm at any date should be thought of as a summary statistic that nets out the revenues from goods sold during the period from those production and marketing expenses that depend directly on the goods sold during that period. For example, the expenses included in true operating profits would consist of direct labor, direct materials, manufacturing overhead, and marketing and administrative expenses that support current-period revenues with no direct effect on future cash flows. It is this true operating profit that has persistence and covaries over time. In the full-information regime,

the capital market directly and perfectly observes all of the four primitives that describe the state of the firm at date 1. Full information is an unattainable ideal but serves as a useful benchmark to evaluate the efficiencies of the other regimes. In the two other regimes, the primitives describing the state of the firm are not directly observable; the capital market receives its information from accounting measurements and reports. In principle, the accountant seeks to measure each of the four primitives but makes errors (and is subject to managerial manipulation) because the boundaries between true investments and true operating profits are fuzzy. We explicitly model three reporting errors that are associated with the measurement and treatment of intangibles.

1. Errors due to misclassifications of operating expenses and intangible investments. These errors arise because of the inherent fuzziness of the boundaries between these two types of expenditure. For example, it is extremely difficult to determine what portion of total marketing expenditures increases future revenues by enhancing customer loyalty for the firm's products and what portion of the expenditure merely increases current-period revenues. Such errors affect both reported operating profits and reported intangibles in the same direction. Thus, if some operating expenditures are mistakenly identified as intangible investments, the report on investment is overstated and so is the report on earnings. We capture this measurement error by a random variable  $\tilde{\omega}$ .
2. Errors due to an inability to discriminate between productive and unproductive components of intangible investments. As discussed earlier, it is inevitable that some random component  $\tilde{\gamma}$  of the expenditures on intangible investments will turn out to be wasteful, in the sense that it benefits neither the present nor the future. In principle, this wasteful component of investment is different from operating expenses, even intangible operating expenses such as those marketing expenses that support the revenues earned in the current period and that are included in the firm's true operating profit. We assume that the inability to discern the unproductive component will result in the entire expenditure of  $N + \tilde{\gamma}$  being accounted the same way.
3. Errors due to misclassifications of tangible and intangible investments. Such misclassifications must be offsetting in the sense that they affect reported tangibles and reported intangibles in opposite directions. We capture this misclassification error by a random variable  $\tilde{\eta}$ .

In the intangibles measurement regime, the reports provided by the accounting system consist of a measurement of tangible investments  $I_K$ , a measurement of intangible investments  $I_N$ , earnings (or operating profits)  $y_c$ , and date 1 net cash flow  $z_c$ . We assume these reports are of the form:

$$\begin{aligned}
I_K &= K + \tilde{\eta}, \\
I_N &= N + \tilde{\gamma} - \tilde{\eta} + \tilde{\omega}, \\
z_c &= \tilde{x}_1 - K - N - \tilde{\gamma}, \\
y_c &= z_c + I_K + I_N = \tilde{x}_1 + \tilde{\omega}.
\end{aligned}$$

As discussed earlier, these specifications incorporate the classification errors and noise associated with the measurement of intangibles. The random variable  $\tilde{\eta}$ , which represents errors that arise from attempts to classify a firm's investments as tangible or intangible, appears in both  $I_K$  and  $I_N$  but with opposite signs. Because the accounting system cannot perfectly discriminate between productive and unproductive expenditures associated with the acquisition of intangible investments, the entire expenditure on intangibles  $N + \tilde{\gamma}$  is reported as intangibles investment. The presence of  $\tilde{\omega}$  in the reported intangibles and in reported earnings reflects the fact that errors due to misclassifications of operating expenses and intangibles affect both measurements in the same direction. Consistent with standard accounting principles, periodic (operating) earnings  $y_c$  is obtained by adjusting the firm's net cash flow by adding back measured investments. We assume that the measurement errors  $\tilde{\eta}$ ,  $\tilde{\gamma}$ , and  $\tilde{\omega}$  are independent of each other and are normally distributed with zero means and variances of  $\sigma_{\tilde{\eta}}^2$ ,  $\sigma_{\tilde{\gamma}}^2$ , and  $\sigma_{\tilde{\omega}}^2$ , respectively.

In the expensing regime, the accounting system measures and capitalizes the firm's tangible investments only and treats all other cash outflows as operating expenses for the period. The reports provided by the accounting system consist of a measurement of tangible investments  $I_K$ , earnings  $y_e$ , and net cash flow  $z_e$  (we use the subscript  $e$  to denote measurements in the expensing regime and the subscript  $c$  to denote measurements in the intangibles measurement regime). Because the expensing regime makes no attempt to separate intangibles from operating expenses, it is clear that the random variable  $\tilde{\omega}$  will not appear in the accounting reports. We assume the accounting reports produced in an expensing regime are of the form:

$$\begin{aligned}
I_K &= K \\
y_e &\equiv \tilde{x}_1 - N - \tilde{\gamma} \\
z_e &\equiv \tilde{x}_1 - K - N - \tilde{\gamma}
\end{aligned}$$

We now give two examples to illustrate the error structure in these reporting regimes. Suppose the only expenditures on intangibles in a firm consist of R&D. The total cash outflow on account of R&D is  $N + \tilde{\gamma}$ , where  $N$  is the productive component and  $\tilde{\gamma}$  is the random unproductive component of R&D. Suppose that a significant amount of R&D expenditures consists of salaries paid to engineers and that, in addition to R&D, engineering services are also supplied for routine production. In the expensing regime there is no need to separate the cost of engineering services supplied for routine production from engineering for R&D because they are both expensed.

This is what produces the earnings report  $y_e \equiv \tilde{x}_1 - N - \tilde{\gamma}$ . However, when R&D is accounted separately from operating income, as in the intangibles measurement regime, the accountant needs to separate the two components of engineering salaries and will likely make errors in doing so. This is what produces the error  $\tilde{\omega}$  that affects both reported operating income and reported intangible investment. Additionally, suppose that some of the R&D results in tangible investments and some in intangible investments. Attempts to separate the two types of investments produces the error  $\tilde{\eta}$ .

Similar to the R&D example, total marketing expenditures generally support both the routine production and sale of goods and the brand building and expansion of the customer base that benefit future sales. The first component (call it  $\tilde{x}_m$ ) is contained in  $\tilde{x}_1$  (because it is in the nature of an operating expense and will covary with next period's operating income), whereas the second component is what we call  $N + \tilde{\gamma}$  (because it is in the nature of an intangible expenditure). The total marketing expenditure is  $\tilde{M} = \tilde{x}_m + N + \tilde{\gamma}$ . In the expensing regime, there is no need to separate  $\tilde{x}_m$  from  $N + \tilde{\gamma}$ , but in the intangibles measurement regime, attempts to separate the two will precipitate the error that we call  $\tilde{\omega}$ .

The presence of  $\tilde{\eta}$  in the intangibles reporting regime and its absence in the expensing regime warrants additional explanation. Expensing of intangibles is inherently a regime where the measurement of investments is extremely conservative. The operational guideline here is "when in doubt, expense." This is why intangibles are expensed, and only observed cash outflows that are *unambiguously* in the nature of investment are measured and reported separately. Strictly speaking, this extreme conservatism implies that the measurement of tangibles in the expensing regime would be stochastically downward biased; that is,  $I_K$  would be a random variable with support  $[0, K]$ , where  $K$  is the true investment in tangibles and  $I_K$  is the accounting measurement of tangibles. Clearly, the only information conveyed by such a report is that  $K \geq I_K$ . In this spirit, the expensing regime as modeled, where  $I_K = K$  is an approximation to a measurement regime with such a stochastic downward bias, where the downward bias is small.<sup>2</sup> An intangibles measurement regime, however, is a more permissive regime where the same strict standards of doubt are not applied. In this more permissive regime, shifting of transactions among operating expenses, intangible investments, and tangible investments becomes feasible.

In both the expensing regime and the intangibles measurement regime, the firm's true operating profit  $\tilde{x}_1$  as well as its productive intangible investment  $N$  cannot be detected, and capital market traders must make inferences on the basis of noisy information. Even though the intangibles measurement regime provides a noisy estimate of the firm's intangible investment  $N$ , such noisy measurements contain no information on the intangibles themselves (see Bagwell [1995], Kanodia and Mukherji [1996]).

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<sup>2</sup> We show later that equilibrium investments in the intangibles measurement regime are unaffected by the magnitude of the variance of  $\tilde{\eta}$ .

However, we show that the intangibles measurement regime does provide strictly more information on the firm's operating profit  $\tilde{x}_1$  than the expensing regime, precisely because of its noisy measurement of intangible investments. This feature is a key difference between the two disclosure regimes. A second key difference is that the conservative aspect of the expensing regime provides a sharp measurement of the firm's tangible investments, whereas the absence of this property in the intangibles measurement regime introduces classification errors between tangible and intangible investments. Taken together, these two differences make the expensing regime more informative about the firm's tangible investments while making the intangibles measurement regime more informative about the firm's operating profits. Given these informational differences, it is unclear, a priori, which disclosure regime is better from a welfare perspective.

### 3. *Equilibrium Investments in the Full-Information Regime*

In the full-information regime, the firm's date 1 operating profit, its investment in tangibles, and its productive intangibles are all observable and available to the capital market for assessing the distribution of future cash flows. Thus, the equilibrium date 1 capital market price is:

$$P(x_1, K, N) = x_1 - K - N - \gamma + E(\tilde{x}_2 | x_1, K, N).$$

Given the market's prior expectations,  $E(\tilde{x}_1 | K, N) = E(\tilde{x}_2 | K, N) = q(K, N)\mu$ , this price reduces to:

$$P(x_1, K, N) = x_1 - K - N - \gamma + q(K, N)\mu + \frac{\rho}{\sigma_x^2}[x_1 - q(K, N)\mu].$$

At date zero, when the firm chooses its investments, the date 1 operating profit  $\tilde{x}_1$  and the unproductive intangibles  $\tilde{\gamma}$  are random variables. The firm maximizes the expectation of the date 1 capital market price. Thus, the firm's objective function is:

$$\text{Max}_{K, N} 2q(K, N)\mu - K - N. \quad (2)$$

Optimal investments are characterized by the first-order conditions,

$$2\mu q_K = 1. \quad (3)$$

$$2\mu q_N = 1. \quad (4)$$

The objective function described in (2) and the optimal investments characterized in (3) and (4) are identical to those that would obtain if the current shareholders did not liquidate their holdings at all and actually held the firm until the terminal date. This is because a fully informed capital market price makes the current shareholders bear the full consequences of their actions even though they liquidate their holdings early. In this sense, capital market prices fulfill a perfect governance role in this full-information economy.

Using the parametric technology  $q(K, N) = K^\alpha N^\beta$ , we obtain closed-form expressions for the firm's optimal investments. The first-order conditions become:

$$2\mu\alpha K^{\alpha-1} N^\beta = 1, \tag{5}$$

and

$$2\mu\beta K^\alpha N^{\beta-1} = 1, \tag{6}$$

which implies that the efficient way to build capital stock is to combine tangible and intangible investments in the fixed proportion,

$$\frac{K}{N} = \frac{\alpha}{\beta} \tag{7}$$

Inserting this relationship between  $K$  and  $N$  into the first-order conditions (5) and (6), yields the following characterizations of the firm's optimal investments:

PROPOSITION 1. *Assuming that  $q(K, N) = K^\alpha N^\beta$ , equilibrium investments in the full information regime are characterized by:*

$$N^{1-\alpha-\beta} = 2\mu\alpha^\alpha \beta^{1-\alpha} \tag{8}$$

$$K^{1-\alpha-\beta} = 2\mu\alpha^{1-\beta} \beta^\beta.$$

#### 4. Equilibrium Investments in the Expensing Regime

In the expensing regime, the accounting system reports the firm's tangible investments  $K$ , date 1 earnings,  $y_e = x_1 - N - \gamma$ , and date 1 net cash flow,  $z_e = x_1 - K - N - \gamma$ . The information available to the market is summarized by the tuple  $\{K, y_e\}$  because clearly the firm's net cash flow is equivalent to  $z_e = y_e - K$  and therefore contains no incremental information. The equilibrium price in the capital market, as a function of the market's information, is,

$$P(K, y_e) = y_e - K + E(\tilde{x}_2 \mid K, y_e).$$

It is not immediately apparent how the market would assess the conditional distribution  $E(\tilde{x}_2 \mid K, y_e)$  because the firm's reported income  $y_e$  contains the unknown intangible investment of  $N$ . Although  $N$  is unobservable by market participants, it is not a random variable and therefore has no defined statistical distribution that can be used to assess the joint distribution of  $(\tilde{x}_2, \tilde{y}_e)$  unless  $N$  is first specified in some way. Because the quantity  $N$  is an endogenous choice for the firm, the market must rationally *anticipate* the firm's equilibrium choice of  $N$ , given its understanding of the firm's incentives, and build this anticipation into its pricing rule (see Bagwell [1995], Kanodia and Mukherji [1996], and Kanodia, Singh, and Spero [2002] for additional discussion). Because the firm's tangible investment  $K$  is observed and because the firm's incentives for choosing intangibles depends, in some fashion, on its choice of tangible investments, it seems reasonable to posit

that the market's anticipation of intangibles is described by some schedule  $N(K)$ , to be determined endogenously. Given these assessments, the market *perceives* reported date 1 earnings as:

$$\tilde{y}_e = \tilde{x}_1 - \tilde{\gamma} - N(K)$$

with

$$E(\tilde{y}_e | K) = q(K, N(K))\mu - N(K)$$

and

$$\text{Cov}(\tilde{x}_2, \tilde{y}_e) = \text{Cov}(\tilde{x}_2, \tilde{x}_1) = \rho.$$

Moreover, the market's prior expectation of  $\tilde{x}_2$  given its observation of  $K$  is  $q(K, N(K))\mu$ . Using these facts, the equilibrium date 1 price in the capital market is:

$$P(K, y_e) = y_e - K + q(K, N(K))\mu + \frac{\rho}{\sigma_x^2 + \sigma_\gamma^2} [y_e - q(K, N(K))\mu + N(K)] \quad (9)$$

The firm chooses its investments to maximize its expectation of the date 1 market price  $P(K, \tilde{y}_e)$ . From the vantage of the firm,  $E(\tilde{y}_e) = q(K, N)\mu - N$ . It is important to distinguish between the firm's *true* intangible investment, which is  $N$ , and the capital market's assessment of the firm's intangible investment,  $N(K)$ . In *equilibrium*, true and assessed intangibles coincide, but in choosing  $N$  the firm takes the market's pricing rule as given and therefore implicitly takes the market's assessment  $N(K)$  as given. Thus, the firm's objective function is:

$$\begin{aligned} \text{Max}_{K, N} & q(K, N)\mu - K - N + q(K, N(K))\mu \\ & + \frac{\rho}{\sigma_x^2 + \sigma_\gamma^2} [q(K, N)\mu - N - q(K, N(K))\mu + N(K)]. \end{aligned} \quad (10)$$

Differentiating (10) with respect to  $N$  yields the first-order condition:

$$\mu \frac{\partial q(K, N)}{\partial N} - 1 + \frac{\rho}{\sigma_x^2 + \sigma_\gamma^2} [\mu \frac{\partial q(K, N)}{\partial N} - 1] = 0,$$

which simplifies to:

$$\mu \frac{\partial q(K, N)}{\partial N} = 1. \quad (11)$$

Comparing (4) with (11), the difference between the full-information regime and the expensing regime is stark. The popular sentiment that the nonobservability of intangibles diminishes the firm's incentive to invest in intangibles is confirmed. The nonobservability of intangibles results in an informational cost that decreases the perceived marginal return to intangibles. When the date 1 operating profits of the firm cannot be observed, the market is forced to update its beliefs of future operating profits on the

basis of current earnings net of the expenditure on intangibles, that is, on the basis of  $y_e$  rather than  $x_1$ . But, because  $\text{Cov}(\tilde{x}_2, \tilde{y}_e) > 0$ , lower reported earnings are rationally interpreted by the capital market as bad news, decreasing the market's expectation of future operating profits and depressing the firm's market value. This effect is purely informational and would disappear if the market were to directly observe the firm's true earnings of  $\tilde{x}_1$ . The nonobservability of intangible investments creates an incentive for the firm to window dress its *reported* earnings by cutting back on these unobservable investments. From the firm's perspective  $E(\tilde{y}_e) = E(\tilde{x}_1) - N$ ; therefore, any expenditure on intangibles beyond the amount that maximizes this quantity is harmful. Such window-dressing does not deceive the capital market. The firm's diminished incentive to invest in intangibles is rationally anticipated and the firm is priced accordingly.

Using the parametric form,  $q(K, N) = K^\alpha N^\beta$ , the first-order condition (11) becomes

$$\mu\beta K^\alpha N^{\beta-1} = 1. \tag{12}$$

Equation (12), and more generally equation (11), defines a relationship between  $N$  and  $K$  that is consistent with the firm's incentives and that the capital market can anticipate. Thus, the schedule  $N(K)$  that describes market anticipations must satisfy (11) and (12).

We now examine the firm's choice of tangible investments. Differentiating the objective function, described in (10), with respect to  $K$  yields the first-order condition:

$$\begin{aligned} &\mu \frac{\partial q(K, N)}{\partial K} \left[ 1 + \frac{\rho}{\sigma_x^2 + \sigma_y^2} \right] - 1 \\ &+ \mu \left[ \frac{\partial q(K, N(K))}{\partial K} + \frac{\partial q(K, N(K))}{\partial N} N'(K) \right] \left[ 1 - \frac{\rho}{\sigma_x^2 + \sigma_y^2} \right] \\ &+ \frac{\rho}{\sigma_x^2 + \sigma_y^2} N'(K) = 0. \end{aligned}$$

Now, at the equilibrium value of  $K$ , the market's assessment of intangibles  $N(K)$  coincides with the firm's actual choice of  $N$ . Therefore, the firm's equilibrium choice of  $(K, N)$  must satisfy:

$$2\mu \frac{\partial q(K, N)}{\partial K} + N'(K) \left[ \mu \left( 1 - \frac{\rho}{\sigma_x^2 + \sigma_y^2} \right) \frac{\partial q(K, N)}{\partial N} + \frac{\rho}{\sigma_x^2 + \sigma_y^2} \right] = 1.$$

Inserting the firm's first-order condition with respect to  $N$ , described in (11), the preceding equation reduces to,

$$2\mu \frac{\partial q(K, N)}{\partial K} + N'(K) = 1. \tag{13}$$

The firm's equilibrium investments are described by (12) and (13).

Closed-form characterizations of these equilibrium investments are obtained in Proposition 2.

PROPOSITION 2. *Assuming that  $q(K, N) = K^\alpha N^\beta$ , equilibrium investments in the expensing regime are described by:*

$$\frac{K}{N} = \left(1 + \frac{1}{1-\beta}\right) \frac{\alpha}{\beta}, \quad (14)$$

$$K^{1-\alpha-\beta} = \left(1 + \frac{1}{1-\beta}\right)^{1-\beta} \mu \alpha^{1-\beta} \beta^\beta, \quad (15)$$

$$N^{1-\alpha-\beta} = \left(1 + \frac{1}{1-\beta}\right)^\alpha \mu \alpha^\alpha \beta^{1-\alpha}. \quad (16)$$

The equilibrium ratios, in which tangible and intangible investments are combined to produce capital stock, can be compared across the full-information regime and the expensing regime. In the full-information regime we found that  $K/N = \alpha/\beta$ . Comparing this with (14) yields the result that in the expensing regime capital stock is built inefficiently because of an excess reliance on tangible investments. Two factors contribute to this inefficiency: (1) there is an informational cost associated with intangibles but no informational cost associated with tangible investments, and (2) tangible investments acquire additional value because they communicate information about the firm's intangibles.

### 5. Equilibrium Investments in the Intangibles Measurement Regime

As discussed earlier, attempts to measure intangible investments precipitate several kinds of measurement error. These errors preclude the perfect observation of intangible investments as well as tangible investments. Similar to the expensing regime, such noisy measurements of endogenous decisions do not contain information on the decisions themselves. Thus, neither the report on intangibles,  $I_N = N + \tilde{\gamma} - \tilde{\eta} + \tilde{\omega}$ , nor the report on tangibles,  $I_K = K + \tilde{\eta}$ , is used to assess the firm's investments. However, these measurements do strongly affect the structure and information content of the date 1 earnings report of the firm. The earnings report is arrived at by adding the measured investments to the publicly observed net cash flow of the firm, that is,  $y_e = z_e + I_N + I_K$ . Thus,

$$\tilde{y}_e = (\tilde{x}_1 - K - N - \tilde{\gamma}) + (N + \tilde{\gamma} - \tilde{\eta} + \tilde{\omega}) + (K + \tilde{\eta}) = \tilde{x}_1 + \tilde{\omega}.$$

Contrast this with the earnings report in the expensing regime,  $\tilde{y}_e = \tilde{x}_1 - N - \tilde{\gamma}$ . The contamination of earnings caused by the unknown investment in intangibles that was present in the expensing regime is completely eliminated in the intangibles measurement regime. However, measurement of intangibles introduces two new measurement errors, described by  $\tilde{\omega}$  and  $\tilde{\eta}$  that were not present in the expensing regime. The error captured by  $\tilde{\omega}$  arises because it is often unclear whether some observed cash outflow

is an intangible investment with future benefits or an operating expense that affects only the current period. The error captured by  $\tilde{\eta}$  arises from misclassification of tangible and intangible investments. The latter error is offsetting in nature; therefore, it is washed out in the earnings report.

In the expensing regime, the nonobservability of intangibles caused the market to price the firm on the basis of *anticipated* intangible investments. In the intangibles measurement regime, the market anticipates both tangible and intangible investments because neither can be observed directly. Let  $\hat{K}$ ,  $\hat{N}$  denote the market's anticipations. Given these anticipations, the market perceives the observed net cash flow of the firm as arising from:

$$\tilde{z}_c = \tilde{x}_1 - \hat{K} - \hat{N} - \tilde{\gamma}.$$

Thus, the market infers  $\tilde{x}_1 - \tilde{\gamma}$  from the observed date 1 net cash flow of the firm, making this net cash flow incrementally informative relative to the earnings report. In fact, the net cash flow in the intangibles measurement regime contains the same information as the earnings report in the expensing regime because in both cases  $\tilde{x}_1 - \tilde{\gamma}$  is inferred. But, additionally, the intangibles measurement regime conveys  $\tilde{x}_1 + \tilde{\omega}$  through its earnings report. Thus, the intangibles measurement regime conveys strictly more information about current-period earnings than does the expensing regime. Is it possible to obtain even more information in the intangibles measurement regime by reversing the measurement of either intangibles or tangibles? Expensing the reported intangibles yields  $\tilde{y}_c - I_N = \tilde{x}_1 - N - \tilde{\gamma} + \tilde{\eta}$ ; therefore, the information here is strictly dominated by the information contained in the firm's net cash flow. Expensing the reported tangibles yields  $\tilde{y}_c - I_K = \tilde{x}_1 - K - \tilde{\eta} + \tilde{\omega}$ , which is strictly dominated by the information contained in the earnings report.

The preceding arguments imply that the information available to the capital market, in the intangibles measurement regime, is summarized by the tuple  $\{\tilde{z}_c, \tilde{y}_c\}$  describing the firm's net cash flow and its reported earnings. Thus, the equilibrium date 1 price in the capital market is:

$$P(z_c, y_c) = z_c + E(\tilde{x}_2 | z_c, y_c).$$

Given anticipated investments of  $\hat{K}$ ,  $\hat{N}$ , the market's prior expectation of  $\tilde{x}_2$  is  $q(\hat{K}, \hat{N})\mu$ , and the assessed joint distribution of  $(\tilde{x}_2, \tilde{z}_c, \tilde{y}_c)$  is multivariate normal. Using standard statistical formulae,

$$E(\tilde{x}_2 | z_c, y_c) = q(\hat{K}, \hat{N})\mu + b_1[z_c - E(\tilde{z}_c)] + b_2[y_c - E(\tilde{y}_c)],$$

where the coefficients  $b_1$  and  $b_2$  are:

$$b_1 \equiv \frac{\text{cov}(\tilde{x}_2, \tilde{z}_c) \text{var}(\tilde{y}_c) - \text{cov}(\tilde{x}_2, \tilde{y}_c) \text{cov}(\tilde{y}_c, \tilde{z}_c)}{\text{var}(\tilde{y}_c) \text{var}(\tilde{z}_c) - \text{cov}^2(\tilde{y}_c, \tilde{z}_c)}, \quad (17)$$

$$b_2 \equiv \frac{\text{cov}(\tilde{x}_2, \tilde{y}_c) \text{var}(\tilde{z}_c) - \text{cov}(\tilde{x}_2, \tilde{z}_c) \text{cov}(\tilde{y}_c, \tilde{z}_c)}{\text{var}(\tilde{y}_c) \text{var}(\tilde{z}_c) - \text{cov}^2(\tilde{y}_c, \tilde{z}_c)}. \quad (18)$$

Now, as perceived by the market:

$$\text{cov}(\tilde{x}_2, \tilde{z}_c) = \text{cov}(\tilde{x}_2, \tilde{x}_1 - \hat{K} - \hat{N} - \tilde{\gamma}) = \text{cov}(\tilde{x}_2, \tilde{x}_1) = \rho$$

$$\text{cov}(\tilde{x}_2, \tilde{y}_c) = \text{cov}(\tilde{x}_2, \tilde{x}_1 + \tilde{\omega}) = \rho$$

$$\text{cov}(\tilde{y}_c, \tilde{z}_c) = \text{cov}(\tilde{x}_1 + \tilde{\omega}, \tilde{x}_1 - \hat{K} - \hat{N} - \tilde{\gamma}) = \sigma_x^2$$

$$\text{var}(\tilde{y}_c) = \sigma_x^2 + \sigma_\omega^2$$

$$\text{var}(\tilde{z}_c) = \text{var}(\tilde{x}_1 - \hat{K} - \hat{N} - \tilde{\gamma}) = \sigma_x^2 + \sigma_\gamma^2.$$

Inserting the preceding equations into (17) and (18), and simplifying yields,

$$b_1 = \frac{\rho \sigma_\omega^2}{\sigma_x^2[\sigma_\omega^2 + \sigma_\gamma^2] + \sigma_\omega^2 \sigma_\gamma^2}, \quad (19)$$

$$b_2 = \frac{\rho \sigma_\gamma^2}{\sigma_x^2[\sigma_\omega^2 + \sigma_\gamma^2] + \sigma_\omega^2 \sigma_\gamma^2}. \quad (20)$$

Additionally, the market's expectations of net cash flow and earnings are,

$$E(\tilde{z}_c) = q(\hat{K}, \hat{N})\mu - \hat{K} - \hat{N}$$

$$E(\tilde{y}_c) = q(\hat{K}, \hat{N})\mu$$

Using the preceding specifications, the equilibrium date 1 capital market price is,

$$P(z_c, y_c) = z_c + q(\hat{K}, \hat{N})\mu + b_1[z_c - q(\hat{K}, \hat{N})\mu + \hat{K} + \hat{N}] + b_2[y_c - q(\hat{K}, \hat{N})\mu].$$

The firm chooses its investments to maximize the expectation of the preceding price, where the expectation is over the random variables  $\tilde{z}_c$  and  $\tilde{y}_c$ . Noting that the firm takes the market's pricing rule and, therefore, the market's anticipation of investments  $\hat{K}$  and  $\hat{N}$  as given, the first-order conditions for a maximum are:

$$[1 + b_1] \frac{\partial E(\tilde{z}_c)}{\partial K} + b_2 \frac{\partial E(\tilde{y}_c)}{\partial K} = 0$$

and

$$[1 + b_1] \frac{\partial E(\tilde{z}_c)}{\partial N} + b_2 \frac{\partial E(\tilde{y}_c)}{\partial N} = 0.$$

Because, from the vantage of the firm,  $E(\tilde{z}_c) = q(K, N)\mu - K - N$  and  $E(\tilde{y}_c) = q(K, N)\mu$ , these first-order conditions reduce to:

$$\mu \frac{\partial q(K, N)}{\partial K} [1 + b_1 + b_2] = 1 + b_1 \quad (21)$$

and

$$\mu \frac{\partial q(K, N)}{\partial N} [1 + b_1 + b_2] = 1 + b_1. \quad (22)$$

The market’s anticipation of the firm’s investments is rational if  $\hat{K}$ ,  $\hat{N}$  satisfy (21) and (22). The market is perfectly capable of forming these anticipations rationally because the parameters  $\mu$ ,  $b_1$ , and  $b_2$  and the firm’s technology  $q(K, N)$ , are common knowledge.

To see how disclosures in the intangibles measurement regime affect the firm’s investments, we now compare these investments with those obtained in the first best economy. From (19) and (20):

$$b_1 + b_2 = \frac{\rho}{\sigma_x^2 + \frac{\sigma_\omega^2 \sigma_y^2}{\sigma_\omega^2 + \sigma_y^2}}.$$

Because, in general,  $\text{var}(x_1) \geq \text{cov}(x_1, x_2)$ , that is,  $\sigma_x^2 \geq \rho$ , it follows that  $b_1 + b_2 < 1$ . Additionally  $b_1 > 0$ ; therefore, it is clear that the firm underinvests in both tangibles and intangibles, relative to first best. However, tangibles and intangibles are combined efficiently to build the firm’s capital stock

because (21) and (22) imply that  $\frac{\frac{\partial q}{\partial K}}{\frac{\partial q}{\partial N}} = 1$ , as in the full-information setting.

The reason for underinvestment in the intangibles measurement regime is similar to that in the expensing regime, that is, the presence of informational costs.<sup>3</sup> Higher net cash flows, which serve the same informational role here as reported earnings in the expensing regime, are interpreted as good news, making the firm reluctant to decrease its date 1 net cash flow by increasing its investments toward the full-information levels. This informational cost applies to both tangible and intangible investments, whereas in the expensing regime it applies only to intangible investments. In the intangibles measurement regime, investments are not treated as operating expenses and therefore do not contaminate earnings. Thus, the informational cost of net cash flow is partially offset by the earnings report. This offsetting effect is described by the weight  $b_2$  on the firm’s reported earnings, whereas the weight  $b_1$  on the firm’s net cash flow captures the informational cost. To see this more clearly, suppose  $\sigma_\omega^2 \rightarrow 0$ , making the earnings report more informative about true date 1 operating earnings of  $\tilde{x}_1$ . In this case,  $b_1 \rightarrow 0$  and  $b_1 + b_2$  becomes larger, moving the firm’s investments toward the full-information levels.

Inserting the Cobb Douglas-like technology into first-order conditions (21) and (22) yields the closed-form solutions described as follows.

**PROPOSITION 3.** *Assuming that  $q(K, N) = K^\alpha N^\beta$ , equilibrium investments in the intangibles measurement regime are described by:*

$$\begin{aligned} \frac{K}{N} &= \frac{\alpha}{\beta} \\ K^{1-\alpha-\beta} &= \left(1 + \frac{b_2}{1 + b_1}\right) \mu \alpha^{1-\beta} \beta^\beta, \end{aligned} \tag{23}$$

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<sup>3</sup> Bushee’s [1998] empirical findings are consistent with this result.

$$N^{1-\alpha-\beta} = \left(1 + \frac{b_2}{1 + b_1}\right) \mu \alpha^\alpha \beta^{1-\alpha}. \quad (24)$$

## 6. Welfare Comparisons and Policy Implications

Having characterized the equilibrium for each of the three disclosure regimes, we can now ask the policy question of whether intangible investments should be measured or left commingled with operating expenses. We begin with the observation that it is vacuous to ask this question without taking into account the change in the equilibrium investments of the firm induced by changes in the disclosure regime. From a policy perspective, any disclosure regime must be evaluated *ex ante* to the actual release of accounting reports. The *ex ante* value of the firm, given that capital market participants form their beliefs rationally, is always  $2q(K, N)\mu - K - N$  in all three disclosure regimes. Thus, if it is *assumed* that the firm's investments are fixed, say at the first-best levels of  $K^*$ ,  $N^*$  regardless of the disclosure regime, it is moot whether intangibles are expensed or identified separately. Expensing or measuring and reporting intangibles separately will, of course, produce different book values and earnings that correlate differently with realized returns and prices in the capital market. But these are mere statistical facts with no economic significance. We show that the firm's equilibrium investments are *not* the same across disclosure regimes. In fact, in both the expensing regime and the intangibles measurement regime, if capital market participants cling to the belief that the firm invests at first best levels, the firm can actually *increase* its value by decreasing its investments below first best.

We evaluate disclosure regimes in terms of two criteria. First, we compare the equilibrium investments of the firm across disclosure regimes. Second, we compare the expected payoff to the firm's current shareholders across disclosure regimes. The expected payoff to prospective shareholders is always zero because, in each disclosure regime, the price paid by prospective shareholders equals the total expected cash flows of the firm. Hereafter, all of the analysis is conducted under the assumption that  $q(K, N) = K^\alpha N^\beta$ .

### 6.1 COMPARISON OF INVESTMENT LEVELS

We use  $K^*$ ,  $N^*$ ,  $q^*$  to denote first-best investments and capital stock,  $K_E$ ,  $N_E$ ,  $q_E$  to denote equilibrium investments and capital stock in the expensing regime, and  $K_c$ ,  $N_c$ ,  $q_c$  to denote equilibrium investments and capital stock in the intangibles measurement regime.

**PROPOSITION 4.** *In both the expensing regime and the intangibles measurement regime, the firm's equilibrium investments in tangibles and intangibles are below first best.*

We now compare investments in the expensing regime to investments in the intangibles measurement regime. Because  $1 - \beta > \alpha$ , there are only three cases to consider:

- (i)  $1 + \frac{b_2}{1+b_1} \leq \left(1 + \frac{1}{1-\beta}\right)^\alpha$
- (ii)  $1 + \frac{b_2}{1+b_1} \geq \left(1 + \frac{1}{1-\beta}\right)^{1-\beta}$
- (iii)  $\left(1 + \frac{1}{1-\beta}\right)^\alpha < 1 + \frac{b_2}{1+b_1} < \left(1 + \frac{1}{1-\beta}\right)^{1-\beta}$

In case (i) it follows from Propositions 2 and 3 that  $K_c < K_E$ ,  $N_c \leq N_E$  (with strict inequality if the inequality in (i) is strict), and therefore  $q_c < q_E$ . Thus, in case (i) the intangibles measurement regime results in strictly lower investments and capital stock than the expensing regime.

In case (ii),  $N_c > N_E$ ,  $K_c \geq K_E$  (with strict inequality if the inequality in (ii) is strict), and therefore  $q_c > q_E$ . Thus, in this case the intangibles measurement regime results in strictly higher investments and capital stock than the expensing regime.

In case (iii),  $N_c > N_E$ , but  $K_c < K_E$ ; therefore, we compare the two regimes in terms of their overall equilibrium capital stocks. In the intangibles measurement regime, Proposition 3 implies,

$$K_c^\alpha = \left( \left(1 + \frac{b_2}{1+b_1}\right) \mu \alpha^{1-\beta} \beta^B \right)^{\frac{\alpha}{1-\alpha-\beta}},$$

$$N_c^\beta = \left( \left(1 + \frac{b_2}{1+b_1}\right) \mu \alpha^\alpha \beta^{1-\alpha} \right)^{\frac{\beta}{1-\alpha-\beta}}$$

so that

$$q_c = \left(1 + \frac{b_2}{1+b_1}\right)^{\frac{\alpha+\beta}{1-\alpha-\beta}} \mu^{\frac{\alpha+\beta}{1-\alpha-\beta}} \alpha^{\frac{\alpha}{1-\alpha-\beta}} \beta^{\frac{\beta}{1-\alpha-\beta}}.$$

Similar calculations for the expensing regime, based on Proposition 2, yield,

$$q_E = \left(1 + \frac{1}{1-\beta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \mu^{\frac{\alpha+\beta}{1-\alpha-\beta}} \alpha^{\frac{\alpha}{1-\alpha-\beta}} \beta^{\frac{\beta}{1-\alpha-\beta}}.$$

Therefore,  $q_c > q_E$  if and only if  $\left(1 + \frac{b_2}{1+b_1}\right)^{\frac{\alpha+\beta}{1-\alpha-\beta}} > \left(1 + \frac{1}{1-\beta}\right)^{\frac{\alpha}{1-\alpha-\beta}}$  or, equivalently, if and only if  $\left(1 + \frac{b_2}{1+b_1}\right) > \left(1 + \frac{1}{1-\beta}\right)^{\frac{\alpha}{\alpha+\beta}}$ . Because  $\alpha < \frac{\alpha}{\alpha+\beta} < 1 - \beta$ , all three cases are summarized in the following proposition.

**PROPOSITION 5.** *The firm’s capital stock is higher (lower) in the intangibles measurement regime than the expensing regime if and only if:*

$$\left(1 + \frac{b_2}{1+b_1}\right) > (<) \left(1 + \frac{1}{1-\beta}\right)^{\frac{\alpha}{\alpha+\beta}}. \tag{25}$$

The right-hand side of (25) depends only on the technological parameters that determine the relative weight of tangible and intangible investments in forming the firm’s capital stock, whereas the left-hand side depends only on the measurement noise in the firm’s accounting system. Because the

profitability parameter  $\mu$  does not appear in this inequality, the *magnitude* of the firm's investment in intangibles or its profitability, or both, is irrelevant to the issue of whether intangibles should be measured or expensed. Capitalization must be preceded by measurement and separation of intangibles from operating expenses. This finding therefore questions popular arguments advocating the capitalization of intangible investments on the grounds that the investment in intangibles is very large and highly profitable. The profitability of intangible investments affects both disclosure regimes in the same way and therefore does not determine the relative advantage of one over the other.

To better understand the forces that drive a preference for measurement or expensing of intangibles, examine each side of (25). The coefficient  $\frac{b_2}{1+b_1}$  can be calculated from (19) and (20) yielding,

$$\frac{b_2}{1+b_1} = \rho \left[ \rho \frac{\sigma_\omega^2}{\sigma_\gamma^2} + \sigma_x^2 \left( 1 + \frac{\sigma_\omega^2}{\sigma_\gamma^2} \right) + \sigma_\omega^2 \right]^{-1}.$$

Clearly,  $\frac{b_2}{1+b_1}$  is strictly decreasing in  $\sigma_\omega^2$ , strictly increasing in  $\sigma_\gamma^2$ , and strictly increasing in  $\rho$ . Recall that  $\sigma_\omega^2$  represents the degree of noise in separating intangible investments from operating expenses. Our analysis indicates that such misclassifications between operating expenses and intangible investments are extremely damaging to the case for the measurement of intangibles. An increase in  $\sigma_\omega^2$  causes an increase in the value of  $b_1$  and a decrease in the value of  $b_2$ ; that is, the market puts more weight on the firm's net cash flow and less weight on reported earnings in pricing the firm. This in turn increases the informational cost of investment, decreasing the firm's incentives to invest in both tangibles and intangibles. Perhaps this is a key factor underlying the FASB's reluctance to permit the capitalization of intangibles. Lev and Sougiannis [1996] remark, "Apparently, U.S. standard setters are concerned with the reliability and objectivity of the estimates required for R&D capitalization, and with the associated audit risk. The specter of providing managers with additional opportunities for earnings management must also weigh heavily on regulators" (p. 108). Our analysis indicates that such concerns are indeed justified.

An increase in the uncertainty associated with the production of intangible investments, represented by  $\sigma_\gamma^2$ , has the opposite effect. This is because such uncertainty decreases the information content of net cash flows and leaves the information content of the earnings report unchanged. However, an important assumption underlying this result is that  $\tilde{\gamma}$  and  $\tilde{\omega}$  are uncorrelated; that is, the presence of random nonproductive expenditures in producing intangibles has no effect on errors in the measurement of earnings. Violation of this assumption may change the effect of  $\sigma_\gamma^2$ .

An increase in  $\rho$  strengthens the case for measurement of intangible investments because the greater the covariance between date 1 operating profits and date 2 operating profits, the greater is the information content of the earnings report that is provided in the intangibles measurement regime.

Consequently, the capital market attaches relatively more weight to the earnings report in pricing the firm, and this increases the firm's incentives to invest. All of these observations apply only to the intangibles measurement regime because, as shown in Proposition 2, equilibrium investments in the expensing regime are completely independent of the noise in accounting measurements.

Because  $\sigma_{\eta}^2$  does not appear in (25), it may appear that the noise due to random classification errors between tangible and intangible investments has no effect on the relative desirability of measuring or expensing intangibles. Actually, the presence of such errors significantly damages the case for measurement of intangibles. To see this, suppose  $\sigma_{\eta}^2 = 0$ . In this case, the report on intangibles becomes  $I_N = N + \tilde{\gamma} + \tilde{\omega}$ , the report on tangibles becomes  $I_K = K$ , and reported earnings remain  $\tilde{y} = \tilde{x}_1 + \tilde{\omega}$ . Now, by reversing the measurement of intangibles, the capital market would calculate  $y - I_N = \tilde{x}_1 - N - \tilde{\gamma}$ . Thus, in the intangibles measurement regime the information available to the capital market would consist of  $\{K, \tilde{x}_1 - N - \tilde{\gamma}, \tilde{x}_1 + \tilde{\omega}\}$ , whereas the expensing regime would provide the information  $\{K, \tilde{x}_1 - N - \tilde{\gamma}\}$ . Thus, the intangibles measurement regime would provide all of the information available in the expensing regime and more, and would strictly dominate the expensing regime. This is essentially the argument made by proponents of capitalization; that is, the capitalization of intangibles could not possibly be harmful because such capitalization could be reversed and the information provided in the expensing regime could be regained. It is argued that, this being the case, even crude estimates of intangibles could only enhance the information provided to the market. Our analysis indicates there are two flaws in these arguments. First, crude (noisy) estimates of intangibles provide no information about the intangible investments. This is not an artifact of our model. It is generically true that noisy information on endogenous actions provides no information on the actions themselves. These crude estimates do change the structure and information content of the earnings report, but they also introduce a new source of noise,  $\tilde{\omega}$ , that is absent in the expensing regime. Second, the measurement of intangibles opens up the possibility of shifting cash flows between tangibles and intangibles (represented by  $\tilde{\eta}$ ), making it impossible to regain the information in the expensing regime. It may be thought that these latter errors would be insignificant and could therefore be ignored. But we show that the *magnitude* of  $\sigma_{\eta}^2$  is irrelevant to the arguments favoring measurement or expensing of intangibles; only the *presence* of  $\tilde{\eta}$  is important. Even a small amount of noise in the classification of investments as tangible or intangible fundamentally changes the information available to the capital market.

To interpret the right-hand side of (25), note that  $\frac{\beta}{\alpha + \beta}$  represents the relative weight of intangibles in building the firm's capital stock. We wish to examine how this relative weight of intangibles affects the desirability of measuring intangible investments. To do this, hold  $\alpha + \beta$  fixed at some value  $r$  satisfying  $0 < r < 1$ , and consider variations in  $\beta$  alone. In terms of  $r$  and  $\beta$ , Proposition 5 can be restated as:

$$q_c > q_E \text{ iff } \left(1 + \frac{b_2}{1 + b_1}\right) > \left(1 + \frac{1}{1 - \beta}\right)^{\frac{r - \beta}{r}}. \tag{26}$$

Let  $f(\beta)$  denote the right-hand side of (26) and note that  $f(\beta)$  is a strictly decreasing function of  $\beta$ . Because  $r$  is fixed, the range of  $\beta$  is  $[0, r]$ . At  $\beta = 0$ ,  $f(\beta) = 2$ , and at  $\beta = r$ ,  $f(\beta) = 1$ . Let  $T(\sigma_\omega^2, \sigma_\gamma^2, \rho)$  denote the left-hand side of (26). Now, the lower bound on  $T$  is 1 because as  $\sigma_\omega^2 \rightarrow \infty$ ,  $T \rightarrow 1$ . The upper bound on  $T$  is 2, which is attained when  $\sigma_\omega^2 = 0$  and  $\rho = \sigma_x^2$ . Thus,  $T \in [1, 2]$  and  $f(\beta) \in [1, 2]$  and  $f(\beta)$  is strictly decreasing. This implies that for any fixed value of  $T$  there exists  $\beta^*(T)$  such that  $\beta > \beta^* \Rightarrow q_c > q_E$ . Conversely, for any fixed  $\beta$  there exists  $T^*(\beta)$  such that  $T > T^* \Rightarrow q_c > q_E$ . We show that the following proposition holds.

**PROPOSITION 6.** *Given any fixed level of noise in the measurement of intangibles, measurement is preferred to expensing if the relative weight of intangibles in building the firm’s capital stock is large enough. Conversely, given the relative weight of intangibles, measurement is preferred to expensing if the noise associated with measuring intangibles is small enough. In all other cases, expensing of intangibles is preferred to measurement.*

### 6.2 COMPARISON OF EXPECTED PAYOFFS TO CURRENT SHAREHOLDERS

The expected payoff to the firm’s current shareholders is equivalent to the expected date 1 price in the capital market, where the expectation is taken from the perspective of date zero before the release of accounting reports. In both the expensing and the intangibles measurement regime, the date 1 capital market price incorporates the market’s anticipation of the firm’s chosen investments. In equilibrium, these anticipated investments coincide with the firm’s actual investments. Thus, in all three regimes the expected payoff to current shareholders is  $V = 2\mu q(K, N) - K - N$ . We show that the equilibrium values of  $K$  and  $N$  are different in the three regimes, leading to differences in the values of the firm’s capital stock  $q$ . However, because the mix of tangibles and intangibles used to form the firm’s capital stock varies from one regime to another, it is not necessarily true that current shareholders are better off when the firm’s capital stock is closer to first best. In the following, we explicitly calculate and compare the welfare of the firm’s current shareholders in terms of the equilibrium expected payoffs they earn in each of the three disclosure regimes. We show that results similar to that in Proposition 6 continue to hold.

Let  $V^*$  denote the current shareholders’ equilibrium expected payoff in the full-information regime, and let  $V_E$  and  $V_c$  denote the corresponding payoffs in the expensing and intangibles measurement regimes, respectively.

From Proposition 1, it follows that:

$$V^* = 2\mu (2\mu\alpha^{1-\beta}\beta^\beta)^{\frac{\alpha}{1-\alpha-\beta}} (2\mu\alpha^\alpha\beta^{1-\alpha})^{\frac{\beta}{1-\alpha-\beta}} - (2\mu\alpha^{1-\beta}\beta^\beta)^{\frac{1}{1-\alpha-\beta}} - (2\mu\alpha^\alpha\beta^{1-\alpha})^{\frac{1}{1-\alpha-\beta}}.$$

Simplifying yields,

$$V^* = (2\mu\alpha^\alpha\beta^\beta)^{\frac{1}{1-\alpha-\beta}} [1 - \alpha - \beta]. \tag{27}$$

Using the results in Proposition 2, similar calculations for the expensing regime yield:

$$V_E = \left( \mu \left( 1 + \frac{1}{1-\beta} \right)^\alpha \alpha^\alpha \beta^\beta \right)^{\frac{1}{1-\alpha-\beta}} \left[ 2 - \left( 1 + \frac{1}{1-\beta} \right) \alpha - \beta \right].$$

For comparison purposes, it is convenient to express  $V_E$  as:

$$\begin{aligned} V_E &= (2\mu\alpha^\alpha\beta^\beta)^{\frac{1}{1-\alpha-\beta}} \left[ 2 - \left( 1 + \frac{1}{1-\beta} \right) \alpha - \beta \right] \\ &\quad \times \left( 1 + \frac{1}{1-\beta} \right)^{\frac{\alpha}{1-\alpha-\beta}} \left( \frac{1}{2} \right)^{\frac{1}{1-\alpha-\beta}}. \end{aligned} \tag{28}$$

Similar calculations for the intangibles measurement regime yield:

$$V_c = (2\mu\alpha^\alpha\beta^\beta)^{\frac{1}{1-\alpha-\beta}} \left[ \frac{2}{T} - \alpha - \beta \right] \left[ \frac{T}{2} \right]^{\frac{1}{1-\alpha-\beta}}. \tag{29}$$

where  $T \equiv 1 + \frac{b_2}{1+b_1}$ .

**PROPOSITION 7.** *The equilibrium expected payoffs  $V_c$  and  $V_E$  of the current shareholders in the intangibles measurement and expensing regimes respectively are strictly lower than the equilibrium payoff  $V^*$  of the current shareholders in the full-information regime. For any fixed value of  $T \in (1, 2)$  there exists  $\beta^{**}(T)$  such that  $\beta > \beta^{**} \Rightarrow V_c > V_E$ . Conversely, for any fixed  $\beta \in (0, r)$  there exists  $T^{**}(\beta)$  such that  $T > T^{**} \Rightarrow V_c > V_E$ .*

We arrive at qualitatively similar conclusions regardless of whether disclosure regimes are evaluated in terms of their induced investments or in terms of the expected payoff to the firm’s current shareholders. Measurement of intangibles is preferred if and only if the measurement noise associated with intangibles is sufficiently small and the relative weight of intangibles in the firm’s capital stock is sufficiently large. In all other cases, it is better to leave intangibles unmeasured and commingled with operating expenses.

We expect that the technology parameters  $\alpha$  and  $\beta$  that fundamentally determine the relative mix of tangibles and intangibles in a firm’s capital stock would vary considerably from one industry to another. The measurement noise associated with intangibles is also likely to vary across industries. Our analysis indicates that *uniform* accounting standards across all industries may be dysfunctional and investors may be better served by industry-specific accounting standards.

## 7. Empirical Implications

Empirical studies document a positive association between estimated intangible investments and stock prices and returns even when the accounting system does not explicitly measure and report intangibles. This finding is consistent with our theory. When intangibles are not reported, the market does *not* naively price the firm as if its intangibles are zero (or \$10 billion, or some other equally arbitrary amount). In our theory, the market rationally (and correctly) *anticipates* the firm's investment in intangibles and prices the firm accordingly. A simplistic regression of price against recorded book values and recorded earnings, where the data are drawn from an expensing regime, assumes that the market prices the firm as if its intangibles are zero. Such regressions would be misspecified and would provide misleading results. It should not be surprising that when an estimate of intangibles is added to the regression, significant coefficient values and improved  $R^2$  are obtained. These results do not necessarily imply that incorporating such estimates in formal accounting reports would actually provide *new* information to the market, nor do they imply that an outside observer could use these estimates to identify mispriced stocks and earn excess returns in the market. What they do imply is that the statistical estimates made by the researcher are a reasonably good proxy for market anticipations.

Our results also indicate that the value relevance of intangibles does not, by itself, imply that intangibles should be measured. In all three disclosure regimes analyzed in this paper, intangible investments are value relevant and are fully reflected in stock prices. How are these disclosure regimes to be ranked on the basis of value relevance alone? But suppose we were to provide the value-relevance approach its best possible chance to evaluate accounting policy. Suppose we were to conduct a hypothetical experiment across two "island" economies, where intangibles are expensed in one economy and measured in the other economy. In each economy, an outside observer estimates a regression of stock price against earnings and book values. In the expensing economy, reported book values and earnings are adjusted by an accurate estimate of intangibles before the regression is estimated, whereas in the economy where intangibles are measured no adjustments are made to accounting reports. Is it legitimate to compare coefficient values and  $R^2$ 's across the two regimes to evaluate accounting policy? Again, the answer is in the negative. The fundamental reason such comparisons are uninformative is that the firm's investments would be *different* in the two islands. Both the levels of tangible and intangibles and the mix of tangibles and intangibles would be different.

Propositions 5 and 6 indicate that the two critical factors that determine whether intangibles should be measured or expensed are (1) the relative weight on intangibles in the firm's capital stock in the expensing regime and (2) the relative weights assigned by the market to cash flows and earnings in the intangibles measurement regime. Measurement of intangibles is preferred when the relative weight on intangibles in the expensing regime,

described by the technology parameter  $\frac{\beta}{r}$ , is large and the weight on cash flows relative to earnings that is implicit in market prices in the intangibles measurement regime, described by  $\frac{1}{T} \equiv \frac{1+b_1}{b_2}$ , is small. If  $\frac{\beta}{r}$  is interpreted as the relevance of intangibles and if  $\frac{1}{T}$  is interpreted as the reliability or precision with which intangibles can be measured, these results shed light on the popular wisdom that there is a trade-off between relevance and reliability that must be taken into account in the determination of accounting standards. We emphasize that this trade-off matters, not through its effect on correlations between accounting numbers and stock prices but through its effect on the firm's incentives to undertake investments in intangibles.

It can easily be verified that in all three disclosure regimes we analyze, the ratio of intangible investments to capital stock,  $\frac{N}{q}$ , is directly proportional to  $\beta$ , which suggests that this ratio can be used to estimate  $\beta$ . Aboody and Lev [1998] use this ratio to provide evidence of a positive association between software development intensity and the likelihood of a firm being a capitalizer. They define software development intensity as the ratio of annual software development costs to sales. To the extent that software development intensity is a proxy for  $\beta$ , their evidence is consistent with the predictions of our theory. Aboody and Lev do not, however, consider the second factor suggested by our theory, which would affect the likelihood of a firm being a capitalizer. This second critical factor,  $T$ , is determined by the coefficients  $b_1$  and  $b_2$  that represent the weights that capital market prices assign to firms' net cash flows and earnings, respectively. In principle, these weights can be estimated and used in Aboody and Lev's regression to yield sharper insights.

Our theory suggests that requiring uniform application of generally accepted accounting principles (GAAP) across all industries may be dysfunctional. The two critical factors  $\beta$  and  $T$  are likely to display considerable cross-sectional variation across industries. Therefore, it is conceivable that measurement of intangibles is better for one industry whereas expensing is better for another industry. For the same reason, our theory questions the wisdom of requiring that R&D expenditures be measured and reported as a line item by firms in all industries. It is plausible that the relative importance of R&D and the difficulty of separating it from operating expenses varies across industries.

Our results may also be of independent interest to empirical researchers evaluating the quality of accounting regimes from a corporate governance perspective. First, when the accounting regime is weak, we expect the quality of earnings to be low, which in turn forces the capital market to rely more heavily on a firm's cash flows rather than on its earnings. Variations in the quality of accounting regimes would therefore map directly into the relative weight that the capital market places on earnings and on cash flows. Second, the capital market's reliance on cash flows deters firms from undertaking positive net present value (NPV) investments. This disincentive to undertake positive NPV investments is higher when the accounting regime is weaker.

## 8. Conclusion

We study the economic consequences of measuring intangibles even though most of the debate on the appropriate accounting treatment for intangibles centers around the issue of whether intangibles should be placed on the income statement or on the balance sheet. By addressing a more primitive question, we shed light on the relevance-reliability trade-off of measuring intangibles. We show that intangibles should be measured only when their relative importance in constituting the firm's capital stock is high and when they can be measured with sufficiently high precision. In all other cases, attempts to separate intangible investments from operating expenses is counterproductive.<sup>4</sup>

There are other potential explanations for FASB's reluctance to permit the capitalization of intangibles. The value of tangible assets can actually be realized by creditors in times of financial distress because this value is transferable and observable in well-organized markets. However, most of the value of intangible assets is likely to be firm specific and nontradable in organized markets. This value cannot be seized by creditors in the event of financial distress. Reporting such intangible assets on the balance sheet may increase auditors' exposure to litigation and legal liability in case of financial distress. Our model does not address this issue.

Advocates of capitalization claim that the advantage of capitalization over expensing stems primarily from the additional disclosures that must accompany the classification of any expenditure as an asset. These enhanced disclosures would include estimates of useful lives and magnitudes of impairment of intangible assets. This important issue cannot be addressed in the kind of static model we analyze. Considerable additional insight could be obtained from a dynamic model where the useful lives of intangible assets changes stochastically over time and where there are opportunities for additional investments over time.

An important limitation to our analysis concerns the assumption that the capital market and the firm are symmetrically informed about the profitability of the firm's capital stock. Given this assumption, noisy measurements of endogenous investments cannot be used to make inferences about the investments themselves. However, if the firm's investments are based on private information regarding the productivity or profitability of investment, noisy measurements of investments would have information content and would lead to noisy signaling equilibria. The results in Kanodia, Singh, and

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<sup>4</sup>We assume that when alternative accounting measurement and disclosure regimes are feasible, only one of these alternatives must be chosen for reporting to the public. In principle, accountants could measure assets and income in multiple ways and disclose all of these multiple statements to the public, letting each investor decide which disclosure to rely on. In the setting we consider, the accountant could measure the firm's investment under successively less conservative principles (the expensing regime being the most conservative) and disclose all of these different measurements. We rule out this possibility. Instead, we analyze the pros and cons of one measurement regime versus the other.

Spero [2002] suggest that in such settings some degree of measurement noise may actually be desirable and therefore the trade-offs determining the desirability of measuring intangibles could change.

APPENDIX

*Proof of Proposition 2.* First, we calculate  $N'(K)$  from (12). Totally differentiating (12) with respect to  $K$  yields,

$$\mu\beta K^{\alpha-1} N^{\beta-2} [\alpha N(K) + (\beta - 1) KN'(K)] = 0,$$

which implies,

$$N'(K) = \frac{\alpha N(K)}{(1 - \beta) K}.$$

Using this, the first-order condition with respect to  $K$  described in (13) becomes,

$$2\mu\alpha K^{\alpha-1} N^\beta(K) + \frac{\alpha N(K)}{(1 - \beta) K} = 1. \tag{A1}$$

Now, inserting the expression for  $N^{\beta-1}(K)$  from (12) into (A1) yields,

$$N(K) \left[ \frac{2\mu\alpha K^{\alpha-1}}{\mu\beta K^\alpha} + \frac{\alpha}{(1 - \beta) K} \right] = 1,$$

which implies that the equilibrium relationship between  $K$  and  $N$  must satisfy,

$$\frac{\beta}{\alpha} \left( \frac{1 - \beta}{2 - \beta} \right) K = N(K). \tag{A2}$$

Substituting for  $N(K)$  from (A2) into (12), implies,

$$\left( \frac{\beta}{\alpha} \right)^{\beta-1} \left( \frac{1 - \beta}{2 - \beta} \right)^{\beta-1} K^{\beta-1} = \frac{1}{\mu\beta K^\alpha},$$

which is equivalent to,

$$K^{1-\alpha-\beta} = \left( 1 + \frac{1}{1 - \beta} \right)^{1-\beta} \mu\alpha^{1-\beta} \beta^\beta. \tag{A3}$$

The equilibrium value of  $N$  is obtained by evaluating  $N(K)$  at the equilibrium  $K$ . Equivalently,  $N(K)$  can be calculated from the equilibrium relationship (A2) rewritten as,

$$K^{1-\alpha-\beta} \left[ \frac{\beta}{\alpha} \left( \frac{1 - \beta}{2 - \beta} \right) \right]^{1-\alpha-\beta} = N^{1-\alpha-\beta}.$$

Now, replacing  $K^{1-\alpha-\beta}$  by the right-hand side of (A3) and simplifying yields,

$$N^{1-\alpha-\beta} = \left(1 + \frac{1}{1-\beta}\right)^\alpha \mu \alpha^\alpha \beta^{1-\alpha},$$

completing the proof.

*Proof of Proposition 3.* For the specification,  $q(K, N) = K^\alpha N^\beta$ , equations (21) and (22) reduce to:

$$\mu \alpha K^{\alpha-1} N^\beta [1 + b_1 + b_2] = 1 + b_1 \quad (\text{A4})$$

and

$$\mu \beta K^\alpha N^{\beta-1} [1 + b_1 + b_2] = 1 + b_1. \quad (\text{A5})$$

Dividing (A4) by (A5) yields  $\frac{K}{N} = \frac{\alpha}{\beta}$ . Substituting for  $K$  and  $N$  successively in (A4) and (A5) yields the desired results.

*Proof of Proposition 4.* From Propositions 1 and 2 it is clear that  $K_E < K^*$  iff  $(1 + \frac{1}{1-\beta})^{1-\beta} < 2$ , and  $N_E < N^*$  iff  $(1 + \frac{1}{1-\beta})^\alpha < 2$ . From our assumption that  $\alpha + \beta < 1$ , it follows that  $1 - \beta > \alpha$ ; therefore, if  $K_E < K^*$ , it must be that  $N_E < N^*$ . The result that  $K_E < K^*$  follows from the algebraic fact that the function  $f(x) = (1 + \frac{1}{x})^x$  is strictly increasing and for  $0 < x < 1$ ,  $1 < f(x) < 2$ . Turning to the intangibles measurement regime, it follows from Propositions 1 and 3 that both tangible and intangible investments are lower than first best if and only if  $\frac{b_2}{1+b_1} < 1$ . This inequality holds because  $\sigma_x^2 \geq \rho$  implies that  $b_2 < 1$  and clearly  $b_1 > 0$ .

*Proof of Proposition 7.* We first verify that  $V_c < V^*$  and  $V_E < V^*$ . The first inequality follows if:

$$\left[\frac{2}{T} - \alpha - \beta\right] \left[\frac{T}{2}\right]^{\frac{1}{1-\alpha-\beta}} < 1 - \alpha - \beta.$$

Now,  $1 < T < 2$ , and over this interval the factor  $\left[\frac{2}{T} - \alpha - \beta\right] \left[\frac{T}{2}\right]^{\frac{1}{1-\alpha-\beta}}$  is strictly increasing in  $T$ , attaining  $1 - \alpha - \beta$  at  $T = 2$ , from which the desired inequality follows. Additionally,  $V_E < V^*$  if and only if,

$$\begin{aligned} & \left[2 - \left(1 + \frac{1}{1-\beta}\right)\alpha - \beta\right] \left(1 + \frac{1}{1-\beta}\right)^{\frac{\alpha}{1-\alpha-\beta}} \left(\frac{1}{2}\right)^{\frac{1}{1-\alpha-\beta}} < 1 - \alpha - \beta \\ & \Leftrightarrow \left[2 - \beta - \left(\frac{2-\beta}{1-\beta}\right)\alpha\right] \left[\frac{2-\beta}{1-\beta}\right]^{\frac{\alpha}{1-\alpha-\beta}} < (1 - \alpha - \beta) 2^{\frac{1}{1-\alpha-\beta}} \\ & \Leftrightarrow \left(\frac{2-\beta}{1-\beta}\right) (1 - \alpha - \beta) \left[\frac{2-\beta}{1-\beta}\right]^{\frac{\alpha}{1-\alpha-\beta}} < (1 - \alpha - \beta) 2^{\frac{1}{1-\alpha-\beta}} \\ & \Leftrightarrow \left(\frac{2-\beta}{1-\beta}\right)^{1-\beta} < 2. \end{aligned}$$

The left-hand side of the preceding inequality is strictly decreasing in  $\beta$  and attains the value 2 at  $\beta = 0$ . Therefore,  $V_E < V^*$  for each  $\beta > 0$ .

We now compare the intangibles measurement regime with the expensing regime. From (28) and (29), it follows that  $V_c > V_E$  if and only if:

$$\left[ \frac{2}{T} - \alpha - \beta \right] T^{\frac{1}{1-\alpha-\beta}} > \left[ 2 - \left( 1 + \frac{1}{1-\beta} \right) \alpha - \beta \right] \left( 1 + \frac{1}{1-\beta} \right)^{\frac{\alpha}{1-\alpha-\beta}}.$$

As shown in the preceding calculations, the right-hand side equals  $(1 - \alpha - \beta) \left[ \frac{2-\beta}{1-\beta} \right]^{\frac{1-\beta}{1-\alpha-\beta}}$ . Therefore,  $V_c > V_E$  if and only if:

$$\left( \frac{\frac{2}{T} - \alpha - \beta}{1 - \alpha - \beta} \right)^{1-\alpha-\beta} T > \left( \frac{2 - \beta}{1 - \beta} \right)^{1-\beta}. \tag{A6}$$

To assess (A6) for feasible values of  $\alpha$ ,  $\beta$ , and  $T$ , once again let  $\alpha + \beta = r$ , hold  $r \in (0, 1)$  fixed, and think of the left-hand side of (A6) as a function of  $T$  and the right-hand side of (A6) as a function of  $\beta$ . Feasible values of  $T$  are contained in the interval (1, 2) and feasible values of  $\beta$  are contained in the interval (0,  $r$ ). Now,

$$V_c > V_E \text{ iff } \left( \frac{\frac{2}{T} - r}{1 - r} \right)^{1-r} T > \left( \frac{2 - \beta}{1 - \beta} \right)^{1-\beta}. \tag{A7}$$

The left-hand side of (A7) does not depend on  $\beta$  and is strictly increasing in  $T$  over the interval (1, 2), attaining the value  $\left(\frac{2-r}{1-r}\right)^{1-r}$  at  $T = 1$  and attaining the value 2 at  $T = 2$ . The right-hand side of (A7) does not depend on  $T$  and is strictly decreasing in  $\beta$  over the interval (0,  $r$ ), attaining the value 2 at  $\beta = 0$  and attaining the value  $\left(\frac{2-r}{1-r}\right)^{1-r}$  at  $\beta = r$ . Thus, as in Proposition 6, for any fixed value of  $T \in (1, 2)$  there exists  $\beta^{**}(T)$  such that  $\beta > \beta^{**} \Rightarrow V_c > V_E$ . Conversely, for any fixed  $\beta \in (0, r)$  there exists  $T^{**}(\beta)$  such that  $T > T^{**} \Rightarrow V_c > V_E$ .

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