Accounting Conservatism and Real Options

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Abstract

I address the interaction between accounting conservatism and real options in both a staged investment and abandonment model. An accounting policy biased towards classifying a Good (Bad) project as Bad (Good) is conservative (aggressive). The accounting signal is optimally conservative when the ex ante unconditional expected terminal value is less than the second investment (staged investment) or value of the asset in its alternative use (abandonment). The relative size of the second investment is a proxy for the degree of sequentiality of the project. Since research and development projects typically require more sequential investment than fixed assets projects, the staged investment results are consistent with the differential treatment of these types of investment under U.S. Generally Accepted Accounting Principles.
1 Introduction

I study how the bias in information affects investment in a real options framework. In particular, I derive conditions under which the optimal accounting information system has a conservative bias. I model two types of real options, staged investment and abandonment. In the staged investment model, the firm can adopt a project that requires sequential investment at two dates. The firm has sufficient capital to make only the first investment and seeks to sell the project to investors. If there are no investors willing to buy the project, the firm drops the project and it produces no cash flows. In the abandonment model, there is only one investment, but the assets have value in an alternative use. The firm sells the project to investors for exogenous liquidity reasons. If the signal is unfavorable, the investors abandon the project in favor of the assets alternative use.

Both models include a public accounting signal that arrives prior to the real option decision point. The signal is noisy and may misclassify projects. An accounting policy that frequently classifies a Good project as Bad (Type I error) but rarely classifies a Bad project as Good (Type II error) is conservative. Conversely, an accounting policy that frequently classifies a Bad project as Good but rarely classifies a Good project as Bad is aggressive. The payoffs, investments, and alternative value (if applicable) are known to the regulator, who sets the accounting policy to maximize the expected surplus in the economy. Because there is no private information in the model, this is equivalent to maximizing the expected proceeds of the sale to the investors.

Increasing conservatism in the staged investment model has competing effects, increasing the price of the project conditional on a High signal, but reducing the probability that the High signal occurs. Higher conservatism, therefore, may not result in higher expected sales proceeds. The choice of optimal accounting policy depends on whether the second investment exceeds the unconditional ex ante expected terminal cash flow. If this is true, investing in Bad projects yields large losses. To make the sale more attractive to investors, it is necessary to set a conservative accounting policy that eliminates Type II errors. If the second investment is lower than the unconditional ex ante expected terminal cash flow, then the opportunity
cost of abandoning a Good project is high, and an aggressive accounting policy is optimal.

The firm is sequentially rational. If the expected proceeds from the sale are less than the initial investment, the firm does not adopt the project. I establish parameter values for which the regulator optimally chooses a conservative accounting policy and the firm adopts the project. The main result of the paper is that this generally occurs when the second investment is a relatively large share of total investment, or, in other words, when the real option aspect of the investment is more important. I argue that this loosely conforms to Generally Accepted Accounting Principles (GAAP). Research and development (R&D) projects typically require sequential investment, and the GAAP requirement of expensing R&D immediately rather than capitalizing is conservative. In contrast, investments in property, plant and equipment are typically less sequential, and the GAAP requirement of capitalization is aggressive.

The results are similar in the abandonment model. Because the project assets have value in an alternative use, the investors buy the project even if the signal realization is unfavorable. In setting the accounting policy, the regulator trades off increasing conservatism to reduce the probability that Bad projects will be pursued with increasing aggressiveness to reduce the probability that Good projects will be abandoned. Conservative accounting dominates when the value of the assets in their alternative use exceeds the unconditional \textit{ex ante} expected terminal cash flow. Otherwise, aggressive accounting dominates.

2 Prior research

There is a large body of empirical literature addressing conservatism in financial reporting.$^1$ Basu (1997) adopts a returns-based approach, arguing that conservatism implies that losses are recognized in earnings on a more timely basis than gains. He finds evidence that returns and earnings are more correlated for loss firms than for gain firms, consistent with conservatism. Penman and Zhang (2002) measure conservatism from a balance sheet perspective as the understatement of assets related to inventory, research and development, and advertising.

The theoretical conservatism literature is less developed. Watts (2003a) suggests that

\footnote{For more references, see Watts (2003b).}
conservatism is related to debt contracts, and in particular may play a role in protecting debtholders against excessive dividend payments. Gjesdal and Antle (2001) model the interaction between income measurement and dividend covenants. Though conservatism may be optimal, the result derives from shareholders trading off cash flows in different periods, not from the need to protect the interests of creditors. Kwon, Newman and Suh (2001) study a limited-liability moral hazard setting. The principal in their model optimally selects a conservative accounting measurement system. The intuition is that the limited liability precludes large negative penalties. As a result, the conservative accounting system, because it increases likelihood ratios for higher outcome reports, is optimal. Gigler and Hemmer (2001) model a principal-agent setting in which the agent can make a voluntary disclosure prior to the noisy earnings report. The authors focus on the implications of conservative accounting rather than the choice of the optimal accounting policy. They find that the value of communication is strictly decreasing in the degree of conservatism in the reporting system.

Venugopalan (2001) examines the role of conservatism in an adverse selection principal-agent model. The properties of the accounting measurement system affect real investment levels as well as capital market prices. He examines both a contractual setting and a market setting. In the contractual setting, conservative accounting unambiguously induces more efficient investment. In the market setting, conservative accounting is more efficient only if it is also more informative. The relative informativeness of conservative and liberal accounting systems depends on the \textit{ex ante} probability of success of the project.

My model is most similar to the market setting in Venugopalan (2001), though there are important differences in both the modeling and the results. Venugopalan (2001) models an agency conflict without a real option. I model a real option without an agency conflict. The accounting signal in my model is useful because it provides guidance on whether to exercise the real option, not because it regulates a control problem between the current owners and investors. Venugopalan (2001) finds that conservative accounting is optimal in the market setting if the probability of success of the project is less than \(\frac{1}{2}\), regardless of the magnitude of the payoff. I find that conservative accounting can be optimal only when the unconditional
*ex ante* expected terminal cash flow is less than the second investment (value of the assets in their alternative use). That is, a combination of probability of success, magnitude of payoff and size of investment yields the optimality of the conservative accounting policy, not just probability of success alone.

The difference between the results follows from the underlying economics. In Venugopalan (2001), the market price depends on both the level of investment and the signal. The owner of the firm has incentive to overinvest to deceive the potential buyers about the value of the firm. By providing separate information about the firm’s type, the accounting signal indirectly disciplines the investment. The signal’s ability to discipline the overinvestment depends critically on its ability to differentiate between states. The payoffs to the states are not important. When the probability of project success is low, conservative accounting discriminates between states more effectively.

As there is no adverse selection problem in my model, the signal’s only role is to inform the decision related to the real option. The informativeness of the signal plays a role, of course, but not independent of the payoffs of the states. In effect, the different states receive different weights. In the staged investment model, for example, the cost of investing in a Bad project is high if the *ex ante* expected payoff is less than the second investment. Hence, a conservative accounting signal in which the High signal is relatively precise is optimal. Conversely, if the *ex ante* expected payoff is higher than the second investment, the opportunity cost of abandoning a good project is high. The regulator prefers an aggressive accounting signal in which the Low signal is relatively precise.

In addition to the conservatism literature, there is also an extensive body of empirical research on the valuation consequences of abandonment options. Berger, Ofek and Swary (1996) show empirical evidence consistent with investors using balance sheet information to abandon to price the option to abandon the firm at its exit value. Burgstahler and Dichev (1997) demonstrate a nonlinear convex relation between market value and earnings consistent with investors valuing the adaptive use of a firm’s assets as an option. Hayn (1995) argues that because assets have a liquidation value, losses will not perpetuate and
finds, consistent with her hypothesis, that losses have a lower earnings response coefficient than gains. The abandonment option is sometimes offered as an alternative explanation for the returns-earnings regularities attributed to conservatism in Basu (1997). My paper shows that disentangling the two explanations is difficult as the presence of real options has direct effects on the optimal level of conservatism.

In the theoretical accounting literature, Zhang (2000) embeds a real option within the Feltham and Ohlson (1996) model. The firm infers operating efficiency from accounting numbers and then determines whether to discontinue, maintain, or increase the scale of operations. In this setting, firm value can be a convex function of accounting variables. Conservatism is also present in the model but, in contrast to my model, does not interact with the inference about firm type. Conservatism, then, affects the weightings on earnings and book value in the valuation equation, but plays no role in determining the value of the real option. Biddle, Chen and Zhang (2001) confirm the prediction of a convex relation between firm value and residual income. Chen and Zhang (2003) extend this work to segment disclosures.

Arya and Glover (2003) model a principal-agent setting in which the principal has an option to abandon a project before the cash flow realization based on the realization of an unverifiable signal. Abandoning the project precludes negative cash flow realizations but also, by eliminating the lower tail of the distribution of outcomes, reduces the informativeness of the realized cash flows. In this control setting, the principal balances the tension by coarsening the information system producing the signal in a way that resembles aggressive accounting. In contrast, conservative accounting in the valuation setting of my model may enhance the value of the real option.

3 Staged Investment Model

The players in the model are a firm, investors and a regulator. All players are risk-neutral and have common information about the project and signal structure. The firm has a project that requires sequential investment at dates 1 and 2 in the amount of $I_1 > 0$ and $I_2 > 0$
respectively. It will be convenient at points in the analysis to refer to aggregate investment $I = I_1 + I_2$ and also to the proportion of aggregate investment that occurs in the first period $I_1 = \alpha I$, where $\alpha \in (0, 1)$, implying that $I_2 = (1 - \alpha)I$. The project is Good with probability $g$ and Bad with probability $1 - g$. If both investments are made (project is funded), the terminal cash inflow for a Good project is distributed uniformly between $V$ and $V + \Delta$, with $V > 0$, $\Delta \in [0, \infty]$, and $\frac{V + \Delta}{2} > I_1 + I_2$. The terminal cash flow for a funded Bad project is distributed uniformly between $V - \Delta$ and $V$. Define $\bar{V} = V + \Delta (g - \frac{1}{2})$ as the ex ante unconditional expected terminal cash flow. The ex ante variance of the terminal cash flows, is $\frac{\Delta^2}{12} + g(1 - g)\Delta^2$, increasing in $\Delta$. Both investments are necessary to achieve the terminal cash flow. The firm’s initial capital is $I_1$, insufficient to make the date 2 investment, so it seeks to sell the project to risk-neutral investors after the realization of the accounting signal described below.\(^2\)

A noisy accounting signal (High or Low) on the project’s type arrives prior to the date of the second investment. A Good project produces a High signal realization with probability $1 - c + h$, Low otherwise. A Bad project produces a High signal realization with probability $1 - c$, Low otherwise.\(^3\) To ensure that these are all valid probabilities, $c \in [h, 1]$. One can interpret the parameter $c$, set by the regulator to maximize economy-wide surplus, as a measure of the conservatism of the accounting system.\(^4\) If $c = 1$ (maximum conservatism, labeled conservative accounting), both types of projects can generate the Low signal, but only a Good project can produce the High signal; if $c = h$ (minimal conservatism, labeled aggressive accounting), both types of projects can produce the High signal, but only a Bad project can produce the Low signal. The tradeoff between Type I (Good projects producing a Low signal) and Type II errors (Bad projects producing a High signal) figures importantly in all of the results. The parameter $h$ determines the quality of the High signal; as $h$ increases, the inference that the project is Good is stronger. Figure 1 displays the information structure.

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\(^2\)The results would be qualitatively similar if the firm could borrow $I_2$ at date 2 instead of selling the project.

\(^3\)The modeling of conservatism is identical (subject to notation change) to Venugopalan (2001). The model of conservatism in Kwon, Newman and Suh (2001) produces qualitatively similar results.

\(^4\)Because of the full information assumption, there is no divergence of preferences between the firm and the regulator. As a result, the firm would make the same choice of accounting policy as the regulator.
and Figure 2a shows the timeline of events.

[INSERT FIGURES 1 and 2 ABOUT HERE]

The signal most naturally relates to asset recognition. The outcome of the test determines the amounts that will be accrued or expensed, respectively. In the time that has elapsed between the investment and the signal, information has become available to the firm’s managers and auditors allowing them to make an assessment of the project’s future profitability. This information is aggregated in the signal. The conservatism parameter $c$ represents the degree of reliability of evidence needed to establish the existence of future benefits and therefore justify asset recognition. I do not model the mapping between the signal realizations and balance sheet and income statement values. Similar to other theoretical papers, I define conservatism in terms of the characteristics of the information structure, not the properties of the balance sheet and income statement.

The modeling of conservatism is identical to Venugopalan (2001) and similar to Kwon, Newman and Suh (2001) and Gigler and Hemmer (2001) in the sense that conservatism is not merely a known and invertible bias in the accounting signal. Rather, there is information loss: varying the degree of conservatism in the accounting measurement system alters the quality of the investors’ inference about the firm’s type. As a result, conservatism has real effects in the models. In Feltham and Ohlson (1996) and Zhang (2002), accounting conservatism has no effect on the inference investors make about the firm’s earnings generation process. Though there is a real option in Zhang (2002), accounting conservatism, which takes the form of accounting depreciation accelerated relative to economic depreciation, has no effect on the firm’s decision. The mechanics of the signal in my model are also consistent with the spirit of the Basu (1997) good news/bad news interpretation of conservatism. As accounting becomes more conservative in the model, it is less likely that good news about the underlying type of the project will be captured by the signal and therefore reflected in returns.

Investors use the signal to update their priors on project type. Define $p_{GH} = \frac{g(1-c+h)}{1-c+gh}$

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$^5$For ease of exposition, I suppress any additional cash flows during this period, which could also provide information about the viability of the investment. Qualitatively, the results are robust to the inclusion of additional cash flows, though at some expositional cost.
as the updated probability that the project type is Good given a High signal, and define
\[ p_{GL} = \frac{g(c-h)}{1-c+gh} \]
as the updated probability that the project type is Good given a Low signal.
Define \( V_H \) (\( V_L \)) as the investor’s expected payoff from the investment conditional on a High (Low) signal realization.

\[ V_H = p_{GH} \left( V + \frac{\Delta}{2} \right) + (1-p_{GH}) \left( V - \frac{\Delta}{2} \right). \]

\[ V_L = p_{GL} \left( V + \frac{\Delta}{2} \right) + (1-p_{GL}) \left( V - \frac{\Delta}{2} \right). \]

If the expected cash flow of a Low project is greater than \( I_2 \), then the investors will buy the project regardless of the signal realization. In this case, neither the signal nor the real option has value. Since the purpose of the study is to examine the interaction between real options and signal properties, I restrict the parameter space to \( I_2 > V - \frac{\Delta}{2} \), guaranteeing an economically meaningful decision problem at the second investment decision date.

I observe also that only Good projects can generate a High signal under conservative accounting. It is always possible, therefore, to set \( c \) such that the expected terminal cash flow given a High signal is greater than the second investment, and the expected terminal cash flow given a Low signal is less than the second investment. The preceding assumption and observation together imply that the regulator sets the accounting policy, \( c \), to maximize the expected payoff conditional on a High signal. Formally, the regulator solves the following program:

\[ \max_c \quad p_{SH}(V_H - I_2) - I_1 \]
subject to

\[ p_{SH}(V_H - I_2) \geq I_1 \]

\[ V_H \geq I_2, \]

where \( p_{SH} \) is the probability of a high signal realization. If the firm adopts the project, it is funded by investors when the signal is high, which occurs with probability \( p_{SH} \). Otherwise,
the initial investment $I_1$ is lost. The basic tension in this model is that increasing conservatism reduces the probability that the investors will buy the project but increases the price if they do. The first constraint is the sequentially rational firm’s incentive compatibility constraint. If the expected proceeds from the sale of the project, $p_{SH}(V_H - I_2)$, are not sufficient to cover the initial investment, the firm does not adopt the project. The second constraint is the investor’s incentive compatibility constraint. Note that the regulator can affect the date 1 investment decision only by altering the distribution of expected sales proceeds at date 2 through its choice of $c$.

I fully characterize the parameter space for the staged investment model in the following proposition. I express the various thresholds in terms of $\alpha$, the proportion of the investment that occurs at date 1. The parameter $\alpha$ is inversely related to the sequentiality of the investment, and therefore also inversely related to the potential value of the real option.

**Proposition 1**

i. The regulator sets an aggressive accounting regime ($c = h$) if $I_2 < \bar{V}$ (equivalent to $\alpha > 1 - \frac{\bar{V}}{V}$), and a conservative regime ($c = 1$) otherwise.

ii. If the accounting regime is aggressive, the firm makes the initial investment if $\alpha < \frac{2[1-(1-g)h(V-I)-\Delta(1-g(2-h)-h)]}{2f(1-gh)}$, and does not adopt the project otherwise.

iii. If the accounting regime is conservative, the firm makes the initial investment if $\alpha < \frac{gh(2V-2I+\Delta)}{2f(1-gh)}$, and does not adopt the project otherwise.

iv. Increasing $\Delta$ increases the area of the respective regions in which conservative or aggressive accounting is optimal and the firm adopts the project.

v. The ratio of projects funded with conservative accounting to projects funded with aggressive accounting is $\frac{h(1-g)^2}{g(1-h+gh)}$, decreasing in $g$, increasing in $h$, and independent of $\Delta$. 

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The first item in the proposition states that the optimal accounting policy depends on the relative sizes of the *ex ante* expected payoff \( \bar{V} \) and the second investment. If \( \bar{V} > I_2 \), the Good projects are so valuable that the regulator does not want to risk an information system that leads to any of them being dropped. An aggressive accounting policy achieves this. If \( \bar{V} < I_2 \), the relatively low payoff from the project induces greater selectivity. To avoid the risk of Bad projects generating a High signal, which lowers investors’ assessments of the expected payoff, the regulator optimally chooses a conservative accounting policy.

The first part of the proposition addresses only the optimal accounting policy; it does not provide conditions under which the firm rationally makes the first investment. Because aggressive accounting is optimal for projects with relatively high *ex ante* unconditional expected terminal cash flows, it is not surprising that there exist conditions under which the firm rationally adopts the project. Part *ii* of the Proposition establishes this result. Since conservative accounting is optimal for projects with relatively low *ex ante* expected cash flows, however, it is not obvious that these projects can ever have \( \text{NPV} > 0 \). Part *iii* establishes that there are conditions under which the regulator sets a conservative accounting policy and the firm adopts the project, the principal result of this section of the paper.

Part *iv* shows that increasing the variance of the terminal cash flows by increasing \( \Delta \) induces the firm to invest over more of the parameter space. Part *v* addresses the relative incidence of conservative and aggressive funded projects. Assuming that \( V \) and \( \alpha \) are independently and uniformly distributed over the parameter space, part *v* shows that the relative incidence of conservatism is strictly decreasing in \( g \), the probability that the project is Good, increasing in \( h \), the precision of the High signal, but fixed with respect to \( \Delta \). Assuming the existence of suitable proxies for the parameters, part *v* potentially provides the basis for empirical tests of cross-sectional tests of relative conservatism.

[INSERT FIGURE 3 ABOUT HERE]

Figures 3a and 3b illustrate the proposition. The horizontal axis is \( \alpha \), the share of total investment made at date 1 \( (I_1/(I_1 + I_2)) \). The vertical axis is \( V \), the midpoint of the range...
of payoffs. There are four distinct regions in Figure 3a. The shaded region in the northeast corner is outside of the parameter space of the model. In this region, the second investment is less than the expected cash flows of a Bad project, implying that the signal is irrelevant and the real option has no value. In the large area starting in the southwest corner, the firm does not adopt the project in the first period because the expected proceeds from selling the project are lower than the initial investment. This can occur if either conservative (region VI) or aggressive (region V) accounting is optimal. Conservative accounting is optimal and investment occurs in the triangle labeled CON, defined by the V-axis, the line above which conservative accounting yields NPV > 0, and the line above which aggressive accounting dominates conservative accounting (regions I and II). In the remaining area (regions III and IV), the firm adopts the project and aggressive accounting is optimal.

In figure 3b, I illustrate the effect of increasing the variance of the project by increasing $\Delta$. Not surprisingly, the potential scope of the real option increases—the shaded region outside the parameter space shrinks because the ex ante expected cash flow from a Bad project is decreasing in $\Delta$. Both the conservative and aggressive regions increase. Part $v$ of the proposition states that both regions increase at the same rate.

For both high and low variance scenarios, conservative accounting tends to dominate for low $\alpha$/low $V$ combinations. The intuition is that if most of the investment takes place at date 2 and the potential gain is lower, even a low probability that a Bad project generates a High signal substantially reduces the investor’s expected net payoff. A conservative accounting policy protects investors from Bad projects. Increasing $\alpha$ has two effects. First, since more of the investment occurs at the first date, the firm’s expected proceeds from selling the project, must be higher to justify adoption of the project at date 1. Second, $\alpha$ increases the expected sale price by reducing the date 2 investment (fixing total $I$ and $V$). The firm’s expected net profit increases at a higher rate for aggressive accounting as $\alpha$ increases. For low values of $V$, the increase in the firm’s expected proceeds is not enough to offset the increase in $I_1$ and eventually it is not profitable to adopt the project. For higher values of $V$, the date 2 investment eventually becomes low enough relative to $V$ that aggressive accounting
dominates.

Casual empiricism suggests that the results are consistent with current Generally Accepted Accounting Principles (GAAP). GAAP treats different forms of investment differently, requiring accrual for some and expensing for others. Research and development expenditures, for example, must in almost all cases be expensed in the period incurred, whereas investments in fixed assets are capitalized. R&D is typically a sequential process in which the firm frequently reassesses the economic viability of the project and decides whether to continue investment. In terms of the model, this is a low $\alpha$ project in which most of the aggregate investment occurs after the initial date, and expensing is a maximally conservative accounting policy. In contrast, most of the necessary investment in fixed assets occurs at the initial date. That is, it is a high $\alpha$ project, and capitalization is an aggressive accounting policy.

The intuition of the model also applies to the diversity within R&D rules. In particular, FAS 86 allows capitalization of software development costs after technology feasibility has been established. One can interpret the feasibility requirement as a sequence of High signals, after each of which the posterior probability that the project is Good increases. Part $v$ of Proposition 1 shows that as the probability that the project is Good, $g$, increases, the relative incidence of conservative accounting declines. This suggests that in a more elaborate model, multiple sequential signals might exhibit a pattern of increasing aggressiveness. Indeed, an extension of the model to a second signal and third investment indicates that the second signal is optimally aggressive even if the first signal is conservative.⁶

4 Abandonment option

In this section, I eliminate the staged investment and incorporate an abandonment option. The project requires a single investment of $I$ at date 0. The project type, the probability structure for the terminal cash flows, and the probability structure for the signal are identical to the staged investment model. Because there is no second investment, I assume that the firm sells the project for liquidity reasons exogenous to the model.

⁶I do not include the extended model to economize on space.
The assets necessary to implement the project have value in an alternative use of $V_A$. There are three decisions with respect to the investment. First, the firm decides at date 0 whether to invest in the assets. Second, the firm decides at date 0 whether to use the assets in the project or in their alternative use. If the firm invests and pursues the project, investors always buy the project at date 1 at a price equal to the expected terminal cash flows conditional on the signal realization. The investors then decide at date 2 whether to continue with the project or abandon it (use the assets in their alternative use). See Figure 2b for the time line.

The regulator solves the following optimization problem:

$$\max \sum \epsilon \left( p_{SH}V_H + p_{SL}V_A - I \right)$$

subject to

$$p_{SH}V_H + p_{SL}V_A \geq I.$$ 

Unlike the earlier optimization program, there is a payoff, of $V_A$, if the signal is Low. The constraint ensures that the firm invests.

Tension between Type I and Type II errors also drives the choice of accounting regime in this setting. A Type I error, in which the investor abandons a Good project, results in a certain payoff of $V_A$ rather than an expected payoff of $V + \frac{\Delta^2}{2}$. A Type II error, in which the investor fails to abandon a Bad project, results in an expected payoff of $V - \frac{\Delta^2}{2}$ instead of a certain payoff of $V_A$. If $V_A$ is less than the expected payoff of a Bad project, the firm will never exercise the real option and it has no value. I impose a restriction on the parameter space of $V < V_A + \frac{\Delta^2}{2}$ to guarantee that the real option decision is meaningful.

The following proposition characterizes the solution to the abandonment option optimization program. I identify four regions in the parameter space: no investment, investment in alternative use, investment in project/aggressive accounting, and investment in project/conservative accounting. Even if the firm initially uses the assets in the project, the investors redeploy them in their alternative use if the signal is Low. I first define threshold values of $V$. The NPV for aggressive accounting is positive if $V > V_{AGG}^C$, the NPV for conservative accounting is positive if $V > V_{CON}^C$, and the NPV for conservative accounting is
greater than the NPV of the assets in their alternative use if \( V > V^{A/C} \). The mathematical expressions for the thresholds are in the Appendix.

**Proposition 2**

i. The regulator sets an aggressive accounting regime \((c = h)\) if \( \bar{V} \geq V_A \), and a conservative regime \((c = 1)\) otherwise.

ii. If the accounting regime is aggressive, the firm pursues the project if \( V > V^{AGG} \).

iii. If the accounting regime is conservative, the firm pursues the project if \( V > V^{CON} \) and \( V > V^{A/C} \).

iv. If the accounting regime is conservative, the firm deploys the assets in the alternative use if \( V < V^{A/C} \) and \( V_A > I \).

v. For all other combinations of parameters \((V < V^{AGG} \cap V < V^{CON} \cap V_A < I)\), the firm does not invest.

Part i of the proposition shows that the optimality of the accounting regime depends on the relative sizes of the value of the alternative use of the assets and the *ex ante* unconditional expected cash flows from the project \( \bar{V} = V_A + \Delta(g - \frac{1}{2}) \). At first glance, this condition suggests that aggressive accounting is always optimal; if the value of the alternative use exceeds the *ex ante* unconditional expected terminal cash flows from the project, why would the firm ever adopt the project? This analysis is incorrect because it ignores the value of the real option, which allows the firm to truncate the distribution of terminal cash flows and boost the equilibrium expected terminal cash flow above \( \bar{V} \). The result closely mirrors the result from the staged investment model, with the opportunity cost of foregoing the alternative value playing an analogous role to the outlay cost of the second investment. No result about the relative incidence of conservative and aggressive accounting exists because,
as Figures 4a and 4b show, the aggressive and conservative regions are both unbounded as $V$ and $V_A$ increase.

Figures 4a and 4b illustrate the results. In the shaded region in the southeast corner, the investors never abandon the project because the expected cash flow of a Low type exceeds $V_A$. The no investment region lies in the southwest corner, where both $V$ and $V_A$ are low. Investment occurs in the remaining parameter space. The choice between aggressive and conservative accounting depends on the tradeoff between Type I and Type II errors. The higher $V$ is relative to $V_A$, the more profit the firm foregoes by abandoning a Good project. The aggressive accounting region, therefore, lies to the right ($V$ higher) of the CON=AGG line. In the northwest region, $V_A$ is so high relative to $V$ that the firm never deploys the assets in the project, preferring instead the alternative use. Figure 4b shows the effect of increasing the variance of the cash flows. Increasing $\Delta$ increases the expected cash flow of a Good project, reducing the region in which the alternative use dominates, and decreases the expected cash flows of a Bad project, reducing the region outside the parameter space.

The results for both types of real option are comparable in some ways to Venugopalan (2001). In the market setting of Venugopalan (2001), the manager has private information about the ex ante probability that the product is good ($\theta$ in his model and $g$ in mine) and also chooses an investment level. Investors price the firm based on an observation of investment and the realization of an accounting signal. Distortions in the equilibrium investment schedule and the informativeness of the accounting signal act as substitutes in disciplining the manager’s investment choice. If $\theta < \frac{1}{2}$, conservative accounting is optimal because it is more informative than aggressive accounting and therefore mitigates the equilibrium investment distortion. In Venugopalan (2001), the dominance of conservatism hinges only on the ex ante probability of failure; the size of the expected payoff is irrelevant. In my paper, the dominance of conservatism hinges not only on the probability of failure but also on the relative sizes of the payoff and the follow-up investment (or abandonment value). Whereas in Venugopalan (2001) it is projects with absolutely low success rates that generate the need

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7 The firm invests only at the first date. There is no abandonment option.
for conservative accounting, in my paper it is projects with low *ex ante* expected payoffs. Fixing the success rate, it is possible to alter the size of the payoff to justify aggressive, rather than conservative, accounting.

The discussion suggests that the surplus-maximizing accounting policy in my model is not generally the most informative. Venugopalan (2001) defines informativeness as $p_{GH} - p_{GL}$. It can be shown that under this definition the conservative (aggressive) policy is most informative if $g < (>) \frac{1}{2}$. Returning to Figures 3a and 3b, note that neither axis is a function of $g$. In principle, then, either conservative or aggressive accounting could be most informative in any of the six regions. As part $v$ of Proposition 1 indicates, the relative incidence of conservatism increases as $g$ decreases. As a result, conservative accounting would more likely be the most informative policy when it is the surplus-maximizing one, and vice versa, but it would not always be.

An alternative definition of informativeness pertains to the posterior variance of security returns. Conservative accounting eliminates all uncertainty about the type of the project, reducing the variance of returns. If the signal is High, the project type is certainly Good; if the signal is Low, there is uncertainty about project type that is irrelevant to security returns because there is no further investment. Under aggressive accounting, some uncertainty about project type remains for a realization of High, adding to the uncertainty about cash flows and increasing the variance of returns. Under this definition of informativeness, there is no link between the surplus-maximizing and most informative accounting policies.

5 Conclusion

This study contributes to the understanding of accounting conservatism by demonstrating a link to real options. I present two different real option models. The first is a staged investment in which two investments are necessary to bring the project to fruition. The second is an abandonment model in which the project assets have value in an alternative use. In both models an accounting signal arrives before the last decision must be made. The basic tension in the accounting system is that the accounting policy can reduce the rate
of Type I errors (mislabling a Good project as Bad and failing to sell or pursue) only by increasing the rate of Type II errors (mislabling a Bad project as Good and failing to drop or abandon to its alternative use).

The results of both models are similar. If the unconditional *ex ante* expected terminal cash flow exceeds the amount of the second investment in the staged investment (value of the project assets is their alternative use in the abandonment model), the opportunity cost of failing to sell (abandoning) Good projects is the dominant force. As a result, the regulator chooses an aggressive accounting policy. Otherwise, it is the Type II errors that dominate, and the regulator sets a conservative accounting policy. The main implication of the paper is that in the staged investment model, conservative accounting is more likely to be the optimal policy when the proportion of the investment occurring at the second date, a proxy for the importance of the real option, is high. I argue that this is consistent with the expensing of R&D and the capitalization of fixed assets in that the former is more likely to entail sequential investment than the latter. Also, it is straightforward that extending the staged investment model to additional periods could explain a sequence of accounting signals in which the early ones are conservative and later aggressive, consistent with the capitalization of software after the establishment of technological feasibility.

There are limitations to the analysis. First, while the model potentially provides an explanation for the evolution of different accounting treatments for investment in R&D and fixed assets, respectively, it does not fully conform to institutional practice. In particular, with the exception of software capitalization, there is no possibility of a high signal under current GAAP treatment of R&D; the firm must expense all R&D expenditures regardless of its assessment of the ultimate viability of the project. Second, the model approaches conservatism from an information perspective–there is no mapping between signal realizations and the income statement and balance sheet. While this is consistent with most of the conservatism theory literature, the empirical literature typically adopts a measurement perspective.
Appendix: Proofs of Propositions

Proof of Proposition 1

Differentiating the objective function with respect to \( c \) yields \( I - \alpha I + \Delta (\frac{1}{2} - g) \), equivalent to \( (1 - \alpha)I - \bar{V} \). The NPV is strictly decreasing in \( c \) if \( \alpha > 1 - \frac{\bar{V}}{I} \), implying that aggressive accounting of \( c = h \) is optimal. Otherwise, the NPV is strictly increasing in \( c \) and conservative accounting is optimal.

Substituting \( c = h \) into the objective function yields the NPV for aggressive accounting:

\[
\frac{1}{2} [2(V - I) - \Delta[1 - g(2 - h) - h] - 2(1 - g)h[V - (1 - \alpha)I]]
\]

Setting equal to 0 and solving for \( \alpha \) yields \( \frac{gh(2V - 2I + \Delta)}{2I(1 - gh)} \), the condition in part ii of the proposition.

Substituting \( c = 1 \) into the objective function yields the NPV for conservative accounting:

\[
\frac{1}{2} gh(\Delta - 2I + 2V) - \alpha I(1 - gh)
\]

Setting equal to 0 and solving for \( \alpha \) yields \( \frac{gh(2V - 2I + \Delta)}{2I(1 - gh)} \), the condition in section iii of the Proposition.

It is necessary to establish that the real option has value in the regions described by the above conditions. The relevant parameter restriction is \( \alpha < 1 - \frac{2V - \Delta}{2I} \). Note that the conservative NPV=0 line, the aggressive NPV=0 line, and the aggressive NPV = conservative NPV line all intersect at \( \alpha = \frac{\Delta gh (1 - g)}{I}, V = I + \Delta [\frac{1}{2} - g(1 - h + gh)] \). I will compare the aggressive NPV = conservative NPV line to the relevant parameter restriction line. If \( \alpha = 0 \), the intercept of the parameter restriction line is \( V = \frac{1}{2}(2I + \Delta) \), higher than the intercept of the aggressive NPV = conservative NPV line of \( V = \frac{1}{2}(2I + \Delta - 2\Delta g) \). If \( \alpha = 1 \), \( V = \frac{\Delta}{2} \) on the parameter restriction line and \( V = \frac{\Delta}{2} - \Delta g \) on the aggressive NPV = conservative NPV line. Therefore the intersection point lies in the allowed parameter space. Also, all six regions on Figures 3a and 3b have area in the allowed parameter space.

Figure 3b shows that the region in which the firm adopts the project and accounting is conservative is a triangle with vertices at \( A (\frac{\Delta gh (1 - g)}{I}, I + \Delta [\frac{1}{2} - g(1 + h - gh)]) \), \( B (0, I - \frac{\Delta}{2}) \), and \( D (0, I - \frac{\Delta}{2} + (1 - g)\Delta) \). The region in which the firm adopts the project and the accounting is aggressive is the sum of the area of the triangle with vertices \( B, F (\frac{\Delta gh}{2}, \frac{1}{2}(\Delta + 2I - 2\Delta gh)) \), and...
C \left( 0, \frac{\Delta}{2} + I \right), \text{ plus the area of the triangle with vertices A, F, and G} \left( \frac{\Delta}{2}, \frac{1}{2}(\Delta + 2I - 2\Delta g) \right), \text{ less the area of conservative accounting. It can be shown that a triangle with vertices} \ (a, b), \ (c, d) \ \text{and} \ (e, f) \ \text{has area} \ \frac{1}{2} \left[ b(c-e) + de - cf + a(f-d) \right]. \ \text{After simplifying the algebra, conservative accounting has area} \ \frac{gh(1-g)^2 \Delta^2}{2I}, \ \text{and aggressive accounting has area} \ \frac{g^2(1+g-h)\Delta^2}{2I}. \ \text{Taking the ratio yields the amount in part v. The derivatives are straightforward.}

\textbf{Proof of Proposition 2}

The objective function is

\[ V - I + \frac{1}{2} \Delta \left[ (1 - c)(2g - 1) + gh \right] + (c - gh)(V_A - V). \]

Differentiating with respect to \( c \) yields \( \Delta \left( \frac{1}{2} - g \right) + V_A - V = -\Delta + V_A \), the condition in the proposition. If accounting is conservative, the NPV is \( V_A - I + \frac{1}{2} gh(\Delta - 2V_A + 2V) \). Setting this equal to 0 and solving for \( V \) yields \( V^{CON} = -\frac{\Delta}{2} + \frac{I - (1-g)hV_A}{gh} \). If accounting is aggressive, the NPV is

\[ V - I - \frac{1}{2} \Delta \left[ 1 + g(2 - h - h) \right] + h(1 - g)(V_A - V) \]

Setting this equal to 0 and solving for \( V \) yields

\[ V^{AGG} = \frac{2[I - h(1-g)VA] + \Delta[1 - h - g(2 - h)]}{2 - 2(1 - g)h} \]

Setting NPV (conservative) equal to NPV (aggressive) and solving for \( V \) yields \( V^{A/C} = V_A + \Delta \left( \frac{1}{2} - g \right) \). It remains to show that the regions described in the Figure always exist. For both regions to exist, it is necessary that the NPV (alternative) = 0 line is always to the left of the NPV (conservative)=NPV (aggressive) line, and the NPV (conservative)=NPV (aggressive) line is always to the left of edge of the valid parameter space. The NPV (alternative) = 0 line is \( V = V_A - \frac{\Delta}{2} \). The line bounding the valid parameter space is \( V = V_A + \frac{\Delta}{2} \). First, subtracting the CON/AGG line from the line bounding the parameter space yields \(-\Delta \). Second subtraction the NPV (alternative) = 0 line from the CON/AGG line yields \(-\Delta(1 + g) \). Therefore, the regions always exist.
References


   *Journal of Accounting and Economics* 24: 3-37.


FIGURE 1
INFORMATION STRUCTURE OF MODEL

\[ \text{Payoff} \sim U[V, V+\Delta] \]

\[ \text{Type I} \]

\[ \text{Payoff} \sim U[V, V+\Delta] \]

\[ \text{Type II} \]

\[ \text{Payoff} \sim U[V-\Delta, V] \]
FIGURE 2a: Timeline for Staged Investment Model

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<tbody>
<tr>
<td>0</td>
<td>Firm, anticipating prices, determines whether to adopt the project or not.</td>
<td>If the firm adopted, the firm invests $I_1$.</td>
<td>Realization of accounting signal. Firm either sells or drops project.</td>
<td>New owners (if sale occurs) invest $I_2$.</td>
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FIGURE 2b: Timeline for Abandonment Model

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<tbody>
<tr>
<td>0</td>
<td>Firm, anticipating prices, determines whether to invest or not.</td>
<td>Firm decides whether to pursue project or alternative.</td>
<td>Realization of accounting signal. Firm sells project.</td>
<td>New owners decide whether to abandon project.</td>
</tr>
</tbody>
</table>
Region I: Only Conservative has NPV > 0.
Region II: Both have NPV > 0, Conservative dominates
Region III: Both have NPV > 0, Aggressive dominates
Region IV: Only Aggressive has NPV > 0.
Region V: Aggressive dominates, but neither has NPV > 0
Region VI: Conservative dominates, but neither has NPV > 0.
Region I: Only Conservative has NPV > 0.
Region II: Both have NPV > 0, Conservative dominates
Region III: Both have NPV > 0, Aggressive dominates
Region IV: Only Aggressive has NPV > 0.
Region V: Aggressive dominates, but neither has NPV > 0
Region VI: Conservative dominates, but neither has NPV > 0.
The shaded region is outside the assumed parameter space.
The shaded region is outside the assumed parameter space.