Corporate Risk Management, Product-Market Competition, and Disclosure*

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Abstract

This paper studies the impact of hedge accounting regulation on corporate risk management and product-market competition. We find that under current accounting standards, firms engage in risk management activities since product-market competition forces them to do so. The resulting equilibrium is desirable from a social standpoint. As we show, attempts for more transparency by additional hedge disclosure may destroy these incentives and create forces to engage in excessive risk-taking. This equilibrium behavior may deter entry and adversely affect the nature of competition in industries. Our findings hence shed light on the desirability of more transparent accounting standards and suggest that more disclosure on risk management may change risk management in undesirable ways.

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1 Introduction

Research in accounting, finance, and economics has devoted considerable attention to understanding the economic consequences of financial reporting and disclosure regulation (see Leuz and Wysocki, 2008, for a comprehensive survey). In light of corporate scandals and the recent financial crisis, a better understanding of these effects is a matter of urgency.

This paper aims to develop a clearer understanding of the effect of hedge accounting for corporate risk management and product-market competition. We find that under current accounting standards, firms engage in risk management activities since product-market competition forces them to do so. The resulting equilibrium is desirable from a social standpoint. As we show, attempts for more transparency by additional hedge disclosure may destroy these “natural incentives” and create forces to engage in excessive risk-taking. This equilibrium behavior may deter entry and adversely affect the nature of competition in industries. Our findings hence shed light on the desirability of more transparent accounting standards and suggest that more disclosure on risk management may change risk management in undesirable ways.

Our model is a signal-jamming model related in spirit to those studied by Holmström (1982, 1999), Fudenberg and Tirole (1986), and Scharfstein and Stein (1990). We focus on a simple market structure with an incumbent and an entrant. The entrant is uncertain of his future profitability in the market and uses current profits of the incumbent to decide whether to enter the market. The established firm can engage in risk management that – given the disclosure regime in effect – may or may not be observable by the entrant. We thereby follow DeMarzo and Duffie (1995) in assuming that risk management improves the informativeness of corporate earnings. Surprisingly, under current disclosure regimes and quite general conditions, the incumbent does not want to “jam” the signal by engaging in excessive risk-taking to discourage entry. Since entrants may interpret high profits as favorable market conditions, firms are “trapped” into risk management activities. They seek to minimize the variance of realized profits to minimize the probability of entry. Competition hence creates strong forces to reduce risk, even though firms are risk-neutral. The resulting equilibrium is socially desirable: the financial market is well informed about product market profitability, and entry is “relatively efficient.” This finding contrasts with equilibrium results under additional hedge disclosures, which a policy-maker may enforce in an attempt for greater transparency. Then, the incumbent may be discouraged from engaging in risk management at all because being forced to credibly communicate its

1 An extensive synopsis of the recent research of financial reporting in general is provided by Beyer et. al. (2010); see also Berger (2011).

2 We will use the terms “hedging” and “risk management” interchangeably throughout this paper.
exposure would reveal proprietary information that an entrant may exploit.

Much anecdotal evidence confirms the concern that accounting items on derivatives may reveal proprietary information to competitors. Although these competitive costs of disclosure have received somewhat limited attention from researchers, the notion is well known among firms and financial analysts alike. The following quotation from a publication of the CFA Institute illustrates some dimensions of the concerns: “The analyst needs to know what price exposure exists, how much of this exposure is covered, and how hedges are managed. Company managers may be hesitant to be fully transparent about some portion of this information for fear that it could be used by the company’s competitors (Kawaller, 2004).” This fear may also serve as the rationale for why firms oppose regulation that increases transparency of their risk management activities. As General Motors phrases it: “If GM disclosed the volume of its commodity derivatives contracts and their anticipated cash flows, a competitor could calculate the purchase price of GM’s components” (Miller and Culp, 1996).

We develop our arguments further in the following four sections. In sections 2 and 3, we elaborate on current literature and institutional background. In section 4, we present structure and assumptions of the model. In section 5, we analyze equilibrium strategies under current standards and beyond. Furthermore, we elaborate on the implications of our results for disclosure regulation, corporate risk management, and anti-trust policy. Finally, section 6 contains concluding remarks.

2 Related Literature

Our paper is related to previous finance and accounting literature on hedge disclosure. DeMarzo and Duffie (1995) analyze a model of risk management where corporate profits serve as a signal of a manager’s ability. They demonstrate that with nondisclosure of hedging activity, full hedging is an equilibrium policy for managers. If hedge decisions are disclosed, however, managers have an incentive to forego risk management opportunities to render inference about their ability difficult for outside investors. Kanodia, Mukherji, Sapra, and Venugopalan (2000) investigate the desirability of hedge disclosures and their informational effect on futures prices. They show that disclosure of hedge activities improves price efficiency in the futures market and improves industry output. Sapra (2002) studies hedge disclosures with a focus on the trade-offs between production and risk management distortions. He finds that mandatory hedge disclosure drives a firm to take extreme positions in the futures market. We follow these papers in evaluating risk management decisions under a mandatory hedge disclosure regime relative to the bench-
mark situation in which firms cannot disclose their risk management activities.\textsuperscript{3} None of these papers considers product-market competition.

Liu and Parlour (2009), Adam, Dasgupta, and Titman (2007), and Mello and Ruckes (2005) study the relationship between risk management and competition. Liu and Parlour (2009) consider the interaction between hedging and bidding in a winner-takes-all auction context in which hedging renders winning more valuable and losing more costly. They find that the ability to hedge with financial instruments (that are not contingent on who wins the auction) makes firms bid more aggressively because of running the risk of overhedging if they lose. Adam, Dasgupta, and Titman (2007) investigate firms’ risk management decisions in the context of an industry equilibrium in which endogenous output prices are a function of aggregate investment and hedging decisions. They illustrate that an individual firm’s incentive to hedge increases as more firms in the industry choose not to hedge and vice versa. They also relate industry characteristics to the proportion of firms that hedge. Mello and Ruckes (2005) study optimal hedging and production strategies of financially constrained firms in imperfectly competitive markets. They find that oligopolistic firms hedge the least when they face intense competition and firms’ financial conditions are similar. We follow this literature in assuming that firms’ risk management activities are not observable under current accounting standards. None of these papers studies the informational effects of hedge disclosures. Also, they focus on situations in which firms face post-entry competition (or situations in which entry is relatively costless). Our paper explicitly investigates pre-entry competition.

\section{3 Institutional Background}

Our results are sensitive to the notion that firms’ risk management activities – and therefore their post-risk-management (=net) exposure – is non-observable under current accounting standards. Given the significant attempts for more expanded disclosure on financial instruments in the late 90s, whether current accounting standards provide this information might not seem obvious. Practitioners are aware that financial statements generally do not. Examining the institutional environment in more detail might therefore be worthwhile. We argue that current accounting regimes help to discipline less sophisticated users of financial derivatives, but they at best give an indication of the effectiveness

\textsuperscript{3}These papers – as we do – implicitly assume that hedge disclosure is sufficiently costly. In fact, current hedge accounting standards already impose substantial direct costs of disclosure on firms, mainly because they are complicated to implement. Some indication of these costs is provided in Corman (2006): in 2006, more than 40 people worked full time to ensure the adequacy of hedge accounting at General Electric – not counting the opportunity costs of those business managers involved in the preparation process.
of a firm’s risk management activities.⁴

In June 1998, the Financial Accounting Standards Board (FASB) issued SFAS No. 133 (1998), entitled *Accounting for Derivative Instruments and Hedging Activities*, a detailed and complex set of (200 pages of) accounting and disclosure requirements. According to these accounting rules – meanwhile amended mainly by SFAS No. 138 (2000), SFAS No. 149 (2003), SFAS No. 155 (2006) – accounting treatment generally requires derivatives to be “marked-to-market” on the balance sheet as either gross assets or liabilities with changes in fair value recorded in a firm’s net income as they occur. Under prior accounting standards, derivatives were either netted against the hedged item or not recognized in the balance sheet at all. The standard, however, permits special accounting treatment – “hedge accounting” – if firms meet a set of requirements regarding hedge effectiveness and documentation. Roughly speaking, if a transaction qualifies for this treatment, gains and losses of financial instrument and hedged item are recognized in net income in the same period: “Fair value hedge accounting” expands fair value accounting to the hedged item. “Cash flow hedge accounting” allows firms to recognize changes in the fair value of derivatives in “other comprehensive income (owner’s equity)” on the balance sheet until the hedged transaction affects earnings. “Hedge accounting for net investments in a foreign operation” does not allow to account for gains or losses in net income; rather, firms must recognize changes directly in “other comprehensive income.”

There is a second accounting standard that addresses financial instruments. In January 1997, the Securities and Exchange Commission (SEC) issued a new standard for the disclosure of market risk inherent in financial instruments: *Disclosure of accounting policies for derivative financial instruments and derivative commodity instruments and disclosure of quantitative and qualitative information about market risk inherent in derivative financial instruments, other financial instruments and derivative commodity instruments (FRR No. 48)*. FRR No. 48 sought to address the SEC’s concern that risk of financial instruments was neither understood well enough by firms’ top management nor presented in financial reports transparently and completely. The new rule requires public companies to report *forward-looking* numerical measures of their market risk exposures (i.e., to changes in interest rates, exchange rates, commodity prices, equity prices) *related to financial instruments and derivatives*. Firms may choose from three alternative methods to disclose these risk categories: the tabular approach, the value-at-risk approach, and the sensitivity approach.

In this paper, we posit that (despite SFAS No. 133 and FRR No. 48) risk management activities of firms are neither (fully) observable nor do they manifest themselves in a

⁴This section owes much to Ryan (2007) and several publications of the CFA Institute, most notably Gastineau, Smith, and Todd (2001).
publicly observable way such that outsiders might be able to infer them (fully) from public reports. A number of reasons motivate this postulate – some of them result from current accounting standards and some from the nature of risk management per se: First, under SFAS No. 133, gains and losses of financial instruments, although accounted for in earnings, are in large parts invisible. Firms generally are not required to disclose the location of their derivative gains or losses on the income statement; indeed, they can and do classify them in any of several line items – in cost of goods sold, SG&A expenses, or directly in earnings. Unless a firm chooses to disclose this information, disentangling the effects of financial instruments is impossible.\(^5\) More importantly, even if a firm does so, each accounting alternative (“marked-to-market,” “cash flow hedge accounting,” and so forth) produces substantially different interim statements. Their informativeness as well as market participants’ ability to use these in order to understand risk management activity is unclear.\(^6\) In fact, the FASB is currently evaluating whether current accounting standards add more confusion rather than more transparency (FASB, 2008 and FASB, 2010).\(^7\)

Second, the usefulness of the disclosures made under FRR No. 48 is limited, mostly due to the wide discretion over how firms may report and measure risk as well as the resulting inconsistency of methods and reporting periods. Similar to the case of SFAS No. 133, each reporting alternative has its own information content in terms of level of aggregation, time horizons over which risk is measured, and indication of nonlinear exposures and covariances. This issue is even amplified as firms may not need to consistently choose

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\(^5\) Another major concern is the mixing of realized and realizable results that cannot be distinguished properly. As a FASB member in the Energy Trading Working Group phrases it in a comment letter, “It is very difficult even for sophisticated investors to extract this information by carefully comparing and contrasting the statement of operations, the balance sheet and the statement of cash flows. In fact, for many individual investors, and for most practical purposes, it is impossible” (Goodman, 2005).

\(^6\) The information content of hedge disclosures and the ability of market participants to understand these has received little attention in finance and accounting research. Notable exceptions are Gigler, Kanodia, and Venugopal (2007), who study the information content of “cash flow hedge accounting” in terms of providing an early warning of financial distress. As they put it, “In its application, mark-to-market accounting sometimes results in a mixed-attribute-model, whereby some items are marked-to-market while others are carried at historical cost. While...academics have...noted this less than perfect application, they tend...to abstract away from the issue.” In a more recent study, Campbell (2009) examines the information content of unrealized cash flow hedge positions about future cash flow levels and investigates how capital markets incorporate this information into their valuation of the firm.

\(^7\) In June 2008, the FASB released proposed amendments to SFAS No. 133 with the intent to “simplify accounting for hedging activities; improve the financial reporting of hedging activities to make the accounting model and associated disclosures more useful and easier to understand for users of financial statements; ...and address differences resulting from recognition and measurement anomalies between the accounting for derivative instruments and the accounting for hedged items” (FASB, 2008).
the same method across different types of risk. Firms may also define the dimension of “risk” in terms of value, earnings, or cash flows. Despite the obvious interconnections, these alternative measures are not identical and are likely to be inconsistent. Clearly, this reasoning might not be applicable to all types of risk management activities or all types of firms. However, taken together, these arguments (among many others) certainly imply that current disclosure standards at least render the assessment of risk management activities by outsiders extremely difficult.

Third, and most importantly, SFAS No. 133 and FRR No. 48 apply to risk management with financial instruments only. In practice, however, corporate hedging is not limited to a risk transfer with marketable securities. For instance, purchase of insurance or contractual agreements with suppliers to lock-in prices can also provide effective risk management. Many of these alternative instruments are off-balance and, by nature, not observable by third parties; just like actions often referred to as “natural hedges” that are at best imperfectly observable. Examples are the choice of plant locations to have costs and revenues in the same currency or strong market power to pass on cost shocks to customers (Gaspar and Massa, 2006). Finally, observability of risk management activity might be hardly justifiable in the case of non-public firms.

4 The Model

4.1 Overview

We model a non-cooperative game among the established firm (or incumbent) \( I \) and the market entrant (or rival) \( R \). The model consists of two periods, \( t = 1, 2 \). In the first period, the incumbent operates as a monopolist. The entrant observes the incumbent’s first-period earnings and uses these to decide whether or not to enter the market in the second period. Firms are risk-neutral, and discount rates are zero.

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8For instance, in a recent survey by Servaes, Tamayo, and Tufano (2009), 44% of the firms in their sample implement risk management decisions through operating means unrelated to financial instruments. The most frequently used risk management instrument of firms in their sample is simply the purchase of insurance. We refer to Smith (1995) for a comprehensive overview on financial and non-financial risk management instruments.
4.2 Payoffs

The realization of first-period earnings of the incumbent is publicly observable. We assume these earnings $y_1$ are uncertain and given by

$$y_1 = \eta + \epsilon,$$

where $\eta$ denotes the quality of the market and $\epsilon$ a stochastic noise term. Nature chooses $\eta$ from a normal distribution with mean $\bar{\eta} > 0$ and variance $\sigma_{\eta}^2$. The pre-entry earnings are also exposed to the stochastic component $\epsilon$, which can be interpreted as the firm’s aggregated transitory exposure. It is independently distributed from $\eta$ and also drawn from a normal distribution with variance $\sigma_{\epsilon}^2$. We set its mean to zero for convenience. $\epsilon$ may incorporate both market-wide uncertainty, such as fluctuations in commodity prices, as well as firm-specific uncertainty, such as effects of shorter or longer than average machine stoppages during production. The prior distributions over $\eta$ and $\epsilon$ are common knowledge. Neither $\eta$ nor $\epsilon$ are directly observed, and they are unknown to the entrant. Market quality $\eta$ is persistent in both periods.

The incumbent may engage in hedging transactions that allow for controlling the distribution of $\epsilon$. Let $h \in [0, 1]$ denote this hedging strategy, where the resulting variance of $\epsilon$ is linear in $h$ and given by $(1 - h)\sigma_{\epsilon}^2$. Thus, $h = 0$ if the incumbent does not engage in hedging, and $h = 1$ if the incumbent fully hedges. As a consequence, the resulting distribution of $y_1$ given the prior estimate of the market quality $\eta$ is normal with mean $\bar{\eta}$ and variance $\sigma_{y_1}^2 := \sigma_{\eta}^2 + (1 - h)\sigma_{\epsilon}^2$. We follow the literature (e.g., Froot, Scharfstein, and Stein, 1999) in assuming that hedging is costless and has no effect on the expected level of $y_1$. Recall that the incumbent may hedge in a number of ways. Corporate hedging is not limited to a risk transfer with marketable securities. Rather, operational activities or insurance contracts may also provide effective risk management to reduce the incumbent’s exposure.

In the second period, earnings of both firms are given by

$$y_{i,2} = (1 - \delta_i)\eta,$$

where $i \in \{I, R\}$ and $\delta_i \in (0, 1)$ parameterizes the duopoly profit from post-entry compe-

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9Using these distributional assumptions enhances the tractability of our results. The posterior will also be distributed normally, and parameters can be updated by simple rules well-known from the literature on “conjugate priors.” As we will see below, although using the normal distribution is convenient for ease of exposition, non-positive profits are possible such that either attracting entry or exit from the industry may be optimal if exit barriers are absent. For the sake of technical convenience, we follow convention in the literature (e.g., Vives, 1984, Gal-Or, 1985, Darrough, 1993) and ignore this artificial possibility by assuming relatively small variance. Then, such an event becomes unlikely. In section 5.1.2, we formalize this assumption explicitly.
tion if entry has occurred. The case of the incumbent enjoying a monopoly position in the second period is normalized to $\delta_I = 0$ and $\delta_E = 1$.

Our formulation of pre- and post-entry earnings in (1) and (2) is worth exploring in more detail. First, profits are serially correlated. High first-period earnings of the incumbent therefore provide favorable news about second-period profitability. Second, earnings of both firms are positively correlated and move in the same direction given a change in the market quality $\eta$. Taken together, these characteristics capture the notion that high profits of an established firm lead potential entrants to believe their own future profits are likely to be high as well. This raises the probability of entry by other firms. Hence, in our formulation, $\eta$ can be interpreted as a permanent and common measure of market profitability that similarly affects firm performance across the industry – factors such as the size of the market, the responsiveness of demand to changes in product prices, the firms’ access to distribution channels, product differentiation over substitute products, or bargaining power over customers.

4.3 Information Structure

We make two informational assumptions.

First, although first-period earnings of the incumbent are publicly observable, the realization of the firm’s aggregated exposure $\epsilon$ is not. In this regard, thinking of $\epsilon$ as an unspecified function of both the numerous risks to which a firm is exposed and the firm’s sensitivity to changes in these risks is useful. As a consequence, even if the hedging choice of the incumbent were observable, the entrant could not distinguish whether profits are high due to favorable market conditions or due to positive realizations of $\epsilon$.

Second, we assume that neither firm knows the quality of the market. Hence, the incumbent and the entrant share the prior distribution of the market quality while making their decisions. Therefore, our model is not a signaling model. In particular, the incumbent may not strategically exploit an informational advantage. The intuition is reasonable. Industries are constantly subject to random shocks that factors such as general economy,

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10The parameter $\delta_i$ captures effects from duopoly competition that remain unspecified in our reduced-form model. These effects are well-known from the literature on industrial organization. First, if entry occurs, the entrant takes market share away from the incumbent. Second, entry intensifies price competition, as more firms imply lower prices. The magnitude of these effects may vary with the type of competition (quantity vs. price), the degree of product differentiation (homogeneous vs. heterogeneous), as well as demand and cost conditions. For reference, see Tirole (1986). Note that our results do not depend on particular parameter choices of $\delta_i$.

11There is strong empirical support that high historical profits are positively related to market entry. We refer to surveys by Geroski (1995) and Siegfried and Evans (1994).
technological innovations, regulation, and so forth can cause. After such shocks, uncertainty about the quality of a market will likely remain similarly unresolved for both firms. Although we recognize that firms attempt to acquire information about the realization of these shocks and may also possess access to superior information, we abstract from these considerations in order to isolate the effects of hedging. Symmetric information about the quality of the market enables a clear-cut analysis without adding another effect from private information.

We summarize the sequence of actions and events in Figure 1.

![Figure 1: Sequence of actions and events](image)

5 Analysis

In the next sections, we examine equilibrium strategies for two informational regimes: (i) a regime that (most) closely corresponds to current accounting standards, namely, one in which risk management activity is not observable; (ii) a regime with mandatory hedge disclosures that go beyond current standards and with risk management activity being (fully) revealed.

5.1 Current Accounting Standards – Non-disclosure Regime

If hedging activity of the incumbent is non-observable/not disclosed, the entrant may condition its belief about the quality of the market only on the observed profits of the incumbent and not on whether the incumbent hedges or not. Then, given the informational assumptions made above, even though the game has a sequential structure, we can solve it “as if” the two firms’ choices were simultaneous. Each firm formulates and responds to a belief about what the other firm’s actual choice is. As a consequence, to solve for equilibrium, we can proceed as follows. We begin with the analysis of entry conditional
on a particular belief of the entrant about the incumbent’s action. Conditional on this conjecture, we can solve for endogenous entry thresholds as a function of observed profits. Then, we investigate the incumbent’s optimal hedging strategy and ask which strategy is preferred given a particular conjecture of the entrant. In equilibrium, the incumbent’s optimal strategy and the entrant’s conjecture converge.

5.1.1 Updating and Entry Strategies

Let market entry incur sunk costs to the entrant of $K$. The entrant chooses to enter if entry costs are less than expected post-entry profits. Since entry does not occur in period 1, it is reasonable to assume that the entrant’s ex-ante perception of post-entry profitability relative to its costs of entry is too low to justify entry and

$$(1 - \delta_R)\bar{\eta} < K.$$ (3)

Given a situation in which an incumbent is already operating in the market, the arguments to motivate this assumption are manifold. For instance, a market’s ex-ante profitability may justify the entry of a pioneering firm with a technological lead. Clearly, such a firm may enjoy a monopoly rent. However, this rent may not (completely) be available to prospective entrants given strong post-entry competition (a high $\delta_R$). As a consequence, a potential entrant may decide to stay out. More importantly, even if post-entry competition is relatively mild (a low $\delta_R$) and competitors are symmetric, the entrant may not choose to enter if its entry costs $K$ are significantly higher than those expended by a pioneering firm. These additional costs may result, for instance, from barriers to entry such as reputational effects and marketing advantages of incumbency (Bain, 1956) or exclusive contracts between buyers and the incumbent seller (Aghion and Bolton, 1987).\(^{12}\)

However, at the end of period 1, new information arrives. The entrant observes the first-period profits $y_1$ of the incumbent. Since distributions of $\eta$ and $\epsilon$ are common knowledge, the entrant can draw inferences from $y_1$. Concretely, conditional on the conjecture about the unobservable hedging choice of the incumbent $h^*$, the entrant updates prior beliefs about market quality $\eta$ according to Bayes’ rule. The mode of Bayesian learning considered here follows from the normality and independency of $\eta$ and $\epsilon$ and is well known from DeGroot (1970, p. 167) and Cyert and DeGroot (1974). Note that the posterior distribution of $\eta$ is also normal.

\(^{12}\)Note that the economics literature has proposed numerous and conflicting definitions of entry barriers (see Carlton, 2004 and Schmalensee, 2004). Our argument most closely follows the recent definition by McAfee, Mialon, and Williams (2004): a barrier to entry is a cost that a new entrant must and that incumbents do not or have not had to incur. For comprehensive treatments of barriers to entry, see also von Weizsäcker (1980) and Tirole (1988).
Specifically, following the observation of $y_1$ and given a conjecture about the unobservable hedging choice of the incumbent, $h^*$, posterior mean and variance of $\eta$ are

$$\bar{\eta}' = E(\eta \mid y_1, h^*) = \alpha y_1 + (1 - \alpha)\bar{\eta}$$  \hspace{1cm} (4)

and

$$\sigma^2_{\eta'} = \sigma^2_{\eta}(1 - \alpha),$$  \hspace{1cm} (5)

where

$$\alpha := \frac{\sigma^2_{\eta}}{\sigma^2_{\eta} + (1 - h^*)\sigma^2_{\xi}}.$$  \hspace{1cm} (6)

Equations (4) to (6) have natural interpretations. First, from equation (4), the revised mean $\bar{\eta}'$ is a weighted average of the observed profit $y_1$ and the unconditional mean $\bar{\eta}$. Hence, observing a higher-than-expected first-period profit of the incumbent, $y_1 > \bar{\eta}$, lifts the prior mean upward since strong profits of the incumbent are more likely for a high $\eta$ and vice versa. Second, from equations (5) and (6), $\sigma^2_{\eta'} < \sigma^2_{\eta}$: the entrant has a more precise (i.e., higher quality) estimate of the market than it had ex-ante. In the extreme case, when the incumbent fully hedges, $\sigma^2_{\eta'}$ equals zero. Third, posterior estimates put more weight on signal $y_1$ if $\alpha$ is large. In fact, $\alpha$ strictly increases in $h$ and decreases in $\sigma^2_{\xi}$. The intuition is straightforward. The more a firm hedges (a high $h$) and the lower the initial variance of the noise term $\sigma^2_{\xi}$, the more informative realized profits are about the quality of the market relative to the initial estimate. Hence, the entrant attributes a strong first-period result rather to favorable market quality than to good luck. The consequence is a large revision of the prior.

Considering these results leads to the entrant’s revised perception about post-entry profits and establishes the following entry rule. Given a conjecture $h^*$ about the unobservable hedging choice of the incumbent, entry occurs if (and only if) expected post-entry profits exceed the cost of entry

$$(1 - \delta_R)E(\eta \mid y_1, h^*) > K,$$

which, by using (4), implies entry if $y_1$ satisfies

$$y_1 > \beta + \gamma(1 - h^*) := y^*,$$  \hspace{1cm} (7)

where

$$\beta := \frac{K}{1 - \delta_R} \text{ and } \gamma := \frac{\sigma^2_{\xi}}{\sigma^2_{\eta}} \left(\frac{K}{1 - \delta_R} - \bar{\eta}\right).$$

The threshold value $y^*$ denotes the first-period profit of the incumbent above which the entrant chooses to enter the market.

A number of interesting properties are associated with the entry threshold $y^*$. These characteristics obviously are corollaries of the properties of conditions (4) to (6). Using
(3) implies $\gamma > 0$; hence, $y^* > \bar{y}$. In addition, more hedging strictly decreases $y^*$. The reason is straightforward. If the incumbent engages in more hedging activities, first-period profits become less noisy and reveal more about the true value of $\eta$ and hence the expected post-entry profitability of the entrant. As a result, realized profits must rise less sharply above the prior mean to trigger entry. In contrast, increases in entry costs $K$ and increases in (the intensity of competition) $\delta_R$ negatively affect post-entry profitability of the entrant, which in turn raises $y^*$. Clearly, the opposite is true for the prior mean $\bar{y}$.

5.1.2 Hedging Strategies and Equilibrium

We are now ready to analyze equilibrium strategies using the findings of the previous section. In equilibrium, the firms’ expectations about each other’s strategies are consistent, and each firm is choosing a best response to what it believes the other firm will do. Constructing an equilibrium of the game between the incumbent and the entrant hence involves several steps. We start from a postulate on the entrant’s conjecture about the incumbent’s hedging strategy $h^*$, which implies an entry threshold value $y^*$ computed from the updating rules derived above. Then, we solve for the incumbent’s best response to this particular conjecture and finally derive the conditions under which $h^*$ is indeed the optimal strategy for the incumbent.

The incumbent chooses $h^*$ to maximize the expected profits given its belief on what the entrant is likely to think about the incumbent’s strategy. Although the choice of the incumbent may influence the entrant’s learning through the information content of first-period profits $y_1$, hedging does not alter its expected value $E(y_1)$. Therefore, to solve for an equilibrium, considering the incumbent’s expected second-period profits is sufficient. We need not explicitly account for first-period profits in the incumbent’s maximization.

Suppose the entrant anticipates a hedging strategy $h^*$ by the incumbent. Let this conjecture by (7) imply an entry threshold $y^*$. What is optimal for the incumbent given this conjecture? Recall that the entrant’s entry decision depends on the realization of first-period profits $y_1$ relative to the entry threshold $y^*$. If $y_1 > y^*$ entry occurs and the incumbent receives $(1 - \delta_I)E(\eta \mid y_1, h)$; otherwise, the entrant chooses to not enter and the incumbent remains monopolist with monopoly profit $E(\eta \mid y_1, h)$. Note that the expression $E(\eta \mid y_1, h)$ is the expected market quality conditional on the realization of first-period profits $y_1$ and given the actual hedging strategy $h$.\(^\text{13}\) Since $E(\eta \mid y_1, h)$ is a function of the random variable $y_1$, it is itself a normally distributed random variable. Let $f(y_1 \mid h)$ denote the density of $y_1$ given hedging choice $h$. Then, the incumbent’s expected

\(^{13}\)Recall that realized profits $y_1$ are only an imprecise signal of second-period earnings (induced by $\eta$) as long as $h \neq 1$. 13
second-period earnings – from an \textit{ex-ante} perspective – are

\[ (1 - \delta_1)\bar{\eta} + \delta_1 \int_{y^*}^{\infty} E(\eta \mid y_1, h) f(y_1 \mid h)dy_1, \tag{8} \]

where the first expression in (8) represents the \textit{expected profit from duopoly} and the second gives the \textit{expected rent from remaining monopolist}. We denote this rent by \( V \) ("\textit{Value of Incumbency}"") in the following. Note that the integral may be interpreted as the first moment of the normal variable \( E(\eta \mid y_1, h) \) that is \textit{censored} on the interval \( y_1 \in (y^*, +\infty) \).

Since the expected duopoly profit, \( (1 - \delta_1)\bar{\eta} \), is independent of the hedging choice \( h \), restricting attention to the incumbent’s expected monopoly rent \( V \) in the following is convenient. \( V \) can be written as

\[ V := \delta_1 \left( \alpha \left[ \bar{\eta} F(y^* \mid h) - \sigma_y^2 f(y^* \mid h) \right] + (1 - \alpha)\bar{\eta} F(y^* \mid h) \right) \]

\[ = \delta_1 \left[ \bar{\eta} F(y^* \mid h) - \sigma_y^2 f(y^* \mid h) \right] \]

\[ = F(y^* \mid h) \delta_1 \left( \bar{\eta} - \sigma_y^2 \frac{f(y^* \mid h)}{F(y^* \mid h)} \right). \tag{9} \]

where \( F(\cdot) \) is the cumulative distribution of \( y_1 \). Note that the first line follows from using (4) as well as well-known results concerning \textit{censored normal distributions}.\footnote{Suppose a random variable \( x \sim N(\mu, \sigma^2) \). Let \( x^* \) denote a random variable transformed from \( x \) such that \( x^* = x \) if \( x^* \leq a \) and \( x^* = 0 \), otherwise. Then, the mean of the censored normal variable \( x^* \) yields \( E(x^*) = \int_{-\infty}^{a} xf(x)dx = \mu F(a) - \sigma^2 f(a) \), where \( f \) is the density and \( F \) the cumulative distribution of \( x \) (see, e.g., Greene, 2003).} The second line follows from substituting \( \alpha \) from condition (6). We find the third line particularly useful for the subsequent analysis. It captures the basic relationship between means of \textit{truncated} and \textit{censored} normal distributions.\footnote{Suppose a normally distributed random variable \( x \) truncated at \( x = a \). Then, its mean yields \( E(x \mid x \leq a) = \int_{-\infty}^{a} xf(x \mid x \leq a)dx = \frac{E(x^*)}{P(\text{Prob}(x \leq a))} = \frac{E(x^*)}{F(a)} \), where \( f(x \mid x \leq a) = \frac{f(x)}{P(\text{Prob}(x \leq a))} \) and \( E(x^*) \) denotes the mean of the censored normal variable \( x^* \). The intuition is that in recognizing the truncation, the conditional density is scaled in such a way that it integrates to one on the interval below \( a \). The properties of truncated normal distributions have been studied extensively in Johnson, Kotz, and Balakrishnan (1995).} Note that \( F(y^* \mid h) \) denotes the probability that the incumbent remains monopolist since first-period profits have realized below the entry threshold \( y^* \).

Equation (9) has an intuitive interpretation. The monopoly rent \( V \) equals to the probability of the incumbent remaining monopolist, \( F(y^* \mid h) \), multiplied by the expected
rent conditional on the incumbent remaining monopolist, $\delta_1 E(E(\eta \mid y_1, h) \mid y_1 \leq y^*)$.\(^{16}\)

Thus, in choosing the optimal hedging strategy $h^*$ to maximize the monopoly rent $V$, the incumbent solves

$$\max_{h \in [0, 1]} F(y^* \mid h) \delta_1 \left( \bar{\eta} - \sigma^2_{\eta} f(y^* \mid h) \right).$$  \quad (10)

The solution to (10) characterizes the set of strategies that is individually optimal for the incumbent, given a conjecture that implies an entry threshold of $y^*$. Then, by assuming a positive monopoly rent $V$ with

$$\bar{\eta} > \sigma_{\eta},$$  \quad (11)

the optimal hedging choice of the incumbent can be summarized as follows.\(^{17}\)

**Lemma 1** Given any conjecture about the entry threshold $y^*$, the monopoly rent $V$ has no local maximum\(^{18}\) on $h \in [0, 1]$. Its maximum $h^*$ is attained on the boundaries of $h \in [0, 1]$. A unique cutoff $\hat{y} \in (A, B)$ exists such that

$$h^* = 1 \quad \text{for} \quad y^* > \hat{y},$$

$$h^* = 0 \quad \text{for} \quad y^* < \hat{y}, \text{ and}$$

$$h^* \in [0, 1] \quad \text{for} \quad y^* = \hat{y},$$

where

$$A := \frac{1}{2} \left( \bar{\eta} + \sqrt{\bar{\eta}^2 + 4\sigma^2_{\eta}} \right) \quad \text{and} \quad B := \frac{\bar{\eta}(\sigma^2_{\eta} - \sigma^2_{\epsilon})}{2\sigma^2_{\eta}} + \frac{1}{2} \sqrt{\left(\frac{\sigma^2_{\eta} + \sigma^2_{\epsilon}}{4\sigma^2_{\eta}} + \bar{\eta}^2(\sigma^2_{\eta} + \sigma^2_{\epsilon})\right)^2}.$$

**Proof.** See appendix.  

The important insight of Lemma 1 is that the incumbent either chooses to fully hedge ($h^* = 1$) or chooses to leave its exposure completely open ($h^* = 0$). For example, if the incumbent believes the entrant has an entry threshold above $\hat{y}$, the best response is $h^* = 1$. The cutoff $\hat{y}$ denotes the value of $y^*$ for which the incumbent is indifferent

---

\(^{16}\)Note that the first expectation is with respect to first-period profit $y_1$ and the second expectation with respect to market quality $\eta$.

\(^{17}\)This assumption corresponds to the hitherto implicit assumption on the distribution of $\eta$ that we elaborated in footnote 9. Section A.2 of the appendix contains a formal treatment. It is important to note that the admissible range of parameters to ensure $V > 0$ cannot be pinned down analytically, as only estimates for $\bar{\eta} - \sigma^2_{\eta} F(\eta^* \mid h)$ are known (see the literature on the Mill’s Ratio, e.g., Patel and Read, 1996, and DasGupta, 2008). Clearly, the parameter restriction is made for reasons of tractability and does not qualitatively affect any of our results.

\(^{18}\)A global extreme point that is not an interior point of the domain of $V$ is not a local extreme point.
between hedging with \( h^* = 1 \) and no hedging with \( h^* = 0 \). To capture the intuition for this result, it is helpful to explore the effects of a marginal change in \( h \) on the monopoly rent \( V \) in more detail.

Following the decomposition proposed in (9), the total change in \( V \) with respect to \( h \)

\[
\frac{\partial V}{\partial h} = \frac{\partial F(y^* | h)}{\partial h} \delta I \left( \bar{\eta} - \sigma^2 \frac{f(y^* | h)}{F(y^* | h)} \right) + F(y^* | h) \times \frac{\partial}{\partial h} \left( \bar{\eta} - \sigma^2 \frac{f(y^* | h)}{F(y^* | h)} \right) \tag{12}
\]

can be decomposed into two very intuitive effects: \(^{20}\) We find that (12) is simply the sum of (a) the marginal change in the probability of remaining monopolist weighted by the conditional monopoly rent if \( y_1 \) is not exceeding \( y^* \) (“Probability Effect”) and (b) the marginal change in this conditional monopoly rent weighted by the probability of remaining monopolist (“Value Effect”).

(a) “Probability Effect.” A higher level of hedging lowers the dispersion of the incumbent’s realized first-period profit \( y_1 \). Due to assumption (3) any candidate entry threshold is above the ex ante expected market profitability: \( y^* > \bar{\eta} \). As a consequence, hedging shifts probability mass below the entry threshold and makes outliers to the right tail of the distribution less likely. It simply affects the probability that the observation will fall in the part of the distribution that induces the entrant to stay out of the market. Thus, the “Probability Effect” provides an incentive for the incumbent to fully hedge its transitory exposure. Figure 2 gives an intuitive graphical representation of this effect.

(b) “Value Effect.” The incumbent’s conditional monopoly rent depends on the distribution of states of market quality \( \eta \) for which, based on a given entry threshold \( y^* \), entry does not occur. For example, if the incumbent fully hedges, entry only does not take place if the realized \( \eta \) is indeed below \( y^* \). If the incumbent does not hedge its entire transitory exposure, the entrant refrains from entering with certain probability even if \( \eta \) is large. Such “mistakes” by the entrant may turn out to be highly profitable for the incumbent as entry decreases the incumbent’s profits proportionally to market quality. The overall effect of a marginal increase in the level of hedging on the incumbent’s conditional monopoly rent is ambiguous. In particular, it is negative and more than compensates the “Probability Effect” for entry thresholds above \( \hat{y} \).

\(^{19}\) Note that no closed-form solution for \( \hat{y} \) exists. We show uniqueness and existence of \( \hat{y} \) in the appendix.

\(^{20}\) The reformulation has some similarity to the Tobit decomposition McDonald and Moffitt (1980) introduce.
We are now ready to construct the equilibrium in our model, which the following proposition summarizes. Recall that (7) gives the entrant’s best response curve to an arbitrary conjecture $h^*$, and Lemma 1 gives the incumbent’s best response to an arbitrary conjecture $y^*$. The unique intersection of the best response curves – as depicted in Figure 3 – pins down the pure-strategy equilibrium. Then, the best response of either firm is consistent with the other firm’s belief. For ease of notation, let $y^*$ and $h^*$ denote the equilibrium strategies in the following. Our finding is a unique equilibrium.

**Proposition 1** In a non-disclosure regime with unobservable risk management activity, a unique equilibrium exists. Depending on parameter values, the equilibrium strategy of the incumbent is either:

(a) full hedging ($h^* = 1$) with an entry threshold of $y^* = \frac{K}{1-\delta_R}$, whenever $\frac{K}{1-\delta_R} > \hat{y}$;

(b) no hedging ($h^* = 0$) with an entry threshold of $y^* = \frac{K}{1-\delta_R} + \frac{\sigma^2}{\sigma_q^2} \left( \frac{K}{1-\delta_R} - \hat{\eta} \right)$, whenever $\frac{K}{1-\delta_R} + \frac{\sigma^2}{\sigma_q^2} \left( \frac{K}{1-\delta_R} - \hat{\eta} \right) < \hat{y}$; or

(c) a mixed strategy between $h^* = 1$ (with probability $p^*$) and $h^* = 0$ (with probability $1 - p^*$) with an entry threshold of $y^* = \hat{y}$, otherwise.

**Proof.** See appendix.
Figure 3: A graphical representation of the reaction curves of incumbent and entrant.

Prposition 1 demonstrates that three cases exist. In the first and most interesting case, when parameters are such that the equilibrium entry threshold is above the cutoff $\bar{y}$, engaging in risk management activities is optimal for the incumbent. The threat of entry creates strong forces to reduce risk – even if firms are risk-neutral.21 In the second case, when the equilibrium entry threshold $y^*$ is below the cutoff $\bar{y}$, the incumbent does not have an incentive to reduce its temporary risk exposure. Although risk management still would increase the chances that the entrant stayed out of the market, the incumbent would suffer disproportionately from a decrease in the value of incumbency conditional on remaining monopolist. In the third case, a mixed strategy equilibrium occurs. The incumbent is indifferent and hence randomizes between hedging and no hedging. The entrant remains uncertain about the risk management strategy of the incumbent.

5.1.3 A Numerical Example

We illustrate Proposition 1 with a numerical example for three straightforward settings. Table 1 presents equilibria for various entry cost $K$ with all other parameters held fixed. Each column shows, for a particular entry cost $K$, the equilibrium strategies $(h^*, y^*)$.

21 In this regard, the model also offers an explanation for why risk-neutral firms may wish to engage in risk management activities in the absence of financial market imperfections.
the expected second-period profits of incumbent and entrant ($\Pi_I^*, \Pi_R^*$), and the entry probability ($q^*$). The examples involve a market quality $\eta$ that is drawn from a normal distribution with mean $\bar{\eta} = 50$ and standard deviation $\sigma_\eta = 20$. The incumbent’s exposure $\epsilon$ is drawn from a normal distribution with mean zero and standard deviation $\sigma_\epsilon = 10$. The effects of competition are captured by $\delta_I = \delta_E = 0.6$, which implies (as in the standard Cournot situation) total profits in a duopoly are lower than in a monopoly. Given these parameter values, it is easily verified that the interval $[57.02, 57.18]$ contains the discrete jump of the incumbent’s best reaction function $h(y^*)$ at $\hat{y}$ as shown in Figure 3.

Recall that $\hat{y}$ cannot be solved for analytically. Nevertheless, a numerical solution, which is $\hat{y} = 57.096$, can be obtained. Then, it is straightforward to show that if $K \leq 22.27$, the incumbent does not hedge ($h^* = 0$), whereas if $K \geq 22.84$, the incumbent engages in risk management ($h^* = 1$). Otherwise, the incumbent chooses a mixed strategy $p^* \in (0, 1)$. Therefore, each of the three entry cost levels in Table 1, namely $K = 21.9$, $K = 22.6$, and $K = 23.2$, corresponds to one of the three different regions described above. Notice also that the expected second-period profits of the incumbent $\Pi_I^*$ strictly increase in $K$, whereas the expected second-period profits of the entrant $\Pi_R^*$ and the entry probability $q^*$ strictly decrease in $K$.

<table>
<thead>
<tr>
<th>Parameters</th>
<th>$\bar{\eta} = 50$, $\sigma_\eta = 20$, $\sigma_\epsilon = 10$, $\delta_I = 0.6$, $\delta_R = 0.6$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Region “low”</td>
<td>Region “medium”</td>
</tr>
<tr>
<td>Entry cost</td>
<td>$K = 21.9$</td>
</tr>
<tr>
<td>Equilibrium results</td>
<td>$h^* = 0$</td>
</tr>
<tr>
<td>$y^* = 56$</td>
<td>$y^* = \hat{y} = 57.096$</td>
</tr>
<tr>
<td>$\Pi_I^* = 34.0$</td>
<td>$\Pi_I^* = 34.6$</td>
</tr>
<tr>
<td>$\Pi_R^* = 2.0$</td>
<td>$\Pi_R^* = 1.91$</td>
</tr>
<tr>
<td>$q^* = 0.394$</td>
<td>$q^* = 0.368$</td>
</tr>
</tbody>
</table>

Table 1: A numerical example illustrating the effect of an increasing entry cost $K$.

### 5.2 Mandatory Hedge Disclosure Regime

In this section, we consider the case in which the entrant observes $h$. This case corresponds to a regime in which regulation mandates firms to disclose all risk management activities. We explore the economic consequences of such reporting regulation on the equilibrium hedging behavior of firms given the competitive threat of market entry.

---

22These bounds for $K$ can be easily derived by solving for $K$ in the two cases in which the reaction curve of the entrant crosses either $(\hat{y}, 0)$ or $(\hat{y}, 1)$.
In contrast to the earlier situation in which $h$ was not observable and therefore the entrant was unaware of the risk management choice previously made by the incumbent, the incumbent now must disclose its level of hedging. Risk management activities are perfectly revealed. The important implication is that both situations differ in their timing. In the earlier analysis, the entrant reacts to a conjecture about the hedge decision of the incumbent and both firms act “as if” they moved simultaneously. Now the firms decide truly sequentially. As we will see below, the incumbent’s hedge decision therefore has an additional informational and strategic effect on the entrant’s entry threshold.

Solving for (subgame perfect) equilibrium is straightforward. The incumbent must anticipate the optimal reaction of the entrant to both, the hedging strategy $h$ of the incumbent and the observed first-period profit $y_1$. Entry takes place if (and only if) expected post-entry profits exceed the cost of entry

$$(1 - \delta_R)E(\eta \mid y_1, h) > K,$$

which by using (4) implies entry, if $y_1$ exceeds the threshold value

$$y^*(h) := \beta + \gamma(1 - h),$$

where

$$\beta := \frac{K}{1 - \delta_R} \text{ and } \gamma := \frac{\sigma^2_\varepsilon}{\sigma^2_\eta}\left(\frac{K}{1 - \delta_R} - \bar{\eta}\right).$$

A similar condition for market entry appeared in the analysis of the non-disclosure regime in section 5.1 (recall the entrant’s optimal entry decision from equation (7)). However, observe that in the regime we consider here, the threshold value $y^*(h)$ is truly the entrant’s reaction to the observed hedging strategy $h$ (and hence a function of $h$), whereas in the earlier analysis, $y^*$ is the entrant’s response to an unobserved, hypothesized, and fixed hedging choice. To put it differently, $y^*(h)$ gives an entry schedule specifying the entrant’s optimal choice for each observed action of the incumbent, $h$, and each first-period profit realization, $y_1$. Since the incumbent can solve for the entrant’s optimal choice as easily as the entrant can, the incumbent anticipates that its hedge decision $h$ will be met with the reaction $y^*(h)$.

As a consequence, the incumbent’s maximization over the monopoly rent $V$ as characterized in (8) to (10) now yields

$$\max_{h \in [0,1]} \delta \int_{-\infty}^{y^*(h)} E(\eta \mid y_1, h)f(y^*(h), h)dy_1 \mid_{\text{Monopoly Rent } V} := \text{Monopoly Rent } V.$$
This maximization problem is similar to the one analyzed in section 5.1.2. The difference is that the incumbent may now elect a point on the entrant’s reaction function $y^*(h)$ that maximizes its own expected profits. Before proceeding with the analysis of equilibrium, we state our central result.

**Proposition 2** In a mandatory hedge disclosure regime with observable risk management activity, a unique (subgame perfect) equilibrium exists. In this equilibrium, the incumbent does not hedge ($h^* = 0$). The threshold value $y^*(h^*)$ above which the entrant chooses to enter the market in equilibrium is given by $y^*(h^* = 0) = \frac{K}{1-\delta_R} + \frac{\sigma^2}{\sigma^2} \left( \frac{K}{1-\delta_R} - \bar{\eta} \right)$.

**Proof.** See appendix.

The striking result is that a mandatory hedge disclosure regime may drive firms to decrease risk management activities. The reason is subtle and combines two notions. First, recall that hedging eliminates noise from the incumbent’s profits, thereby increasing the informativeness of first-period profits about market quality. Second, if hedging choices are disclosed, the entrant conditions its posterior belief about the market quality on one additional and credible signal (besides the first-period profit $y_1$), namely, the hedge decision $h$. Therefore, in contrast to the previous case of current accounting standards, risk management now has a direct influence on the entry threshold above which the entrant chooses to enter the market. Mandatory hedge disclosure gives rise to a strategic benefit to the incumbent of not engaging in risk management activities.

To see the intuition, differentiate (13) – the upper limit of the integration in (14) – with respect to $h$. Using (3) implies $\gamma > 0$; hence, more hedging strictly decreases $y^*(h)$. If the incumbent engages in more hedging activities, first-period profits are less noisy, reveal more about the true quality of the market $\eta$, and allow the entrant to better infer from first-period profits. On the other side, if the incumbent does not hedge at all, realized profits $y_1$ are a less precise signal of $\eta$, which results in an upward shift of the entry threshold $y^*(h)$. This upward shift in the entry threshold (induced by the strategic influence of the observable hedge decision on the entrant’s behavior) is clearly beneficial to the incumbent and is in fact the dominating effect in Proposition 2.

Therefore, the implication of Proposition 2 is that in a mandatory disclosure regime, hedging is not in the incumbent’s interest, as hedging leads to an entrant making a more precise competitive move. In fact, the result establishes that the incumbent has an incentive to garble the information conveyed through the first-period profit $y_1$ and that mandatory disclosure encourages excessive risk-taking. The natural incentives to engage in hedging activity under many circumstances as Proposition 1 posits is destroyed.

---

23By comparing the upper limits of the integration in (8) and (14), it is easy to see that this strategic effect of hedging does not exist in the earlier analysis of unobservable hedging.
Corollary 1 Under the parameter values of Proposition 1a, the volatility of the incumbent’s first-period profit is strictly higher in a mandatory hedge disclosure regime than in a non-disclosure regime. Also, the informativeness of profits about a firm’s intrinsic value in a mandatory hedge disclosure regime is strictly lower than the informativeness of profits in a non-disclosure regime.

Proof. The variance of first-period profits is given by $\sigma_n^2 + \sigma_e^2$ (mandatory hedge disclosure regime) and $\sigma_n^2$ (non-disclosure regime). Comparing the “signal-to-noise ratios” yields $\frac{\sigma_n^2}{\sigma_n^2 + \sigma_e^2} < \frac{\sigma_n^2}{\sigma_n^2} = 1$. This establishes the corollary. ■

Two implications immediately emerge from the corollary. First, profits in a mandatory disclosure regime are more volatile as firms’ risk management activities go down. As a result, we should observe a higher variability in firms’ profits following a regulatory act, even though the variability of the underlying fundamentals (here: $\eta$) is kept constant. Second, profits are less informative about a firm’s intrinsic value/quality, thereby increasing informational asymmetries between firms and outside stakeholders. As a consequence, earnings become less useful as indicators for a firm’s intrinsic value not only for competitors but also for other uninformed parties, in particular, outside investors. The reason is that less risk management implies a lower signal-to-noise ratio due to more total variance in profits from noise. Interestingly, our model suggests that a mandatory disclosure regime, which is a regulator’s attempt for greater transparency, is associated with a higher magnitude of informational asymmetries and less “real transparency” about a firm’s current condition.

Corollary 2 Under the parameter values of Proposition 1a, the probability of entry in a mandatory hedge disclosure regime is strictly lower than the probability of entry in a non-disclosure regime.

Proof. See appendix. ■

Corollary 2 implies that the mandatory disclosure regime may negatively affect industry structure. The increase of uncertainty about the quality of the market raises barriers to entry. Therefore, disclosure fosters more concentrated industry structures, inhibits competition, and reduces social surplus. This externality of disclosure policy would be hardly desirable from a social and economic point of view for most industries.

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24To see why, observe that the quality of the market $\eta$ defines the value of assets/projects in the market, which clearly determines a firm’s intrinsic value.
6 Conclusion

This paper analyzes three important areas of disclosure research: hedge accounting, corporate risk management, and product-market competition. We demonstrate that accounting standards substantially affect equilibrium hedging strategies. Under current accounting standards, even risk-neutral firms have strong incentives to engage in risk management activities. In this regard, we provide a novel explanation for why firms may wish to engage in risk management. The model also demonstrates that under a more transparent disclosure regime, hedging may not be an equilibrium strategy if firms face the threat of entry in their product markets. Hence, our findings shed light on the desirability of more transparent accounting standards and suggest that more disclosure on risk management may change risk management incentives of firms in undesirable ways.
A Appendix

A.1 Proof of Lemma 1

The proof involves several steps. The procedure in the proof is (i) to show $V$ has no local maximum (the first part of the lemma) and (ii) to determine the behavior of $\frac{\partial V(h)}{\partial h}$ on $h \in [0, 1]$ for all admissible parameter values. The second step is the main difficulty. The proof involves three lemmas:

1. **Lemma 2:** The monopoly rent $V$ has no local maximum on $h \in [0, 1]$. A unique local minimum $h^0 \in (0, 1)$ exists if and only if $A < y^* < B$, where

   $$B := \frac{\bar{\eta}(\sigma_2^2 - \sigma_2^2)}{2\sigma_2^2} + \frac{1}{2}\sqrt{\left(\sigma_1^2 + \sigma_2^2\right)(4\sigma_1^2 + \bar{\eta}^2(\sigma_2^2 + \sigma_2^2))}$$

   and

   $$A := \frac{1}{2}(\bar{\eta} + \sqrt{\bar{\eta}^2 + 4\sigma_2^2}).$$

2. **Lemma 3:** On $h \in [0, 1]$, if $y^* \geq B$, the monopoly rent $V$ has a global maximum, which is $h^* = 1$, whereas if $y^* \leq A$, the global maximum is $h^* = 0$.

3. **Lemma 4:** On $h \in [0, 1]$, if $A < y^* < B$, a unique cutoff $\hat{y}$ exists such that if $y^* > \hat{y}$ then $h^* = 1$, whereas if $y^* < \hat{y}$ then $h^* = 0$, and if $y^* = \hat{y}$ the incumbent is indifferent between $h^* = 1$ and $h^* = 0$.

It is helpful to study figures 3a to 3c before proceeding. They are meant to provide intuition behind the steps to prove Lemma 2-4.

![Monopoly Rent $V$](image)

**Figure 3a:** Monopoly Rent $V$ in Region 1 (“low”), when $y^* \leq A
We construct the figures for an example in which $\eta = 50$, $\sigma_\eta = 20$, $\sigma_e = 10$, $\delta_I = 0.6$, and three different threshold levels $y^* = 57$, $y^* = 57.10$, and $y^* = 60$, each of which corresponds to the three different regions described above: (i) Region 1 ("low"): $y^* \leq A$; (ii) Region 2 ("medium"): $A < y^* < B$; and (iii) Region 3 ("high"): $y^* \geq B$ with $A = 57.02$ and $B = 57.18$. The expected monopoly rents $V$ are on the vertical axes. The incumbent’s hedging choices $h$ are on the horizontal axes. Note that none of the general properties in each region depends on the specific parameters we use.

Figures 3a and 3c clearly suggest that if the conjectured entry threshold is in Region 1 ("low"), here $y^* = 57$, more hedging decreases the monopoly rent $V$; hence $h^* = 0$. If the entry threshold is in Region 3 ("high"), however, for instance, $y^* = 60$, hedging is beneficial and $h^* = 1$. Figure 3b points to the less straightforward case of $y^* = 57 \in (A, B)$.
(Region 2, “medium”) in which a local minimum \( h^0 \) exists and the graph of \( V(h) \) is similar to a parabola that opens upward. Then, the global maximum of \( V \) is attained on the boundaries. In our example, \( h^* = 1 \). In the following, we show these properties hold in general in each region.

**Lemma 2** The monopoly rent \( V \) has no local maximum on \( h \in [0, 1] \). A unique local minimum \( h^0 \) exists if and only if \( A < y^* < B \), where

\[
B := \frac{\bar{\eta}(\sigma^2_y - \sigma^2_\varepsilon)}{2\sigma^2_\eta} + \frac{1}{2} \sqrt{\left(\frac{\sigma^2_\varepsilon + \sigma^2_\eta}{\sigma^2_\eta}\right)^2 + \left(4\sigma^2_\eta + \bar{\eta}^2(\sigma^2_\varepsilon + \sigma^2_\eta)\right)}
\]

and

\[
A := \frac{1}{2}(\bar{\eta} + \sqrt{\bar{\eta}^2 + 4\sigma^2_\eta}).
\]

**Proof.** The procedure in the proof is straightforward. We solve for the usual first- and second-order conditions. To reduce the notational burden, define

\[
\sigma^2_y := \sigma^2_\eta + (1 - h)\sigma^2_\varepsilon;
\]  

thus, the density of \( y_1 \) at \( y_1 = y^* \) given hedging choice \( h \) is

\[
f(y^* \mid h) := \frac{1}{\sigma_y \sqrt{2\pi}} e^{-\frac{1}{2}(\frac{y^* - \bar{\eta}}{\sigma_y})^2}.
\]

Recall from (9) that

\[
V = \delta I \left[F(y^* \mid h) \times \bar{\eta} - \sigma^2_\eta \times f(y^* \mid h)\right];
\]

hence

\[
\frac{\partial V(h)}{\partial h} = \delta I \left[\bar{\eta} \frac{\partial F(y^* \mid h)}{\partial h} - \sigma^2_\eta \frac{\partial f(y^* \mid h)}{\partial h}\right]
\]

\[
= \delta I \left[\bar{\eta} \frac{(y^* - \bar{\eta})\sigma^2_\varepsilon}{2\sigma^2_y} f(y^* \mid h) + \sigma^2_\eta \sigma^2_\varepsilon \frac{(y^* - \bar{\eta})^2 - \sigma^2_\varepsilon}{2\sigma^4_y} f(y^* \mid h)\right]
\]

\[
= \delta I f(y^* \mid h) \frac{\sigma^2_\varepsilon}{2\sigma^2_y} \left[\bar{\eta}(y^* - \bar{\eta})\sigma^2_\varepsilon + \sigma^2_\eta \sigma^2_\varepsilon (y^* - \bar{\eta})^2 - \sigma^2_\varepsilon\right]
\]

\[
= \delta I f(y^* \mid h) \frac{\sigma^2_\varepsilon}{2\sigma^2_y} \left[\bar{\eta}(y^* - \bar{\eta})\sigma^2_\varepsilon + \sigma^2_\eta \sigma^2_\varepsilon ((y^* - \bar{\eta})^2 - \sigma^2_\varepsilon)\right],
\]

where the second line follows from both using (22) and using

\[
\frac{\partial f(y^* \mid h)}{\partial h} = -f(y^* \mid h) \frac{(y^* - \bar{\eta})^2 \sigma^2_\varepsilon}{2\sigma^2_y} + f(y^* \mid h) \frac{\sigma^2_\varepsilon}{2\sigma^2_y}
\]

\[
= -f(y^* \mid h) \frac{\sigma^2_\varepsilon (y^* - \bar{\eta})^2 - \sigma^2_\varepsilon}{2\sigma^2_y}.
\]
Substituting for (15) and solving the first-order condition \( \frac{\partial V(h)}{\partial h} = 0 \) yields

\[
h^0 = \frac{\bar{\eta}(y^* - \bar{\eta})\sigma^2_e + \sigma^2_{\eta}(y^* - y^* \bar{\eta} - \sigma^2_{\eta}) - \sigma^4_{\eta}}{\sigma^2_e(\bar{\eta}(y^* - \bar{\eta}) - \sigma^2_{\eta})}.
\]  \( (18) \)

Imposing \( h^0 \in (0, 1) \) implies that \( h^0 \) is on the interval \((0, 1)\) if and only if

\[
\frac{1}{2}(\bar{\eta} + \sqrt{\bar{\eta}^2 + 4\sigma^2_{\eta}}) < y^* < \frac{\bar{\eta}(\sigma^2_{\eta} - \sigma^2_e)}{2\sigma^2_{\eta}} + \frac{1}{2} \sqrt{\frac{(\sigma^2_{\eta} + \sigma^2_e)(4\sigma^2_{\eta} + \bar{\eta}^2(\sigma^2_{\eta} + \sigma^2_e))}{\sigma^4_{\eta}}} \quad \text{where} \quad A := \frac{1}{2}(\bar{\eta} + \sqrt{\bar{\eta}^2 + 4\sigma^2_{\eta}})
\]

and

\[
B := \frac{\bar{\eta}(\sigma^2_{\eta} - \sigma^2_e)}{2\sigma^2_{\eta}} + \frac{1}{2} \sqrt{\frac{(\sigma^2_{\eta} + \sigma^2_e)(4\sigma^2_{\eta} + \bar{\eta}^2(\sigma^2_{\eta} + \sigma^2_e))}{\sigma^4_{\eta}}}.
\]

Checking for the second-order condition yields

\[
\frac{\partial^2 V(h^0)}{\partial h^2} = \frac{\bar{\eta}(y^* - \bar{\eta})\sigma^2_e + \sigma^2_{\eta}(y^* - y^* \bar{\eta} - \sigma^2_{\eta}) - \sigma^4_{\eta}}{\sigma^2_e(\bar{\eta}(y^* - \bar{\eta}) - \sigma^2_{\eta})^2} > 0.
\]

Hence, if \( h^0 \in (0, 1) \) exists, it is a local minimum. Note that the expression under the square root in (20) is never negative if (19) holds.\(^{25}\) This establishes that \( h^0 \) is the unique local extreme point, a minimum, iff \( A < y^* < B \), where

\[
A := \frac{1}{2}(\bar{\eta} + \sqrt{\bar{\eta}^2 + 4\sigma^2_{\eta}})
\]

and

\[
B := \frac{\bar{\eta}(\sigma^2_{\eta} - \sigma^2_e)}{2\sigma^2_{\eta}} + \frac{1}{2} \sqrt{\frac{(\sigma^2_{\eta} + \sigma^2_e)(4\sigma^2_{\eta} + \bar{\eta}^2(\sigma^2_{\eta} + \sigma^2_e))}{\sigma^4_{\eta}}}.
\]

**Lemma 3** On \( h \in [0, 1] \), if \( y^* \geq B \), the monopoly rent \( V \) has a **global maximum**, which is \( h^* = 1 \), whereas if \( y^* \leq A \), the **global maximum** is \( h^* = 0 \).

**Proof.** Recall that in (16) the term \( \bar{\eta}\sigma^2_e(y^* - \bar{\eta}) + \sigma^2_{\eta} \left((y^* - \bar{\eta})^2 - \sigma^2_{\eta}\right) \) alone determines the algebraic sign of the derivative, because the other terms are positive. It is straightforward to show that

\[
\frac{\partial V(h)}{\partial h} > 0 \quad \text{on} \quad h \in [0, 1] \quad \text{if} \quad y^* \geq B
\]

and

\[
\frac{\partial V(h)}{\partial h} < 0 \quad \text{on} \quad h \in [0, 1] \quad \text{if} \quad y^* \leq A.
\]

Hence, the incumbent’s optimal strategy is attained at the boundaries: \( h^* = 1 \) if \( y^* \geq B \) and \( h^* = 0 \) if \( y^* \leq A \). This establishes the lemma. \( \blacksquare \)

\(^{25}\)Calculating \( \frac{\partial^2 V(h)}{\partial h^2} \) and substituting for \( h^0 \) is straightforward. However, the expression is lengthy and reveals no additional insight. We therefore omit its exposition here. The derivation is available upon request.
Lemma 4 On \( h \in [0, 1] \), if \( A < y^* < B \), a unique cutoff \( \hat{y} \) exists such that if \( y^* > \hat{y} \) then \( h^* = 1 \), whereas if \( y^* < \hat{y} \) then \( h^* = 0 \), and if \( y^* = \hat{y} \) the incumbent is indifferent between \( h^* = 1 \) and \( h^* = 0 \).

Proof. From Lemma 2 it is known that if the conjectured entry threshold belongs to the interval \( A < y^* < B \), a unique local minimum \( h^0 \in (0, 1) \) exists. This means that in this interval, the (global) maximum of \( V \) is attained on the boundaries \( h^* = 0 \) or \( h^* = 1 \). We prove the existence and uniqueness of \( \hat{y} \) by examining the behavior of the difference in the monopoly rent at the boundaries, \( V(y^* \mid h = 0) \) and \( V(y^* \mid h = 1) \) (see Figure 3b).

Define \( \Delta V(y^*) = V(y^* \mid h = 1) - V(y^* \mid h = 0) \). Note that \( \hat{y} \) solves \( \Delta V(y^*) = 0 \), which cannot be done explicitly since no closed-form solution for \( \hat{y} \) exists. We therefore apply the intermediate value theorem to establish the lemma.

Clearly, \( \Delta V(A) < 0 \) and \( \Delta V(B) > 0 \) from Lemma 2. Therefore, according to the intermediate value theorem, the continuous function \( \Delta V(y^*) \) must have at least one zero on \([A, B]\). Since \( \frac{\partial \Delta V(y^*)}{\partial y^*} > 0 \) for all \( y^* \in [A, B] \) (which we prove below), it follows that \( \Delta V(y^*) \) has a unique zero.

First, differentiating \( \Delta V(y^*) \) with respect to \( y^* \) yields

\[
\frac{\partial \Delta V(y^*)}{\partial y^*} = f(y^* \mid h = 1)y^* - f(y^* \mid h = 0) \frac{\tilde{\eta} \sigma_e^2 + y^* \sigma_h^2}{\sigma_e^2 + \sigma_h^2},
\]

and therefore proving \( \frac{\partial \Delta V(y^*)}{\partial y^*} > 0 \) on \([A, B]\) is equivalent to proving

\[
\frac{f(y^* \mid h = 1)}{f(y^* \mid h = 0)} \frac{y^*}{\frac{\tilde{\eta} \sigma_e^2 + y^* \sigma_h^2}{\sigma_e^2 + \sigma_h^2}} = e^{-\frac{(y^* - \hat{y})^2 \sigma_e^2}{2\sigma_e^2 (\sigma_e^2 + \sigma_h^2)}} \frac{y^* (\sigma_e^2 + \sigma_h^2)^2}{\sigma_h (\tilde{\eta} \sigma_e^2 + y^* \sigma_h^2)} > 1.
\]

The solution is found by recognizing that \( e^{-x} \) is an upper bound of \( \frac{1}{(x+1)^2} \) on \( x \in [0, 2] \) and observing that \( 0 \leq \frac{(y^* - \hat{y})^2 \sigma_e^2}{2\sigma_e^2 (\sigma_e^2 + \sigma_h^2)} \leq 2 \) for \( y^* \in [A, B] \). Then, for \( y^* \in [A, B] \),

\[
e^{-\frac{(y^* - \hat{y})^2 \sigma_e^2}{2\sigma_e^2 (\sigma_e^2 + \sigma_h^2)}} \frac{y^* (\sigma_e^2 + \sigma_h^2)^2}{\sigma_h (\tilde{\eta} \sigma_e^2 + y^* \sigma_h^2)} \geq \frac{1}{(\frac{4(y^* - \hat{y})^2 \sigma_e^2}{2\sigma_e^2 (\sigma_e^2 + \sigma_h^2)} + 1)^2 \sigma_h (\tilde{\eta} \sigma_e^2 + y^* \sigma_h^2)}
\]

\[
= \frac{4y^* \sigma_h^3 (\sigma_e^2 + \sigma_h^2)^2}{(\tilde{\eta} \sigma_e^2 + y^* \sigma_h^2) ((y^* - \hat{\eta})^2 \sigma_e^2 + 2\sigma_e^2 \sigma_h^2 + 2\sigma_h^4)^2} > \frac{4 \sigma_h^3 (\sigma_e^2 + \sigma_h^2)^2}{((y^* - \hat{\eta})^2 \sigma_e^2 + 2\sigma_e^2 \sigma_h^2 + 2\sigma_h^4)^2} > 1,
\]

where the second line follows from using \( y^* > \hat{\eta} \) and the third from (11) after some lines of algebra. As a consequence, a unique solution \( \hat{y} \in (A, B) \) exists such that \( \Delta V(\hat{y}) = 0 \).
Hence, if \( y^* > \tilde{y} \) then \( h^* = 1 \), whereas if \( y^* < \tilde{y} \) then \( h^* = 0 \). By definition, \( y^* = \tilde{y} \) leaves the incumbent indifferent between \( h^* = 1 \) and \( h^* = 0 \). This establishes the lemma.

### A.2 A Formal Treatment to \( V > 0 \) if Equation (11) Holds

In the following, we prove that the monopoly rent \( V \) is positive on \( h \in [0, 1] \) if \( \tilde{\eta} > \sigma_\eta \), which is equivalent to proving \( \frac{\tilde{\eta}}{\sigma_\eta} > \frac{f(y^* | h)}{F(y^* | h)} \).

**Proof.** Observe that \( \frac{f(y^* | h)}{F(y^* | h)} \) cannot be represented in terms of elementary functions. The solution is found by recognizing an upper bound for \( \frac{f(y^* | h)}{F(y^* | h)} \), namely,

\[
\sigma_y^{-1} \frac{2}{y^* - \tilde{\eta} + \sqrt{\left(\frac{y^* - \tilde{\eta}}{\sigma_y}\right)^2 + 4}} > \frac{f(y^* | h)}{F(y^* | h)}, \text{ for } y^* > \tilde{\eta}. \tag{21}
\]

Then, by utilizing \( y^* > 0 \) and \( \tilde{\eta} > \sigma_\eta \), it is straightforward to show that

\[
\frac{\tilde{\eta}}{\sigma_\eta^2} > \max_{h \in [0,1]} \sigma_y^{-1} \frac{2}{y^* - \tilde{\eta} + \sqrt{\left(\frac{y^* - \tilde{\eta}}{\sigma_y}\right)^2 + 4}} = \frac{2}{y^* - \tilde{\eta} + \sigma_\eta \sqrt{\left(\frac{y^* - \tilde{\eta}}{\sigma_\eta}\right)^2 + 4}}.
\]

which establishes the claim. Inequality (21) follows from

\[
\frac{2}{x + \sqrt{x^2 + 4}} > \frac{\varphi(x)}{\Phi(x)}, \text{ for } x > 0
\]

and

\[
\sigma_y^{-1} \frac{\varphi\left(\frac{y^* - \tilde{\eta}}{\sigma_y}\right)}{\Phi\left(\frac{y^* - \tilde{\eta}}{\sigma_y}\right)} = \frac{f(y^* | h)}{F(y^* | h)},
\]

where \( \varphi(x) \) denotes the pdf of the standard normal distribution and \( \Phi(x) \) its cdf.

### A.3 A Formal Investigation of the Probability and Value Effects

The first expression, the “Probability Effect,” is positive as

\[
\frac{\partial F(y^* | h)}{\partial h} = \frac{(y^* - \tilde{\eta})\sigma_y^2}{2\sigma_y^2} f(y^* | h) > 0. \tag{22}
\]

Here the important insight is that hedging increases the probability of deterring entry. The interpretation is intuitive.

The second part of (12), the “Value Effect,” reflects the effect of \( h \) on the conditional monopoly rent in the second period given that \( y_1 \) is not exceeding \( y^* \). While the “Probability Effect” suggests the incumbent has clear incentives to fully hedge, the “Value
Effect” is ambiguous. From (12), the sign of the “Value Effect” (and therefore the overall sign of the derivative) obviously is contingent on \(-\frac{f(y^* | h)}{F(y^* | h)}\) being increasing or decreasing in \(h\). For instance, it is straightforward to verify that if \(-\frac{f(y^* | h)}{F(y^* | h)}\) is increasing in \(h\), then the “Value Effect” and therefore the total monopoly rent \(V\) is increasing in \(h\) as well. As a consequence, the incumbent chooses a full hedge, \(h^* = 1\).

More generally, applying the quotient rule

\[
- \frac{\partial}{\partial h} \frac{f(y^* | h)}{F(y^* | h)} = \frac{\partial}{\partial h} \frac{f(y^* | h)F(y^* | h)}{F(y^* | h)^2} + \frac{\partial}{\partial h} \frac{F(y^* | h)f(y^* | h)}{F(y^* | h)^2}
\]

and equation (22) (namely, \(\frac{\partial F(y^* | h)}{\partial h} > 0\)) reveals the key for the “Value Effect” being increasing or decreasing is how the density \(f(y^* | h)\) changes at the threshold level \(y^*\). The “Value Effect” increases in \(h\), either if \(\frac{\partial}{\partial h} f(y^* | h) < 0\) or if \(f(y^* | h)\) increases not too rapidly in \(h\). In fact, it can be easily shown that this is true if \(y^*\) is sufficiently large. The “Value Effect” decreases in \(h\), however, if \(\frac{\partial}{\partial h} f(\cdot)\) increases quickly in \(h\), which is true if \(y^*\) is sufficiently small. It is interesting that in this case, either of the two effects – “Probability Effect” or “Value Effect” – may actually dominate the equilibrium outcome.

A.4 Proof of Proposition 1

A graphical illustration to the proof of the (a) and (b) parts of Proposition 1 follows in Figure 3. It is easy to show that the best reaction curves of incumbent and entrant can cross only once. Recall from (7) that the reaction curve of the entrant is given by \(y^* = \beta + \gamma(1 - h^*)\), where from (3) \(\beta > 0\) and \(\gamma > 0\). This implies that \(h^* = 1 + \frac{\beta}{\gamma} - \frac{1}{\gamma} y^*\) is downward sloping. The pattern of the best response function of the incumbent – it is non-continuous and involves a jump up at \(y^* = \hat{y}\), where \(\hat{y} \in (A, B)\) – follows from Lemma 1. The mixed-strategy equilibrium – the (c) part of Proposition 1 – can be easily derived. The incumbent is indifferent between playing \(h^* = 1\) and \(h^* = 0\) if \(y^* = \hat{y}\). When the incumbent randomizes over these strategies, the induced outcome to the entrant corresponds to a lottery over the pure-strategy payoffs weighted by the probabilities with which \(h^* = 0\) and \(h^* = 1\) are being played. Hence, \(p^* \in (0, 1)\) solves

\[
(1 - \delta_R) (p^* E(\eta | \hat{y}, h^* = 1) + (1 - p^*) E(\eta | \hat{y}, h^* = 0)) = K.
\]
A.5 Proof of Proposition 2

By using (9) and (14), the incumbent’s monopoly rent $V$ in the mandatory hedge disclosure regime is

$$V(y^*(h), h) := \delta_I \int_{-\infty}^{y^*(h)} E(\eta \mid y_1, h) f(y^*(h), h) dy_1$$

$$= F(y^*(h), h) \times \delta_I \left( \bar{\eta} - \sigma_\eta^2 \frac{f(y^*(h), h)}{F(y^*(h), h)} \right),$$

where $F(y^*(h), h)$ denotes the probability of remaining monopolist and $\delta_I \left( \bar{\eta} - \sigma_\eta^2 \frac{f(y^*(h), h)}{F(y^*(h), h)} \right)$ denotes the value of incumbency conditional on $y_1$ not exceeding $y^*(h)$. Following the decomposition proposed in (9), the total change in the monopoly rent $V(y^*(h), h)$ with respect to $h$ can be disaggregated into

$$\frac{dV(y^*(h), h)}{dh} = \frac{dF(y^*(h), h)}{dh} \times \delta_I \left( \bar{\eta} - \sigma_\eta^2 \frac{f(y^*(h), h)}{F(y^*(h), h)} \right)$$

>0 from (11)

“Probability Effect”

$$+ F(y^*(h), h) \times \frac{d}{dh} \delta_I \left( \bar{\eta} - \sigma_\eta^2 \frac{f(y^*(h), h)}{F(y^*(h), h)} \right).$$

>0 “Value Effect”

Proposition 2 follows immediately from showing that $\frac{dV(y^*(h), h)}{dh} < 0$ on $h \in [0, 1]$. The proof clearly involves two lemmas:

1. **Lemma 5**: The probability of the incumbent remaining monopolist strictly decreases in the incumbent’s hedging choice $h$; hence $\frac{dF(y^*(h), h)}{dh} < 0$.

2. **Lemma 6**: The value of incumbency conditional on $y_1$ not exceeding $y^*(h)$ strictly decreases in the incumbent’s hedging choice $h$; hence $\frac{d}{dh} \delta_I \left( \bar{\eta} - \sigma_\eta^2 \frac{f(y^*(h), h)}{F(y^*(h), h)} \right) < 0$.

Both lemmas can be established as follows.\(^{26}\)

**Lemma 5** The probability of the incumbent remaining monopolist strictly decreases in the incumbent’s hedging choice $h$; hence $\frac{dF(y^*(h), h)}{dh} < 0$.

\(^{26}\)In what follows, we will omit the functional dependence of $f(\cdot)$ and $F(\cdot)$ on $y^*(h)$ and $h$ for notational convenience where possible.
Proof. Taking the total derivative of $F(y^*(h), h)$ with respect to $h$ yields
\[
\frac{dF(y^*(h), h)}{dh} = \frac{\partial F(y^*(h), h)}{\partial y^*(h)} \frac{dy^*(h)}{dh} + \frac{\partial F(y^*(h), h)}{\partial h}
\]

"Strategic Effect"
\[
= f(y^*(h), h) \left( - \frac{\sigma_y^2}{\sigma_\eta^2} \left( \frac{K}{1 - \delta_R} - \overline{\eta} \right) + \frac{(y^*(h) - \overline{\eta}) \sigma^2_y}{2 \sigma_\eta^2} \right)
\]

\[
= f(y^*(h), h) \frac{\sigma_y^2}{\sigma_\eta^2} \left( \frac{K}{1 - \delta_R} - \overline{\eta} \right) \left( -1 + \frac{1}{2} \right)
\]

\[
< 0.
\]

The first term in the first line reflects the incumbent’s first-mover (i.e., Stackelberg leader) position. This “strategic effect” results from the influence of the hedging choice $h$ on the entry threshold and does not exist in the earlier analysis of unobservable hedging activity. The second line follows from \( \frac{\partial F(y^*(h), h)}{\partial y^*(h)} = f(y^*(h), h) \), \( \frac{dy^*(h)}{dh} = -\frac{\sigma_y^2}{\sigma_\eta^2} \left( \frac{K}{1 - \delta_R} - \overline{\eta} \right) \), and \( \frac{\partial F(y^*(h), h)}{\partial h} = \frac{(y^*(h) - \overline{\eta}) \sigma_y^2}{2 \sigma_\eta^2} f(y^*(h), h) \), which follows along the lines from (22). The third line substitutes $y^*(h)$ from (13).

Lemma 6 The value of incumbency conditional on $y_1$ not exceeding $y^*(h)$ strictly decreases in the incumbent’s hedging choice $h$; hence \( \frac{d}{dh} \delta_I \left( \overline{\eta} - \sigma_\eta^2 f(y^*(h), h) \right) < 0 \).

Proof. Taking the total derivative of $\delta_I \left( \overline{\eta} - \sigma_\eta^2 f(y^*(h), h) \right)$ with respect to $h$ yields
\[
\frac{d}{dh} \delta_I \left( \overline{\eta} - \sigma_\eta^2 f(y^*(h), h) \right) = -\delta_I \sigma_\eta^2 \frac{df(y^*(h), h)}{dh} = -\frac{\delta_I \sigma_\eta^2 f(y^*(h), h)}{F(h)} < 0
\]

if the sign of the numerator in (24) is positive. This can be easily established by using \( \frac{df(y^*(h), h)}{dh} < 0 \) from (23) and
\[
\frac{df(y^*(h), h)}{dh} = \frac{\partial f(y^*(h), h)}{\partial y^*(h)} \frac{dy^*(h)}{dh} + \frac{\partial f(y^*(h), h)}{\partial h}
\]

\[
= \left( \frac{(y^*(h) - \overline{\eta})}{\sigma_\eta^2} * \frac{\sigma_y^2}{\sigma_\eta^2} \left( \frac{K}{1 - \delta_R} - \overline{\eta} \right) - \frac{\sigma_y^2 ((y^*(h) - \overline{\eta})^2 - \sigma_y^2)}{2 \sigma_\eta^2} \right) f(\cdot)
\]

\[
= \frac{\sigma_y^2 (\sigma_\eta^2 (1 - h)(K - (1 - \delta_R) \overline{\eta})^2 + \sigma_\eta^2 (K - (1 - \delta_R) \overline{\eta})^2 + \sigma_\eta^4 (1 - \delta_R))^2}{2 \sigma_\eta^4 (1 - \delta_R)^2} f(\cdot)
\]

\[
> 0.
\]

Observe that the second line follows from \( \frac{\partial f(y^*(h), h)}{\partial y^*(h)} = -\frac{(y^*(h) - \overline{\eta})}{\sigma_\eta^2} f(y^*(h), h) \), \( \frac{dy^*(h)}{dh} = -\frac{\sigma_y^2}{\sigma_\eta^2} \left( \frac{K}{1 - \delta_R} - \overline{\eta} \right) \) and from using \( \frac{df(y^*(h), h)}{dh} = -\frac{\sigma_y^2 ((y^*(h) - \overline{\eta})^2 - \sigma_y^2)}{2 \sigma_\eta^2} f(y^*(h), h) \), which has been derived in (17). The third line follows from substituting for (13). The threshold value $y^* = \frac{K}{1 - \delta_R} + \frac{\sigma_y^2}{\sigma_\eta^2} \left( \frac{K}{1 - \delta_R} - \overline{\eta} \right)$ follows from (13).
A.6 Proof of Corollary 2

Proof. In a mandatory hedge disclosure regime, the entry threshold is given by

$$y^*_D = \frac{K}{1-\delta_R} + \frac{\sigma^2}{\sigma^2_\eta} \left( \frac{K}{1-\delta_R} - \tilde{\eta} \right),$$

whereas the entry threshold in a non-disclosure regime under the parameter values of Proposition 1a is

$$y^*_ND = \frac{K}{1-\delta_R}.$$

Clearly, $y^*_D > y^*_ND$. Note that the probability of entry is given by $1 - \Phi \left( \frac{y^*_D - \tilde{\eta}}{\sqrt{\sigma^2 + \sigma^2_\eta}} \right)$ and $1 - \Phi \left( \frac{y^*_ND - \tilde{\eta}}{\sqrt{\sigma^2_\eta}} \right)$, respectively, where $\Phi(\cdot)$ denotes the cdf of the standard normal distribution. Observe that $\frac{\partial \Phi(x)}{\partial x} > 0$ for all $x$. Showing that $\frac{y^*_D - \tilde{\eta}}{\sqrt{\sigma^2 + \sigma^2_\eta}} > \frac{y^*_ND - \tilde{\eta}}{\sqrt{\sigma^2_\eta}}$ establishes the result. ■
References


36