Journal of Risk (47–72) Volume 10/Number 2, Winter 2007/08

Corporate risk management and speculative motives

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We develop a simple framework for analyzing corporate risk management decisions when managers have a directional prediction on future price levels. The optimal hedging strategy with "a view" retains a partial exposure and requires rebalancing. This can help explain the active trading behavior of some managers, the large cross-sectional and time series variation in hedge ratios and the prevalence of partial hedging. In addition to providing a simple account of the stylized facts, the model generates new testable implications for corporate hedging policy. We parameterize and estimate the model using foreign exchange hedging data from a large multinational corporation and find support for the model's predictions.

1 INTRODUCTION

Financial theory has identified numerous explanations for financial risk management by non-financial corporations. These include avoiding financial distress, minimizing expected tax liabilities, agency conflicts and reducing the costs associated with accessing external capital markets. In general, these explanations imply that, since firm value or managerial utility is a concave function of cashflow, using financial derivatives to reduce cashflow variability can be desirable. The extant empirical research has primarily focused on exploring which theories best explain the use of derivatives by non-financial corporations. While there is some evidence in support of each of these explanations, the empirical literature does not conclusively resolve the issue in favor of a particular theory.

The empirical literature also documents a growing set of stylized facts concerning the use of derivatives by non-financial firms.

We would like to thank Andres Almazan, Murray Carlson, Sheridan Titman, Klaus Toft and workshop participants at the University of Texas at Austin, the University of Western Ontario, and the University of North Carolina at Chapel Hill for their comments. Any remaining errors are our sole responsibility.

- Most companies do not completely hedge financial exposures with derivatives. For example, Tufano (1996) documented that in the gold mining industry only about 17% of firms shed 40% or more of their near-term price risk.
- There exists considerable cross-sectional variation in the degree of derivative use inside of specific industries and even inside of particular companies. For example, Haushalter (2000) documented the risk management practices of oil and gas producers and found significant differences across firms in the percentage of exposure hedged.
- Companies vary their degree of derivative use significantly through time. Brown *et al* (2006) documented time-series variation in hedge ratios for a variety of companies and found that changes in firm-specific variables predicted by financial theory explain little of the variation.
- Many surveys suggest that risk managers incorporate their predictions of future price levels (views) when determining risk management policies. Bodnar *et al* (1998) reported that 59% of firms responding to the 1998 Wharton Risk Management Survey indicate that market views of exchange rates alter the timing of their hedges 61% state that views alter the size of their hedges and 32% actively take positions in currency derivatives based on their views.[1]
- Firms use both linear and nonlinear derivatives (eg, forwards and options) in implementing their risk management strategies.
- Firms hedge near-term exposures more. Bodnar *et al* (1998) reported that firms using foreign currency derivatives hedge only a very small part of their exposures beyond a one-year horizon.

While the existing theoretical literature on corporate risk management posits some compelling reasons of why firms manage risk, it is not obvious how all of these stylized facts can be explained within the existing framework(s). In this paper we provide an explanation by applying the principle of Occam's Razor: when faced with competing theories that make exactly the same predictions, the one that is simpler is better. In particular, we propose that the simple and well-documented phenomena of managers having speculative motives can explain much of the observed hedging behavior.

Our model examines a firm's endogenously determined risk management decision. Specifically, we consider a firm endowed at some future date with a unit of an asset whose price fluctuates randomly as a geometric Brownian motion. However, the firm faces market imperfections (such as bankruptcy costs or a progressive tax schedule) that result in a concave value function.[2] In this setting,

[1]Anecdotal evidence of managers hedging with a view is also widespread. In one recent case, Placer Dome, Inc., a major Canadian gold producer, decided to completely abandon its policy of hedging gold price risk because of a strong bullish view on future gold prices. (Heinzl (2000)).
[2]Such market imperfections are a well-established motive for risk management; see Froot *et al* (1993) or Smith and Stulz (1985). However, the thrust of our results does not rely on these market frictions.

hedging behavior is known to be static in the sense that the firm will capitalize (or short) the exposure and invest the proceeds in a riskless bond. We argue that managerial views can cause departures from this complete (static) hedging scenario and that they imply significant cross-sectional variation in hedge ratios around the static "full" hedge.[3]

While we explore the impact of speculative motives (or, equivalently, managerial views) on corporate behavior, our goal is not to take a stand on the merits of managers' views. Instead, we conceptually consider cases where risk managers will and will not have superior information about future prices. For example, some empirical research suggests that managers have superior information about the value of their publicly traded shares.[4] Consequently, it seems reasonable that a corporate risk manager would use this information when trading in the company's own stock for reasons related to share repurchases or the employee stock option plan (ESOP). This may explain the increasing tendency for firms to sell put options and buy call options on their own shares. It is also reasonable to assume that commodity producers such as OPEC member countries or agricultural producers have superior information about the future prices of their outputs (Stulz (1996)). Likewise, it may be that high-volume foreign exchange and fixed income trading desks obtain valuable price information by observing order flow.[5] It is less plausible that hedgers whose primary exposures are not related to their core production would be able to predict future prices. For example, large multinational corporations are often exposed to exchange rate and interest rate risk, but it seems unlikely that risk managers in these companies would have valuable private information about these markets. However, even if risk managers do not have superior information, they may still (erroneously) have a view, and this view could impact hedging activity. The growing behavioral literature on overconfidence supports this notion (see Odean (1998) for a survey).

Our results make some specific contributions to the field of corporate risk management. First, the model we develop can be viewed as a practical contribution as our stylized setting can easily be modified to provide a precise method for hedging

[3]We recognize that the speculative motives may arise from a behavioral bias rather than an actual informational advantage. If so, then this bias should be grounded in clearly defined psychological assumptions that are evident in a variety of different contexts. Moreover, to avoid becoming an *ad hoc* story with no predictive power, the suggested explanation must account for the stylized facts *and* provide testable out-of-sample empirical implications. Finally, we note that if the proposed explanation does affect the firm's hedging demands, then these demands may potentially be related to and consistent with some of the market pricing anomalies documented in Barberis *et al* (1998), Daniel *et al* (1999) and Odean (1998).

[4]Seyhun (1986) summarizes the extant empirical evidence on the quality of management's private information about its publicly traded shares.

[5]However, there is some recent empirical evidence to the contrary (Naik and Yadav (2000)).

should a manager actually have superior information.[6] Second, our analysis relates several distinct and testable empirical implications that have not yet been thoroughly examined. Consequently, we also parameterize and estimate our model to see whether factors relating to market views and confidence in those views can explain a significant portion of the variation in hedge ratios. Using foreign exchange hedging data from a large multinational producer of durable goods, we find distinct factors that determine the direction and magnitude of market views as well as the degree of confidence. For example, the difference between spot and forward exchange rates is important for determining the direction and size of views but not the confidence in those views. In contrast, the outcome (profit or loss) of a prior hedges is important in determining the level of confidence in a view (consistent with managerial overconfidence or biased self-attribution) but not the direction or size of views.

The remainder of the paper is organized as follows: in the next section we briefly summarize some related risk management theory; Section 3 specifies the assumptions of the model and defines the economy; the implications of managerial market views are presented in Section 3 along with analytical solutions for the optimal hedging strategy; Section 4 discusses some empirical implications and a test of the model; and Section 5 concludes.

2 RISK MANAGEMENT THEORY

A majority of the theoretical and empirical research pertaining to corporate risk management focuses on why firms undertake such activities and the related value implications. In this section we briefly describe this research, explain why it does not appear to provide an adequate explanation for the observed empirical regularities and, finally, relate it to our analysis.

Several common explanations for hedging suggest static risk management policies for firms. For example, theory suggests that a convex tax schedule or financial distress costs can motivate a firm to minimize the variation in its (taxable) cashflow (Smith and Stulz (1985)). Similarly, a firm with a risk-averse manager may find it less costly to allow the manager to reduce risk at the firm level than to pay an additional risk-premium. If hedging is costless these theories in their simplest form predict that a firm will completely hedge. If hedging is costly (eg, there exist market imperfections) but the costs of hedging do not change over time, then these theories predict that firms would hedge a constant proportion of their exposure so that the marginal benefit of hedging equaled the marginal cost of hedging.[7] However, these basic explanations alone are not able to account for

[6] The asset pricing implications of heterogenous beliefs have been examined extensively. Instead of looking at price behavior, we focus on the risk management implications of asymmetric information. In addition, since our model is in a corporate setting where the agent is maximizing firm value, the optimal strategy differs from that of a risk-averse investor making a portfolio decision.

[7] This proportion could be complete hedging, no hedging or some "interior" hedge depending on the type of cost. Again, see Smith and Stulz (1985).

the significant time-series variation in hedge ratios without significant time-series variation in the tax code, the costs of bankruptcy or managerial risk aversion; each of which seems unlikely.

Theory also suggests that informational asymmetries between managers and shareholders can lead to risk management with derivatives. DeMarzo and Duffie (1991, 1995) explored the role of proprietary information and hedge accounting, respectively, in the decision to use derivatives. These two-period models concentrate on the decision by firms to use derivatives and less on the extent of derivative use. However, DeMarzo and Duffie (1995) note that hedge accounting may be an important determinant of the types of derivatives preferred by firms. Both papers also note the potential impact of market risk premiums, a factor potentially related to market views, on optimal hedging behavior. DeMarzo and Duffie (1991) show that even if futures contracts trade at a nonzero risk premium, the optimal hedging policies described still suggest complete hedging. DeMarzo and Duffie (1995, p. 768) note that, "If hedging involved expected gains or losses . . . managers would deviate to some extent from full hedging . . . ".

Froot *et al* (1993) suggested that a firm should follow a risk management policy which coordinates the firm's optimal investment policy and internally generated cashflows thus minimizing the costs of accessing external capital markets. In this setting the optimal hedging policy depends crucially on the correlation between investment opportunities and internal cashflows. Resulting hedge ratios will not generally be equivalent to a "complete hedge" unless there is perfect correlation between investment and fully hedged cashflow. For example, a firm may not hedge at all if investment opportunities are perfectly correlated with unhedged cashflow. The model suggests that firms would only change their hedging policies substantially if investment opportunities (including correlations) or the costs of external capital also changed significantly. It again seems unlikely that this would be the case over the short horizons for which firms are observed adjusting their hedge ratios. Froot *et al* (1993) also examined an interesting case where the firm's investment opportunity set is uncertain, in this case the firm's optimal hedging strategy will, in general, be nonlinear and depend on the demand for financing in each future state.[8]

Mello *et al* (1995) derived a model of a multinational firm with flexibility in its location of production and the ability to contract in financial derivatives. The model suggests that a financial hedging strategy can be used to minimize the expected costs associated with switching production location and financial distress. While, the model is set in continuous time the optimal hedge is typically static and therefore also suggests that significant changes in optimal hedge ratios must be due to changes in firm-specific parameters (eg, switching or bankruptcy costs).

Several studies have examined models with certain features more closely related to those we examine subsequently. Mello and Parsons (2000) examined the

[8]Brown and Toft (2002) also discussed how unhedgable risks will lead to (static) nonlinear hedging strategies.

role of liquidity in determining an optimal hedging strategy. The results indicate that a full hedge will typically "over-hedge" the firm owing to intertemporal liquidity concerns. In general, optimal hedges will be time varying and depend on the value of the firm. Differences in types of derivative contracts are also noted, although primarily in the context of the differing cashflow properties of linear contracts (ie, forwards, futures and swaps). Mozumdar (2001) examined the relation between speculative incentives of corporations and the swap market. It is shown that for less-profitable, poorly capitalized firms the risk-shifting incentives of debt can lead to a desire for unbounded speculation by corporations in the swap market. However, speculative motives in this model derive from the ability to expropriate bondholder wealth instead of from market views.

Stulz (1984) presented a model of a risk-averse manager that is allowed to hedge with derivatives in continuous time. Stulz concentrated on the risk preferences of the manager and the manager's compensation contract but also considered the case when there is the potential to earn excess returns from investing in the risky asset. The results suggest that managers will generally choose not to hedge exactly 100% of an exposure and that the hedge ratio will change through time and depend on market risk premia. However, Stulz's consideration of market risk premia is not the same as managerial market views but instead are akin to an investor choosing exposure to a risky asset in the traditional portfolio management problem.

Conceptually closest to our analysis is Stulz (1996) who discussed the role of managerial views in setting hedge ratios. Stulz suggested that firms with a comparative advantage in the financial market (such as a large producer or dealer) may find it optimal to incorporate their views into a "selective" hedging policy. In one sense, a goal of this analysis is to formalize this behavior, quantify its impact and provide new testable implications.

Our model also relates to models in the asset pricing literature. For example, Zhou's (1998) equilibrium analysis shows that a *risk-averse* agricultural producer faced with uncertain production and a liquidity constraint will seek to replicate the payoff of a put option. In contrast, we consider the case of a value-maximizing corporation, with some deadweight costs, facing price uncertainty.

Finally, recent works by Barberis *et al* (1998), Daniel *et al* (1999) and Hong and Stein (1999) suggest it may be important to consider behavioral biases or imperfections when analyzing financial problems. All of these studies are motivated by the evidence on short-run continuation and long-term reversals in securities returns. While Daniel *et al* focus on the effects of two psychological biases, overconfidence and biased self-attribution, Hong and Stein relate the effect of interactions between heterogenous agents who differ in their informational endowments. Barberis *et al* rely on the behavioral heuristics of representativeness and conservatism to motivate investors who mistakenly view a random earnings process as either mean reverting or trending. While our model shares elements with each of these studies, we differ in that our focus is to explain corporate hedging behavior. Moreover, our analysis argues that a way to understand corporate hedging behavior is in the context of speculative motives that could arise from either overconfidence or informational asymmetries.

In summary, while many of these models are able to explain certain empirical features of hedging practices (such as partial hedging, nonlinear or dynamic strategies, etc), none appear to explicitly account for all observed features. In particular, most models appear to come up short in two areas. First, most models do not predict substantial time-series variation in hedge ratios. Second, the models do not explicitly model the impact of managers' market views. In our opinion these two phenomena are likely closely related and it is for this reason that we subsequently explore the potential impact of managerial views on hedging behavior. This allows us to isolate in a simplified setting the impact of reasonably sized views on the magnitude of hedge ratios to determine whether it is consistent with the variation observed in practice.

3 RISK MANAGEMENT AT A VALUE-MAXIMIZING FIRM

In this section we present the assumptions underlying the economy and define the firm's problem. We consider a finite horizon, $[0, T]$, economy with a traded risky and a riskless asset, and a manager who acts on behalf of a firm to implement a risk management strategy. The firm is endowed with no initial wealth but receives an uncertain payoff from a single unit of the risky asset at the terminal date T. In this frictionless market in which all future claims can be sold on fair terms, the firm can hedge uncertainty by taking long or short positions in either of the two assets.

3.1 The economy

The firm is endowed only with income from a unit exposure to the risky asset at time T and we assume trading takes place in continuous time over a finite horizon.[9] Uncertainty is represented by a complete probability space $(\Omega, F, \{F_t\}, P)$, on which a one-dimensional Brownian motion, B_t, is defined. The traded securities are the risk-free numeraire and a risky asset that are assumed

[9] We choose a continuous-time setting for several reasons. The primary reason is that we seek to understand the behavior of risk managers in a dynamic setting. Second, a goal of this paper is to compare the hedging decisions of a value-maximizing manager and risk-averse manager – a problem which is well understood in a continuous-time setting. Third, we have found it easier to obtain closed-form solutions for the case with a view in a continuous-time setting. Finally, since some of the more recent risk management literature is set in continuous-time, we want to maintain consistency and comparability.

by the market to follow:[10]

$$dS_0(t) = S_0(t) r \, dt \tag{1}$$

$$dS_1(t) = S_1(t)[\mu \, dt + \sigma \, dB_t] \tag{2}$$

respectively, where the interest rate r, the drift μ and the volatility σ are all assumed constant. Given our focus on characterizing economic behavior, allowing for more general price processes would not yield additional insight into the issues we examine:

Dynamic market completeness (under no arbitrage) implies the existence of a unique state price density process H_t, where:

$$H_t = \frac{Z_t}{S_0(t)} \tag{3}$$

$$dZ_t = -Z_t \theta \, dB_t \tag{4}$$

Here, $\theta = (\mu - r)/\sigma$ is the market price of risk or the Sharpe-ratio process and $Z_t \equiv (dQ/dP)_t$ is the Radon–Nikodym derivative of the risk-neutral probability measure Q with respect to the historical measure P. The quantity $H_T(\omega)$ is interpreted as the Arrow–Debreu price per unit probability of one unit of consumption good in state $\omega \in \Omega$ at time T.

3.2 A risk-averse manager

Consider first a firm that is owned by a risk-averse manager, for instance some firms are closely held by individuals (eg, farms) and could represent most or all of the owners wealth. Likewise, if the manager with control over risk-management operations has a significant portion of their personal wealth invested in the firm (either directly through stock or options or indirectly through human capital) then there is potential for agency conflicts to influence corporate policy. In this case, a risk-averse manager will maximize expected utility and will solve the following problem:

$$\max_{\pi(t)} \quad E_0[U(W_T)] \tag{5}$$

$$\text{subject to} \quad W_T = G(T) + W_e \tag{6}$$

$$W_e = S_1(0) \tag{7}$$

[10]Unless explicitly stated all processes are assumed adapted to the augmented filtration generated by $B(t)$. All stated (in)equalities involving random variables are assumed to hold P-almost surely. All processes are assumed to be well defined without explicitly stating the regularity conditions ensuring this. We assume throughout that all of the required integrability conditions on the price and portfolio process are satisfied and assume that they are well defined, without explicitly stating the regularity conditions ensuring this. The required integrability conditions on the price and portfolio process as well as the Novikov/Kazamaki condition can be found in Karatzas and Shreve (1999). Anticipating quantities introduced subsequently, technical conditions on enlargement of Brownian filtrations can be found in Amendinger (1999) and Jacod (1985).

where E_0 is the expectation conditional on time zero information under the physical measure and W_T is the terminal wealth. The terminal wealth consists of the market value of the endowed income and any trading gains, $G(T)$, realized at the terminal date. The choice of dollar amounts invested at time t in the riskless and the risky asset are denoted by $\pi_0(t)$ and $\pi_1(t)$, respectively.

While the firm receives its cashflow at time T, the timing of this cashflow is inconsequential in the current setting where the firm can capitalize its exposure. Capitalizing a cashflow implies receiving a payment of W_e at $t = 0$. While it can be argued that moral hazard or adverse selection problems may lead to the absence of such an insurance market, our setting abstracts from such concerns as the firm can easily short the exposure, which in effect capitalizes it, and then optimally invest the proceeds. Since this does allow for the possibility of large losses over the period $(0, T)$, the caveat of no liquidity constraints is necessary.

The firm's dynamic hedging problem can be also be expressed, as is well known, as a static problem. In this case, the firm's problem reduces to choosing the optimal distribution of terminal wealth over the set of budget feasible terminal wealth distributions, as follows:

$$\max_{W_T} \quad E_0[U(W_T)] \tag{8}$$

$$\text{subject to} \quad E_0[H_T W_T] \leq W_e \tag{9}$$

Note that the discounting in (9) uses the state price density. Since the product of a payoff and the state price density is equal, in expectation, to the current value of the payoff, the budget constraint ensures that the expected discounted optimal terminal wealth equals the firm's endowment. Hence, there is no creation of wealth, which explains the "budget constraint" nomenclature.

The manager's problem is twofold: (i) the optimal terminal distribution of wealth, W_T^*, subject to a budget constraint must be determined; and (ii) a representation problem which entails a search for a strategy to achieve the optimal wealth. The manager's optimal terminal wealth can be obtained using standard constrained optimization techniques. Once the optimal terminal distribution of wealth, W_T^*, is determined, the solution to the representation problem follows by defining a wealth process,[11] $\widehat{W}_t = E_t(\widehat{W}_T^*)$, and trading to enforce this equality. The optimal hedging strategy follows from an application of Itô's lemma to characterize $\widehat{W}_t$ and then equating coefficients with the wealth process for a generic strategy. In this case the firm will choose an optimal terminal wealth that is a random variable. A quick way to see this is to note that the above-constrained maximization reduces to the following problem with the Lagrange multiplier λ:

$$\max\{E_0 U(W_T) + \lambda(W_e - E_0[H(T)W_T]\}$$

$$\max\{\lambda W_e + E_0[U(W_T) - \lambda[H(T)W_T]\}$$

[11]Throughout, we will denote a random variable discounted by the state price density as $\widehat{x}_t \equiv H_0(t)x_t$.

and thus the first-order condition for optimality implies:

$$U'(W_T) = \lambda H(T)$$

This implies that a risk-averse investor would choose a terminal wealth such that the marginal utility of wealth is proportional to the state price density in that state. This well-known result is intuitive as the state price density is the price of receiving, with probability one, a unit of the consumption good in a particular state. Thus, a risk-averse investor would choose a wealth level in every state such that the marginal utility of wealth in that state is proportional to the price of consumption in that state.

In light of the fact that the optimal terminal wealth is a random variable, and that the hedging strategy seeks to replicate a wealth process such that $\widehat{W}_t = E_t(\widehat{W}_T^*)$, the risk-averse agent must retain some exposure to the risky asset. As is well known, this risk-averse agent with logarithmic utility will, after shorting or capitalizing the exposure, allocate a fixed proportion of their wealth, $(\mu - r)/\sigma^2$, to the risky asset (note that this result implies active trading behavior on the part of the manager to maintain this fixed proportion). A simple way to see this is to first note that changes in wealth depend on π as:

$$\frac{\mathrm{d}W_t}{W_t} = \pi_1\left(\frac{\mathrm{d}S_1}{S_1}\right) + (1 - \pi_1)\left(\frac{\mathrm{d}S_0}{s_0}\right)$$

and, hence:

$$\frac{\mathrm{d}W_t}{W_t} = (\mu\pi_1 + r(1 - \pi_1))\,\mathrm{d}t + \pi_1\sigma\,\mathrm{d}B(t)$$

Next, use the method of Aase (see Oksendal (1998, p. 225)) for a log utility function, which relies on the differential operator, $L^{\pi_1}(\cdot)$, of the wealth process, W_t. This differential operator simplifies to $L^{\pi_1} f(x) = \mu\pi_1 + r(1 - \pi_1) - \sigma^2(\pi_1^2/2)$, and it is well known that $E\log(W_T^*) = \log(W_0) + E_0\int_0^T L^v f(x)\,\mathrm{d}s$. Hence, substituting the expression for the differential operator gives:

$$E\log(W_T^*) = \log(W_0) + E_0\int_0^T \mu\pi_1 + r(1 - \pi_1) - \sigma^2(\pi_1^2/2)\,\mathrm{d}s$$

This expectation is maximal if the integrand is maximized, implying $\pi_1 = (\mu - r)/\sigma^2$.

3.3 The value-maximizing firm

As discussed by Zhou (1998), the value-maximizing firm's objective is to maximize the value of terminal wealth, $E_0[H_T\ W_T]$. While this follows naturally from the definition of $H(t)$ as the state price density, this is an often overlooked but important distinction from a risk-averse investor. Equivalently, this definition of the value-maximizing manager's objective can be stated as:

$$\max_{W_T} \frac{E_0^Q[W_T]}{S_0(T)} \tag{10}$$

$$\text{subject to} \quad E_0[H(T)W_T] \leq W_e \tag{11}$$

In this case, all terminal wealth distributions are of equal value to the manager. Hence, the manager is indifferent between the budget-feasible terminal wealths and remains in the realm of the Modigliani–Miller indifference proposition.

Traditionally, the risk-management literature makes the hedging decision relevant by arguing that the firm should maximize a concave function, f, of terminal wealth. This concave function is typically motivated by various market imperfections. For example, Smith and Stulz (1985) show that a progressive corporate income tax or bankruptcy costs result in a concave firm value function. Froot *et al* (1993) show how a cost of external finance that is increasing with the amount raised will induce the firm to maximize a concave function of terminal wealth. In general, a deadweight cost that is convex in the firm's value (or, similarly, profits) will result in a concave value function. Note that the concavity of the value function does not imply that the firm is risk averse *per se*, but merely that the value-maximizing firm faces market imperfections; our analysis of this functional form is motivated by its widespread use and for ease of comparison.

Given our interest in characterizing economic behavior, we specialize to a logarithmic form for f. In this case, the value-maximizing firm's objective is to maximize $E_0[H_T\ f(W_T)]$ and the firm's problem is modified to:

$$\max_{W_T} \quad \frac{E_0^Q[f(W_T)]}{S_0(T)} \tag{12}$$

$$\text{subject to} \quad E_0[H(T)W_T] \leq W_e \tag{13}$$

where E_0^Q is the expectation under the risk-neutral measure conditional on time zero information and W_T is the terminal wealth which consists of the market value of the endowed income realized at the terminal date and the trading gains, $G(T)$. As above, the dollar amounts invested at time t in the riskless and the risky asset are denoted by $\pi_0(t)$ and $\pi_1(t)$, respectively.

The extant risk management literature (eg, Froot *et al* (1993)) shows that a value-maximizing manager will completely hedge such an exposure. In that literature this result follows as a straightforward implication of Jensen's inequality; an analogous observation can be made in our current setting.

Observation 1 *The firm's optimal terminal trading strategy is to completely hedge so that:*

$$\pi_1(t) = 0 \tag{14}$$

and firm's terminal wealth is a constant. Thus:

$$W_T^* = W_e e^{rT} \tag{15}$$

The rationale for the elimination of exposure to the risky asset is intuitive, as can be seen most directly by noting that with the Lagrange multiplier λ the above-constrained maximization reduces to the following:

$$\max\{E_0 H_T f(W_T) + \lambda W_e - E_0[H(T)W_T]\}$$

$$\max\{\lambda W_e + E_0[H_T f(W_T) - \lambda[H(T)W_T]\}$$

and thus the first-order condition for optimality implies:

$$f'(W_T) = \lambda$$

In the above case, the manager will simply capitalize the exposure (or, equivalently, short it) and then invest the proceeds in the riskless bond. Recall also that the effective initial wealth is equal to the price of the risky asset at time 0, $S_1(0)$. Hence, the firm's optimal terminal wealth will be certain and equal to $S_1(0)e^{rT}$. Thus, complete hedging maintains a constant terminal wealth and maximizes firm value, consistent with many of the static hedging results in the existing literature.

This result is best understood by noting that the firm's problem is one of choosing an optimal terminal cashflow from among several of equal market value, as ensured by the budget constraint. However, as a result of the market imperfections mentioned above, the firm differs from the market in its private valuation of the budget feasible cashflows. As all assets have the same expected return under the risk-neutral measure, and as the objective function is concave, the firm opts to avoid all risk and prefers a complete hedge.

3.4 The firm's beliefs

In practice managers concede that their views concerning future prices affect their hedging strategies. Such a manager has a different opinion on the probability law (measure) governing the economy and, hence, the risky asset's price dynamics. In particular, if the different probability measure is labeled V, then $\mathrm{d}B_t^v = \mathrm{d}B_t - \alpha\,\mathrm{d}t$ and:

$$\mathrm{d}S_1(t) = S_1(t)[(\mu + \sigma\alpha)\,\mathrm{d}t + \sigma\,\mathrm{d}B_t^v] \tag{16}$$

As a result, this manager has a "private estimate" of the drift of the risky price process. Furthermore, this private estimate of the drift can be related to the fundamental factors that characterize it. For instance, one can imagine a risk manager having a price target for the risky asset, $S_1(T)$. If this information is precise in the sense that they know with certainty the terminal price, then the firm can make arbitrarily large profits. However, perfect knowledge of the future is not realistic and even informed managers realize that their view of the terminal price is distorted by noise. Hence, managers incorporate a level of confidence into their views; such an imprecision can be accommodated within our setting.

More specifically, suppose that at time zero the manager receives a noisy information signal, V_P, where

$$V_P = S_1^*(T) + \varepsilon \tag{17}$$

and the error variance ε is $N(0, \sigma_\varepsilon^2)$ (so the signal precision is $1/\sigma_\varepsilon^2$).[12] If the information has already been impounded into the market price then $\sigma_\varepsilon^2 = \infty$.

[12] $S_1^*(\cdot)$ is a monotonic function of $S_1(\cdot)$ and equal to the value of the Brownian motion, $B(\cdot)$. When the volatility of the price process is constant, knowing the terminal value of the Brownian motion is equivalent to knowing the terminal price of the risky security, since $S_1(t) = S_1(0)[\sigma B(t) + (\mu - \frac{1}{2}\sigma^2)t]$.

Even if the information has been impounded into the market price and $\sigma_\varepsilon^2 = \infty$, a boundedly rational manager can erroneously assign this noisy signal a finite variance. On the other hand, if the manager is truly informed and $\sigma_\varepsilon^2 < \infty$, then the manager confidence's may be correctly assigned to be finite. We focus on the case where the risk manager estimates their error variance, σ_c^2, to be finite, although the manager may be boundedly rational in making this assumption.

Equation (17) is a simple yet sufficient representation of the manager's views, about the price of the risky asset at the hedging horizon, $S_1(T)$. Although the manager only observes an imprecise signal of the terminal price, extreme confidence or perfect knowledge of the future is captured by a zero variance ($\sigma_c^2 = 0$). On the other hand as σ_c^2 increases without bound, then the manager has very little confidence in their views or, equivalently, no views ($\sigma_c^2 = \infty$). Note also that this differing belief is common knowledge to all, but other market participants may not believe that the manager is better informed. Otherwise, in the absence of noise traders, managerial actions would be fully revealing and it would not be possible for managers to implement their views.

This representation of private information is motivated by standard techniques from the theory of stochastic processes that capture information about the future as knowledge of some future random variable.[13] This random variable together with the old Brownian is then transformed via the Girsanov theorem to a new Brownian motion (see Amendinger (1999)) on an enlarged information set. This new Brownian is substituted into the original risky price process resulting in a modified price process with an altered drift. Thus, at each time t the manager's view is captured by augmenting the drift of the original price process by $\sigma\alpha$, where:

$$\alpha = \frac{V_P - S_1^*(t)}{(T-t) + \sigma_c^2}$$

3.5 The value-maximizing firm with a view

The manager bases their view on what they consider proprietary information and therefore "expect" to do better than other market participants. If the manager's view is in fact realized, then a higher terminal value results from following the modified strategy. The optimal strategy for a value-maximizing firm with a view that faces a concave (logarithmic) function of terminal wealth is recorded in the following proposition.

Observation 2 *The firm's optimal trading strategy is to retain a proportion $p_1 \equiv \pi_1/W_t$ of its exposure to the risky asset where:*

$$p_1(t) = \frac{V_p - S_1^*(t)}{\sigma((T-t) + \sigma_c^2)} \tag{18}$$

[13] We are aware of two main approaches to the representation of private information. The first, pioneered by Kyle (1985) and Back (1992), considers an auction market with a market maker, a noise trader and an insider. The other, initiated by Duffie and Huang (1986), is set in a standard multi-period security markets with heterogeneously informed agents. In this tradition, Karatzas and Pikovsky (1996) studied this problem in a continuous-time diffusion model.

This observation follows immediately from Karatzas and Pikovsky, who solve the equivalent problem for a risk-averse investor (logarithmic utility) with a view. Such a risk-averse investor who believes the drift of the risky asset to be $(\mu + \sigma\alpha)$, optimally allocates a proportion $(\mu - r)/\sigma^2 + \alpha/\sigma$ of their wealth to the risky asset. As noted, the key difference between the risk-averse and value-maximizing manager is that the latter maximizes a concave function of wealth under the risk-neutral measure. In the risk-neutral economy, the return of every asset including the risky one is equal to the risk-free rate r. The observation then follows by setting μ equal to r in the optimal risky asset allocation for the risk-averse agent with a view. The observation is also immediate from the manager's problem. As a result of the difference of opinion, the manager with a view maximizes $E_0^V[H_T\, f(W_T)] = E_0^P[Z_T^v\, H_T\, f(W_T)]$, where $Z_t^v \equiv (\mathrm{d}V/\mathrm{d}P)_t$ is the Radon–Nikodym derivative of the probability measure V with respect to P. Note that the expectation:

$$E_0^P[Z_T^v\, H_T\, f(W_T)] = E_0^P\left[\frac{Z_T^v\, Z_T\, f(W_T)}{S_0(T)}\right] = E_0^P\left[\frac{Z_T^{v+p}\, f(W_T)}{S_0(T)}\right]$$

In the last equality, $\mathrm{d}Z_t^{v+p} = -Z_t^{v+p}\theta^{v+p}\,\mathrm{d}B_t$, where:

$$\theta^{v+p} = \frac{\mu - (r + \sigma\alpha)}{\sigma}$$

A Girsanov transformation yields:

$$E_0^P\left[\frac{Z_T^{v+p}\, f(W_T)}{S_0(T)}\right] = E_0^\xi\left[\frac{f(W_T)}{S_0(T)}\right]$$

where ξ is a measure under which the risky asset has a drift of $(r + \sigma\alpha)$. Maximizing $E_0^\xi[f(W_T)/S_0(T)]$ is equivalent to the standard portfolio optimization problem, but the drift of the risky asset is $(r + \sigma\alpha)$. Note that the proportion invested in the risky asset must then equal:

$$\frac{(r + \sigma\alpha) - r}{\sigma} = \alpha$$

The observation follows by noting that:

$$\alpha = \frac{V_P - S_1^*(t)}{(T - t) + \sigma_c^2}$$

Without a view the value-maximizing manager's optimal policy is to short the risky asset and optimally invest the proceeds in the riskless asset. In that case, the proportion of wealth invested in the risky asset is zero. Equation (18) notes that when the manager has a view, the optimal hedging strategy will retain some exposure to the risky asset. The difference between the two hedging strategies can be traced to the additional information that is (perceived) to be available in the latter case. Likewise, owing to their belief the manager with a view has a higher *ex ante* (perceived) expected value than the ordinary manager.

To gain intuition regarding the result in (18) we examine some special cases and comparative statics. To begin with we examine the optimal hedge with a view under an extreme assumption. Consider the case when the manager has no confidence at all in their view, in other words $\sigma_c^2 = \infty$. Relevant characteristics are apparent by taking the limit of the optimal hedge ratio as $\sigma_c^2 \to \infty$. Note that in this case the manager will not retain any exposure to the risky asset, thus reverting to the case of no view. This result is intuitive: if the manager has a view and yet has no confidence in it, this is equivalent to having no view at all.

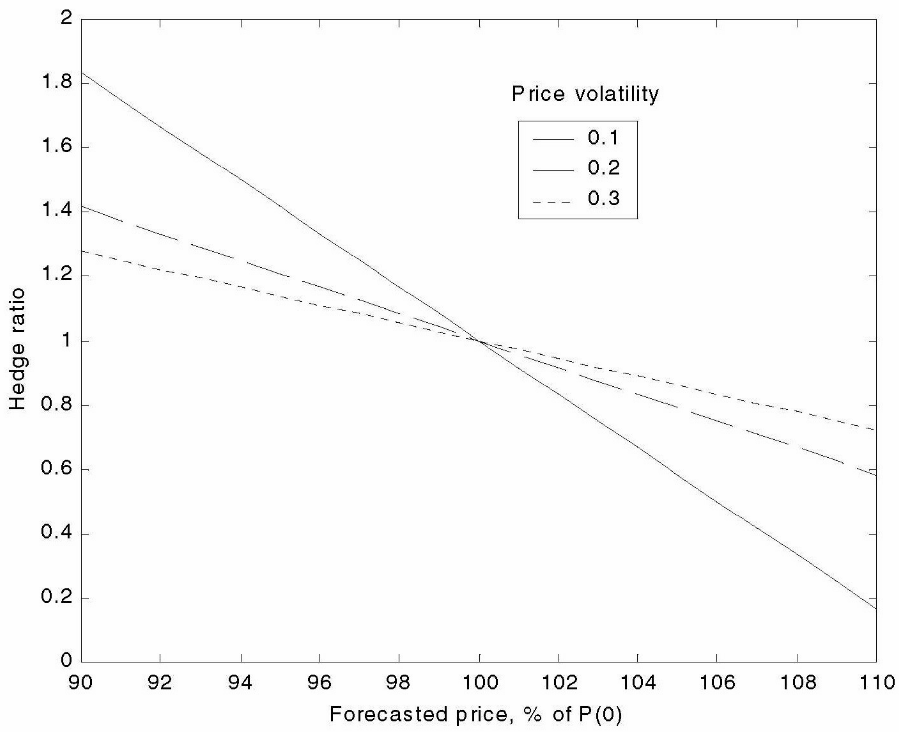
An obvious but important observation is that when the manager has a view on the terminal price of the risky asset, the firm will retain some exposure to the risky asset. The direction and magnitude of the optimal hedge should depend on the degree of (perceived) mispricing. As intuition suggests, a manager that has a bullish view (ie, believes $V_p - S_1^*(t)$ to be positive) will take on a long exposure to the risky asset and vice versa. Likewise, the size (in absolute value) of the optimal hedge depends on the magnitude of $V_p - S_1^*(t)$. Greater confidence in a view should result in a larger (in absolute value) exposure to the risky asset. A high degree of confidence means that σ_c^2 is small. Thus, given a bullish view a very confident manager will take larger positions in the risky asset and vice versa. Equation (18) also shows that a manager will be less likely to remain exposed to a riskier asset. This is because the manager trades off the increase in expected return from incorporating the market view with the possibility of financial distress (or other deadweight costs).

Equation (18) provides an exact formula for the optimal hedging strategy at time t. We can think of a producer with an effective long position in the underlying asset as choosing an initial optimal hedge ratio $h = S_1(0) - \pi_1(0)$. For example, if $S_1(0) = 1$ and $\mu = r = 0$ then h is equivalent to the optimal hedge ratio in percentage terms (eg, $h = 0.5$ implies the optimal hedge is half of the exposure). In practice, a company would choose to enter into a short position in forward contracts with this notional value (as a percentage of exposure).

This interpretation of the optimal trading strategy allows for an intuitive analysis of how the model's parameters impact the optimal hedge ratio. Consider a base case where views are expressed as a percentage of the initial price $S(0)$ (also the forward price since $r = 0$). Figure 1 shows the optimal initial ($t = 0$) hedge ratios for various price forecasts when $T = 1$, $\sigma_c = 0.2$ and $\sigma = \{0.1, 0.2, 0.3\}$. As noted above, when a risk manager expects the forecasted price of the good to be higher than the current spot price, the optimal hedge ratio is less than 1.0. Intuitively, the manager remains partially unhedged to capture expected gains from being long with the risky asset. If the manager is bearish (ie, the expected price is below the spot price), the manager hedges more than 100% (ie, $h > 1$).[14] For a given level of view, the optimal hedge ratio moves closer to 1.0 as the price volatility increases. This derives from the relative value of the risk manager's information. As the underlying price volatility increases, it is less likely that the

[14] In practice, hedge ratios greater than 100% are rarely observed. This is probably due to additional factors such as the liquidity constraints discussed in the previous section.

FIGURE 1 Optimal initial hedge ratios as a function of forecasted price.



The magnitude of the optimal hedge ratio at $t = 0$ is shown for three different levels of price volatility (0.1, 0.2, 0.3). Other parameters are $T = 1.0$ and $\sigma_c = 0.2$.

manager will be able to profit from their view and the optimal strategy is to deviate less from the riskless hedge.

Figure 1 also provides an indication of the wide range of hedge ratios that can be obtained from fairly mild views on future prices. For example, a risk manager who believes prices will be 6% above the spot price will choose to be only about halfway hedged when price volatility is 0.1. Small variations in the manager's view can also have a large effect on the optimal hedge ratio. In this case, a 1% change in view changes the optimal hedge ratio by approximately 8%. Likewise, a change in the underlying asset price holding the manager's view constant will result in the same change.

In practice, some corporations adjust their hedge positions infrequently. Instead risk managers open a derivative position as a hedge and adjust it when exposure forecasts (eg, sales estimates) are revised. In this case a risk manager could choose to approximate as closely as possible the optimal hedging strategy with a static derivative position. One simple mechanism for accomplishing this is to match the "delta" and "gamma" of the optimal initial hedging strategy with that of a static derivative portfolio (with an expiration date equal to T). The "delta" of the optimal hedging strategy is given by $-h$ and the "gamma" is given by $-\mathrm{d}h/\mathrm{d}P$. In most cases, this suggests that a risk manager will hold a portfolio that is both short forwards and either long or short options. Referring back to (18), it can be shown that the optimal gamma will depend only on the direction of the view. When a risk manager is bullish (bearish) the gamma will be positive (negative) and the optimal static portfolio will be long (short) options. Thus, we have provided another potential explanation for managers holding portfolios of linear and nonlinear derivatives.

3.6 Extensions

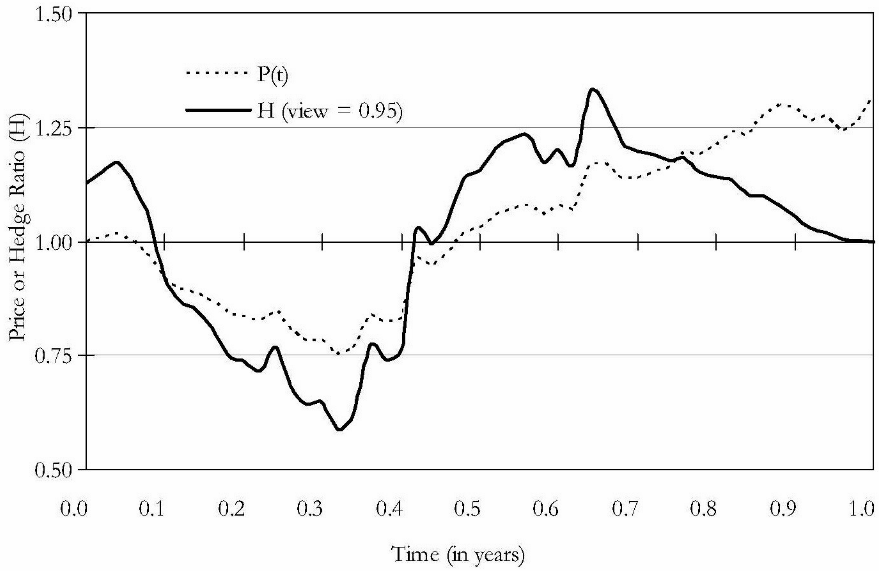
The model above studies the effect of managerial views on a firm's hedging decision in a stylized setting when the manager's confidence level remains constant. This assumption has the counterintuitive implication that managers do not update their confidence in light of subsequent outcomes. While this simplification is useful it has the extreme effect that an instant before maturity the manager may stubbornly stick to an erroneous view.

First consider the case when at time zero the manager estimates an error variance of σ_c^2 (and, hence, a confidence level $1/\sigma_c^2$ for their view). Assume that as the hedge approaches maturity at time T this confidence level decreases to zero, implying that $\sigma_c^2 \to \infty$. For the logarithmic form of the firm value function that we study, the effect of this is to replace the constant confidence level in (18) with a time-dependent confidence level. At the initial time, there is little difference between this changing confidence case and the case when confidence remained constant. However, as $t \to T$ the manager will no longer retain an exposure to the risky asset. This type of behavior would be consistent with a very simple learning model where the manager updates confidence about their view as a function of how likely they are to be correct given the time horizon of the hedge. In other words, managers are likely to rationally update the probability of market views being incorrect as the probability of being correct declines.[15] This type of learning is also similar to Bayesian updating of beliefs in portfolio choice problems with parameter uncertainty (Xia (2001)) and models of stock price valuation with learning about profitability (Pastor and Veronesi (2003)).

As an example, we plot a hypothetical price process over time and the associated hedging strategy with a changing confidence level. The lighter dotted line in Figure 2 shows one possible evolution of the asset's price over a one-year horizon. During the first few months the price declines from its initial level of 1.0 to about 0.75; for the rest of the year the asset price trends upward ending at a

[15]While it is reasonable to expect that confidence decays over time, psychological evidence also suggests that individuals tend to exhibit biased self-attribution, implying asymmetric shifts in confidence. Thus, outcomes that confirm existing beliefs tend to disproportionately increase confidence while disconfirming outcomes decrease confidence too little.

FIGURE 2 Example of price path and hedges.



An example of a hypothetical price path (dotted line) and hedge ratios from a hedging strategy. The dark solid line, labeled H (view = 0.95), depicts the evolution of the optimal hedge ratio for a manager with time-dependent confidence who believes the terminal price will be 0.95. We assume an initial one-year hedge horizon, an asset volatility of 0.30 and a confidence level of $0.30/(T - t)^2$.

value of about 1.30. The darker solid line in Figure 2 shows the optimal hedge ratio for a manager that forecasts a terminal price level of 0.95. Since the initial price of 1.0 is greater than the manager's forecasted price, the optimal hedge ratio is greater than one. However, as the price declines below 0.95, the managers view changes from bullish to bearish, and the optimal hedge ratio falls to about 0.6. At about $t = 0.4$ the optimal hedge ratio increases to above 1.0 as the price once again climbs above 0.95. For the remaining time the asset price increases on average, yet at about $t = 0.65$ the optimal hedge ratio starts reverting toward 1.0 (ie, the exposure to the risky asset decreases to zero). This is the intuitive result we expect when the manager's confidence in their market view declines as the time to the exposure realization is approached. Moreover, this highlights a difference between the case of changing and constant confidence, as with the latter the manager would stubbornly stick to their view and may take very large exposures as t approached 1.0. (This difference points out a testable implication of our model that we elaborate upon below.)

4 EMPIRICAL IMPLICATIONS AND ESTIMATION

In this section we describe some additional empirical implications of our model and estimate a parametrization of the model using a proprietary dataset of foreign exchange hedging transactions from a Fortune 100 multinational corporation.

4.1 Additional empirical implications

Prior research suggests that price declines should lead to increased hedging since when prices (of outputs) decline the probability of financial distress increases. Perhaps the most surprising implication of our analysis is that when prices decline, firms can prefer to hedge less. As illustrated in Figure 2, a decline in the price level (during $t = 0$ to $t = 0.3$) results in the hedge ratio declining. Inspection of Equation (18) reveals this to be the case whenever the manager has a bullish view. The time series in Figure 2 also indicates that hedge ratios can be substantially more volatile than the underlying asset's price process. For example, during $t = 0$ to $t = 0.3$ the asset price declines about 25% whereas the hedge ratio declines about 50%. Likewise, over the next few months, a 50% increase in price results in approximately a doubling of the hedge ratio.[16]

Additional implications derive from the (usually) unobserved variables describing the size and confidence of the risk manager's views (ie, V_P and σ_c^2). However, it is still possible to indirectly test the model's predictions. Whether views are based on comparative advantages or overconfidence, managers are more likely to incorporate views when they believe they have superior information. Thus, firms may be more likely to retain exposures close to their core competencies. For example, our analysis implies that IBM is less likely to retain its exposures to exchange rates but may keep its exposure to DRAM prices. Likewise, an energy concern might retain exposure to oil prices but hedge interest rate risk. In short, firms with several lines of business are more likely to retain exposures related to their core competencies.

The psychological literature documents the phenomenon of biased self-attribution. In the language of Daniel *et al* (1999) this can cause "asymmetric shifts in investor's confidence as a function of investment outcomes", thus it would be informative to study how hedge ratios react to changes in price. However, if risk manager's incorporate views into their hedging decisions, then after controlling for price effects, managers may overreact to favorable outcomes and underreact to disconfirming outcomes. Since these results are directly attributable to asymmetric shifts in confidence, such a test would be a test of our theory (assuming it is unlikely that manager's hedge with a view and yet violate biased self-attribution). In addition, there may exist a relation between prior hedging outcomes and the

[16]The effect of the view is diminished as the asset volatility increases and as the manager's confidence in their view declines. However, as one departs from the logarithmic form of the value function towards a more linear form (ie, the firm is less constrained and faces lower financing constraints, taxes, etc), the effect of the views is magnified. Thus, considering a logarithmic form is conservative, in the sense that the effect of views is least prominent.

confidence of managers' views. Specifically, if managers become less confident of their views when their hedges lose money then we should observe a negative relation between prior hedging profits and the (estimated) measure of uncertainty in the manager's views (ie, σ_c).

4.2 Estimating the model

In practice, testing the model's predictions is a challenge because a manager's views and confidence levels are usually not directly observable and detailed data on hedging transactions are hard to obtain. In addition, firm-specific effects complicate empirical tests because different factors may be important in forming views and confidence levels for managers of different firms. However, there exist a few detailed datasets on derivative transactions and managers views may be well approximated by a few observable variables (as noted above).

In this section we utilize a proprietary dataset described in Brown (2001) that contains hedge ratios for foreign currency exposures from a large US-based durable goods producer (denoted by HDG for confidentiality reasons). HDG uses currency derivatives to hedge net sales revenue denominated in foreign currency. The firm's hedging horizon is roughly one year and for accounting purposes it tracks hedge positions for each future quarter separately. We utilize quarterly hedge ratios for 15 currencies from 1995 to 1998 for three different hedging horizons (one, two and three subsequent quarters).

Brown (2001, p. 413) describes how risk managers at HDG incorporate market views into their hedging decisions noting that "... to varying degrees, most [risk managers at HDG] believe they have the ability to adjust hedge parameters so as to increase the expected net cashflow from derivative transactions". Brown also estimates the effects of proxies for "market views" on HDG's observed hedge ratios in a linear fixed-effects regression model and finds that historical price trends and prior hedging outcomes are important determinants of hedge ratios. In this section we apply the model derived in the prior section to the same setting described in Brown (2001). Our approach has several advantages. First, our model explicitly distinguished between a market view and a manager's confidence in that view thus allowing the effects to be estimated separately. Second, our model precisely describes the relation between hedge ratios, hedging time horizon and asset price volatility, whereas Brown (2001) estimates the models separately for different horizons and includes asset price volatility as another (linear) explanatory factor. Finally, our model makes a precise statement of the functional relation between market views and hedge ratios which, if closer to the true form, could increase the power of statistical tests.

To operationalize our model we parameterize the hedge ratio specification discussed in the prior section. Specifically, we linearly parameterize both the size of the manager's view and the confidence in this view, thus:

$$-H(i, j, t) = 1 - \mu_i - \frac{\boldsymbol{\beta}_1'\mathbf{X}_1}{\sigma_{ijt}((T-t) + (\boldsymbol{\beta}_2'\mathbf{X}_2)^2)} + \epsilon_{ijt} \tag{19}$$

where $-H(i, j, t)$ is the hedge ratio for currency i in quarter j for hedging horizon t, $\mathbf{X}_1$ is a matrix containing factors that determine the manager's market views for observation (i, j, t) and $\mathbf{X}_2$ is a matrix containing factors that explain the manager's confidence level for observation (i, j, t). In addition, μ_i is a normally distributed random effect for each currency, σ_{ijt} is the implied volatility and ϵ_{ijt} is a normally distributed (mean zero) error term.

Brown (2001) suggests that a variety of factors determine the views of HDG's risk managers. We follow that analysis to make specific predictions for our empirical model.

- HDG believes that a large difference between forward exchange rates and spot exchange rates (*forward points*) makes hedging less valuable because a high relative forward rate amounts to locking in a weak exchange rate (ie, forward rates are biased). We therefore predict *forward points* will negatively affect the magnitude of the view but should not necessarily affect the confidence level.
- HDG closely follows the profits and losses from derivatives transactions (*derivative P&L*). Anecdotal evidence from interviews with risk managers suggests that past levels of P&L affect current hedge ratios because of regret about over-hedging or under-hedging. Positive P&L is often attributed to skill which is indicative of overconfidence or biased self-attribution. Consequently, we predict that lagged values of derivative P&L would have a positive effect on the confidence in that view (ie, a negative coefficient on the β_2 confidence parameter).
- HDG uses historical price trends (ie, technical analysis) in an attempt to predict future exchange rate movements. Specifically, managers track the level of current spot rates relative to the high and low exchange rates over the last 12 months. Managers believe these indicators are a measure of relative value, therefore we predict that these variables will primarily affect the magnitude of views. By this logic, managers will perceive (USD/FCU) exchange rates close to recent highs as an unfavorable exchange rate and therefore hedge less. Similarly, managers will perceive (USD/FCU) exchange rates close to recent lows as a favorable exchange rate and therefore hedge more.
- Finally, Brown (2001) finds some evidence that HDG hedges less when there is more uncertainty about the exposure size (ie, *exposure volatility* is high). This uncertainty may also affect the level of confidence in a market view. If this is the case, we would expect a negative relation between exposure volatility and the level of confidence (ie, a positive coefficient on the β_2 confidence parameter).

We employ maximum likelihood estimation (using the Gauss–Hermite quadrature method) to obtain parameter estimates for Equation (19). These are reported in Table 1. The first three columns report coefficient estimates, standard errors and p-values for β_1, which quantifies effects on managers' views. The next three columns report similar statistics for β_2, which quantifies effects on managers' confidence levels.[17]

The results for *forward points* are consistent with our predictions. When the forward rate is relatively far above the spot rate, HDG hedges less but there is no significant effect on confidence levels. Also as predicted, the lagged values of derivative P&L have a significant effect on the confidence level of (but not the magnitude of) views. In particular, the manager's estimated confidence level increases when the prior quarter's hedges were profitable. The variables measuring the current spot rate relative to historical highs and lows are both significant determinants of market views, although only the coefficient on the spot price relative to the 12-month high has the predicted sign. Both of the measures also explain managers' confidence levels perhaps suggesting that managers perceive exchange rates far from recent market highs and lows as more difficult to predict. The sign of the β_2 coefficient for exposure volatility is the predicted sign but not statistically different from zero indicating that quantity risk is not an important factor in determining confidence levels.

To gauge the economic significance of these factors we calculate marginal effects for each variable by calculating the difference between the predicted hedge ratio at the mean value of each variable and the predicted hedge ratio with each variable perturbed by +1 standard deviation (SD) holding other variables at their means. Values are reported in the last column of Table 1 and the estimated economic significance of some factors is large. For example, a +1 SD increase in derivative P&L changes the hedge ratio by −0.046 or −14.7% of HDG's mean hedge ratio of 0.312. The spot exchange rate relative to its 12-month high has an even larger effect. We also calculate a measure of goodness of fit. We define the pseudo-R^2 as $1 - L_c/L$ where L_c is the estimated log-likelihood of the model with only random effects and L is the estimated log-likelihood of the full model. While this statistic should be interpreted with caution, the large value of 0.815 suggests that the model explains a large amount of the variation in hedge ratios.

Overall, these results are generally more consistent with the predictions of Brown (2001) than the findings in the original paper. It is also important to note that our results, are not simply a restatement of those results, but instead we find somewhat different factors to be important and distinguish between effects on the direction of views and the confidence in those views.

5 CONCLUSIONS

In this analysis we have examined the optimal trading strategy for a firm that faces market imperfections and a risk manager that has a view on the future price level. Specifically, the optimal hedging strategy:

[17] The reported results are robust to several alternative specifications. For example, interacting forward points with the price trend variables does not appreciably change the reported coefficient values or significance levels. In addition, market share (also examined by Brown (2001)) is not a significant explanatory variable and so we exclude it to retain a parsimonious equation.

TABLE 1 Parameter estimates and marginal effects.

	View (b1)			Confidence (b2)			Marginal effect
	Coefficient	SE	p-value	Coefficient	SE	p-value	
Forward Points (%)	−0.113	0.040	0.013	0.737	3.528	0.838	−0.020
Derivate P&L $(t-1)$	0.011	0.011	0.342	−3.047	0.762	0.001	−0.046
Spot % below 12-Month							
High (USD/FCU)	−0.109	0.018	<0.0001	4.145	0.486	<0.0001	−0.048
Spot % above 12-Month							
Low (USD/FCU)	−0.043	0.016	0.016	2.845	0.640	0.001	−0.009
Exposure volatility	−0.006	0.004	0.106	0.049	0.186	0.794	−0.005
Constant	0.003	0.001	0.074	−0.276	0.093	0.010	
Random effects							
Mean	0.916	0.022	<0.0001				
Standard error	0.003	0.001	<0.0001				
Observations			630				
Pseudo R^2			0.815				

- will be risky, in so far as it will not fully hedge the company against price changes;
- will involve trading as compared with the optimal static hedge when there is no view or market imperfection;
- can result in considerable cross-sectional and time-series variation in hedge ratios;
- will depend on the confidence of managers views;
- will depend on the volatility of the underlying price process; and
- will increase firm value, on average, if managers are in fact better informed than the market.

Whether or not risk managers actually have superior information and can trade profitably is an open empirical question (Brown *et al* (2006)). However, most corporate risk managers do incorporate a view into their hedging decisions. Our results indicate that even if managers have relatively mild views on future prices this can have a large impact on hedge ratios. In addition, if managers follow the optimal strategy, they will adjust their exposure through trading. Thus, our simple model sheds light on many empirical regularities documented by prior research. Our empirical tests suggest that factors possibly relating to managers' views may be economically important determinants of hedge ratios in practice. Finally, if views and market imperfections are, in fact, as important as our findings suggest, future empirical researchers need to control for these factors when examining fundamental determinants for corporate risk management.

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