MANAGING FOREIGN EXCHANGE RISK WITH DERIVATIVES

by

Gregory W. Brown*
The University of North Carolina at Chapel Hill

July, 1999
Version 1.4

Abstract

United States based HDG Inc. (pseudonym) is an industry leading manufacturer of durable equipment with sales in more than 50 countries. Foreign sales account for just under half of HDG's gross revenue. This study investigates the firm's foreign exchange risk management program. The analysis relies primarily on a three month field study in the treasury of HDG. Detailed descriptions of the organizational and operational procedures of the firm's hedging activity are presented. Precise examination of factors affecting why and how the firm manages its foreign exchange exposure are explored through the use of internal firm documents and communiqués, extensive discussions with management, and data on more than 3100 foreign-exchange derivative transactions over a three and a half year period. Results indicate that many commonly cited reasons for corporate hedging are not the primary motivation for *why* HDG undertakes a risk management program. Instead, informational asymmetries, facilitation of internal contracting, and competitive pricing concerns motivate hedging. *How* HDG hedges depends on foreign exchange volatility, exposure volatility, technical factors, and recent hedging outcomes.

* Department of Finance, Kenan-Flagler Business School, The University of North Carolina at Chapel Hill, CB 3490 – McColl Building, Chapel Hill, NC 27599-3490. Voice: (919) 962-9250, Fax: (919) 962-2068, Email: gregwbrown@unc.edu. A more recent version of this document may be available from my web page: http://itr.bschool.unc.edu/faculty/browngr. I gratefully acknowledge the assistance of the treasury staff of HDG for providing data and allocating time to this endeavor. This study also benefited from the advice and comments of David Haushalter, Jay Hartzell, Laura Starks, Klaus Toft, and especially Peter Tufano. Furthermore, many improvements have been made due to the suggestions of seminar participants at the University of Texas at Dallas.

MANAGING FOREIGN EXCHANGE RISK WITH DERIVATIVES

Abstract

United States based HDG Inc. (pseudonym) is an industry leading manufacturer of durable equipment with sales in more than 50 countries. Foreign sales account for just under half of HDG's gross revenue. This study investigates the firm's foreign exchange risk management program. The analysis relies primarily on a three month field study in the treasury of HDG. Detailed descriptions of the organizational and operational procedures of the firm's hedging activity are presented. Precise examination of factors affecting why and how the firm manages its foreign exchange exposure are explored through the use of internal firm documents and communiqués, extensive discussions with management, and data on more than 3100 foreign-exchange derivative transactions over a three and a half year period. Results indicate that many commonly cited reasons for corporate hedging are not the primary motivation for *why* HDG undertakes a risk management program. Instead, informational asymmetries, facilitation of internal contracting, and competitive pricing concerns motivate hedging. *How* HDG hedges depends on foreign exchange volatility, exposure volatility, technical factors, and recent hedging outcomes.

1 Introduction

Despite many recent empirical studies of corporate risk management programs, there is only weak evidence explaining why and how non-financial firms use derivatives. In general, cross-sectional tests attempting to determine why firms use derivatives have not consistently supported theoretical explanations for value-maximizing objectives. Instead, we are left with some stylized facts such as larger firms are more likely to use derivatives (Dolde, 1993), firms with more growth options are more likely to use derivatives (Nance, Smith, and Smithson, 1993 and Geczy, Minton, and Shrand, 1997), and hedging increases with leverage (Block and Gallagher, 1986, and Wall and Pringle, 1989). Even these results are not found in all samples though. More robust results are obtained by Tufano

(1996) who finds that management incentives and tenure are important determinants for the cross-sectional differences in gold mining firms' risk management decisions.

Studies analyzing the structure of derivative portfolios are almost nonexistent. To date, the academic literature has not attempted to explain *how* firms structure their derivative positions -- for example, how firms choose between linear and nonlinear contracts or the hedging time horizon. However, the applied literature does address this decision (for example, Lewent and Kearney, 1990)

One explanation for the lack of consistent results explaining derivative use is that the theories being tested are incomplete or not applicable to current business practices. Alternatively, the power of the tests used in most studies could be hampered by the lack of detailed and consistent data for US corporations. Certainly, a primary reason no large empirical study explores how firms structure their hedges is that data describing derivative positions are not publicly available for most firms. Typically, data are limited to only notional values and (depending on the firm and accounting treatment of a position) some mark-to-market values of derivatives aggregated across type of exposure (e.g., foreign exchange). For example, it may be possible to determine that a firm holds $100 million (M) in currency options but not the underlying currencies or even whether the firm is long or short. Furthermore, firms are often tight-lipped about their use of derivatives. Currently, firms are required to disclose only very general aspects of their motivations for risk management activities.

This study circumvents these pitfalls. In the spring of 1998, I spent approximately three months in the treasury department of HDG Inc.[1] United States based HDG is an industry-leading manufacturer of durable equipment with sales in more than 50 countries. Foreign sales account for just under half of HDG's more than $10 Billion in 1997 gross revenue. The firm actively manages much of its non-US Dollar (USD) currency exposures with financial derivatives. For example, in 1997 the notional values

[1] As a condition for undertaking this study HDG required that I enter into a non-disclosure agreement. Specifically, I am not able to expose the true identity of the firm. I can only describe the firm as a "industry-leading manufacturer of durable equipment." In regards to specific data, I am not able to identify particular currencies (hence they are labeled with letters A through X), nor can I report disaggregated data (e.g., sales by country by quarter, though "average sales in currency Z" is permitted). A general restriction prevents me from disclosing any information that would allow a resourceful person to identify the company.

of foreign exchange derivatives held at fiscal year-end totaled approximately $2.8 billion and notional value of derivative transactions for the year was over $15 billion.

During the study, I observed the implementation of foreign exchange (forex) risk-management decisions. I conducted extensive discussions with treasury personnel and senior management, reviewed new and existing internal documents and collected historical data on 3110 individual foreign currency derivative transactions for 14 quarters (1995:Q1-1998:Q2). The derivatives are written on 24 different currencies, some of which enter the sample during the observation period.

This paper addresses three specific topics. First, I detail the foreign exchange risk management policies and operations. This provides insights into the mechanics of the hedging program thus providing a framework in which more in-depth questions may be posed and analyzed. I calculate the impact of foreign exchange derivative positions on reported earnings, aggregate cash flows, and individual country exposures. In general, hedging reduces the variation in USD earnings and cash flow. However, the economic meaningfulness of the reduction is not overwhelming.

Second, I explore the economic reasons *why* HDG manages foreign exchange risk. By observing the daily operations of the group and their interaction with management, I am able to report on observed motivations of the firm's risk management program as well as apparent managerial motivation (agency) issues. I find that several traditional academic explanations for why a firm would manage hedgable risks (such as minimizing taxes and avoiding financial distress) do not capture the primary motivations of HDG. Instead, there appear to be more subtle explanations relating to information asymmetries between investors and management, competitive strategies involving pricing decisions, and efficiency gains through improved internal decision making and evaluation. For example, the primary focus of the forex hedging group is the determination and management of a "hedge rate" used in *ex ante* planning decisions (e.g., in determining annual budgets, sales targets, and strategic decisions) and *ex post* evaluation and reporting.

Finally, I investigate the precise structure of the foreign currency hedges with the 14 quarters of transaction data, internal exposure forecasts, and realized foreign exchange revenues. Attention is paid to cross-sectional differences between currencies, the

dynamic properties of derivative positions, and the choice of hedging contract types. I am also able to test specific implications from recent theoretical models by Ahn, Boudouk, Richardson, and Whitelaw (1999), Brown and Toft (1999). The main findings of this section are that HDG has a strong preference for hedging with put options because of more favorable accounting treatment. Factors that determine the characteristics of the hedge portfolios (i.e., notional value, delta, gamma, and vega) include exchange rate volatility, underlying exposure volatility (quantity risk), technical factors that may be associated with market views, and recent hedging outcomes.

The remainder of the paper is organized as follows: Section 2 describes the operations of the forex risk management group and the impact of hedging on earnings and cash flows. Section 3 describes the reasons why HDG undertakes forex risk management and tries to reconcile stated objectives and actual practice with economic theory. Section 4 presents an analysis of the transaction data and empirical tests of the hedging theories. Section 5 concludes.

2 The Firm and the Risk Management Operations

HDG is a manufacturer of durable goods for consumers, business, and government. The firm operates in a highly competitive industry with numerous large and small competitors. Competition comes from both US-based and foreign manufacturers. HDG is tightly focussed in its primary industry which is a growing market and highly dependent on technologically innovation. HDG business strategy seeks to (1) lead the industry in "efficient procurement, manufacturing, and distribution," (2) provide customers with "value-added services and insight into [industry] trends," (3) "make it easier for customers to do business with HDG, reduce their costs and HDG's, and enhance relationships with our customers and suppliers" (corporate statement).[2]

[2] Throughout the paper direct quotes from HDG employees or documents will be presented between quotation marks. If it is not clear from context the source of the quote, the citation will be followed by a description of the document (e.g., corporate mission statement) or title of the employee (e.g., Manager of Foreign Exchange) in parentheses. Any items paraphrased or changed to protect the identity of HDG are isolated between square brackets (e.g., [industry] instead of the original description of HDG's industry).

2.1 The Structure of Foreign Exchange Risk Management

HDG "uses foreign currency purchased option contracts and forward contracts to reduce its exposure to currency fluctuations involving probable anticipated, but not firmly committed, transactions and transactions with firm foreign currency commitments" (government filing). Due to unexpected losses and loose controls in foreign currency derivatives transactions prior to the study period, HDG put in place a very precise forex risk-management policy. This policy is described in the official corporate document *Treasury Policy and Procedure Manual*. In effect, the policy limits the types, sizes, and timing of derivative positions. It also specifies the precise procedures followed by all employees involved with foreign exchange transactions.

The policy separates functions into three broad groups. The first group is best described as oversight functions. The policy states that "the Board of Directors has ultimate responsibility for approval of [HDG's] foreign exchange policy." Specifically, the Finance Committee has direct responsibility for "approval of policy revisions, quarterly performance review, and the annual policy review." In practice, the Foreign Exchange Management Committee (FXMC) provides most of the oversight function. The members of the FXMC are the Chief Financial Officer (CFO), Corporate Controller, Treasurer, regional Vice-Presidents (Americas, Asia-Pacific, Europe, Japan), and the Manager of Foreign Exchange. *Ex Officio* members include most other senior treasury managers.

The FXMC is chaired by the CFO and reports to the Finance Committee. The committee is responsible for quarterly reports on foreign exchange performance, hedging strategy, and accounting issues. It must also prepare an annual performance review and report on foreign exchange controls. All proposed revisions to policies and procedures must be presented by the FXMC or CFO and approved by the Finance Committee. Typically, the FXMC meets monthly. The primary function of the monthly meeting is to review the existing foreign exchange position and formally approve the current *hedging strategy* of the firm. While not specifically defined in the *Treasury Policy and Procedure* document, a hedging strategy amounts to a decision to use derivatives to hedge a foreign currency exposure and general guidelines concerning the type, notional value, and maturity of derivative contracts.

The second group of tasks defined by the policy statement is best described as accounting and control functions. The Treasury Accounting Group is assigned the responsibilities of confirming all foreign exchange transactions, determining the accounting treatment of derivative positions, and "monitoring compliance with exposure management guidelines." In short, accounting verifies hedging activity is consistent with firm policy and GAAP. For example, only seven employees at HDG (all in the accounting group) are allowed to confirm foreign exchange transactions including derivative trades. By design, none of these individuals are allowed to enter into foreign exchange trades on the firm's behalf. This, now standard, separation of responsibilities lessons the potential for fraud or "rogue" trading.

The third and final set of tasks described in the policy statement can be classified as operational responsibilities. These are the ongoing duties of the Foreign Exchange Group. Members of this group are responsible for executing the hedging strategy approved by the FXMC. This includes compiling data on underlying exposures, proposing appropriate derivative transactions, executing approved transactions, and monitoring the ongoing status of foreign exchange exposures and contract positions. Because this group runs the daily operations for foreign exchange risk management, the next section investigates their day-today activities in more detail.

Perhaps the most important facet of the foreign exchange policy statement is the definition of exposures and the specific criteria for hedging these exposures. HDG recognizes three types of foreign currency exposures: "Exposures arising from transactions denominated in currencies other than the functional currency of each legal entity (transaction exposure),[3] exposure arising from the translation of foreign currency financial statements into US dollars (translation exposure), and exposure to anticipated foreign currency flows that are currently not reflected in accounting systems or other records (economic exposures)." HDG does not actively hedge its translation exposure, although the policy allows for this. Transaction exposure is typically hedged in a very

[3] Legally, HDG is structured as a conglomerate of international business units (IBUs). Each of these foreign subsidiaries reports in a "functional" currency (as defined in FAS 52). In practice, the determination of the functional currency depends on many factors including local legal restrictions, tax treatment, even currency liquidity. Most of the analysis in this paper deals with IBUs whose functional currencies are not US dollars.

mechanical fashion. As economic exposures become transaction exposures (almost always in the current quarter), forward or spot transactions are used to hedge the full anticipated amount of foreign currency. Consequently, the subsequent analysis, as well as the effort of the foreign exchange group, derives mainly from the management of economic exposures. However, it should be noted that what HDG considers an economic exposure would be considered by many as more typical of a transaction exposure. Economic exposures are often referred to as cash flow risks arising from macroeconomic shocks, competitive forces, and/or strategic concerns. For HDG, the cash flows to be hedged are the result of anticipated but not firmly committed sales.

Specifically, HDG's economic exposures arise primarily from the following four sources: "(1) Anticipated sales from HDG's manufacturing plants to be based on HDG's Business Plan; (2) anticipated procurement in currencies other than each entity's functional currency, based on the entity's Purchasing Plan; (3) anticipated operating expenses in currencies other than each entity's functional currency, based on the entity's Expense Plan; and (4) anticipated third-party sales in currencies other than the reporting entity's functional currency, based on a Sales Plan" (treasury policy and procedure manual). In other lines of business with longer contracting periods it is likely that these exposures could be classified as transaction. At a minimum, it is important to recognize that objective classification of exposures as either transaction or economic is not always possible. In the case of HDG, the economic exposures are likely somewhere between the most general definition of "economic" and the accounting definition of "transaction" depending on factors such as the hedge time horizon, the characteristics of the product market, and the level of uncertainty in the exposure forecasts.

The policy statement also defines a set of "approved hedging instruments." These are foreign exchange spot and forward contracts, currency put options and currency call options. "Long-term currency swaps and futures are explicitly not allowed as hedge instruments." The policy does not restrict the use of "exotic" contracts such as derivatives with average price (Asian) or barrier features. The manager of foreign exchange may make revisions to the list of approved hedging instruments subject to the FXMC's approval.

Minimum and Maximum degrees of hedging are specified in the policy and are determined by the duration of the economic exposure. The figure below shows maximum and minimum hedge ratios as a function of the expected time to exposure realization:

Expected Time to Exposure	Minimum Hedge	Maximum Hedge
Current quarter	60%	90%
1 quarter	40%	90%
2 quarters	25%	85%
3 quarters	0%	85%
4 quarters	0%	85%

Hedging anticipated economic exposures more than four quarters in the future requires approval of the Finance Committee. Exceptions to the minimums and maximums in this policy can be granted by the CFO. Furthermore, hedge ratios exceeding these bounds (to a maximum hedge ratio of 100%) are allowed if the deviation is due to a revision in the forecasted exposure.

This section has provided a brief synopsis of the official foreign exchange management policy of HDG. The actual policy document includes over 75 pages of additional detail mostly concerning the individual responsibilities of each employee involved in the process and precise descriptions of directives outlined above. Only passing attention is paid to motivation for hedging; this is discussed in Section 3.

2.2 The Practice of Foreign Exchange Risk Management

The day-to-day management of foreign exchange exposure is the responsibility of the Foreign Exchange (Forex) Group. Most duties related to forex hedging are carried out by four members of this group: three Treasury Analysts with responsibilities for distinct global regions (Europe/Africa, Asia-Pacific, and the Americas) and the Manager of Foreign Exchange. These employees interact on an almost daily basis with the regional Treasury Managers (based abroad), the Director of Global Treasury, and the Corporate Treasurer (both based in the US). A rough count of full-time employees dedicated to foreign exchange risk management yields 11 (US-based Foreign Exchange Group (4),

Regional Treasury Managers (2), Senior Management (1), Treasury Accounting (2), and support (2)). [4]

The actual process of implementing a hedge is quite complex but centers around the determination of a foreign exchange rate termed the *hedge rate*.[5] The process starts with the treasury, specifically the forex group, providing a *hedge rate indicator*. This amounts to a rough estimate of the final hedge rate. Foreign business units then uses this exchange rate to prepare a business plan. This plan is passed on to Tax Accounting which determines the official foreign exchange exposure which as a control mechanism prevents the forex group from being able to internally manipulate exposure forecasts.

At this point, the forex group prepares a hedging strategy. Initially, a "market outlook" is determined. The outlook represents a view on the current level of the exchange rate and the pricing of related derivatives. The group relies on outside market forecasts, internal technical and fundamental analysis, and views on the relative pricing of options and forward contracts (e.g., option implied volatilities and forward points). With this in hand, the firm "explores hedge strategy alternatives" (training document). These alternatives amount to a subset of allowed hedging strategies; for example, one alternative may be to hedge with forwards and another to hedge with put options. Through discussions with the Manager of Foreign Exchange, the Director of Global Treasury and regional Treasury Managers, the forex group prepares a hedge analysis (comparing different alternatives) and formally recommends a hedging strategy to the FXMC. In practice, this process is often routine for currently-hedged currencies. Unusual market circumstances (such as the Asian crises) and the addition of a new currency to be hedged require a more thoughtful execution of this procedure.

If the hedging strategy is approved by the FXMC, the forex group executes the hedge trades. First, the specifics of the transaction are determined. These include the notional value, type of instrument, and strike price (if applicable) of the derivative. By convention all contract expiration dates are set to approximately two weeks after the end of the exposure quarter. The *Treasury Policy and Procedure* document specifies the set

---

[4] I aggregated across employees with responsibilities beyond forex hedging, e.g., senior management.
[5] The following description draws primarily from personal observations and internal training documents.

of financial entities with which the trade can be executed. These include five domestic and twelve foreign institutions. The policy requires that each counter-party be a "major commercial or investment bank that meets the minimum credit standards as approved by the CFO."

After executing the trades, the forex group establishes the new hedge rate. This is disseminated to operations and the IBU who use it to update the business plan and consequently the exposure forecast. Clearly, this process is dynamic; exposure forecasts and hedge strategies are updated at approximately monthly intervals though derivative trading may be more or less frequent.

Foreign currency exposures are not aggregated across quarters, currencies, or regions. Instead, each quarter's foreign currency is treated independently. For example, at any given time, HDG will have up to five separate "hedges" in place for the German Mark (DEM): one for the current quarter and one for each of the next four quarters. Consequently, each currency-quarter has a separate hedge rate.[6]

The hedge rate is calculated as a function of current market rates and the cost of derivatives used to hedge for that quarter. Specifically, it is the sum of the current "effective hedge rate times the percent hedged and the all-in cost of adding hedge up to 100% of forecast times the percent unhedged" (treasury training manual).[7] For example, assume the current spot rate for German Marks is 1.6617 and the forward rate is 1.6517. If the exposure is currently 71% hedged with a current effective hedge rate of 1.6258 and

---

[6] To complicate matters further, HDG actually uses four different exchange rates for each currency for each quarter. These rates are described in a treasury training manual. First, a *plan rate* is set "prior to the beginning of the fiscal year for corporate budgeting and planning purposes." Plan rates are fixed for the year and include the impact of any existing derivative positions. Second, the official *hedge rate* is "set seven weeks prior to the beginning of a quarter for near-term planning and accounting purposes." At this time the hedge rate is fixed for the quarter. Third, the *effective hedge rate* is the "breakeven rate of actual hedges in place. This rate is not fixed until final hedge adjustments for the quarter are made after quarter-end." The effective hedge rate is best thought of as the final effective rate used when translating foreign currency revenues into US dollars for a given quarter. Finally, the *pricing rate* is "used for out-quarters in bid/tender pricing activity, as well as by planning for out-quarter forecasts." Notice that the previous notion of the hedge rate does not fit squarely into any one of these categories. Instead, the common usage of hedge rate at HDG can more aptly be described as an anticipated hedge rate, in other words, as a *best estimate* of the effective hedge rate. Subsequent analysis of the *hedge rate* will refer to this estimated effective hedge rate. Variation in this estimated hedge rate in both absolute terms and relative to the plan rate is a major concern of the forex group.

[7] The calculation can be more complex in practice because the upper limit of the current percent hedged is 100% (which can occur if exposure forecasts are revised downward) and net proceeds from previous transactions are also included in the calculation to the extent that the exposure was not overhedged.

the cost of the option required to bring the hedge to 100% is 0.0220 then the hedge rate is 0.29*(1.6517 + 0.220) + 0.71*(1.6258) or 1.6397. This method for calculating the hedge rate biases the result toward lower anticipated dollar revenues. This occurs because the cost of the option is figured into the calculation without a corresponding adjustment for the increase in expected effective hedge rate for the unhedged exposure. In other words, the hedge rate is calculated using only the cost and not the benefit of the option. If derivatives are fairly priced then the (risk-neutral) expectation should not include the cost of the option and the (risk-neutral) hedge rate should be 1.6333 (assuming the current effective hedge rate is calculated in the same manner).

In summary, two observations are worth noting. First, it is clear that the foreign exchange hedging operations of HDG are an integral part of firm-wide operations. Forex activities affect everything from initial planning to final reporting. Second, the process of determining the exchange rate to use for ongoing business activities is complex and may include systematic biases.

2.3 The Direct Impact of Foreign Exchange Risk Management

The HDG-specific numerical data for this study are obtained directly from the HDG treasury database and archives. Although HDG has sales in over 50 countries, only 24 of these are local currency business units (functionals) that give rise to direct foreign exchange exposures. Table 1 shows the countries and functional currencies of 40 of the largest foreign entities. Most foreign operations in developed and newly-developed countries are foreign currency functionals. Together the non-USD entities account for the vast majority of foreign revenues.

The observation period for the study includes the 14 quarters (3.5 years) from 1995:Q1 through 1998:Q2. The data include the details of all derivative transactions in each currency (and the assigned quarter of each position). Forecasted foreign currency exposures were obtained from Tax Accounting as of three dates: {9, 6, 3} months prior to the target quarter's end. Where available, spot and forward exchange rates are collected from DataStream. Forward rates not available from DataStream are calculated using appropriate-maturity US Treasury Bill rates and short-term interest rates reported by foreign central banks. Volatilities used to mark positions to market are from currency

options traded on the Philidelphia Stock Exchange (PHLX) when available and are calculated from the past three months of daily spot prices when unavailable.[8] The combination of these data allows for the calculation of most interesting quantitative features of HDG's derivative positions.

Table 2 shows the aggregate impact of foreign currency derivatives on reported earnings, cash flows, and stock returns.[9] The impact of the derivative positions was calculated by taking the sum of trading profit and losses (P&L) for all contracts assigned to a particular quarter and the net proceeds of positions held to maturity. The first column shows values for reported (hedged) earnings and the second column shows values excluding the after-tax aggregate derivative profit and loss (unhedged earnings).[10] The first row reports the mean values. Derivatives have a positive impact ($6.23M) on average quarterly earnings. However, if derivatives are being used as risk management tools then it is likely that the *variation* in earnings is reduced by hedging. To measure the impact of derivatives on earnings volatility the next five rows of Table 1 calculate statistics based on changes in earnings.[11] Hedging increases the mean change in earnings by $1.5M (or about 0.9% for the earnings growth rate). More interesting is the impact of hedging on the standard deviation of earnings changes. Hedging decreases the standard deviation from $20.14M to $15.70M (a $4.44M, or 22.0% decrease). However, HDG's line of business is seasonal and outside analysts typically compare earnings to the same quarter from the previous year (year-over-year). The third line in the table shows the standard deviation for these year-over-year earnings changes. Measuring the impact of

---

[8] These may be poor estimates of implied volatilities in some cases, for example, Asian currencies during the Asian crises of 1997 and 1998. Fortunately, there are only a few option transactions in these Asian currencies during this period (most hedges were constructed with forward contracts). These issues are discussed in greater detail in Section 4. The PHLX data provide implied volatilities for a variety of maturities and strike prices. To approximate the appropriate value as closely as possible, I average implied volatilities from four put options: the two with closest strike prices and closest expiration before the relevant option and the two with closest strike prices and expirations after the relevant option.

[9] Cash flow is defined as the net increase in cash plus any funds spent on share repurchases, plus cash used in investment activities plus research and development expenditures (R&D). I add back R&D because I subsequently use this as a measure of free cash flow. Adding back R&D has little impact on the qualitative results reported here because these costs grow at a fairly constant rate. The adjustment for share repurchases and purchases and sales of marketable securities is necessary because these can have large (and uninteresting) impacts on net increases of cash.

[10] After-tax derivative P&L is calculated using average effective tax rates as recorded in the annual reports.

hedging in this way shows a similar impact; the standard deviation of reported earnings decreases by about $3.98M (only a 10.2% decrease because of the larger basis).

Standard deviation may not be the appropriate metric for evaluating the impact of HDG's foreign exchange hedging activities. Analysis in subsequent sections indicates that HDG is more concerned with downside risk (e.g., lower than expected earnings) than upside risk (e.g., higher than expected earnings). To address this possibility, I estimate downside semi-deviations by computing the standard deviation of the minimum of actual earnings changes and mean earnings changes (i.e., $SD\left[\min\left(\Delta E_i, \Delta\overline{E}\right)\right]$). The fourth and fifth rows of Table 2 show the semi-deviations of quarterly and year-over-year earnings changes. The results are similar to those for standard deviations of earnings but less pronounced. On a quarterly basis, hedging decreases semi-deviations from $7.76M to $6.65M, and on a year-over-year basis the decline is negligible, from $15.61M to $15.47M.[12]

The last two columns of Table 2 (Panel A) show similar calculations for the cash flow variable. The results are largely similar to those for earnings: consistent but small reductions in both quarterly and year-over-year cash flow variation. However, all of the calculations in Table 2 are based on only 13 quarterly observations (10 year-over-year observations) and F-tests indicate that none of the differences are significant at the 10% level. Interpreting the economic magnitude of these declines is complicated by the fact that HDG's earnings are large and grew rapidly over the sample period. For example, one might consider a 22.0% decrease in standard deviation large but a $4M reduction in standard deviation when mean earnings are $170M seems much less substantial. Members of HDG management indicate that these reductions are in line with their expectations from foreign exchange hedging, noting that less than half of revenues are foreign and underlying business risk can not be hedged directly with derivatives.

---

[11] Because HDG's earnings are growing rapidly during the sample. Standard (and semi-) deviations of the level of earnings would not be particularly informative. Specifically, HDG's quarterly earnings grew from about $50 million to over $350 million over the 14 quarter sample period.

[12] A previous version of this paper calculated these values using the percent changes in earnings. This resulted in *increases* in earnings volatility due to hedging on a year-over-year basis. Because some of the growth rates are large and this may confound the results, I have decided to report the results in dollar instead of percentage terms.

The last row of Table 2 (Panel A) reports the correlation between quarterly changes in earnings (or cash flow) and the derivative P&L. The negative values are consistent with the already reported results (and indicate that HDG is, in fact, hedging), but the relatively small correlations (-0.37 and -0.28) reveal that much of the variation in earnings and cash flow are not hedged with derivatives. This may be because HDG is not fully hedged or some risks are not hedgable (e.g., foreign and domestic sales).

Panel B of Table 2 reports coefficient estimates from linear regressions with HDG quarterly stock returns as the dependent variable. The first column includes market returns of an industry index and changes in the trade-weighted USD exchange rate as explanatory variables.[13] The exchange rate is not a significant explanatory variable for HDG's stock market returns. The lack of relationship could be due to a number of factors. First, HDG may effectively remove exchange rate exposure through hedging. Second, the trade-weighted series may be a poor proxy for the true exposure, though using an index of weighted by HDG sales does not appreciably change the results. Third, the model may be misspecified since industry returns may not capture the impact of all other factors that explain returns. Finally, the power of the test is limited by the small number of observations. The second column repeats the analysis but includes derivative P&L as an explanatory variable. The coefficient estimate is statistically significant at the 10% level in a one-tailed test. The economic importance of the coefficient is substantial. The estimate of 5.00 implies an increase in derivative P&L of 1% of average exposure ($6.6M) is associated with an increase in market capitalization of approximately $800M. This result is consistent with the findings of Allayannis and Weston (1998) that foreign exchange derivative use is associated with higher market valuation. Since the market value of HDG rose rapidly during the sample period and derivative P&L may proxy for other firm-specific factors, the estimated coefficient for Derivative P&L may be exaggerated. Estimating regressions at higher frequencies (monthly, weekly, and daily) also indicate that exchange rates are poor explanatory variables for HDG's stock market returns (results not reported).

---

[13] The CRSP value-weighted index is not a significant explanatory variable when industry returns are included and since the number of observations is small (N=16) it is excluded from the specification. This does not materially change the magnitude or significance of estimated coefficients. The trade-weighted USD exchange rate is from the Federal Reserve Board.

Derivative data are available at the transaction level, consequently the impact of foreign exchange hedging can also be analyzed by currency. I do this by comparing the unhedged USD exposure (assuming exposures are translated at the end of quarter spot exchange rate) with the actual hedged exposure. Table 3 reports the results of this analysis. The table is broken into three sections. The first section reports the results for aggregate foreign currency positions. The fifteen currencies for which HDG hedged in all quarters of the sample period (labeled A through O subsequently) are denoted as *full-sample currencies*. These are shown individually in the second section of the table. The nine currencies for which HDG hedged during only part of the sample period (labeled P through X) are denoted as *partial-sample currencies*. These are shown individually in the third section of the table.

The first column of Table 3 reports two items. For "Totals" the value is the number of currencies in the aggregation. For individual currencies two values are reported. The first value indicates the number of quarters HDG undertook derivative transactions in a given currency. The second value reports the number of quarters the Tax Accounting Group recorded an exposure in the currency. For full-sample currencies these numbers are both 14 quarters (by definition). For partial-sample currencies, there is an average lag of three quarters between the first identification of an exposure (i.e., the creation of a new foreign currency functional) and the adoption of a hedging strategy. The decision to hedge a currency with derivatives is further explored in Section 4.

The next three columns of Table 3 report the unhedged dollar exposure, the combined profit or loss from derivative transactions, and the total premium as a percent of the unhedged exposure. First, note the large disparity between the average sizes of unhedged USD exposures. For full-sample currencies, average exposures range from $2.5 million to $239.0 million; for partial-sample currencies most exposures are small, ranging from $2.0 million to $15.5 million. The average quarterly exposure for all currencies was $704.9 million, the vast majority of which can be attributed to full-sample currencies ($663.1 million).[14] The minimum and maximum unhedged exposures are also

[14] Note that values reported for totals are generally not the same as summing components from the main part of the table. This is because data is aggregated across quarters and then statistics applied. For example, the minimum unhedged exposure for all currencies is not the sum of the reported minimum unhedged exposure for each currency.

reported. These again show substantial variation. On average and in total, minimum exposures are roughly half of the average exposure and maximum exposures are roughly twice the average exposure. Much, though not all, of this variation is due to the rapid growth of revenues across most currencies during the sample period.

The next column of Table 3 reports net payoffs from derivatives transactions (including any premiums paid). Average P&Ls are generally positive for both full and partial-sample currencies. Most likely, this results from all net foreign currency exposures for HDG being positive (inflows) and the general strengthening of the USD over the sample period.[15] The average total payoff for all currencies is $8.9 million. However, there is substantial variation in the net profit and losses by quarter. For all full-sample currencies, derivative trading resulted in a loss for at least one quarter. Likewise, at least one quarter was profitable. This is the case for six of the nine partial-sample currencies as well (though the exceptional currencies were hedged for only 3-5 quarters). For all currencies, the maximum quarterly loss was $8.4 million and the maximum profit was $40.9 million. As would be expected from the size of the exposures, the profit and losses from the partial-sample currencies are typically smaller than for the full-sample currencies.

Inspection of the mean, minimum and maximum P&Ls shows that the returns to hedging appear positively skewed. For almost all currencies the difference between the maximum and average P&L is greater than the difference between the average and minimum P&L. Aggregate returns from derivative trading are also positively skewed for both sub-groups and all currencies together. This is indicative of the preference for non-linear (option) hedging strategies discussed in Section 4.

Because HDG makes extensive use of options in its hedging activities, I also calculate the total premium spent on derivatives as a percentage of the underlying exposure. These calculations include any net premium from round-trip transactions, but are not the same as profits and losses from option transactions because they do not include payoffs from positions held to maturity.[16] The goal is to obtain a measure of how

---

[15] This can also be interpreted as indirect evidence that HDG is in fact hedging rather than speculating.
[16] For example, a long position in an at-the-money put option that becomes in-the-money will result in a negative premium if sold before maturity. This type of trade is often undertaken and is referred to as "rolling strikes." For only one currency were net short (call) option positions sold as a hedge.

much HDG is willing to spend on up-front premiums. The fourth column of Table 3 reports these figures. The values can be negative indicating that the firm took in more from closing existing long positions in options than it paid out in initial premiums.

The results for individual full-sample currencies show that premiums are on average a small positive percentage of the exposure (roughly 1%). For partial-sample currencies, premiums are most often zero indicating that no options were used to hedge these exposures. The maximum and minimum values indicate that net premiums can be quite substantial though. For example, for Currency J HDG realized a net profit from trading options equal to 22.2% of the underlying exposure in one quarter. The upper limit the firm is willing to spend also appears to be substantial. Specifically, for six of the fifteen full-sample currencies, HDG spent more than 5% of the underlying exposure on premiums in at least one quarter and for currency K it spent almost 9% in one quarter. The results are substantially different when aggregated across currencies. For the full-sample and all currencies combined, the average expenditure is notably negative (-3.36% and –2.91%, respectively) indicating the firm made substantial profits from trading options. In contrast to the case for individual currencies, the largest outlay for premiums in any one quarter across all currencies is only 0.70%. Again, the net positive premium is most likely due to the general strengthening of the USD over the sample period.

The ability of the hedging program to reduce USD exposure volatility by currency can also be calculated. The previous results concerning the firms earnings and cash flows showed that volatility was decreased at the quarterly frequency and on a year-over-year basis. Because earnings and cash flow include the revenues from domestic operations (and foreign USD functionals) there is additional variation in the aggregate due to volatility in these figures. As a consequence, examining volatilities currency by currency provides a clearer picture of the impact of hedging on foreign currency exposures. The last four columns of Table 3 report volatilities for both unhedged and hedged exposures. I report standard deviations at the quarterly horizon to give a sense of the USD magnitude of the variations, however I will concentrate on standard deviations and semi-deviations of percent changes to facilitate comparison across currencies.[17]

---

[17] The standard deviations in levels and percent changes yield similar but not identical qualitative results. Calculating percent changes results in one observation (quarter) being lost. As noted previously, these

At the quarterly frequency, the standard deviation of USD exposures is reduced in only 10 of the 24 currencies. Furthermore, for both of the sub-samples and all currencies combined, the standard deviation of unhedged exposures is *less* than that of the hedged exposures. The results are very similar for semi-deviations though volatility is reduced for a slightly different set of currencies. As noted before, HDG's underlying business is seasonal and these seasonal effects are much more pronounced at the country level than at the firm wide level. To adjust for this effect, the last two columns of Table 3 repeat the volatility calculations using year-over year changes in USD exposures. A minimum of six hedged quarters is required to calculate year-over-year volatilities thus excluding six of the partial-sample currencies from the analysis. In this case, the effect of hedging on volatility is more consistent. Hedging reduces the standard deviation of USD exposure for 12 of the 18 currencies and the semi-deviation of USD exposure for 15 of the 18 currencies. Both the standard and semi-deviations are lowered by hedging for the sub-samples and all currencies together. For full-sample currencies, standard deviation is reduced from 26.0% to 21.8% and semi-deviation is reduced from 8.9% to 7.4%. For all currencies combined, the standard deviation is reduced from 22.9% to 19.5% and the semi-deviation is reduced from 7.8% to 6.5%.

While the evidence is somewhat mixed, the bulk of the evidence indicates that the foreign exchange hedging activities at HDG do reduce the variation in aggregate USD exposures. Perhaps the most important aspect of the results is that the extent of any decrease in cash flow variation is modest. For example, the decrease in year-over-year earnings (cash-flow) volatility was $4M ($14M), only about 10% (6%) of the total volatility of $39M ($241M). There are at least three possible explanations for this result. First, it could be that HDG's hedging program, while extensive, is poorly executed. Second, the goal of the program may not be solely the reduction in variation of USD exposures. Third, other types of business risks may simply dominate the currency effect making the isolation of the impact of foreign currency risk management difficult. In the next two sections I explore each of these possibilities.

---

values may be significantly biased by the assumption that all foreign revenue is translated into USD at the rate prevailing at the close of the quarter.

3 Motivations for Foreign Exchange Risk Management

3.1 Stated Objectives

The *Treasury Policy and Procedure* document provides surprisingly little evidence concerning the motivations for foreign currency risk management. It states, "The goal of [HDG]'s economic and transaction hedging programs is to minimize the effects of exchange rate movements on these exposures, accomplished by maximizing the dollar cash flow to [HDG]." Despite being somewhat ambiguous, in an efficient capital market and without firm-specific economic imperfections, this statement is incongruent. In other words, for this goal to be achievable, HDG must be able to trade profitably in foreign exchange derivatives *and/or* there exists some unspecified economic cost to not hedging.

As for the first possibility, evidence indicates that HDG management does not have a clear position on whether or not it can trade profitably in the foreign exchange markets. This is reflected in an electronic mail message to the treasury analyst covering Europe-Africa (cc: forex group) from the Director of Global Treasury regarding a technical model used by the analyst to forecast exchange rates: "The results from the model look good so far. Remember that we do not speculate, but to the extent that we can improve our trade timing, we could use this model." This and conversations with members of the forex group reveal that, to some extent, most individuals believe they have the ability to adjust hedge parameters so as to increase the expected net cash flow from derivative transactions. As the Manager of Foreign Exchange explained, "We do not take speculative positions, but the extent we are hedged depends on our views." This aspect of the risk management program at HDG is not unique. For example, Bodnar et al. (1998) report that the majority of US firms responding to the Wharton Survey indicate that their market views impact the size or timing of their hedges; Nam and Thornton (1998) find evidence supporting the hypothesis that firms use interest rate swaps to "take a view." Stulz (1996) provides economic arguments for this behavior. In the next section, I explore the impact market views have on how HDG structures its derivative positions.

On the other hand, it may also be the case that HDG can reduce certain economic costs with foreign exchange hedging. However, the official policy statement does not explicitly state any potential sources of savings. Other documents provide insight into possible sources of economic benefits. A treasury training manual states that, "the primary currency risk management directives are (1) to increase the certainty of operating margins by supporting planning and pricing decisions with expected rates and by hedging forecasted exposures (2) to reduce negative impacts from currency movements on competitiveness by continuously managing forecasted transactions and by providing competitive information to senior management." While this description is more detailed, it is still not clear if these motivations are the result of potential economic savings. In the same document, a somewhat tongue-in-cheek example proposes the reason for hedging (in the example) is "a weaker DEM makes [HDG] Germany's revenues less in USD terms and [the regional manager's] compensation is based on a USD P&L." This suggests, if lightheartedly, that there may exist internal agency issues similar to those described by Tufano (1996) providing a motive to hedge.

In a briefing to the Worldwide Executive Finance Meeting the Manager of Forex stated the "current FX objectives" as "reducing spot volatility, reducing FX uncertainty on planning, and enhancing competitiveness." These are in essence equivalent to the objectives stated in the training manual. Other documents also repeat these objectives.

Though these objectives do not make plain the source of benefits from foreign exchange hedging, a consistent assumption in economic theory is that "you do not have to know physics to shoot pool." In other words, HDG may not be explicitly aware of the fundamental economic rational behind its foreign exchange risk management program but nonetheless acting optimally in undertaking its forex hedging activities. The next two subsections explore new and existing rationales for hedging at HDG. The first explores "traditional motivations" such as those found in many corporate finance texts. Next, I suggest "alternative motivations" inspired by HDG's stated objectives. Variations on these have appeared in the literature but are explored here in detail as they pertain to HDG.

3.2 Traditional Motivations

Traditional explanations of why firms manage marketable risks have typically relied on the most commonly-cited violations of the Modigliani and Miller (1958) assumptions. For instance, a convex tax schedule, financial distress costs (direct and indirect), and owner and managerial risk-aversion can all provide motivations for risk management.

A firm facing a convex tax schedule can minimize its expected tax liability by reducing the volatility of its expected taxable earnings (Smith and Stulz, 1985). Graham and Smith (1999) show that many but not all firms face an effectively convex tax schedule.[18] Their method uses a simulation technique to measure the effective convexity of a firm's tax function and allows for the inclusion of uncertainty in taxable income, tax-loss carrybacks and carryforwards, investment tax credits and the alternative minimum tax. Of these, uncertainty in taxable income is the most important for HDG.[19] To estimate the effective convexity of HDG's tax function, I calculate the standard deviation of quarterly pre-tax income growth excluding the P&L attributed to derivative transactions.[20] I annualize this figure and calculate pre-tax income for a six standard deviation interval centered at four times each quarterly earnings value. This yields fourteen estimates of (approximately) a 99% confidence interval for annual pre-tax earnings.[21] The lowest value from this procedure is $220 million, more than ten times the value of the final change in the US tax schedule ($18.3 million). I therefore conclude that the probability of HDG's pre-tax derivative-adjusted income being in a convex region of the tax code is negligible.[22]

---

[18] However, Graham and Rogers (1998) find that convexity of the tax schedule does not explain the degree of hedging in a large sample of US firms.

[19] HDG had no significant carrybacks or carryforwards, investment tax credits, nor was subject to the alternative minimum tax during the sample. The most important complication may be foreign income taxed at different rates which had the effect of lowering the effective tax rate in each year of the sample. Unfortunately, I do not have enough specific information to allow me to calculate the convexity implication. Also, a recent annual report indicates that the company has "not recorded a deferred income tax liability [of $X] for additional taxes that would result from the distribution of certain earnings of its foreign subsidiaries, if they were repatriated. The company currently intends to reinvest indefinitely these undistributed earnings of its foreign subsidiaries." Again, I can not determine the convexity implication of this result.

[20] Pre-tax income was calculated by taking quarterly net income and dividing by one minus the annual effective tax rate. For the sample period the average effective US federal statutory rate was 35% and the average annual effective tax rate (adjusted for foreign income taxed at different rates) was 30%.

[21] If biased at all, this method should overestimate the volatility of annual pre-tax earnings.

[22] Over the sample period, HDG fits the description of the "second-quartile" firm described in Graham and Smith (1999).

Direct questions to the management of HDG also indicated that reducing expected US taxes was not a motivation for currency hedging, although the tax liability associated with repatriating some foreign profits was a contributing factor in a decision to issue USD-denominated debt. This raises the possibility that interaction between foreign and domestic tax regimes could have an impact on either the decision to hedge or the structure of hedges. For example, the structure of the hedging program could be influenced by tax treatment or the ability to undertake some type of tax arbitrage. Another possibility is that the decision by HDG to hedge each currency separately could be the result of a need for flexibility in a tax-arbitrage strategy. Alternatively, foreign taxes could effect the type of hedge; if two otherwise similar hedging strategies (e.g., buying a put or dynamically replicating a put) have differing foreign and domestic tax treatments, this could be the deciding factor in the choice of strategy.[23] While these or other tax effects could contribute to HDG's desire to hedge, the lack of direct concern by management suggests these factors are (at best) of secondary importance.[24]

Smith and Stulz (1985) and Shapiro and Titman (1986) show that direct and indirect costs of financial distress lead to optimal hedging strategies. For example, Smith and Stulz (1985) show that a levered firm that hedges can lower expected bankruptcy costs and increase firm value. Shapiro and Titman (1986) suggest that the firm can lower costs in a number of indirect ways by hedging. Specifically, if hedging lowers the probability of financial distress then risk-averse firm stakeholders with undiversified claims (such as employees, suppliers, and customers) will require a lower risk-premium for contracting with the firm. These savings increase firm value.

These potential cost savings for HDG are probably very small. The probability of financial distress for HDG is close to zero in the near-term. At no point during the sample period did the level of long-term debt plus debt in current liabilities exceed 30% of cash and short-term investments. Moreover, cash and short-term investments exceeded the level of *all* current liabilities during the entire sample period. In fact, HDG

---

[23] These points are pure conjecture on my part.

[24] As additional indirect evidence of the lack of concern for tax implications no (potential or existing) derivative dealers suggested tax arbitrage strategies for HDG. This is telling because the dealers would discuss hedging objectives with management, prepare a "pitch," and then visit HDG to meet with

repurchased more than $1.5 billion in common stock during the sample period. In short, it seems unlikely the forex risk management program can be justified as significantly reducing the probability of financial distress over this sample period.[25]

Another possibility is that the managers or shareholders themselves hold non-diversified positions and wish to reduce the volatility of their aggregate wealth by hedging (see Stulz, 1984, Smith and Stulz, 1985, Tufano, 1996, and Chang, 1997). In the case of HDG, many individuals appear to have a large part of their personal wealth as equity stakes in the company. One individual holds more than 10% of shares outstanding. Several directors and executive officers of the company hold pure equity positions worth over $10 million as of the second quarter of 1998. Nonetheless, I believe there are three reasons these undiversified positions are not the motivation for forex hedging. First, HDG has an extensive employee stock option plan in which all members of management receive call options as part of their compensation package. Research has shown that call options provide incentives for managers to increase the volatility of the share price rather than reduce it.[26] More specifically, Smith and Stulz (1985) show that a sufficiently convex compensation contract can completely offset a managers desire to hedge personal wealth. Second, the general attitude of the senior managers at HDG is better described as bold risk-takers than as risk-averse bureaucrats. Anecdotal evidence, such as HDG's rapid overseas expansion, supports this claim. It seems unlikely that management would seek to insure their wealth with foreign exchange hedging while at the same time risking it by aggressively expanding into very competitive new markets. Finally, in interviews with senior management I inquired specifically as to whether this was an incentive to hedge and no one in management indicated that it was.[27]

Froot et al. (1993) suggest that if procuring external capital is costly then a firm should use its risk management policy to coordinate internal cash flows with investment

---

management to sell their idea. Of the four pitches I attended, none of the dealers mentioned tax implications. Reviews of material from previous pitches also showed no attention to taxes.

[25] The low debt level of HDG also suggests that agency models that explain risk management, such as Campbell and Kracaw (1990), are less likely to be relevant.

[26] A general theoretical model of this possibility is presented by Haugen and Senbet (1981). Empirical evidence supporting this claim is provided by DeFusco, Johnson, and Zorn (1990).

[27] In an attempt to get as honest an answer as possible, I asked managers some variation of the following: "Is a side benefit of hedging that it lowers the variation in your [HDG] stock holdings?" While

needs. To a large extent, HDG has a natural hedge. In its industry, and for HDG in particular, investment needs are likely to be positively correlated with cash flows. For HDG the correlation between investment (defined as capital expenditures plus research and development expenditures) and cash flow is 0.65.[28] This suggests that HDG would probably benefit from hedging less than a firm with a low or negative correlation. In addition, it seems unlikely that the investment needs of HDG would be constrained by having to raise external funds. As noted above, HDG has significant liquid assets, has almost no debt, and undertook a large share repurchase during the study period. From 1994 to 1998, investment was never more than 52.0% of cash flow and averaged only 13.3% of cash and short-term investments. In sum, it appears that HDG would not benefit significantly from using its foreign exchange risk management program to help coordinate investment needs and cash flow over this period.

In conclusion, the evidence indicates that minimizing expected tax liabilities, reducing expected costs associated with financial distress, managerial risk-aversion, and equating cash flow with investment are probably not the primary motivations for managing foreign currency risk at HDG for the period under study.

3.3 Alternative Motivations

A stated goal of the hedging program at HDG is "to increase the certainty of operating margins." In practice this may have been translated into an attempt to minimize the impact of changes in foreign exchange rates on reported earnings. A mantra at HDG is "linear" earnings growth or a consistent growth rate for quarterly earnings announcements. Although reducing earnings volatility by hedging is not intrinsically value enhancing, recent theoretical and empirical research has suggested possible explanations for this behavior (beyond those discussed in the previous section). For example, Dye (1988) presents a model where current owners wishing to sell shares use accounting reports to signal a higher value of the company. Trueman and Titman (1988), among others, show that a value-maximizing manager may smooth a firm's

---

management generally believes that hedging reduces share price variation, none would admit to this being a noteworthy personal benefit.

[28] Quarterly for the 20 quarters from 1994:Q1 to 1998:Q2. This calculation also assumes that investment was not distorted by financial constraints.

income stream as the result of information asymmetries between management and investors. Smith and Stulz (1985) and DeMarzo and Duffie (1991, 1995) suggest similar possibilities as they relate to corporate hedging.

The concern for "linearity" at HDG seems to stem from a perceived adverse impact on the share price of volatility in reported accounting numbers consistent with these theories. Specifically, management believes that higher-than-expected earnings result in an unrealistic upward revision of market expectations for subsequent earnings. If market participants (e.g., analysts) are then disappointed by subsequent "average expected" earnings, this would result in a net decrease in share price. In short, management's view is that the market reaction to lower-than-expected earnings is more negative than the positive reaction to higher-than-expected earnings; consequently lower volatility in earnings increases share price.[29]

The goal of minimizing the variation in earnings due to foreign exchange has a side effect. Because accounting treatment differs across type of derivative, using options for economic hedges is preferable to using forward contracts (see FAS 52). Forward contracts used to hedge economic exposures for subsequent quarters must be marked-to-market and can therefore have the effect of increasing volatility in reported earnings. In practice, this was an important concern for HDG in determining the types of instruments used in constructing hedges thus implicitly confirming the desire for low variability of earnings.[30] A revealing example comes from a memo to the CFO and Treasurer from the Manager of Foreign Exchange concerning the impact of marking-to-market forward contracts used to hedge forex exposures in Asia: "While we recognize that this strategy has been economically beneficial to the company, the positive results are not easily identified. We will be working with Corporate Communications to craft the right message for the [quarter's] earning release as we anticipate a noticeable negative mark-to-market impact in F&O [Financing and Other] from these currencies."

---

[29] More generally, HDG management is of the opinion that analysts are overly concerned with the impact of foreign exchange on earnings. Specifically, the Manager of Foreign Exchange believes that HDG would be "[penalized] if we did not hedge and [penalized] if we hedge incorrectly. To analysts, hedging foreign exchange risk is a box that must be checked. If you do not do it they will [penalize] you with a higher discount rate."

[30] To the extent that this impacts the decision on how HDG structures hedges, additional analysis is deferred until the next section.

Returning to the evidence presented in the previous section, it is difficult to test the effectiveness of the hedging program in attaining the goal of "linearity." Derivative transactions appear to decrease earnings and cash flow volatility but not substantially. At the currency level, the decrease in USD exposure variation is only evident at the year-over-year frequency. This raises the question: Is it more important to have smooth quarterly earnings growth or smooth year-over-year earnings growth since these may be different goals? Since HDG does not explicitly target earnings, there is no stated preference.

Two other items shed some light on this potential motivation for hedging. First, HDG is enormously concerned about the impact on earnings of Statement of Financial Accounting Standards No. 133 (FAS 133) which will require firms to change the accounting methods for many derivative transactions (essentially requiring that many types of positions which previously qualified for hedge accounting be marked-to-market). A limited internal evaluation of the impact of FAS 133 suggested that there would be a notable increase in reported-earnings volatility. This caused substantial concern on the part of HDG management and may dramatically impact the hedging strategy. The second item suggests that the impact of hedging on earnings is not as important as has already been suggested. With the exception of the just-noted analysis, I am not aware of any ongoing or comprehensive analysis of the total impact of foreign exchange transactions on reported earnings. While there is substantial evidence that the impact on earnings of particular transactions, events, or types of derivatives is closely examined, I am not aware of any internal analysis such as that provided in Tables 2 and 3.

Another stated goal of the hedging program is "to reduce negative impacts from currency movements on competitiveness … by providing competitive information to senior management." In practice, this is viewed as the hedging program allowing the firm to maintain competitive pricing in the output market without reducing margins. How this provides an increase in expected economic profits is not immediately obvious. One possibility is that maintaining margins is a valuable and primary strategic goal of the firm, taking precedence over sales volume. Consequently, short-run adverse foreign exchange movements would, in turn, adversely effect sales through higher prices in foreign markets. Hedging would allow the firm to smooth through exchange rate

fluctuations. This would be economically important if maintaining relationships with customers requires consistently competitive product pricing. Likewise, there may be other costs associated with adjusting prices in foreign markets (e.g., updating pricing information or the loss of a "value reputation"). Time-series evidence (for example, Mark and Choi, 1997) indicates that exchange rates are often mean-reverting but also very persistent.[31] This brings into question whether the hedging horizon of HDG (typically less than one year) is sufficient to act as a smoothing mechanism for exchange rates. However, hedging in the near-term may allow for the simultaneous stabilization of margins and preservation of competitive standing while longer-term competitive solutions are implemented (e.g., changing suppliers, relocating operations). This would be consistent with Mello, Parsons, and Triantis (1995) which shows that a multinational firm with international production flexibility will implement a financial hedging program as part of its optimal operating strategy.

Other theoretical work suggests that competitive and strategic factors can lead to optimal hedging strategies. For example, recent theoretical work by Downie and Nosal (1998) shows that under certain conditions a firm that possesses market power in the product market can achieve a first-mover advantage over rival firms through the use of risk management products. Froot, Scharfstein, and Stein (1993) suggest that hedging can be an important part of the optimal investment strategy of multinational corporations, particularly for firms facing product-market competition where investment is a "strategic substitute." Allayannis and Ihrig (1998) develop a model showing the competitive impact of foreign exchange exposure and test the implications on a set of US manufacturing firms. They show that firms in more competitive industries (such as HDG's) have an increased exposure to exchange rates. Géczy, Minton, and Shrand (1997) find that users of currency derivatives are more likely to face import competition and that these hedgers are more likely to use short-term (dynamic) hedging strategies instead of longer-term strategies. Finally, Allayannis and Weston (1999) find that multinational firms in more competitive industries are more likely to use currency derivatives.

---

[31] The first-order autocorrelation for the monthly trade-weighted US dollar exchange rate from 1973 to 1998 is 0.98.

HDG management strongly believes that its particular foreign exchange risk management strategy provides an important competitive advantage in the product market. This belief, in part, motivates their desire to keep their identity hidden. It is also an important determinant of how the firm structures its hedges. As evidence of this, HDG actively researches the hedging programs of its major US-based competitors. The forex group makes a quarterly report to the FXMC detailing publicly-available information regarding the foreign exchange hedging programs of its four main competitors. Most of this information is collected from government filings (10-Q, 10-K, and annual reports). The forex group also interprets the information in an attempt to determine the exposures of its competitors. For example, the report on one competitor reads, "[Competitor's] hedging practice should leave them exposed to a strengthening USD. At December 31, 1996, [competitor] had forward contracts designated to hedge transaction exposures but there was no disclosure of anticipatory hedges." Tracking the hedging activities of competitors may be especially important for HDG since the majority of other large firms in their industry also use currency derivatives (Géczy, Minton, and Shrand, 1997, Table II)

HDG is also aware of the impact currency movements can have on its competitive position in relation to foreign competitors. For a given country, these competitors can be either local manufacturers or from a third country. HDG managers express concern over the "double whammy" of simultaneous strengthening of the dollar and weakening of a major foreign competitor's home currency against the currency of a country which represents a large amount of foreign sales. By firm policy, HDG could not directly hedge this secondary exposure.

Another concrete example of how HDG believes its hedging program can translate into competitive benefits concerns the firm's hedging strategy in Southeast Asia during the Asian crisis. The firm maintained a small short position in foreign currency forward contracts during the time of the most significant devaluations. Consequently, the firm did not have to pay out significant sums on derivative contracts as it suspects some of its competitors did. This translated into significant immediate cost savings that were passed on to customers as a price cut (not immediately matched by competitors). In a

press release the firm announced that, "Any negative effect on [HDG] from conditions in Asia was more than offset by associated reductions in procurement costs."

If foreign exchange rates impact the competitive position of HDG in its foreign markets, this could be reflected in the company's share of foreign markets.[32] Table 4 reports coefficient estimates from fixed-effects panel regressions with HDG's market share (first column) and change in market share (second column) as the dependent variables.[33] The data are for the 15 full-sample currencies for the 14 quarters in the sample (13 quarters for changes). The estimation includes 3 explanatory variables. First, the 3-month change in the spot exchange rate for each currency[34] is included to capture the near-term impact of exchange rate movements. The significantly positive coefficient in the second column indicates that as foreign currencies strengthen against the USD, HDG's market share tends to increase. Conversely, this suggests that HDG is exposed to adverse exchange rate movements.

Second, the relative position of the spot rate to the previous 12-month high is included to measure the exchange rate status relative to the most favorable condition in the previous 12 months. The significantly positive coefficients for this variable suggest that in countries with a relatively weak foreign currency (which should be bad news for HDG if they are not properly hedged), both the level of their market share and changes in market share increase. This is the expected result if hedging lets HDG improve its competitive position. The third and final variable included in the estimation is derivative P&L as a percent of the actual exposure. If profits from derivatives are used to gain a competitive advantage, a positive relationship should be observed between derivative P&L and market share. Both of the coefficients for this variable are positive though only the coefficient in the first (levels) regression is significantly different from zero. All together, the evidence from these statistical tests supports the hypothesis that HDG obtains competitive advantages from managing foreign exchange risk.

In general, HDG's product market is highly competitive and consequently, very price sensitive. Long-term product contracts are the exception and both input and output

---

[32] Alternatively, to the extent that HDG's hedging program neutralizes the effects on market share, exchange rate changes may not impact market share.
[33] The market share data were obtained from an independent source that provides such data commercially.
[34] USD/FCU measured one quarter before the beginning of the observation quarter.

prices are quite volatile. Complicating issues further for HDG, the firm is rapidly expanding its overseas operations and has a very short history in many of the countries in which it operates thus making competitive pressures all the more important. In sum, it appears that competitive pricing issues could be a primary motivation for HDG's hedging program.

As mentioned in the previous section, the day-to-day operations of the forex group are centered around the *hedge rate*. The importance of the hedge rate in internal decision making is enormous. The rate is used to set product prices in local currency, forecast sales and consequently production, and set goals for divisions and managers. HDG has two opposing objectives in determining the hedge rate. First it wishes to have as constant a rate as possible. It is believed that variation in the hedge rate induces undesirable variation in other business forecasts. Second, it wishes to have as "favorable" a rate as possible. If a foreign currency strengthens against the USD and HDG has locked into an unfavorable hedge rate, this is viewed as undesirable for business operations in the foreign country.

Hedging with foreign exchange derivatives so as to determine a hedge rate has at least two potential benefits. First, it may improve the ability of management to make value-maximizing decisions--for example investment and pricing decisions. When HDG makes a decision to expand into a new country, the treatment of foreign exchange risk is an important factor.[35] Contrary to the evidence presented previously, this suggests an indirect link between the investment policy of HDG and currency exposure. If forex hedging allows the firm to more closely follow its optimal investment policy, this will increase firm value. For example, it may be beneficial for HDG to expand its market presence in a particular country but uncertainty surrounding the decision process increases the chance of rejecting this beneficial project. The ability to use a hedge rate decreases the uncertainty surrounding the project decision and increases the chance of accepting the project. Existence of a hedge rate could also affect pricing policy. If foreign managers feel more certain of the final USD margins they will obtain, this could induce them to chose a more aggressive (and potentially value-increasing) pricing policy. This may relate closely to the potential competitive rationales for hedging noted already.

Second, a hedge rate may allow for more efficient internal contracting between divisions, with employees including management, and even external contracts with suppliers or resellers. Increasing the certainty surrounding the terms of contracts may provide for incentive contracts that are more closely related to the variables under the control of the agents. For example, if using a hedge rate prevents a well-performing manager from being penalized by changes in the exchange rate over which she has no control, then this could be in the best interest of the firm (for related analysis, see Stulz, 1984). On the other hand, it may be optimal for the manager to react to changes in the exchange rate and the optimal response could be hampered by using a hedge rate (see Tufano, 1998).

In practice, the forex group must balance several factors when determining the hedge rate. Because the hedge rate is net of option premiums, using put options to eliminate downside risk while leaving room for upside potential has a substantial negative impact on the hedge rate. Similarly, locking in a rate with forward contracts may later turn out to be "unfavorable."

This problem is not lost on regional managers whose operations (and compensation) are materially affected by the hedge rate. The forex risk management program has ended up producing some undesirable side effects. For example, regional managers' lobbying of the central treasury operation for a better hedge rate. Apparently, the problem can be quite severe. In the words of the Manager of Foreign Exchange, "I spend more time managing managers than I do managing currencies." In response to the problem, a proposed reorganization of the program was under development at the time my study concluded. A second potential problem is the extreme amount of attention paid to "hedge rate variance," or time-series variation in the hedge-rate. Considerable regard is also paid to the difference between the spot rate and the hedge rate. Perhaps because of a belief in inefficient foreign exchange markets or because of the (biased) method for determining the hedge rate, there is considerable attention paid to "beating the spot rate." In some sense, the goal is to "beat the market" rather than to just reduce volatility. In particular, when the hedge rate is "worse" than the spot rate from the viewpoint of

---

[35] The next section details this process.

foreign managers, there is concern about the impact of the unfavorable hedge rate on foreign operations.

In contrast to most existing agency theories that suggest agency problems may result in risk management, HDG shows that risk management can actually cause (internal) agency problems. This is similar to a models proposed by Tufano (1998) in which risk management can lead to agency costs when hedging replaces the need to raise funds in the external capital markets (see also Chang, 1997). In the case of foreign managers at HDG, the "external market" could be the US-based parent. For example, foreign managers at HDG using a hedge rate *they helped to set* may undertake sub-optimal operational decisions so as to acquire private benefits from their own foreign operations.

In conclusion, the motivations for hedging at HDG do not seem to be the result of simple violations of the classic model of the firm. Instead, earnings management (perhaps to lessen informational asymmetries), competitive concerns in the product market, and improved internal contracting are explanations for hedging more consistent with the risk management program at HDG. The largely unanswered question is whether or not hedging for any (or all) of these reasons results in higher firm value. Unfortunately, the indirect nature of these motivations and a lack of data prevents me from quantifying the potential benefits directly.

4 The Structure of Derivative Portfolios

Most previous studies have not been able to precisely measure the derivative positions of non-financial corporations because transaction-level data are not widely available. One notable exception is Tufano (1996) who is able to calculate position deltas and implied gammas for firms in the gold mining industry. I take an approach similar to Tufano's, but also pay attention to factors specific to HDG that help determine hedging strategies and the decision to hedge a currency at all. First, I discuss general determinants of hedging strategies and factors that could affect the hedging decision. Second, I calculate aggregate hedge parameters for each currency-quarter for each of the three forecast

horizons. Third, I statistically test the implications of theoretical models and other possible determinants of hedging policy. Specifically, I estimate a fixed effects panel regression (across currency and time) with hedge parameters as the dependent variable and various exposure and market factors as explanatory variables.

4.1 The Process of Structuring Derivative Portfolios

As noted already, one important determinant of the hedging strategy is the accounting treatment of derivatives. For HDG, few exposures beyond the current quarter are transaction exposures that would allow forward contracts to qualify for hedge accounting. Instead, HDG must primarily use options for longer-dated exposures to get beneficial hedging treatment. This is an important factor for HDG because of their desire for "linearity" in reported earnings – derivatives marked-to-market could dramatically impact earnings variability. As a consequence, HDG uses put options for much of its hedging beyond the current quarter. The concerns over accounting treatment are not unique to HDG; Bodnar et al. (1998) find that 80% of the Wharton Survey respondents express moderate or high concern regarding accounting treatment of derivatives. Typically when an economic exposure becomes a transaction exposure an option hedge is replaced with a forward hedge.

Since forwards and put options are used almost exclusively, HDG is left with essentially three parameters to adjust. First, HDG must determine what percentage of the exposure it wishes to hedge. The policy statement provides substantial leeway for this decision, especially for more distant exposures. Second, HDG must decide on the mix of forward and option contracts. Third, HDG must chose the strike price(s) for any option component of the hedge.

Before undertaking this process, HDG must decide if it wishes to hedge at all. For example, during my study, HDG was making this decision for a Latin American currency (Currency Z). HDG was expanding rapidly into this country and prepared a report for the FXMC detailing the issues around currency risk. The first question for management was if the proposed business unit should be a USD or Currency Z functional. Three primary questions were considered for this decision. First, "in what currency will primary cash flows take place?" Second, "what is the impact of a return to

a high inflationary regime?" Third, "what are the legal and accounting restrictions/benefits?" As secondary issues, the forex group included information on the types of hedging instruments available, how freely HDG could enter into derivative contracts in Currency Z (derivative market liquidity), how the foreign entity will be structured for tax purposes, and the ability of HDG to accurately quantify foreign currency exposures (quantity risk). Particular attention was paid to the possibility of "regime shifts" (devaluations). While it is not possible to quantify the impact of each of these items, it is interesting to note their explicit consideration.

Because 9 of the 24 currencies that HDG hedges entered the sample during my observation period, I am able to quantify aspects of the ultimate decision to hedge for this subset. Table 5 shows statistics based on the USD exposure of partial-sample currencies in the first quarter each is hedged. The mean value of $6.0 million is substantially less than the full-sample average of $44.2 million suggesting that a currency need not be a substantial exposure before it is hedged. Likewise, there does not appear to be a thresh-hold value which triggers the hedging decision: the minimum exposure is only $1.2 million while the maximum is more than an order of magnitude larger, $16.2 million. This is confirmed by the fact that the exposure in the first hedged quarter for 6 of the 9 currencies was less than the average exposure in the last unhedged quarter (individual values not reported). There is not an obvious pattern in the USD exposure of newly-hedged currencies suggesting that other qualitative aspects (such as those mentioned above) are the deciding factors. However, it is true that all exposures in excess of $20.6 million are hedged or are followed by a quarter that is hedged.[36]

An important factor in forex hedging at HDG is the quantity risk of the exposure. The effect of quantity risk on hedging strategy has been studied extensively in the agricultural hedging literature (for example see, Moschini and Lapan, 1995). Chowdhry (1995) investigates the role of uncertain foreign cash flows on hedging and capital structure policies. In a more general setting, Brown and Toft (1999) show that quantity risk can have a significant impact on the optimal degree and type of hedging. To

[36] This is not a strong statement though since 92% of partial-sample hedged quarters have exposures less than $20.6 million. Again, accounting restrictions may be an important factor since typically the exposure must meet a threshold relating to the confidence of the exposure forecast before it can be deemed "hedgable."

estimate the degree of quantity risk in the foreign currency exposures of HDG, I calculate the mean and standard deviation of exposure forecast errors for 3-, 6-, and 9-month forecasts. The first four columns of Table 6 show the results of this analysis. There are not large or systematic biases in the exposure forecasts for most currencies; in aggregate exposure forecast errors are only slightly negative for full-sample currencies, partial-sample, and all currencies. This is somewhat surprising given the rapid growth of HDG over the sample period and indicates that all of this growth was anticipated. The time series of errors is also without apparent trend; the bias is actually smaller at the 9-month horizon than at the 3-month horizon for the full-sample.

To measure the variation in these errors I calculate the standard deviation for each forecast horizon (STD). Consistent with expectations, there is a strong tendency for the quality of forecasts to improve as the forecast horizon decreases. To adjust for the time effect, I annualize these figures by dividing by the square root of the forecast horizon in years (An. STD). This also allows for the averaging across all horizons. The volatility of exposure forecasts is quite large (greater than 25%) for most individual currencies. Most partial-sample currencies show extreme annual exposure forecast volatility (over 100% in some cases). However, much of this error is currency specific; the annual volatility for full-sample currencies is only 14.2%, and for partial-sample currencies, only 21.8%. All currencies combined are forecasted even more precisely with an error volatility of only 13.7%. One interesting feature is that (in aggregate) the annualized standard deviations increase with the forecast horizon. This suggests that even the relative quality of exposure forecasts deteriorates as the horizon increases perhaps, indicating why HDG hedges with only a one-year horizon.[37] However, the relationship is less obvious at the currency level where forecast error volatilities vary much more.

The exposure forecast error is important to HDG for a variety of reasons. First, the policy limits the size of positions as a percent of the forecasted exposure. In effect, the forex group tracks hedge positions in terms of percent hedged, so the exposure forecast is crucial in determining the notional value of positions. Second, exposure forecast volatility implies a major risk for HDG. If HDG puts in place a hedge and the exposure is revised significantly downward, then the firm could inadvertently create a

new exposure opposite of its original exposure. Intuitively, this provides a rationale for using long positions in options because the loss from a derivative position is capped by the premium amount. If HDG uses forwards to hedge an uncertain exposure then it leaves open the possibility of the exposure not materializing and also realizing a loss on a forward transaction. Theoretical models (such as those noted above) also show that quantity risk implies an optimal hedge that is non-linear. Empirical research has also identified risks relating to the underlying exposure as significant determinants of hedge ratios. For example, Haushalter (1999) finds that basis risk is an important factor in explaining the hedging practices of oil and gas producers.

Theoretical work by Campbell and Kracaw (1990), Froot, Scharfstein, and Stein (1993), Moschini and Lapan (1995), and Brown and Toft (1999), among others indicates that the correlation between an uncertain exposure and the marketable risk factor is an important determinant of the optimal hedging strategy. The next part of Table 6 reports correlations between HDG's foreign currency exposures and exchange rates calculated using several different approaches. The first column shows the correlation between changes in the exposure forecasts and changes in the exchange rate at 3-month intervals. The next column shows a similar calculation for updates from the 9-month forecast to the actual realized exposure. The next three columns report correlations from the *time series* of realized exposures and the realized exchange rate. This is done at the quarterly frequency for levels and changes and on a year-over-year basis for percent changes only. The results are very difficult to interpret. Different methods yield dramatically different results for both individual currencies and for the aggregates. In part, this may be the result of the small number of observations used in the calculations, but it points out a potential weakness in models that require an estimate of correlation between exposure quantity and the exchange rate.

With 14 observations, only correlations with absolute values greater than 0.47 are significantly different from zero at the 10% level (assuming a bivariate normal distribution). Correlations estimated using revisions to exposure forecasts are almost all insignificant and never both significant and consistently of the same sign. Correlations between the level of exposure and the level of the exchange rate are consistently negative

---

[37] Conversely, HDG might expend less effort forecasting since they hedge less at longer horizons.

and significant. This is due to the large average growth in HDG's overseas exposure and the general weakening of foreign currencies against the USD during the sample period (exchange rates are calculated on a USD per FCU basis). When correlations are calculated on changes in quarterly values or on a year-over-year basis, the correlations are generally much closer to zero (though there are a substantial number of significant *positive* correlations for individual currencies on a year-over-year basis). In sum, there is not a clear or consistent correlation between exposure changes and the exchange rate for HDG in the sample period. This may explain why HDG does not explicitly incorporate an estimate of the correlation in its hedging decisions. Altogether, it appears that HDG is faced with a high degree of uncertainty in regards to the statistical properties of its underlying foreign exchange exposure, and (as suggested by the aforementioned theoretical models) this may have a measurable impact on the hedging strategy.

4.2 Characteristics of Derivative Portfolio Hedge Ratios

The transaction-level derivatives data allows for the calculation of hedge portfolio properties at the 3-, 6-, and 9-month intervals. Specifically, I calculate the notional value, delta, gamma, and vega of each hedge for each currency in the sample. I assume a Garman and Kohlhagen (1983) economy and use interest rates and volatilities as described in Section 2. Table 7 reports the mean, maximum, and minimum of these values for each currency and for the full-sample, partial-sample, and all currencies. The values have been normalized to an exposure of 1.0 to facilitate comparison across currencies.

Average notional values follow the trend suggested by the policy statement. Hedging as measured by mean notional value increases as the exposure draws closer for all exposures except Currencies Q and U which have a mean notional value of zero for all horizons.[38] For all currencies, the hedge ratios are 32%, 57%, and 74% for the 9-, 6-, and 3-month horizons, respectively. The full-sample hedge ratios are fairly similar across currency. In contrast, the partial-sample hedge ratios are substantially lower for longer horizons and zero in many cases. The maximum and minimum values show that there is

[38] Although all reported hedge parameters for Currencies Q and U are zero, HDG still used derivatives to hedge exposures in the currencies for horizons of less than 3 months.

tremendous variation in the hedge ratios and some possible violations of the policy statement (e.g., values exceeding 100%). Notional values in excess of 100% of the exposure could be due to data errors associated with stale exposure forecasts.[39] Notional values less than 25% at the 6-month horizon and less than 40% at the 3-month horizon violate the policy's lower bound. With a few exceptions, violations for full-sample currencies are small. Violations for the partial-sample currencies are frequently extreme; for currencies R and X, HDG is *over*-hedged by more than 100% in one quarter. Likewise, the minimum notional values show that in at least one quarter all of the partial-sample currencies were under-hedged. For most of the partial-sample currencies, the mean hedge ratio is zero at the 9-month horizon.[40] On average, the partial-sample currencies are hedged much less than the full-sample currencies.

There are several potential explanations for these specific features. First, the partial-sample currencies are generally less liquid and therefore hedging with derivatives may be relatively more expensive (in terms of bid/ask spreads) thus limiting the degree of hedging. This possibility is supported by remarks from the Manager of Foreign Exchange indicating that forwards and options in these currencies are frequently "too expensive", though these remarks also applied to implied volatilities that were viewed as unreasonably large. Second, by definition, the partial-sample currencies have not been hedged for as long a time period, suggesting the possibility that HDG limits hedging activity until it climbs a learning curve for each currency. This is consistent with the common waiting period between first recording an exposure and the subsequent decision to hedge it. Third, HDG could limit hedging because of the greater exposure uncertainty of the partial-sample currencies (reported in Table 6). This possibility is suggested by the theoretical models of Moschini and Lapan (1995) and Brown and Toft (1999). Fourth, primarily because of accounting treatment, HDG has a stated preference for options when structuring hedge portfolios. Since options are generally less viable as hedging instruments in these currencies, HDG may prefer to leave an exposure underhedged or even unhedged rather than use forward contracts.

---

[39] Exposure forecasts were recorded as the last forecast before the observation date and may therefore not be exactly contemporaneous with the reported forecast horizon.
[40] I do not have data on whether or not these possible violations were approved by the FXMC.

Calculating hedge parameters for each currency's derivative portfolios facilitates description and comparison of the differing qualities of the hedge portfolios beyond just the magnitude of the hedge. The portfolio delta describes the sensitivity of the hedge portfolio to changes in the underlying exchange rate (Table 7 shows deltas for the hedge portfolios).[41] As expected, normalized deltas show qualitative features very similar to the hedge ratios. As the exposure horizon decreases, mean deltas are always increasingly negative (for currencies with hedges in place). For the full-sample currencies, the aggregate delta decreases noticeably from –0.17 to –0.46 as the horizon decreases from 9 to 3 months. For the partial-sample currencies, the aggregate delta is essentially zero for the 9- and 6-month horizons (-0.01, -0.05) suggesting almost no (local) impact on USD exposures. For the 3-month horizon the aggregate delta for partial-sample currencies declines substantially but is only a third of the value for the full-sample currencies (-0.14 as compared to –0.44).

Hedge portfolio gammas and vegas provide a measure of the "optionality" in the optimal hedge. A larger value of gamma (in magnitude) indicates a greater local convexity of the hedge portfolio. The third block of columns in Table 7 reports portfolio gammas. For full-sample currencies, the mean gammas are positive and increasing for all currencies except currency N.[42] The aggregate gamma for the full-sample currencies also increases monotonically as the hedging horizon decreases. This is expected of a hedge portfolio that holds primarily near-the-money options. The results for the partial-sample currencies are notably different. In only 3 of the 9 currencies are any options used in the hedge portfolio and only one of these (Currency P) uses options for all horizons. This results in an average convexity near zero for all horizons in the partial-sample currencies. Although it is not captured in the reported figures, the gamma frequently drops to zero--even for full-sample currencies--as the options are replaced by forward contracts in the current quarter.

---

[41] All subsequent hedge parameters (deltas, gammas, and vegas) are normalized to a notional exposure of 1.0 to facilitate comparison.

[42] Currency N is somewhat unique for HDG in that a significant amount of input factors are procured in this currency. However, net USD exposures are still positive for all quarters in the sample period. The negative convexity comes from a strategy of writing covered calls on the currency in the earlier half of the sample period for 9- and 6-month horizons. It is not clear why this strategy was followed and how it relates to the unusual characteristics of operations in Currency N.

These results indicate that the extent of optionality in the typical hedge portfolio increases substantially as the hedging horizon decreases. This occurs for two reasons. First, as an at-the-money put option approaches maturity its gamma increases.[43] HDG typically trades in options so as to maintain positions near-the-money ("rolling strikes"). Second, the average increase in notional value of the hedge will increase convexity if this increase is due to options. These results are consistent with the predictions of Ahn et al. (1999) and Brown and Toft (1999) for an optimal put-option hedge but contrary to those suggested by Brown and Toft for an optimal exotic hedge (that convexity should *decrease* as the exposure draws closer).

Portfolio vegas also provide a measure of the optionality in the hedge portfolios. Specifically, vegas measure the local sensitivity of hedge-portfolio values to changes in volatility. As opposed to gamma, the vega of an at-the-money option decreases with time to maturity. The last group of columns in Table 7 shows hedge portfolio vegas for each currency at different horizons. As has already been indicated by the portfolio gammas, the full-sample currencies are more likely to have option-like characteristics than the partial-sample currencies. However, the relationship between hedging horizon and vega is generally not monotonic. For currencies hedged with options, the vegas typically increase between the 9- and 6-month horizons and subsequently decrease between the 6- and 3-month horizon. This result is due to the effect of an increase in the notional value of options in the hedge portfolio as the hedge horizon shortens. Between 9 and 6 months, the increase in notional value of options dominates the time decay in vega, but the opposite occurs between 6 and 3 months. Consequently, the hedge portfolios are most sensitive to changes in exchange rate volatility near the 6-month horizon. A large vega could be a potential benefit if changes in volatility are positively correlated to changes in exposure magnitude. However, it could be costly if there exists a volatility risk premium in the currency options market and HDG receives no benefit from paying this premium.

In summary, the structure of the full-sample hedge portfolios is generally consistent with the HDG policy statement and the earlier evidence describing a

---

[43] For comparison, a Garman-Kohlhagen at-the-money put option on a unit of foreign currency with a 20% volatility, domestic and foreign risk-free rates of zero, and time to maturity of 9, 6, and 3 months have gammas of 2.3, 2.8, and 4.0 respectively.

preference for options. Both notional values and deltas increase in magnitude as the time to the exposure decreases. The corresponding increase in convexity suggests that any increase in relative weighting of forwards is overcome by the increase of option convexity thus yielding a more "option-like" hedge (up to at least three months before an exposure is realized). For partial-sample currencies, there is a distinct tendency to hedge less; so little on average as to violate the firm's stated hedging policy. In addition, there is only a minor amount of convexity in the partial-sample hedge portfolios. The precise reasons for this are not observable, though they may be the result of the relatively illiquid market for derivatives in these currencies or uncertainty surrounding the exposure itself.

4.3 Determinants of Derivative Portfolio Hedge Ratios

The hedging problem of an industrial company differs fundamentally from the hedging problem of a financial institution. For example, consider a derivatives dealer that acts as the counter-party for one of HDG's option transactions. The financial institution has a well-defined exposure and access to sophisticated financial models allowing it to easily quantify or dynamically hedge its risk. Furthermore, the number of risk factors that the financial institution must consider are limited (e.g., models with two sources of uncertainty are usually sufficient for hedging derivatives on a single asset) and the objective of hedging is straightforward (e.g., hedge the derivative position so as to minimize net value variation). In contrast, an industrial company such as HDG is often faced with an ill-defined exposure, multiple (perhaps conflicting) objectives, and few quantitative models for constructing an optimal hedge with derivatives. In this section, I investigate the role of several factors that may impact the hedge portfolios of HDG and, when possible, test specific predictions from the theoretical models of Ahn et al. (1999) and Brown and Toft (1999). I separate factors into three general groups: (1) current foreign exchange market factors, (2) underlying exposure factors, (3) factors that may capture "market views".

As applied to hedging a foreign currency exposure with put options, the model of Ahn et al. (1999) predicts:

1. A U-shaped pattern in optimal delta as the time to exposure increases (though the point of inflection depends on parameter values),

2. A negative relationship between optimal delta and price volatility (for most reasonable scenarios), and
3. A positive relationship between optimal hedge-portfolio delta and forward points. (However, the magnitude of the effect is predicted to be small.)

The first of these predictions is not supported by the data for HDG. Table 7 indicates that portfolio deltas are non-increasing as the time to exposure decreases. However, it may be that the observed values for HDG are all to one side of the predicted inflection point. Hypotheses 2 and 3 are tested in the regression analysis presented below.

Brown and Toft (1999) make the following predictions for a firm with low or negative correlation between price and quantity when the firm has the ability to transact in any fairly priced derivative:

1. The optimal hedge portfolio will always have positive convexity,
2. As the time to an exposure decreases the (normalized) delta of the optimal hedge approaches -1.0 and the convexity approaches 0.0,
3. Increased quantity risk implies less hedging but a more convex optimal hedge portfolio, and
4. A decrease in the ratio of price volatility to quantity risk increases optimal convexity.

The first of these predictions is largely supported by the results in Table 7. As measured by the average portfolio gamma, all derivative portfolios have non-negative convexity with the exception of Currency N (at the 9- and 6-month horizons). The currencies with zero convexity are mostly partial-sample currencies where options may be extremely illiquid or unavailable. Table 7 provides mixed evidence for the second hypothesis. Consistent with the prediction, as the hedging horizon decreases, the degree of hedging increases for all currencies. Contrary to the hypothesis, the convexity of the hedge portfolios *increases* (for all currencies with non-zero gamma) as the time to exposure decreases. The remaining hypotheses are also tested below.

As noted already, HDG often incorporates a view on the level of future exchange rates when determining hedging policy. Since options are used extensively, HDG (at least implicitly) also incorporates a view on the *volatility* of future exchange rates. In its analysis, the forex group uses various technical indicators and outside forecasts from

financial institutions. Whether or not views significantly or systematically impact the characteristics of the hedge portfolios is difficult to test since data describing the sentiments of the forex group are not available. Instead, I employ several technical factors that may proxy for views.

To test how various factors impact the construction of hedge portfolios, I estimate a set of fixed-effect panel regressions using the hedge parameters of full-sample currency-quarters as the dependent variables.[44] I do this for each of the three forecast horizons and for delta, gamma, and vega. Seven independent variables are included to proxy for the aforementioned factors: (1) Exchange rate implied volatility, labeled *FX Volatility*, is used to capture the effect of price risk. (2) The difference between the 6-month forward exchange rate and the spot exchange rate in percent, labeled *Forward Points (%)*, is a measure of the current forward point spread. (3) The absolute difference between the exposure forecast and the actual exposure, labeled *Exposure Volatility*, is used as a proxy for quantity risk. (4-5) The percentage difference between the current spot exchange rate and the highest (lowest) level of the spot exchange rate in the previous 12 months, labeled *Spot % Below (Above) 12 Month High (Low)*, is used as a proxy for technical variables that seek to determine market tops or bottoms. (6) The percentage change in the spot exchange rate over the previous 60 trading days, labeled *3 Month Change in Spot*, is used to capture trend-following behavior. (7) The actual profit or loss on the hedge in the previous quarter, labeled *Derivative P&L (t-1)*, is included (only for the three-month forecast horizon) to measure the impact of recent hedging results. This variable may capture the effect of regret from under-hedging or over-hedging in the previous quarter.

Table 8 shows the results of estimating these panel regressions. As predicted by Ahn et al., there is a negative relation between forex volatility and portfolio delta at the 9-month forecast horizon. However, there is no significant relationship at the 6- or 3-month horizon. A negative coefficient implies that HDG decreases the delta (hedges

[44] Hausman specification tests for random effects vs. fixed effects did not consistently choose one model over the other. However, the size and significance of parameter estimates from the two models did not differ dramatically. For brevity, I only report the results of the fixed-effects estimation. The estimation is made using only full-sample currencies because of the large number of currency-quarters with missing values in the partial-sample currencies.

more) as exchange rate volatility increases. Intuitively, as forex volatility increases, HDG's nominal USD risk increases, which in turn should increase the incentive to hedge. However, HDG's preference for options implies that the up-front cost of hedging will also be greater perhaps explaining the lack of a significant relationship at the 6- and 3-month horizons. Results using portfolio gamma as the dependent variable are also consistent with the hypothesis of a negative relation between price risk and hedge portfolio convexity. As predicted by Brown and Toft, the coefficients on *FX Volatility* are significantly negative (at the 6- and 3-month horizons). While neither model makes a signable prediction concerning the impact of *FX Volatility* on hedge portfolio vega, a statistically significant positive relation is observed at the 9- and 6-month horizons. This could be a mechanical artifact of the tendency for HDG to hedge higher volatility currencies more.

The next row reports coefficients for *Forward Points (%)*. Contrary to the predicted of Ahn et al. there is a significant negative relation between this variable and the hedge portfolio delta but only at the 3-month horizon. The magnitude of *Forward Points (%)* may also be a measure of the cost of hedging. If forward rates are not an unbiased predictor of realized spot rates, but derivative prices are generated under the risk-neutral measure, this variable could proxy for an incremental cost of hedging. If the current spot rate is the best predictor of future spot rates, a large value of *Forward Points (%)* would imply "expensive" derivatives. Consequently, this could result in less hedging and bias against finding the result predicted by Ahn et al. Table 8 also shows that *Forward Points (%)* has a significantly positive relation to hedge portfolio gamma and vega at the 3-month horizon, suggesting a bias toward a more option-like hedge when *Forward Points (%)* is large.

Intuitively, greater exposure volatility (quantity risk) makes hedging more difficult because of the increased uncertainty concerning the magnitude of the realized exposure. Brown and Toft predict this will lead to less hedging (a less negative delta) but a more convex hedge (a greater gamma). The second row in Table 8 reports the estimated coefficients for exposure volatility. In support of the hypothesis, a significant positive relation is observed between exposure volatility (quantity risk) and delta at the 9 and 6 month horizons. However, no significant effect is found for hedge portfolio gamma or

vega. This may be due to the strong preference for options. Specifically, instead of substituting away from options towards forwards as quantity risk decreases, HDG simply hedges less.

The estimated coefficients on the technical variables (next three rows of Table 8) show a significant but mixed impact of these variables on the portfolio deltas, gammas, and vegas. For example, the level of the current spot rate relative to its 12-month high has a significantly negative impact on delta at the 6-month horizon and a significantly positive impact at the 3-month horizon. The level of the current spot rate relative to its 12-month *low* has a significantly positive impact on delta at only the 3-month horizon. To the contrary, recent trends in the exchange rate are only significantly related to portfolio delta at the 9-month horizon. This positive relationship suggests that if the foreign currency appreciates against the USD then HDG will tend to hedge less. One interpretation of these results is that the degree of hedging depends on market views derived from these technical factors. An alternative explanation is that these factors capture other (perhaps competitive) factors that determine the optimal hedge ratio (as discussed above).

For portfolio gammas and vegas, each of the technical variables is significantly different from zero for at least one forecast horizon. However, many of the significant coefficients change sign at different forecast horizons.[45] While it is interesting to note that these technical variables are significant factors for explaining hedge portfolio characteristics, in the absence of theory it is difficult to interpret their meaning.

The final row shows the impact of the previous quarter's derivative P&L (*Derivative P&L*) on the portfolio delta.[46] The coefficient is significantly negative suggesting that HDG hedges more in a currency if the profit from last quarters hedge was large (i.e., the currency moved against the underlying exposure). This may indicate either a belief in exchange rate trends or a larger need for hedging after a significant adverse exchange rate move. A significant negative relation is also observed between

---

[45] This finding suggests a potential problem with collinearity. However, an analysis of the data did not reveal strong linear dependencies.

[46] This variable is included in only the 3-month horizon specification because it is lagged. Inclusion at the 6- and 9-month horizons would reduce the number of quarters in the analysis to 12 and 11 respectively.

Derivative P&L and hedge portfolio gamma and vega. In other words, HDG uses a less option-like hedge when the gains from hedging last quarter were large. The statistical significance of these coefficients are the strongest of any in this analysis. The economic significance is also notable: a one standard deviation increase in *Derivative P&L (t-1)* would be expected to result in a -0.10 change in delta.

In sum, the explanatory power of these regressions (R^2) increases as the forecast horizon shortens, implying that these explanatory variables are more important in determining shorter-run hedging decisions. The evidence for *FX Volatility* and *Exposure Volatility* is consistent with theoretical predictions for the hedge-portfolio delta and gamma. The relationship between the technical indicators and hedge parameters is statistically strong but difficult to interpret because of the unstable signs of estimated coefficients. Finally, the strongest and most consistent relationship is between the hedge parameters and the lagged derivative P&L. This suggests that recent hedging history has a powerful impact on how HDG hedges. Unfortunately, it is not possible to determine if this is a rational hedging strategy or a behavioral reaction to recent events.

5 Conclusions

Most theoretical models and empirical studies have by necessity simplified the analysis of a firm's hedging decision. The primary advantages of this approach are analytical tractability in the case of theoretical work and the creation of a large sample in empirical work. This paper has instead focussed in detail on foreign exchange risk management at a single, large, multinational corporation. Advantages of this method include a more precise understanding of the risk management process and institutional details, identification of specific motivations and decision factors, and access to otherwise unavailable transaction level data. My analysis has centered around three basic questions:

Estimating the 6- and 9-month equations with Derivative P&L results in qualitatively similar but statistically weaker results.

First, how is the risk management program structured and what is its overall impact on the firm? I showed that HDG has a foreign exchange hedging policy that is in line with current best practices. Thorough oversight, control, and operating policies govern the process; for example, the policy forbids certain types of hedging instruments and controls speculative trading. The primary goal of hedging is the determination of a *hedge rate* that is used for budgeting, pricing, and *ex post* evaluation of foreign operations and managers. The impact of hedging on firm-wide earnings is not substantial. Over the three and a half year sample period, derivatives transactions directly increased earnings growth by about 1.0%, reduced the standard deviation of quarterly earnings by $4.4M (22.0%), and the standard deviation of year-over-year earnings by about $4.0M (10.2%). The reduction in volatility at the currency level is primarily at the year-over-year frequency and averaged 14.9%.

Second, what are the motivating factors that determine why the firm manages foreign exchange risk? Many common explanations for risk management (such as minimizing expected taxes, avoiding costs of financial distress, managerial risk aversion, and coordination of cash flows and investment) do not mesh with the evidence from HDG nor are they espoused by management. In addition, the hedging policy provides little guidance in trying to answer this question. Other documents and discussions with management indicate a variety of alternative reasons for risk management at HDG. These include income smoothing, facilitation of internal contracting (via the hedge rate), and obtaining competitive pricing advantages in the product market. Some evidence suggests that risk management may cause an internal agency problem between foreign managers and the central treasury.

Third, how does the firm structure the derivative portfolios used for foreign exchange risk management? Since, the program focuses on the establishment of a hedge rate, each currency and quarter is treated independently. Typical derivative positions are initiated approximately one year before the end of a particular quarter. The notional value of the hedge increases as the exposure draws closer so that HDG is almost fully hedged by the beginning of a quarter. Primarily because of accounting treatment, HDG has a strong preference for using options to structure its hedges in out-quarters. In fact, it appears that for some less liquid currencies for which options are less viable, HDG would

rather not hedge at all than use forwards. The gamma of the typical hedge portfolio increases monotonically as the horizon shortens. In contrast, the portfolio vegas generally have a maximum between 3- and 9-months before quarter end. Results from statistical tests support some predictions of theoretical models that propose exchange rate volatility and exposure volatility are important determinants of optimal hedging policies. Finally, some of the evidence suggests that managerial views and recent hedging history are important determinants of hedging behavior.

There are still important questions that remain unanswered, however. In particular, it is not possible to precisely determine whether or not the hedging program is being executed optimally or if it increases firm value. Because the risk management goals are difficult to quantify, benchmarking is a problem. How do the different (and possibly conflicting) goals of HDG interact? For example, is income smoothing more or less important than obtaining a competitive pricing advantage? How do these differing goals affect how the firm structures its hedges? Perhaps most importantly, what is the magnitude of the economic impact of foreign exchange risk management? In other words, even if the program is managed optimally, how much does it actually increase firm value?

References

Ahn, Dong-Hyun, Jacob Boudoukh, Matthew Richardson, and Robert F. Whitelaw, 1998, Optimal Risk Management Using Options, *Journal of Finance*, Vol. 54, No. 1, 359-375.

Allayannis, George, and Jane Ihrig, 1998, Exchange Rate Exposure and Industry Structure, University of Virginia Working Paper.

Allayannis, George, and James P. Weston, 1998, The Use of Foreign Currency Derivatives and Firm Market Value, University of Virginia Working Paper.

Allayannis, George, and James P. Weston, 1999, The Use of Foreign Currency Derivatives and Industry Structure, University of Virginia Working Paper.

Block, Stanley and Timothy Gallagher, 1986, The Use of Interest Rate Futures and Options by Corporate Financial Managers, *Financial Management*, Autumn 1986, 73-78.

Bodnar, Gordon M., Gregory S. Hayt, and Richard C. Marston, 1998, 1998 Wharton Survey of Financial Risk Management by US Non-financial Firms, Financial Management, Vol. 27, No. 4, Winter 1998, 70-91.

Brown, Gregory W., and Klaus Bjerre Toft, 1999, How Firms Should Hedge, University of North Carolina Working Paper.

Campbell, Tim S., and William A. Kracaw, 1990, Corporate Risk Management and the Incentive Effects of Debt, *Journal of Finance*, Vol. 45, No. 5, 1673-1686.

Chang, Chun, 1997, Does Hedging Aggrevate or Alleviate Agency Problems? A Managerial Theory of Risk Management, University of Minnesota Working Paper.

Chowdhry, Bhagwan, 1999, Corporate Hedging of Exchange Rate Risk When Foreign Currency Cash Flow is Uncertain, *Management Science*, Vol. 41, No. 6, 1083-1090.

DeFusco, Richard A., Robert R. Johnson, and Thomas S. Zorn, 1990, The Effect of Executive Stock Option Plans on Stockholders and Bondholders, *Journal of Finance*, Vol. 45, No. 2, 617-627.

DeMarzo, Peter M., and Darrell Duffie, 1991, Corporate Financial Hedging with Proprietary Information, *Journal of Economic Theory*, Vol. 53, 261-286.

DeMarzo, Peter M., and Darrell Duffie, 1995, Corporate Incentives for Hedging and Hedge Accounting, *Review of Financial Studies*, Vol. 8, No. 3, 743-771.

Dolde, Walter, 1995, Hedging, Leverage, and Primitive Risk, *The Journal of Financial Engineering*, Vol. 4, No. 2, 187-216.

Downie, David and Ed Nosal, 1998, Corporate Hedging: A Strategic Approach, University of Waterloo Working Paper.

Dye, R., 1988, Earnings Management in an Overlapping Generations Model, *Journal of Accounting Research*, Vol. 26, 1988 195-235.

Froot, Kenneth, David Scharfstein, and Jeremy Stein, 1993, Risk Management: Coordinating Corporate Investment and Financing Policies, *The Journal of Finance*, Vol. 48 No. 5, 1629-1658.

Garman, H. B., and S. W. Kohlhagen, 1983, Foreign Currency Option Values, *Journal of International Money and Finance*, Vol. 2, December, 231-237.

Géczy, Christopher, Bernadette A. Minton, Catherine Schrand, 1997, Why Firms Use Currency Derivatives, *Journal of Finance*, Vol. 52, No. 4, 1323-1354.

Graham, John R., and Daniel A. Rogers, 1998, Is Corporate Hedging Consistent with Value-Maximization? An Empirical Analysis, Fuqua School of Business working paper.

Graham, John R. and Clifford W. Smith Jr., 1999, Tax Incentives to Hedge, forthcoming *Journal of Finance*.

Haugen, Robert A., and Lemma Senbet, 1981, Resolving the Agency Problems of External Capital through Options, *Journal of Finance*, Vol. 36, No. 3, 629-647.

Haushalter, G. David, 1999, Financing Policy, Basis Risk, and Corporate Hedging: Evidence from Oil and Gas Producers, forthcoming *Journal of Finance*.

Lewent, J.C., and A.J. Kearney, 1990, Identifying, Measuring and Hedging Currency Risk at Merck, *Journal of Applied Corporate Finance*, 2, 19-28.

Mark, Nelson, and Doo-Yull Choi, 1997, Real Exchange Rate Prediction over Long Horizons, *Journal of International Economics*, 43(1/2), August 1997, 29-60.

Mello, Antonio S., John E. Parsons, and Alexander J. Triantis, 1995, An Integrated model of Multinational Flexibility and Financial Hedging, *Journal of International Economics*, Vol. 39, 27-51.

Modigliani, Franco and Merton H. Miller, 1958, The Cost of Capital, Corporate Finance, and the Theory of Investment, *American Economic Review*, Vol. 30, 261-297.

Moschini, Giancarlo, and Harvey Lapan, 1995, The Hedging Role of Options and Futures Under Joint Price, Basis, and Production Risk, *International Economic Review*, Vol. 36, No. 4, 1025-1049.

Nam, Jouahn, and John H. Thornton, 1998, Interest Rate Swap Usage by Corporations: Hedging or "Taking a View," Georgia State University Working Paper.

Nance, Deana, Clifford Smith, and Charles Smithson, 1993, On the Determinants of Corporate Hedging, *Journal of Finance*, Vol. 48, No. 1, 267-284.

Shapiro, Alan C. , and Sheridan Titman, 1986, An Integrated Approach to Corporate Risk Management, in Joel Stern and Donald Chew, Eds.: The Revolution in Corporate Finance (Basil Blackwell, Ltd. Oxford, England and Basil Blackwell, Inc., Cambridge, Mass.).

Smith, Clifford and René Stulz, 1985, The Determinants of Firms' Hedging Policies, *Journal of Financial and Quantitative Analysis*, Vol. 20, No. 4, 391-402.

Stulz, René, 1984, Optimal Hedging Policies, *Journal of Financial and Quantitative Analysis*, Vol. 19, No. 2, 127-140.

Trueman, Brett, and Sheridan Titman, 1988, An Explanation for Accounting Income Smoothing, *Journal of Accounting Research*, Vol. 26, Supplement, 127-139.

Tufano, Peter, 1996, Who Manages Risk? An Empirical Examination of Risk Management Practices in the Gold Mining Industry, *Journal of Finance*, Vol. 51, No. 4, 1097-1137.

Tufano, Peter, 1998, Agency Costs of Corporate Risk Management, *Financial Management*, Vol. 27, No. 1, 67-77.

Wall, Larry and John Pringle, 1989, Alternative Explanations of Interest Rate Swaps: A Theoretical and Empirical Analysis, *Financial Management,* Summer 1989, 59-73.

(Possible) items to be included in subsequent drafts:

General:

- Cite remaining appropriate articles

Section 2

- More firm specifics: Manufacturing facilities, sales by region, profitability, debt, cash, capital expenditure, working capital, market returns v. USD, age of company
- Estimated cost of the hedging program
- Use analyst earnings estimates as benchmark
- Derivative transaction costs
- Graph currencies over sample horizon
- History of hedging group

Section 3

- Detailed discussion of theory in "Alternative Motivations"
- Hedge Rate variance
- Why is foreign manager compensation in USD?
- Volatility of output prices

Section 4

- More explanation of "Rolling Strikes"
- Local vs. global hedge

Table 1: Functional Currencies

This table reports country, local currency, and functional currency of the largest foreign markets for HDG. Of the 40 countries listed, 24 are not USD exposures. Panel B reports the effect of foreign exchange derivative profit and losses on reported earnings and cash flows. The unhedged results are calculated by subtracting after-tax derivative profit and losses from reported earnings and cash flow. Both standard deviations and Semi-deviations of dollar changes are reported for sequential quarterly results and year to year results. Reported results are based on 14 quarters of data from 1996:Q1 to 1998:Q2. Semideviations are calculated as the average of deviations below the mean change or zero whichever is less. Values in Panel B are in USD millions. All of the foreign currency functionals for which HDG hedged with derivatives are listed in the table.

Country	Local Currency (Symbol)	Exposure	Country	Local Currency (Symbol)	Exposure
Argentina	Argentine Peso (ARS)	USD	Italy	Italian Lira (ITL)	USD
Austria	Austrian Schilling (ATS)	ATS	Japan	Japanese Yen (JPY)	JPY
Australia	Australian Dollar (AUD)	AUD	Malaysia	Malaysian Ringgit (MYR)	MYR
Bangladesh	Bangladesh Taka (BDT)	USD	Mexico	Mexican Peso (MXP)	USD
Belgium	Belgian Franc (BEF)	BEF	Netherlands	Dutch Guilder (NLG)	NLG
Brazil	Brazilian Real (BRL)	USD	New Zealand	New Zealand Dollar (NZD)	NZD
Canada	Canadian Dollar (CAD)	CAD	Norway	Norwegian Krone (NOK)	NOK
Chile	Chilie Peso (CLP)	USD	Pakistan	Pakistani Rupee (PKR)	USD
China	Chinese Renminbi (CNY)	USD	Philippines	Philippine Peso (PHP)	USD
Colombia	Colombia Peso (COP)	USD	Poland	Poland Zloty (PLZ)	USD
Czech Republic	Czech Koruna (CZK)	USD	Singapore	Singapore Dollar (SGD)	SGD
Denmark	Danish Kroner (DKK)	DKK	South Africa	South African Rand (ZAR)	ZAR
Finland	Finnish Markka (FIM)	FIM	South Korea	S. Korean Won (KRW)	KRW
France	French Franc (FRF)	FRF	Spain	Spanish Peseta (ESP)	ESP
Germany	German Mark (DEM)	DEM	Sri Lanka	Sri Lankan Rupee (LKR)	USD
Great Britain	British Pound Corp (GBP)	GBP	Sweden	Swedish Krona (SEK)	SEK
Hong Kong	Hong Kong Dollar (HKD)	HKD	Switzerland	Swiss Franc (CHF)	CHF
India	India Rupee (INR)	USD	Taiwan	Taiwanese Dollar (TWD)	TWD
Indonesia	Indonesia Rupiah (IDR)	USD	Thailand	Thai Baht (THB)	THB
Ireland	Irish Punt (IEP)	IEP	United Arab Emirates	UAE Dirham (AED)	USD

Table 2: The Impact of Hedging on Earnings, Cash Flow, and Stock Returns

This table reports the effect of foreign exchange derivative profit and losses on reported earnings, cash flows, and stock returns. In Panel A, the unhedged results are calculated by subtracting after-tax derivative profit and losses (P&L) from reported earnings and cash flow. Both standard deviations and semi-deviations of dollar changes are reported for sequential quarterly results and year-to-year quarterly results. Reported values are based on 14 quarters of data from 1996:Q1 to 1998:Q2. Semi-deviations are calculated as the average of deviations below the mean change or zero whichever is less. Values are in USD millions. Panel B reports coefficient estimates and t-statistics from regressions with HDG quarterly stock returns as the dependent variable and the S&P industry returns, changes in the trade-weighted exchange rate of the USD, and derivative P&L as the independent variables. Asterisks (***, **, *) represent significance at the 10%, 5%, and 1% level in a one-tailed test.

Panel A: Earnings and Cash Flow

	Hedged Earnings*	Unhedged Earnings*	Hedged Cash Flow*	Unhedged Cash Flow*
Mean	$169.40	$163.17	$389.04	$382.80
Mean (Change)	$22.87	$21.37	$80.23	$78.72
Standard Deviation (Change)				
Quarterly	$15.70	$20.14	$146.40	$153.02
Year-over-Year	$34.91	$38.89	$241.50	$256.40
Semi-Deviation (Change)				
Quarterly	$6.65	$7.76	$53.78	$56.83
Year-over-Year	$15.47	$15.61	$103.36	$109.92
Correlation (Unhedged Quarterly Changes, Derivative P&L)	-0.370		-0.280	

* USD millions

Panel B: Stock Returns

	Dependent Variable: HDG Quarterly Stock Returns	
Constant	0.12	0.46
	1.00	1.36
Industry Returns	2.09 ***	1.65 **
	3.32	2.45
Change in USD/FCU	1.01	-1.43
	0.39	-0.47
Derivative P&L		5.00 *
		1.42

Table 3: Exposures, Derivative P&Ls, and the Impact on USD Cash Flows

This table presents the average, minimum, and maximum values across 14 quarters for unhedged exposure, profit/loss from derivatives, and the total premium as a percent of the dollar exposure. Also shown are standard deviation (in levels and percent) and semi-deviation for quarterly hedged and unhedged exposures and year-over-year exposures. For partial sample currencies statistics are calculated using only hedge quarters (as defined in main text). Currencies A-O are full sample currencies and Currencies P-X are partial sample currencies. Asterisks denote hedged exposures with a lower volatility measure than unhedged exposure. Dollar figures are in $1,000.

							Quarterly			Year over Year		
	Number of Curr.		Unhedged Dollar Exposure	Derivative Profit/Loss	Total Premium (% of Exp)		Unhedged Exposure Volatility	Hedged Exposure Volatility		Unhedged Exposure Volatility	Hedged Exposure Volatility	
Totals												
Full-Sample	15	Ave	$663,085	$7,590	-3.36%	Std Dev.	$313,844	$319,418		--	--	
Currencies		Min	$358,071	-$8,569	-8.31%	Std Dev. %	13.52%	13.89%		25.98%	21.80%	*
		Max	$1,336,793	$38,127	0.94%	Semi Dev.	5.43%	5.53%		8.91%	7.42%	*
Partial-Sample	9	Ave	$41,787	$1,314	0.04%	Std Dev.	$30,622	$32,301		--	--	
Currencies		Min	$6,954	-$2,700	-0.16%	Std Dev. %	24.34%	26.30%		122.73%	114.64%	*
		Max	$96,340	$10,850	0.46%	Semi Dev.	9.75%	10.49%		48.41%	45.17%	*
All	24	Ave	$704,872	$8,905	-2.91%	Std Dev.	$341,725	$348,849		--	--	
Currencies		Min	$366,089	-$8,440	-7.79%	Std Dev. %	12.73%	13.19%		22.88%	19.47%	*
		Max	$1,433,132	$40,942	0.70%	Semi Dev.	5.12%	5.25%		7.76%	6.50%	*
Full-Sample Currencies	Quarters Hedged/ Exposed											
Currency A	14	Ave	$239,046	-$2,453	1.03%	Std Dev.	$139,027	$138,252	*	--	--	
	/14	Min	$126,450	-$8,252	-0.93%	Std Dev. %	28.84%	28.70%	*	56.22%	56.57%	
		Max	$558,234	$2,670	3.21%	Semi Dev.	9.56%	9.84%		20.15%	20.00%	*
Currency B	14	Ave	$64,793	$2,495	0.53%	Std Dev.	$30,169	$30,978		--	--	
	/14	Min	$30,976	-$2,282	-17.74%	Std Dev. %	18.45%	18.37%	*	35.20%	36.78%	
		Max	$115,848	$11,825	7.44%	Semi Dev.	7.33%	7.20%	*	14.33%	12.90%	*
Currency C	14	Ave	$59,754	$1,035	0.43%	Std Dev.	$34,326	$34,683		--	--	
	/14	Min	$24,908	-$1,740	-10.99%	Std Dev. %	21.66%	22.86%		27.47%	16.83%	*
		Max	$122,019	$8,192	4.33%	Semi Dev.	7.60%	8.71%		11.58%	6.74%	*
Currency D	14	Ave	$36,076	$183	1.04%	Std Dev.	$18,836	$19,499		--	--	
	/14	Min	$19,257	-$2,135	-10.51%	Std Dev. %	26.24%	27.02%		44.90%	39.77%	*
		Max	$73,573	$3,325	8.20%	Semi Dev.	10.58%	10.40%	*	16.36%	14.61%	*
Currency E	14	Ave	$17,293	$403	0.61%	Std Dev.	$9,386	$9,524		--	--	
	/14	Min	$7,437	-$643	-7.45%	Std Dev. %	24.31%	26.14%		23.76%	23.18%	*
		Max	$33,655	$2,460	5.09%	Semi Dev.	8.32%	9.11%		9.62%	8.88%	*
Currency F	14	Ave	$35,010	$891	-0.12%	Std Dev.	$17,615	$17,577	*	--	--	
	/14	Min	$15,121	-$888	-12.80%	Std Dev. %	24.74%	21.26%	*	43.40%	30.76%	*
		Max	$75,701	$4,587	4.81%	Semi Dev.	9.54%	8.76%	*	16.58%	12.12%	*
Currency G	14	Ave	$14,885	$34	0.97%	Std Dev.	$4,380	$4,486		--	--	
	/14	Min	$9,874	-$683	-7.04%	Std Dev. %	21.71%	22.21%		32.89%	22.85%	*
		Max	$23,895	$1,587	4.78%	Semi Dev.	8.24%	8.35%		12.33%	9.10%	*
Currency H	14	Ave	$12,367	$213	0.35%	Std Dev.	$3,716	$3,800		--	--	
	/14	Min	$7,369	-$622	-19.03%	Std Dev. %	25.06%	22.53%	*	26.99%	15.64%	*
		Max	$18,500	$1,998	4.78%	Semi Dev.	11.05%	9.71%	*	10.79%	6.27%	*
Currency I	14	Ave	$16,767	$574	0.66%	Std Dev.	$6,444	$6,644		--	--	
	/14	Min	$9,558	-$741	-9.48%	Std Dev. %	19.06%	20.17%		32.52%	25.26%	*
		Max	$29,536	$2,845	7.40%	Semi Dev.	6.58%	6.98%		13.07%	10.12%	*
Currency J	14	Ave	$2,868	$91	0.15%	Std Dev.	$931	$930	*	--	--	
	/14	Min	$1,844	-$144	-22.22%	Std Dev. %	30.40%	30.80%		33.87%	27.34%	*
		Max	$5,354	$522	7.50%	Semi Dev.	12.27%	12.49%		12.22%	10.22%	*

Table 3 (continued)

	Quarters Hedged/ Exposed		Unhedged Dollar Exposure	Derivative Profit/Loss	Total Premium (% of Exp)		Quarterly Unhedged Exposure Volatility	Quarterly Hedged Exposure Volatility		Year over Year Unhedged Exposure Volatility	Year over Year Hedged Exposure Volatility	
Currency K	14	Ave	$2,471	$37	0.93%	Std Dev.	$1,197	$1,218		--	--	
	/14	Min	$1,022	-$126	-10.41%	Std Dev. %	33.95%	33.56%	*	59.92%	56.00%	*
		Max	$4,972	$243	8.95%	Semi Dev.	13.54%	13.45%	*	23.36%	21.99%	*
Currency L	14	Ave	$5,628	$102	-0.11%	Std Dev.	$3,552	$3,607		--	--	
	/14	Min	$1,251	-$128	-14.02%	Std Dev. %	33.35%	31.93%	*	50.90%	47.80%	*
		Max	$12,865	$815	3.51%	Semi Dev.	12.13%	11.30%	*	20.32%	18.47%	*
Currency M	14	Ave	$64,940	$825	0.39%	Std Dev.	$34,661	$36,526		--	--	
	/14	Min	$24,181	-$2,291	-1.41%	Std Dev. %	31.27%	31.50%		44.15%	45.07%	
		Max	$134,980	$6,143	0.90%	Semi Dev.	12.25%	12.26%		17.62%	18.16%	
Currency N	14	Ave	$73,190	$2,552	0.06%	Std Dev.	$18,741	$20,669		--	--	
	/14	Min	$54,707	-$50	-1.25%	Std Dev. %	19.51%	19.79%		22.72%	25.15%	
		Max	$109,346	$8,209	2.70%	Semi Dev.	6.68%	6.94%		9.74%	10.32%	
Currency O	14	Ave	$17,996	$609	0.54%	Std Dev.	$10,250	$11,104		--	--	
	/14	Min	$4,005	-$431	-1.14%	Std Dev. %	82.29%	86.81%		100.18%	100.73%	
		Max	$38,681	$3,654	1.98%	Semi Dev.	25.19%	25.59%		42.78%	42.68%	*
Partial-Sample Currencies												
Currency P	5	Ave	$4,327	$404	0.49%	Std Dev.	$736	$951		--	--	
	/6	Min	$3,750	$186	-3.35%	Std Dev. %	23.18%	18.13%	*	--	--	
		Max	$5,568	$786	2.55%	Semi Dev.	8.61%	6.38%	*	--	--	
Currency Q	11	Ave	$15,524	$62	0.00%	Std Dev.	$7,570	$8,646		$7,570	$8,646	
	/14	Min	$6,954	-$2,486	0.00%	Std Dev. %	30.01%	39.74%		39.51%	60.48%	
		Max	$31,359	$2,375	0.00%	Semi Dev.	11.69%	14.87%		16.51%	23.16%	
Currency R	10	Ave	$5,575	$184	0.06%	Std Dev.	$3,532	$3,881		$3,532	$3,881	
	/10	Min	$1,378	-$253	0.00%	Std Dev. %	107.92%	130.64%		141.83%	125.45%	*
		Max	$11,742	$1,839	0.58%	Semi Dev.	33.31%	37.86%		55.55%	49.01%	*
Currency S	6	Ave	$8,691	$406	0.49%	Std Dev.	$3,373	$3,600		$3,373	$3,600	
	/10	Min	$4,621	-$11	-0.02%	Std Dev. %	16.70%	16.58%	*	27.50%	7.77%	*
		Max	$13,978	$857	1.98%	Semi Dev.	7.95%	6.53%	*	10.50%	2.75%	*
Currency T	5	Ave	$3,593	$461	0.00%	Std Dev.	$885	$1,003		--	--	
	/6	Min	$2,984	-$267	0.00%	Std Dev. %	32.26%	47.79%		--	--	
		Max	$5,087	$1,524	0.00%	Semi Dev.	11.28%	16.18%		--	--	
Currency U	3	Ave	$12,748	$2,955	0.00%	Std Dev.	$2,571	$4,745		--	--	
	/8	Min	$10,171	$442	0.00%	Std Dev. %	17.60%	28.10%		--	--	
		Max	$16,187	$5,508	0.00%	Semi Dev.	22.94%	9.93%	*	--	--	
Currency V	3	Ave	$10,188	-$67	0.00%	Std Dev.	$2,278	$2,326		--	--	
	/10	Min	$7,888	-$105	0.00%	Std Dev. %	104.65%	5.03%	*	--	--	
		Max	$12,443	$1	0.00%	Semi Dev.	10.16%	1.78%	*	--	--	
Currency W	4	Ave	$3,717	$225	0.00%	Std Dev.	$2,357	$2,034	*	--	--	
	/8	Min	$2,383	-$278	0.00%	Std Dev. %	99.86%	99.42%	*	--	--	
		Max	$7,241	$859	0.00%	Semi Dev.	24.15%	37.68%		--	--	
Currency X	3	Ave	$1,962	$66	0.00%	Std Dev.	$1,062	$1,082		--	--	
	/8	Min	$1,069	$33	0.00%	Std Dev. %	109.92%	122.05%		--	--	
		Max	$3,376	$91	0.00%	Semi Dev.	35.62%	45.33%		--	--	

Table 4: Market Share and Foreign Exchange Risk

This table shows coefficient estimates and t-statistics from fixed-effects panel regressions for 14 quarters (13 for changes) and the 15 full-sample currencies (N=210 and 195). The dependent variables are the market share and change in market share for HDG in each of these currency-quarters. The independent variables are defined as follows: 3 Month Change in Spot is the percentage change in the spot exchange rate over the previous 60 trading days. Spot % Below 12 Month high is the percentage difference between the current spot exchange rate (as measured in USD/FCU) and the highest level of the spot exchange rate in the previous 12 months using daily values. These two variables are recorded six months prior to the end of each currency-quarter. Derivative P&L is the actual profit or loss on the derivative portfolio. The asterisks (*, **, ***) represent significance in a two-tailed test at the 10%, 5%, and 1% levels, respectively. Hausman specification tests for random effects vs. fixed effects rejected the random effects models in favor of the fixed effects models. T-statistics are calculated using heteroskedasticity-robust standard errors.

		Market Share		Change in Market Share	
3-Month Change in Spot (USD/FCU)	coef.	0.036		0.060	**
	t-stat	1.09		2.39	
Spot % Below 12-Month High (USD/FCU)	coef.	0.110	***	0.031	*
	t-stat	4.79		1.73	
Derivative P&L	coef.	0.051	*	0.020	
	t-stat	1.86		0.92	

Table 5: Newly-Hedged Currencies

This table details information regarding currencies that were not hedged at the beginning of the sample period but were hedged at the end of the sample period (newly-hedged currencies). The values in the Newly Hedged column are based on the first quarter hedged. Dollar figures are in 1,000s. Full sample figures are based on the full sample means.

	Newly Hedged	Full Sample
Mean	$6,006	$44,206
Median	$4,207	$17,996
Minimum	$1,226	$2,471
Maximum	$16,187	$239,046
Standard Dev.	$5,263	$59,176
Number of Observations	9	14

Table 6: Exposure Forecast Errors and Correlations

This table presents the exposure forecast errors and correlations between exposure forecast errors (or revisions) and changes in exchange rates. The mean, standard deviation and annualized standard deviation of forecast errors are reported for forecast horizons of 3, 6, and 9 months. Correlations between exposures and exchange rates are calculated in two ways. The first two columns under correlations show values for forecast updates and changes in rates. The next three columns show quarterly or year-over-year correlations using time series data. The average is of columns 1-4. Currencies A-O are full-sample currencies and Currencies P-X are partial-sample currencies. Values are calculated using 14 quarters of data.

		Exposure Forecast Errors					Correlations (Exchange Rate v. Exposure)					
		9 Month	6 Month	3 Month	Mean		Sub-periods	Actual - 9 Mo.	Qtrly Levels	Qtrly % Ch.	Yr-Yr % Ch.	Mean
Totals												
Full-Sample	Mean	1.22%	-4.61%	-3.92%	-2.43%	6-9 Mo.	0.22	0.43	-0.91	0.33	-0.55	-0.18
Currencies	STD	16.51%	7.99%	6.18%		3-6 Mo.	-0.08					
	An. STD	19.07%	11.31%	12.35%	14.24%	Act-3 Mo.	0.05					
Partial-Sample	Mean	-3.56%	-0.54%	1.00%	-1.03%	6-9 Mo.	0.21	0.34	-0.79	-0.01	0.80	0.08
Currencies	STD	21.17%	16.19%	8.98%		3-6 Mo.	-0.20					
	An. STD	24.45%	22.90%	17.96%	21.77%	Act-3 Mo.	0.07					
All	Mean	1.21%	-4.28%	-3.58%	-2.21%	6-9 Mo.	0.23	0.44	-0.93	0.34	-0.66	-0.20
Currencies	STD	15.97%	7.83%	5.75%		3-6 Mo.	-0.06					
	An. STD	18.44%	11.07%	11.51%	13.67%	Act-3 Mo.	0.13					
Full-Sample Currencies												
Currency A	Mean	-9.62%	-0.77%	1.17%	-3.07%	6-9 Mo.	0.14	0.11	0.56	-0.04	-0.01	0.16
	STD	27.77%	14.63%	10.18%		3-6 Mo.	0.02					
	An. STD	32.06%	20.69%	20.36%	24.37%	Act-3 Mo.	0.07					
Currency B	Mean	15.84%	14.25%	9.51%	13.20%	6-9 Mo.	0.15	0.76	-0.87	0.25	0.53	0.16
	STD	38.73%	25.27%	16.54%		3-6 Mo.	-0.10					
	An. STD	44.72%	35.74%	33.08%	37.85%	Act-3 Mo.	0.30					
Currency C	Mean	-12.33%	-6.11%	-6.15%	-8.20%	6-9 Mo.	0.07	-0.07	-0.88	-0.32	0.67	-0.15
	STD	10.60%	9.07%	7.95%		3-6 Mo.	-0.15					
	An. STD	12.24%	12.82%	15.89%	13.65%	Act-3 Mo.	0.17					
Currency D	Mean	-11.37%	3.13%	-0.91%	-3.05%	6-9 Mo.	0.17	-0.11	-0.70	-0.03	0.13	-0.18
	STD	22.74%	26.73%	26.37%		3-6 Mo.	-0.31					
	An. STD	26.26%	37.80%	52.75%	38.94%	Act-3 Mo.	-0.17					
Currency E	Mean	-3.94%	0.94%	-1.78%	-1.59%	6-9 Mo.	0.37	0.03	-0.90	-0.27	0.22	-0.23
	STD	16.63%	17.25%	10.83%		3-6 Mo.	0.38					
	An. STD	19.20%	24.39%	21.66%	21.75%	Act-3 Mo.	-0.25					
Currency F	Mean	0.07%	6.20%	-2.33%	1.31%	6-9 Mo.	0.56	0.18	-0.84	0.41	0.71	0.12
	STD	32.59%	24.02%	15.15%		3-6 Mo.	0.06					
	An. STD	37.64%	33.97%	30.30%	33.97%	Act-3 Mo.	0.63					
Currency G	Mean	1.59%	4.07%	1.55%	2.40%	6-9 Mo.	0.08	0.41	-0.69	-0.22	0.86	0.09
	STD	14.08%	9.14%	9.12%		3-6 Mo.	-0.08					
	An. STD	16.26%	12.92%	18.24%	15.81%	Act-3 Mo.	0.40					
Currency H	Mean	6.00%	11.25%	9.88%	9.04%	6-9 Mo.	-0.09	0.74	-0.65	0.28	0.75	0.28
	STD	21.11%	20.16%	19.20%		3-6 Mo.	-0.16					
	An. STD	24.38%	28.51%	38.40%	30.43%	Act-3 Mo.	0.14					
Currency I	Mean	1.79%	2.66%	1.46%	1.97%	6-9 Mo.	0.23	0.38	-0.79	-0.05	0.64	0.05
	STD	15.69%	16.73%	14.98%		3-6 Mo.	0.03					
	An. STD	18.12%	23.66%	29.96%	23.91%	Act-3 Mo.	0.06					
Currency J	Mean	30.01%	22.96%	23.46%	25.48%	6-9 Mo.	0.49	0.63	-0.65	-0.04	0.47	0.10
	STD	52.23%	40.47%	43.81%		3-6 Mo.	0.00					
	An. STD	60.31%	57.23%	87.62%	68.39%	Act-3 Mo.	0.16					

Table 6 (continued)

		Exposure Forecast Errors					Correlations (Exchange Rate v. Exposure)					
		9 Month	6 Month	3 Month	Mean		Sub-periods	Actual - 9 Mo.	Qtrly Levels	Qtrly % Ch.	Yr-Yr % Ch.	Mean
Currency K	Mean	19.63%	12.95%	2.59%	11.73%	6-9 Mo.	0.31	-0.01	-0.66	-0.01	0.26	-0.11
	STD	62.54%	42.87%	24.50%		3-6 Mo.	0.04					
	An. STD	72.22%	60.63%	49.00%	60.62%	Act-3 Mo.	-0.30					
Currency L	Mean	2.42%	-3.31%	-0.74%	-0.54%	6-9 Mo.	-0.12	-0.28	-0.85	0.48	0.28	-0.09
	STD	24.79%	14.15%	12.55%		3-6 Mo.	0.22					
	An. STD	28.62%	20.01%	25.11%	24.58%	Act-3 Mo.	-0.16					
Currency M	Mean	-1.88%	-0.32%	2.67%	0.16%	6-9 Mo.	0.04	0.51	-0.73	-0.30	-0.26	-0.20
	STD	26.49%	11.76%	8.08%		3-6 Mo.	0.15					
	An. STD	30.59%	16.63%	16.17%	21.13%	Act-3 Mo.	0.22					
Currency N	Mean	9.46%	11.48%	5.94%	8.96%	6-9 Mo.	0.16	-0.21	-0.69	0.03	0.37	-0.12
	STD	28.02%	24.85%	13.15%		3-6 Mo.	0.15					
	An. STD	32.36%	35.15%	26.30%	31.27%	Act-3 Mo.	0.28					
Currency O	Mean	0.84%	-1.20%	2.31%	0.65%	6-9 Mo.	-0.35	0.56	-0.36	0.13	0.64	0.24
	STD	17.11%	18.91%	22.34%		3-6 Mo.	-0.40					
	An. STD	19.75%	26.74%	44.68%	30.39%	Act-3 Mo.	0.25					
Partial-Sample Currencies												
Currency P	Mean	-10.98%	5.22%	7.40%	0.55%	6-9 Mo.	-0.08	0.45	0.10	-0.26	--	0.10
	STD	27.23%	34.30%	31.88%		3-6 Mo.	-0.21					
	An. STD	31.44%	48.50%	63.76%	47.90%	Act-3 Mo.	0.16					
Currency Q	Mean	-7.73%	-4.62%	-2.39%	-4.91%	6-9 Mo.	-0.18	-0.14	-0.79	-0.15	0.55	-0.13
	STD	23.29%	15.79%	14.57%		3-6 Mo.	0.03					
	An. STD	26.90%	22.34%	29.14%	26.12%	Act-3 Mo.	-0.17					
Currency R	Mean	32.82%	4.75%	2.04%	13.20%	6-9 Mo.	0.15	-0.40	-0.58	-0.77	0.70	-0.27
	STD	116.14%	61.82%	43.52%		3-6 Mo.	-0.02					
	An. STD	134.11%	87.42%	87.04%	102.86%	Act-3 Mo.	-0.14					
Currency S	Mean	-18.79%	1.15%	8.26%	-3.13%	6-9 Mo.	0.21	0.82	-0.91	0.11	0.05	0.02
	STD	24.40%	28.09%	13.23%		3-6 Mo.	0.20					
	An. STD	28.18%	39.72%	26.46%	31.46%	Act-3 Mo.	-0.12					
Currency T	Mean	-10.04%	-25.78%	-13.34%	-16.39%	6-9 Mo.	0.54	0.24	-0.72	-0.41	--	-0.30
	STD	78.10%	20.48%	13.16%		3-6 Mo.	0.03					
	An. STD	90.18%	28.96%	26.31%	48.48%	Act-3 Mo.	-0.56					
Currency U	Mean	22.29%	23.78%	11.39%	19.15%	6-9 Mo.	-0.08	0.23	-0.06	0.31	--	0.16
	STD	58.01%	49.50%	24.95%		3-6 Mo.	-0.44					
	An. STD	66.98%	70.00%	49.90%	62.30%	Act-3 Mo.	-0.26					
Currency V	Mean	-19.50%	-2.72%	0.61%	-7.20%	6-9 Mo.	0.06	-0.04	-0.65	-0.16	--	-0.28
	STD	81.86%	75.39%	73.44%		3-6 Mo.	-0.26					
	An. STD	94.52%	106.62%	146.88%	116.01%	Act-3 Mo.	-0.24					
Currency W	Mean	76.57%	68.19%	48.36%	64.38%	6-9 Mo.	-0.13	-0.87	-0.58	0.33	--	-0.37
	STD	90.59%	71.24%	48.67%		3-6 Mo.	-0.01					
	An. STD	104.61%	100.75%	97.33%	100.90%	Act-3 Mo.	-0.27					
Currency X	Mean	85.90%	53.75%	27.93%	55.86%	6-9 Mo.	0.66	-0.32	-0.47	-0.46	--	-0.42
	STD	76.18%	52.38%	26.29%		3-6 Mo.	-0.19					
	An. STD	87.96%	74.07%	52.58%	71.54%	Act-3 Mo.	0.14					

Table 7: Notional Values and Hedge Parameters of Derivative Holdings

This table presents the average, minimum, and maximum values across 14 quarters for notional value as a percent of exposure, normalized delta, normalized gamma, and normalized vega. Forecast horizon is the number of months before the close of the relevant quarter. Values for delta, gamma and vega are normalized to a notional exposure of 1.0. For partial-sample currencies averages are calculated using only hedge quarters (as defined in main text). Totals are weighted by actual dollar exposure. Currencies A-O are full-sample currencies and Currencies P-X are partial-sample currencies.

		Notional Value			Normalized Delta			Normalized Gamma			Normalized Vega		
Forecast Horizon		9 Mo.	6 Mo.	3 Mo.	9 Mo.	6 Mo.	3 Mo.	9 Mo.	6 Mo.	3 Mo.	9 Mo.	6 Mo.	3 Mo.
Totals													
Full-Sample	Mean	33.4%	59.7%	76.8%	-0.17	-0.31	-0.46	1.38	2.76	4.20	0.10	0.14	0.11
Currencies	Min	9.1%	28.3%	51.0%	-0.26	-0.53	-0.74	0.60	1.62	1.63	0.03	0.07	0.04
	Max	48.8%	78.5%	96.9%	-0.05	-0.15	-0.17	2.05	4.84	7.90	0.15	0.20	0.17
Partial-Sample	Mean	0.6%	5.0%	15.7%	-0.01	-0.05	-0.14	0.01	0.08	0.24	0.00	0.00	0.00
Currencies	Min	0.0%	0.0%	0.0%	-0.07	-0.29	-0.47	0.00	0.00	0.00	0.00	0.00	0.00
	Max	7.7%	30.9%	48.9%	0.00	0.00	0.00	0.08	0.53	1.38	0.01	0.02	0.02
All	Mean	31.8%	56.9%	73.6%	-0.16	-0.30	-0.44	1.31	2.62	4.00	0.10	0.13	0.10
Currencies	Min	8.3%	26.7%	49.5%	-0.25	-0.49	-0.68	0.55	1.59	1.51	0.03	0.07	0.04
	Max	46.5%	73.7%	91.7%	-0.04	-0.15	-0.16	1.88	4.54	7.41	0.15	0.18	0.16
Full-Sample Currencies													
Currency A	Mean	32.3%	53.8%	64.4%	-0.16	-0.24	-0.28	1.48	2.94	4.28	0.10	0.14	0.11
	Min	10.3%	14.2%	19.2%	-0.40	-0.42	-0.49	0.62	1.08	1.48	0.03	0.04	0.04
	Max	88.2%	101.2%	103.1%	-0.06	-0.05	-0.04	3.19	6.77	7.86	0.30	0.28	0.16
Currency B	Mean	36.7%	64.3%	92.1%	-0.18	-0.37	-0.60	1.32	2.60	4.39	0.12	0.15	0.13
	Min	10.2%	29.6%	65.3%	-0.42	-0.60	-1.14	0.48	1.37	0.54	0.03	0.07	0.02
	Max	89.1%	112.7%	140.3%	-0.05	-0.08	-0.16	2.80	4.16	8.58	0.31	0.30	0.24
Currency C	Mean	33.1%	69.9%	84.8%	-0.17	-0.37	-0.50	1.40	3.28	4.74	0.11	0.17	0.13
	Min	9.9%	22.6%	62.9%	-0.36	-0.67	-0.84	0.52	1.53	0.83	0.03	0.06	0.03
	Max	66.4%	112.6%	109.6%	-0.04	-0.16	-0.21	2.90	6.31	9.01	0.23	0.31	0.23
Currency D	Mean	38.8%	56.1%	80.3%	-0.17	-0.26	-0.39	1.49	2.38	3.95	0.11	0.13	0.10
	Min	9.0%	34.1%	49.3%	-0.35	-0.63	-0.84	0.56	1.39	0.60	0.03	0.06	0.02
	Max	84.2%	70.7%	104.8%	-0.04	-0.05	-0.01	2.29	3.36	8.21	0.18	0.18	0.20
Currency E	Mean	30.4%	55.6%	81.5%	-0.15	-0.29	-0.50	1.24	2.36	3.89	0.10	0.13	0.12
	Min	8.4%	20.1%	45.5%	-0.26	-0.57	-0.87	0.44	1.23	0.88	0.02	0.05	0.03
	Max	50.0%	75.4%	99.1%	-0.04	-0.15	-0.17	2.31	3.76	9.62	0.17	0.19	0.20
Currency F	Mean	27.8%	52.9%	75.9%	-0.14	-0.29	-0.50	1.10	2.33	3.73	0.09	0.13	0.11
	Min	5.6%	19.8%	44.3%	-0.26	-0.56	-0.86	0.25	1.05	0.64	0.02	0.05	0.02
	Max	50.1%	85.0%	99.5%	-0.02	-0.14	-0.18	2.17	4.01	7.55	0.17	0.20	0.20
Currency G	Mean	39.9%	71.7%	88.6%	-0.17	-0.32	-0.44	1.73	3.57	5.44	0.13	0.17	0.13
	Min	10.0%	28.5%	69.2%	-0.34	-0.59	-0.81	0.61	2.10	0.97	0.03	0.08	0.03
	Max	85.0%	104.2%	103.9%	-0.05	-0.12	-0.11	3.18	7.67	9.69	0.28	0.28	0.20
Currency H	Mean	42.9%	69.3%	82.8%	-0.22	-0.34	-0.45	1.80	3.54	5.05	0.14	0.17	0.13
	Min	9.7%	28.4%	53.0%	-0.50	-0.61	-0.90	0.59	1.55	0.79	0.03	0.08	0.03
	Max	84.2%	107.0%	109.4%	-0.04	-0.16	-0.22	3.05	8.73	11.58	0.28	0.30	0.23
Currency I	Mean	43.1%	77.7%	86.1%	-0.23	-0.41	-0.54	1.41	2.93	3.42	0.14	0.19	0.12
	Min	9.5%	52.0%	54.2%	-0.51	-0.68	-1.17	0.37	1.84	0.71	0.03	0.13	0.03
	Max	84.6%	107.0%	132.4%	-0.07	-0.22	-0.17	2.70	4.62	5.88	0.27	0.27	0.19
Currency J	Mean	51.8%	80.5%	93.2%	-0.29	-0.46	-0.61	1.79	3.41	4.60	0.15	0.18	0.13
	Min	9.8%	30.3%	39.7%	-0.83	-0.90	-1.00	0.00	0.00	0.00	0.00	0.00	0.00
	Max	108.8%	127.6%	149.5%	-0.04	-0.21	-0.19	4.20	9.04	13.75	0.37	0.36	0.31

Table 7 (continued)

		Notional Value			Normalized Delta			Normalized Gamma			Normalized Vega		
Forecast Horizon		9 Mo.	6 Mo.	3 Mo.	9 Mo.	6 Mo.	3 Mo.	9 Mo.	6 Mo.	3 Mo.	9 Mo.	6 Mo.	3 Mo.
Currency K	Mean	35.0%	65.7%	94.9%	-0.18	-0.40	-0.60	1.43	2.69	4.43	0.11	0.14	0.11
	Min	0.0%	38.2%	60.3%	-0.50	-0.75	-1.36	0.00	0.00	0.00	0.00	0.00	0.00
	Max	86.0%	110.9%	188.7%	0.00	-0.16	-0.12	4.00	5.37	17.06	0.28	0.26	0.37
Currency L	Mean	31.6%	68.2%	74.1%	-0.16	-0.39	-0.48	1.36	2.89	3.61	0.10	0.15	0.10
	Min	0.0%	22.2%	36.1%	-0.29	-0.86	-0.98	0.00	0.00	0.00	0.00	0.00	0.00
	Max	53.8%	88.4%	105.2%	0.00	-0.15	-0.12	2.37	5.44	7.32	0.18	0.21	0.17
Currency M	Mean	27.5%	49.9%	64.4%	-0.12	-0.23	-0.35	2.30	4.37	7.32	0.09	0.12	0.11
	Min	0.0%	22.0%	37.7%	-0.29	-0.43	-0.88	0.00	1.36	2.72	0.00	0.06	0.06
	Max	74.8%	106.0%	119.7%	0.00	-0.09	-0.07	6.67	7.31	15.50	0.25	0.19	0.25
Currency N	Mean	12.0%	16.4%	27.5%	-0.07	-0.11	-0.28	-0.08	-0.44	0.20	0.00	0.01	0.01
	Min	0.0%	0.0%	0.0%	-0.34	-0.54	-0.90	-1.52	-3.92	0.00	-0.04	-0.03	0.00
	Max	59.0%	91.9%	90.2%	0.00	0.00	0.00	0.88	0.97	2.12	0.06	0.07	0.10
Currency O	Mean	18.4%	43.8%	61.1%	-0.10	-0.22	-0.31	0.96	2.63	3.97	0.06	0.11	0.10
	Min	0.0%	18.5%	36.4%	-0.22	-0.37	-0.65	0.00	1.15	2.01	0.00	0.05	0.05
	Max	42.5%	70.8%	114.5%	0.00	-0.06	-0.07	2.18	4.29	6.78	0.14	0.20	0.17
Partial-Sample Currencies													
Currency P	Mean	8.6%	39.0%	70.3%	-0.05	-0.25	-0.55	0.40	1.77	2.96	0.03	0.09	0.09
	Min	0.0%	0.0%	41.0%	-0.13	-0.58	-0.78	0.00	0.00	1.52	0.00	0.00	0.04
	Max	26.8%	84.5%	92.7%	0.00	0.00	-0.23	1.19	3.05	4.12	0.09	0.20	0.12
Currency Q	Mean	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Max	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Currency R	Mean	0.0%	2.7%	66.8%	0.00	-0.03	-0.61	0.00	0.00	0.71	0.00	0.00	0.01
	Min	0.0%	0.0%	0.0%	0.00	-0.27	-2.95	0.00	0.00	0.00	0.00	0.00	0.00
	Max	0.0%	26.5%	295.0%	0.00	0.00	0.00	0.00	0.00	7.09	0.00	0.00	0.10
Currency S	Mean	4.9%	30.7%	49.7%	-0.05	-0.28	-0.46	0.00	0.73	1.25	0.00	0.02	0.02
	Min	0.0%	0.0%	0.0%	-0.29	-0.67	-0.90	0.00	0.00	0.00	0.00	0.00	0.00
	Max	29.4%	67.5%	93.6%	0.00	0.00	0.00	0.00	3.12	4.95	0.00	0.07	0.05
Currency T	Mean	3.7%	52.6%	83.0%	-0.04	-0.53	-0.83	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.0%	0.0%	0.0%	-0.19	-1.02	-1.74	0.00	0.00	0.00	0.00	0.00	0.00
	Max	18.7%	101.8%	174.2%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Currency U	Mean	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Max	0.0%	0.0%	0.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Currency V	Mean	0.0%	3.3%	18.7%	0.00	-0.03	-0.19	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.0%	0.0%	0.0%	0.00	-0.10	-0.29	0.00	0.00	0.00	0.00	0.00	0.00
	Max	0.0%	10.0%	29.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Currency W	Mean	0.0%	12.2%	43.7%	0.00	-0.12	-0.44	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.0%	0.0%	0.0%	0.00	-0.49	-1.04	0.00	0.00	0.00	0.00	0.00	0.00
	Max	0.0%	48.9%	104.0%	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Currency X	Mean	0.0%	63.7%	105.4%	0.00	-0.64	-0.91	0.00	0.00	0.00	0.00	0.00	0.00
	Min	0.0%	0.0%	31.6%	0.00	-1.53	-2.37	0.00	0.00	0.00	0.00	0.00	0.00
	Max	0.0%	153.1%	237.5%	0.00	0.00	-0.32	0.00	0.00	0.00	0.00	0.00	0.00

Table 8: Determinants of Hedge Portfolio Characteristics

This table shows coefficient estimates and t-statistics from fixed-effects panel regressions for 14 quarters and the 15 full-sample currencies (N=210). The dependent variables are the hedge portfolio parameters (delta, gamma, and vega) for 9-, 6-, and 3-month exposure forecast horizons. The independent variables are defined as follows: FX volatility is the implied volatility for the USD/FCU exchange rate for the appropriate horizon. Exposure volatility is the absolute difference between the exposure forecast and the actual exposure. Derivative P&L (t-1) is the actual profit or loss on the hedge in the previous quarter. Spot % Below (Above) USD/FCU 12 Month high is the percentage difference between the current spot exchange rate (as measured in USD/FCU) and the highest (lowest) level of the spot exchange rate in the previous 12 months using daily values. 3-Month Change in Spot is the percentage change in the spot exchange rate over the previous 60 trading days. Forward Points (%) is the difference in percent between the 6-month forward exchange rate and the spot exchange rate. The asterisks (*, **, ***) represent significance in a two-tailed test at the 10%, 5%, and 1% levels, respectively. Hausman specification tests for random effects vs. fixed effects did not consistently choose one model over the other. However, the size and significance of coefficient estimates for the two models did not differ dramatically. T-statistics are calculated using heteroskedasticity-robust standard errors. The first observations for Derivative P&L (t-1) are set to the average for the remaining 13 quarters. Alternatively, omitting the first quarter did not appreciably effect the results.

		Delta			Gamma			Vega		
Independent Variable		Prior 9 Mo.	6 Mo.	3 Mo.	Prior 9 Mo.	6 Mo.	3 Mo.	Prior 9 Mo.	6 Mo.	3 Mo.
FX Volatility	coef.	- -0.92 **	0.11	0.46	- -1.80	#### ***	#### ***	0.67 ***	0.44 *	-0.16
	t-stat	-2.02	0.18	0.57	-0.50	-2.95	-4.97	2.68	1.89	-0.76
Forward Points (%)	coef.	+ 0.44	1.58	-7.24 **	0.57	####	60.63 *	-0.23	-0.86	1.39 *
	t-stat	0.25	0.64	-2.41	0.04	-0.67	1.81	-0.24	-0.93	1.79
Exposure Volatility	coef.	+ 0.33 **	0.40 **	0.40	+ 0.52	0.64	-0.29	+ -0.03	0.01	-0.02
	t-stat	2.23	1.98	1.57	0.65	0.35	-0.11	-0.33	0.19	-0.02
Spot % Below 12 Month High	coef.	-0.28	-0.58 **	0.77 **	4.28 ***	-3.49	-0.08	0.27 **	-0.16 *	-0.04
(USD/FCU)	t-stat	-1.44	-2.29	1.97	2.79	-1.50	-0.02	2.50	-1.73	-0.37
Spot % Above 12 Month Low	coef.	0.10	0.48	1.89 ***	3.82	#### ***	-8.69	0.30 *	-0.47 ***	-0.27 *
(USD/FCU)	t-stat	0.32	1.10	3.24	1.56	-2.81	-1.33	1.75	-2.88	-1.78
3 Month Change in Spot	coef.	0.45 **	0.40	0.09	-2.20	5.77 **	10.27 **	-0.27 **	0.20 *	0.27 ***
(USD/FCU)	t-stat	2.09	1.36	0.21	-1.30	2.13	2.32	-2.30	1.79	2.61
Derivative P&L (t-1)	coef.			-1.88 ***			#### ***			-0.60 ***
	t-stat			-4.09			-4.45			-4.97
Adjusted R-squared		0.21	0.37	0.55	0.25	0.42	0.53	0.290	0.37	0.510