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Corporate Risk Management under Information Asymmetry

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Abstract: This paper examines the financial and operational hedging activities of US pharmaceutical and biotech firms that are subject to a high level of information asymmetry stemming from R&D investments during 2001–2006. We find evidence in support of the information asymmetry hypothesis à la Froot, Scharfstein and Stein (1993) that hedging helps mitigate the under-investment problem. Specifically, we find that the use of financial derivatives is associated with greater firm value and that the value enhancement is larger for firms subject to greater information asymmetry and better growth opportunities. There is a synergy between financial hedging and operational hedging where the latter is used to counter product development risk. The results are robust with respect to alternative performance measures, industry-specific growth measures, and the endogeneity problem. Our work is differentiated from existing studies that examined commodity-based industries without addressing information asymmetry.

Keywords: corporate risk management, R&D, financial hedging, operational hedging, information asymmetry, pharmaceutical or biotech firms

1. INTRODUCTION

With perfect capital markets, corporate risk management is irrelevant since shareholders can hedge risk on their own at the same cost as the firm. In the real world, market imperfections such as taxes, agency costs or information asymmetry provide a rationale for corporate risk management. Therefore, hedging can be a value-enhancing strategy for a firm under imperfect markets. We are particularly interested in information asymmetry, which has several implications for corporate risk management. One approach focuses on the impact of information asymmetry on the cost of capital and the attendant investment outcome. Froot, Scharfstein and Stein (1993) theorize that hedging can help relieve the under-investment problem when a firm faces growth opportunities. Uncertainty in the valuation of the firm's assets due to

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information asymmetry may cause under-investment assuming that external financing is costlier than internal financing. In a similar vein, DeMarzo and Duffie (1995) argue theoretically that hedging improves the information content of corporate earnings as a signal for managerial ability. Risk management can thus free management to pursue optimal corporate investment and growth leading to value enhancement, and information asymmetry is an important issue in this.[1]

Empirical results in existing studies are ambiguous with respect to the valuation impact of corporate hedging. Tufano (1996) and Jin and Jorion (2007) find no relation between hedging and firm value for gold mining firms. Similarly, Jin and Jorion (2006) find no evidence of value premium associated with hedging for oil and gas producers. However, Mackay and Moeller (2007) and Carter, Rogers and Simkins (2006) report positive hedging value premiums for oil refiners and airliners, respectively. These studies examined corporate hedging in largely commodity-based industries where information asymmetry is unlikely to be significant. Industry-wide studies such as Geczy, Minton and Schrand (1997), Graham and Rogers (2002) and Allayannis and Weston (2001) also show varying hedging premiums due to such factors as taxes, multinationality and others, but none document the role of information asymmetry in the motives or the consequences of corporate hedging.

In this paper, we examine the implications of information asymmetry for corporate risk management by focusing on financial and operational hedging activities of pharmaceutical and biotech firms. According to the Lehman Brothers Report in 2003, the estimated total R&D expenses in 2002 were US$ 55 billion, of which at least US$ 37 billion was in drug development. A salient feature of pharmaceutical and biotech firms is that they are subject to a high degree of information asymmetry stemming from R&D investments. Investment in new product development increases growth opportunities, but it also heightens risk for the firm. Product development in these industries requires multiple phases with long gestation periods, has low odds of success, and very few outsiders have good information about individual projects (Pisano, 1989; Nicholoson, Danzon and McCullough, 2005). As such, pharmaceutical and biotech firms often develop multiple products for the same market to increase the probability of having at least one successful drug (Girotra, Terwiech and Ulrich, 2007).

The high level of information asymmetry due to the essentiality of R&D activities separates the pharmaceutical and biotech firms from those in gold mining, airline, or oil and gas industries examined in existing work where commodity risk is paramount. While R&D is essential for product development and growth in the pharmaceutical and biotech industry, the uncertainty of the R&D process is such that the possibility of failure makes external financing costly. Aboody and Lev (2000) show that R&D is a major source of information asymmetry between corporate insiders and stockholders. Guo, Lev and Zhou (2004) similarly show that information asymmetry is significantly higher for biotech companies than for other firms. Although information asymmetry admittedly is a generic problem across all industries, pharmaceutical and biotech firms are particularly sensitive to information asymmetry stemming from R&D investments as well as the long, uncertain period of development, certification and approval processes. These characteristics of high information asymmetry, high growth potential and costly external financing make the pharmaceutical and biotech industry unique and

1 Another approach emphasizes managerial motivations for hedging in the presence of agency cost. For example, Smith and Stulz (1985) theorize the manager's personal wealth and utility as a basis of corporate hedging; they are silent as to whether or not corporate hedging leads to value enhancement.

particularly well suited for an investigation of the information asymmetry hypothesis à la Froot, Scharfstein and Stein (1993).

We find evidence in support of the information asymmetry hypothesis à la Froot, Scharfstein and Stein (1993) that financial hedging helps mitigate the under-investment problem. Specifically, we find that firms with greater information asymmetry experience greater value enhancement through financial hedging. The value enhancement from hedging is greater for firms subject to greater information asymmetry as well as larger growth opportunities. Combined use of financial and operational hedging is beneficial because operational hedging can reduce a firm's product development risk while financial hedging can reduce transaction risk exposure. We used detailed growth measures specific to the pharmaceutical and biotech industry such as the number of patents and products-in-pipeline in addition to the usual proxy variables for operational hedging. The results are robust with respect to alternative performance measures, industry-specific growth measures, or the endogeneity problem.

We estimate that the hedging premium of our sample of pharmaceutical and biotech firms is about 13.8%. The magnitude of the hedging premium not only contrasts with Tufano (1996) and Jin and Jorion (2006, 2007) who found no hedging premiums for gold mining, or oil and gas producers, but is also greater than those documented for oil refiners (Mackay and Moeller, 2007) or airliners (Carter, Rogers and Simkins, 2006). We attribute this difference to higher information asymmetry in pharmaceutical and biotech firms compared to mining or commodity firms which are more transparent. Such attribution is supported by evidence that shows the significance of proxy variables measuring growth, financial constraints and information asymmetry. On the whole, these results support the information asymmetry hypothesis in Froot, Scharfstein and Stein (1993) that value enhancement results from hedging that helps relieve the under-investment problem arising from information asymmetry. We believe this is the first work of its kind that tests the specific Froot–Scharfstein–Stein information hypothesis or the role of information asymmetry in hedging non-commodity risk.

The rest of the paper is organized as follows. Section 2 reviews existing work and develops hypotheses. Section 3 describes data and variables used in our empirical tests. In Section 4, we present basic empirical results, and Section 5 reports additional results as robustness check. Section 6 concludes the paper.

2. EXISTING WORK AND HYPOTHESIS DEVELOPMENT

(i) Financial Hedging and Firm Value

Prior research has explored several theories of hedging, in which optimal hedging policies are derived from introducing some friction into the classic Modigliani and Miller (1958) world. Smith and Stulz (1985) argue that financial hedging can reduce the expected tax liability if taxes are a convex function of earnings. They further suggest, as well as Mayers and Smith (1982), that hedging can reduce the likelihood of financial distress and thus enhance expected firm value. The increase in firm value arises from a reduction in the deadweight cost of bankruptcy. Froot, Scharfstein and Stein (1993) present a model in which managers possess private information, and the information asymmetry between the managers and outside investors causes external financing to be more costly than internal funding. They argue that the stability of internal funds that can be achieved by corporate hedging might be helpful in mitigating the underinvestment problem, suggesting that hedging will be more valuable to firms with greater growth opportunities and with more costly external financing. Hedging would be value-enhancing to the extent that the firm has sufficient internal capital to take advantage of investment opportunities.

Another line of theory argues that hedging is a result of managers' incentive to maximize their personal utility function (Smith and Stulz, 1985), suggesting that poorly diversified managers would prefer to hedge. Thus the incentive for a firm to hedge should increase with managers' equity ownership, and has implications for the design of the compensation contract in order to motivate optimal hedging by managers. DeMarzo and Duffie (1995) suggest that hedging improves the informativeness of corporate earnings as a signal of management ability and project quality by eliminating extraneous noise. However, given the career objectives of managers, the extent to which optimal hedging strategies are chosen is a function of accounting policies and the nature of information conveyed by these policies. In the same vein, Marshall and Weetman (2007) find that managers do not fully disclose information related to foreign exchange risk management, particularly in competitive industries. Chung et al. (2012) find that a mechanical increase in the quantity of derivative disclosures does not lead to a more rational equity valuation, suggesting the importance of the quality of derivative disclosure information.

Most empirical studies on corporate hedging have focused on the relationship between hedging policy and firm characteristics. For example, Haushalter (2000) documents a significantly positive relationship between hedging and leverage, lending support to a view that hedging mitigates the likelihood of financial distress and thereby increases debt capacity. Graham and Rogers (2002) also find that debt capacity is important but that the tax shield is not a primary driver of the firm's hedging policy. Various empirical studies such as Geczy, Minton, and Schrand (1997) and Allayannis and Ofek (2001) document a positive relationship between the hedging policy and the firm's growth opportunities. Regarding the *valuation* impact, Allayannis and Weston (2001) find that the Tobin's Q of the US multinational firms using foreign currency derivatives is 5.7% higher than that of the non-users during 1990–95. Kim, Mathur and Nam (2006) also show a hedging premium of similar magnitude for US firms in 1998. Focusing on non-linearity, MacKay and Moeller (2007) report that exposed concave revenues and concave costs subject to hedging each represent about 2% of firm value for 34 oil refiners for the period from 1985 to 2004. In contrast, Jin and Jorion (2006, 2007) respectively study 119 US oil and gas producers during 1998–2001 and 44 North American gold mining firms during 1991–2000, and find no evidence that financial hedging improves firm value.

Industries studied in existing literature – gold mining (Tufano, 1996; Jin and Jorion, 2007), airline (Carter, Rogers and Simkins, 2006), and oil and gas (Jin and Jorion, 2006) – are similar in that a major source of risk is commodity-based. The commodity risk exposure is relatively easy to identify and hedge by individual investors and also is less subject to information asymmetry. In contrast, information asymmetry is severe in the pharmaceutical and biotech industry due to the essentiality of the R&D investments, which are more difficult to value and whose risk is more complex. The high level of information asymmetry, growth opportunities, and potential external financing constraints make the pharmaceutical and biotech industry well-suited for an investigation into the potential channel by which financial hedging affects firm value.

As suggested by Froot, Scharfstein and Stein (1993), hedging may help relieve the underinvestment problem, when firms have many growth opportunities and external financing is more expensive than internally generated funds. Information asymmetry in the pharmaceutical and biotech industry leads to a high cost of external financing and is therefore prone to the under-investment problem (Myers, 1977). This implies that hedging would be particularly beneficial for industries with these characteristics since a reduction of cash flow uncertainty by hedging would enable firms to rely on internal finance to capture positive NPV projects. Therefore, we develop the following testable hypotheses:

H_1: Firms with more severe information asymmetry will experience a greater value enhancement from financial hedging.

H_2: Firms with better growth opportunities will experience a greater value enhancement from financial hedging.

(ii) Endogeneity of Financial Hedging and Its Interaction with Operational Hedging

While we analyze the effect of financial hedging on firm value, we recognize the endogeneity in the decision to use derivatives. We argue that the extent of financial hedging depends on corporate characteristics as well as the alternative method of managing risk. As has been amply discussed in the previous section, the pharmaceutical and biotech firms are beset with growth and information asymmetry created by the high level of R&D intensity. In addition, the fast pace of innovation and fierce competition in the sector underscores the importance of advertisement or infomercial regarding new products or a new use of existing products. Advertising and R&D intensity are often used as measures of the value of growth or intangibles arising from internal markets (e.g., Morck and Yeung, 1991). Geczy, Minton and Schrand (1997) find that the use of currency derivatives is positively related to the amount of R&D investments. We expect that R&D and advertising intensity in pharmaceutical and biotech firms will have positive impacts on the use of financial derivatives.

An alternative way of managing risk for corporations is to hedge through business operations (Smith and Stulz, 1985). Multinational firms, with operations in different countries, may benefit from offsetting changes in currency exchange rates as well as risk reduction due to diversified operations. In addition, multinationals can exploit their network to utilize various channels of international fund transfers, inter-company loans and lead and lag of trade credits. Also, multinationals can access international capital markets to lower their overall cost of capital, shift profits to lower their taxes and take advantage of international diversification of markets and production sites to reduce the riskiness of their earnings (Shapiro, 1999). Allayannis, Ihrig and Weston (2001) and Guay and Kothari (2003) suggest that the exclusion of operational hedging can bias the observed valuation effect of financial hedging.

Several authors such as Lim and Wang (2007) and Kim, Mathur and Nam (2006) show that financial hedging and operational hedging are more often complementary than substitutive because financial hedging can be used to reduce the common component of profit variability while operational hedging can reduce firm-specific risk exposures. However, Allayannis, Ihrig and Weston (2001) find that operational hedging is not an effective substitute for financial risk management. Pantzalis, Simkins and Laux (2001), in contrast, find that the ability to construct operational hedging leads to lower currency exposures for the pooled sample as well as for firms with positive exposure (net importers) and negative exposure (net exporters). Choi and Kim (2003) document that the mitigation of Asian currency risk exposure by US firms is related to the pattern of their international asset deployment and operations as well as financial hedging. Similarly, Choi and Jiang (2009) show that multinational firms have lower exchange risk exposure coefficients than non-multinationals due to the greater use of operational hedging. Using an international sample, Bartram, Brown and Fehle (2009) also show that derivative use is related to operational hedging. These studies suggest varying degrees of complementarities between financial and operational hedging. Therefore, we have the following hypothesis:

H_3: The likelihood of a firm engaging in financial hedging is positively related to its involvement in operational hedging.

3. SAMPLE AND DATA DESCRIPTION

(i) Sample Selection

Our initial sample is obtained from COMPUSTAT North America Industrial files. We first select all firms with four-digit SIC codes of 2833 (Medicinal Chemicals and Botanical Products), 2834 (Pharmaceutical Preparations), 2835 (In Vitro and In Vivo Diagnostic Substances) and 2836 (Biological Products, Except Diagnostic Substances) that were present in the COMPUSTAT database in year 2001. These firms broadly represent the pharmaceutical and biotech industry. Appendix A lists the top three largest companies in terms of assets for each subgroup. We also report in Appendix B the mean values of a few firm characteristics variables for the four subsamples of firms with distinct four digits SIC codes. Firms in the industry of 'Pharmaceutical Preparations' and 'Biological Products (Except Diagnostic Substances)' are larger in size, are more R&D intensive, and have better investment opportunities as reflected in Tobin's Q than firms in the other subgroups. Firms from the 'In Vitro and In Vivo Diagnostic Substances' industry has the lowest leverage ratio but the highest profitability (ROA) compared to the other three subgroups.

We further restrict the sample to those with total assets of US$ 50 million or more. This is partly due to the lack of consistent data on financial and operational hedging for small firms. Large firms are also more likely to engage in hedging activities; very small firms lack sufficient resources to engage in hedging.

Our sample period is 2001 to 2006. We start our sample period in 2001 because beginning in 2001, every US firm should have started reporting the fair market values of derivatives rather than notional values as per the accounting guidelines laid out in FASB Statement 133 and subsequent related statements 137 and 138. Since we analyze firms' foreign exposure as either foreign sales or geographical diversification, we also limit our sample to the firms that are present in the COMPUSTAT segment files. This leads to a final sample of 74 pharmaceutical and biotech firms with 443 firm-year observations. There are 68 firms present in all years (2001–06).

The data on financial hedging activities are hand collected from the 10-K reports and notes of the annual statements from the EDGAR database. All firms in our sample explicitly mentioned in their 10-K filings or annual reports that they use financial derivatives for hedging purposes, not for speculation. Hence, we assume that, for our sample firms, using financial derivatives is equivalent to engaging in financial hedging.

Other firm characteristic variables are obtained from the COMPUSTAT annual industrial database. Operational segment data are retrieved from the SEGMENT files of the COMPUSTAT, and missing information is hand collected from the 10-K reports. Stock return data are obtained from the CRSP database. The number of subsidiaries and geographic segment data are hand collected from the corporate annual reports.

(ii) Variable Construction

(a) Measures of Firm Performance

The primary measure of firm performance is Tobin's Q. We compute Tobin's Q as the ratio of the market value of common equity plus the book value of debt and preferred equity to the book value of assets. We also used alternative measures of firm performance such as return on equity (ROE) and return on asset (ROA) and find similar results. ROE is operating income scaled by the market value of equity and ROA is net income scaled by total assets.

(b) Financial Hedging

To identify firms that use financial derivatives, we collect the fair market value of the derivatives carried and changes in the fair values of these derivatives. We record the total fair value of derivatives and the types of derivatives including futures, forwards, options and swaps for each firm in a particular year. Of the total firm-year observations of 443, about 63% or 277 observations indicate use of derivatives, and the rest (166 observations) indicate no use of derivatives. However, only 227 of the 277 observations report the nature and specific amount of financial derivatives positions.[2] To help readers understand what type of information is disclosed under FASB 133 and others, we present in Appendix C an example of derivatives disclosure by Bristol-Myers Squibb Co. in its 2002 10-K filings. Bristol-Myers Squibb provides detailed disclosures as to the types and amounts (both notional and fair market value) of financial derivatives it used to hedge interest rate and foreign currency risk in the fiscal year of 2002.

Panel A of Table 1 describes summary statistics of financial derivatives used by our sample firms that disclose their exact derivatives positions during 2001–06. This sample of pharmaceutical and biotech firms has on average US$ 33.035 million (fair market value) net position of all financial derivatives, in the form of forwards, futures, options and swaps. Prior studies have documented the usage of financial derivatives, however these have been documented in terms of notional values.[3] We do not report notional values of derivatives since our study focuses on the post- FASB Statement 133 period, in which firms are required to disclose fair market values of financial derivatives but not notional values. As a result, only a small proportion of our sample firms report the notional value of derivatives in addition to fair values. For comparison purposes, we also provide signed derivative data for specific types of instruments in Table 1, and report summary statistics on interest rate and foreign currency derivatives for the firms

2 That is, we do not have information on the exact amount of derivatives for 50 observations (about 11% of our sample) though we know they used derivatives.

3 Allayannis and Weston (2001) report that, from 1990–1995, the mean notional gross value of foreign currency derivatives is US$ 185.36 million for a sample of 720 large US non-financial firms. Kim, Mathur and Nam (2006) show that in a sample of 212 operationally hedged firms, mean derivatives usage is US$ 1,254 million (notional gross value).

Table 1

Descriptive Statistics for Corporate Uses of Financial Derivatives

Variables	*Mean*	*Median*	*Max*	*Min*	*Std. dev.*	*N*
Panel A: Derivative users (using interest rate and/or FOREX derivatives)						
Financial Derivatives ($ mill)	33.035	7.357	507.500	−224.800	108.416	227
Forward/Future ($ mill)	4.342	0.000	461.250	−265.000	71.339	227
Option ($ mill)	3.007	1.065	311.549	−358.540	61.233	227
Swaps ($ mill)	11.750	0.000	300.000	−52.972	53.651	227
Panel B: Interest rate derivative users						
Interest Rate Derivatives ($ mill)	62.170	16.900	456.91	−126.709	102.953	116
Panel C: FOREX derivative users						
FOREX Derivatives ($ mill)	19.524	8.370	507.500	−189.412	112.316	129

Notes:

Panel A presents summary statistics for the fair market value of financial derivative net positions by all pharmaceutical and biotech firms that report usage of financial derivatives during the period 2001 to 2006. Financial derivatives include both interest rate and foreign currency derivatives as reported by the firms at the end of each fiscal year. They are broken down into three types of derivative contracts: forward/futures, options and swaps. Panel B reports summary statistics on interest rate derivatives for the sample of firms that disclose such data. Panel C reports summary statistics on foreign currency derivatives for the sample of firms that disclose such data. *N* is the number of observations.

that disclose such data. The mean and median values of interest rate derivatives are US$ 62.17 million and US$ 16.90 million, respectively. The mean and median values of FOREX derivatives are US$ 19.52 million and US$ 8.37 million, respectively.[4]

As mentioned above, about 50 firm-year observations in our sample do not report the exact amount of financial derivatives, though they do disclose that they use derivatives at the end of the fiscal year. To include these observations in our analysis, we construct an indicator variable for financial hedging, *Dfinhedge*, which takes a value of one if a firm uses financial derivatives and zero otherwise.

We also measured financial hedging as a continuous variable that is the sum of the absolute fair market value of all the financial derivatives outstanding at the end of the fiscal year scaled by sales. The results of using this variable are similar to those of the hedging indicator variable in basic value estimations (results not reported but available upon request).

(c) Operational Hedging

We construct various measures of operational hedging following Allayannis and Weston (2001). They include the number of operating segments, the number of geographic segments, and the number of foreign subsidiaries. We use these variables individually, but we also construct an aggregate composite of operational hedging using factor analysis. For this we first perform factor analysis with the three operational hedging variables, and then generate principal factors based on the factor loading of each variable.

4 In Table 1, the number of observations in Panels B and C do not add up to the number of observations in Panel A. This is because some firms use both interest rate and foreign currency derivatives.

(d) Variables Proxy for Information Asymmetry

The model in Froot, Scharfstein and Stein (1993) suggests that firms facing greater information asymmetry will benefit more from hedging. To gauge the extent of information asymmetry a firm faces, we follow Frankel and Li (2004) and construct two variables to proxy for information asymmetry. One is the standard deviation of analyst earnings forecasts (*Forecast dispersion*) in a given year. The second is intangible assets divided by total assets (*Intangibles*). Baker and Gompers (2003) argue that in firms with greater intangible assets, the cost of information verification is very high. Intangible assets are particularly important in pharmaceutical and biotech firms. Hence we choose the proportion of intangible assets to book value of total assets as a proxy for information asymmetry.

(e) Variables Proxy for Growth Opportunities

We use several measures, including R&D intensity, as proxies for growth opportunities. R&D intensity is the ratio of R&D expenses to total assets. Geczy, Minton and Schrand (1997) find that the use of currency derivatives is positively related to the amount of R&D investments. Nance, Smith and Smithson (1993) document that firms with greater R&D intensity are more likely to hedge their foreign exchange exposure.

In addition to the R&D intensity, we also use the number of patents and products-in-pipeline as proxies for growth opportunities. Pharmaceutical and biotech firms maintain portfolios of new products under development at different stages. These products are unique and when fully developed, provide an exclusive right of marketing to the firm. Thus the number of patents and products-in-pipeline indicates the future growth opportunities of a firm. We hand collect data on these from corporate proxy reports and use them as alternative measures of growth opportunities for pharmaceutical and biotech firms.

(f) Other Variables

In the Tobin's Q regressions, we follow existing work (Morck and Yeung, 1991; Allayannis and Weston, 2001) and include several control variables, such as firm size, profitability, leverage, liquidity, advertising intensity, growth opportunities and firm risk. Firm size is measured by the natural logarithm of total assets. Profitability is measured by ROA. Leverage is measured as the book value of total debt scaled by total assets. *Ddividend* is a dummy variable for dividend paying firms. Advertising intensity is the ratio of advertising expenses to total assets. We also include the ratio of capital expenditures to total assets as an alternative measure of a firm's growth opportunities. Firm risk is proxied by the standard deviation of daily stock returns during the previous calendar year. To control for time effect and refined industry effect, we include dummy variables for each calendar year and each 4-digit SIC code in the regression.

We report a correlation matrix of the variables discussed above in Appendix D.

(iii) Descriptive Statistics

Table 2 reports descriptive statistics for our sample of pharmaceutical firms. We have about 64% of pharmaceutical and biotech firms in the sample using financial

Table 2
Sample Descriptive Statistics

Variable	*Mean*	*Median*	*Max*	*Min*	*Std. dev.*	*N*
Dfinhedge	0.635	1.000	1.000	0.000	0.494	443
Assets ($ mill)	9,194.614	1,656.237	123,684.000	57.301	18,766.630	443
Sales ($ mill)	5,485.846	738.096	53,194.000	0.419	10,728.550	443
Tobin's Q	2.932	2.591	9.934	0.421	1.663	398
Foreign sales	0.376	0.380	1.000	0.000	0.271	380
Nopseg	2.089	2.000	8.000	1.000	1.395	384
Ngeoseg	3.440	3.000	10.000	0.000	1.728	366
Nforgsub	36.775	11.500	438.000	0.000	63.970	356
Nproduct-pipeline	18.225	7.000	249.000	0.000	36.538	346
Npatent	68.419	7.000	1, 490.000	0.000	182.060	265
Forecast dispersion	0.065	0.024	1.984	0.000	0.182	307
R&D intensity	0.107	0.091	0.680	0.005	0.083	428
Capital intensity	0.042	0.034	0.301	0.000	0.034	398
Advertising intensity	0.011	0.000	0.240	0.000	0.028	398
Ddividend	0.423	0.000	1.000	0.000	0.495	426
Leverage	0.207	0.170	1.337	0.000	0.200	443
ROA	0.112	0.131	0.409	−0.478	0.145	443
RET Volatility	0.028	0.024	0.091	0.006	0.014	403
Intangibles	0.204	0.130	0.714	0.000	0.189	422

Notes:
This table provides summary statistics of the sample used in our analysis. The sample includes 74 firms in pharmaceutical and biotech industries (SIC codes of 2833, 2834, 2835 and 2836) for the period 2001–2006. *Dfinhedge* is a dummy variable that takes a value of one if a firm uses financial derivatives, and zero otherwise. *Tobin's Q* is the ratio of market value of assets to book value of assets. *Foreign sales* is the ratio of foreign sales to net sales. *Nopseg* is the number of operating segments. *Ngeoseg* is the number of geographical segments. *Nforgsub* is the number of foreign subsidiaries of a firm. *Nproduct-pipeline* is the number of products under development. *Npatent* is the number of patents. *Forecast dispersion* is the standard deviation of analyst earnings forecasts. *R&D intensity* is the ratio of total R&D expense to total assets. *Capital intensity* is the ratio of capital expenditures to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *Ddividend* is a dummy variable that equals one for firms paying dividends, and zero otherwise. *Leverage* is the ratio of book value of total debts to total assets. *ROA* is net income scaled by total assets. *RET Volatility* is the standard deviation of daily stock returns during the previous calendar year. *Intangibles* is the ratio of intangible assets to total assets. All the variables are winsorized at 1% and 99% values.

derivatives during 2001–06. We do have a large variation in firm size, given that the minimum and maximum of assets are US$ 57.3 million and US$ 123.684 billion, respectively. The book value of assets in our sample is comparable to that reported in Allayannis and Weston (2001) and Kim, Mathur and Nam (2006). Since the pharmaceutical and biotech industry is a high growth sector, our sample firms have a higher Tobin's Q than is reported in Allayannis and Weston (2001) for all industries.

4. EMPIRICAL RESULTS

In this section, we first perform the univariate tests to compare the users and non-users of financial derivatives. We then examine the valuation impacts of financial hedging as well as moderating variables such as information asymmetry and growth opportunities in a multivariate setting. Then we estimate a logit regression to estimate the likelihood of a firm using financial derivatives. To take account of endogeneity, we then use

Table 3
Univariate Tests of Users and Non-users of Financial Derivatives

Variable	*Financial Derivative Users*	*Financial Derivative Non-users*	*Difference*	*T-stat*
Tobin's Q	2.945	2.910	0.035	0.315
R&D intensity	0.104	0.118	−0.014	−1.469
Advertising intensity	0.013	0.006	0.007	2.615***
Capital intensity	0.042	0.040	0.002	0.447
Ngeoseg	3.977	2.669	1.308	8.056***
Nopseg	2.436	1.599	0.837	6.495***
Nforgsub	51.981	7.357	44.624	9.557***
Nproduct-pipeline	24.985	8.035	16.950	5.174***
Npatent	76.484	64.162	12.322	0.535
Forecast dispersion	0.075	0.057	0.018	0.702
ROA	0.151	0.046	0.085	3.869***
Firm size	9.708	6.778	2.830	13.686***
Foreign sales	0.459	0.261	0.198	7.390***
Leverage	0.208	0.205	0.003	0.061
RET Volatility	0.024	0.034	−0.010	−7.521***

Note:
This table reports the mean values of various characteristic variables for firms that use financial derivatives and those that do not use financial derivatives. *Tobin's Q* is the ratio of market value of assets to book value of assets. *R&D intensity* is the ratio of total R&D expense to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *Capital intensity* is the ratio of capital expenditures to total assets. *Ngeoseg* is the number of geographical segments. *Nopseg* is the number of operating segments. *Nforgsub* is the number of foreign subsidiaries of a firm. *Nproduct-pipeline* is the number of products under development. *Npatent* is the number of patents. *Forecast dispersion* is the standard deviation of analyst earnings forecasts. *ROA* is net income scaled by total assets. *Firm size* is the natural logarithm of sales. *Foreign sales* is the ratio of foreign sales to net sales. *Leverage* is the ratio of book value of total debts to total assets. *RET Volatility* is the standard deviation of daily stock returns during the previous calendar year. T-tests are used to examine the null hypothesis that the mean of each variable is the same between the two groups. *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

the predicted value of financial hedging from the logit regression as an explanatory variable in the performance regressions.

(i) Univariate Tests for Derivative Users and Non-users

In Table 3, we present results from tests of differences between the means of firm characteristics for users and non-users of financial derivatives. We do not find a significant performance difference in terms of Tobin's Q between users and non-users. However it is interesting that user firms show a significantly better performance in terms of the return on asset (ROA) than non-users. Nevertheless, the two groups of firms are no different with respect to variables concerning growth opportunities, including the R&D intensity, the number of patents, and the capital intensity. However, firms using financial derivatives have significantly larger numbers of operating segments, geographic segments, subsidiaries and foreign subsidiaries. This suggests a positive association between financial and operational hedging. In addition, user firms appear to be significantly larger in size, and to exhibit lower stock return volatility and more advertising intensity than non-users. These results are sensible since larger firms are better positioned to adopt a financial hedging program, and using derivatives enables firms to reduce the volatility of their stock returns.

Our evidence from the univariate tests parallels the mixed evidence in existing studies concerning whether the use of financial derivatives enhances value. However, we have noticed that other factors such as firm size and the extent of operational hedging are related to financial hedging policy as well as firm value. Therefore we proceed to a multivariate setting to formally test our hypotheses.

(ii) Impacts of Financial Hedging Interacted with Information Asymmetry and Growth Opportunities

To benchmark with existing studies, we first estimate the following regression model to assess the impact of financial hedging on firm value:

$$Ln(Tobin's\,Q) = \beta_0 + \beta_1{}^{*}\,Dfinhedge + \sum Control\ Variables + \varepsilon, \tag{1}$$

where Tobin's Q is a measure of firm value, *Dfinhedge* is a dummy variable for financial hedging. We also control for other variables that could have an impact on Tobin's Q, including ROA, firm size, the R&D intensity, the advertising intensity, the capital intensity, foreign sales ratio, a dummy for dividend paying firms, leverage and the volatility of stock return.

The regression results of equation (1) are reported in model (1) of Table 4. The coefficient estimate on the financial hedging dummy is positive and significant at the 5% level, indicating that financial hedging is associated with higher market valuation. As for the economic magnitude of the effect of financial hedging, given that the use of financial derivatives increases Ln(Tobin's Q) by 0.129 in model (1) while the sample mean of Tobin's Q is 2.932, we can compute a hedging premium of 13.8%.[5] This estimate of the hedging premium is larger than those documented (about 5%) by Allayannis and Weston (2001) and Allayannis, Ihrig and Weston (2001) for large industrial firms. The larger premium suggests the importance of hedging in pharmaceutical and biotech firms that face severe information asymmetry and large growth opportunities.

Our primary hypothesis for value enhancement with financial hedging is based on information asymmetry. If the firm value increases because financial hedging mitigates the under-investment problem as suggested by Froot, Scharfstein and Stein (1993), we would expect that the extent of value added will increase with the level of information asymmetry (H1) and growth opportunities (H2).

Information asymmetry is proxied by dispersion in analyst earnings forecasts, and the intangible asset ratios. For growth opportunities, we include not only the R&D intensity but also several variables specific to the pharmaceutical industry such as the number of products-in-pipeline, and the number of patents.[6] While all pharmaceutical and biotech firms invest heavily in R&D, they differ significantly in the number of products-in-pipeline and the number of patents. These unique measures from the pharmaceutical and biotech industry allow us to better gauge the growth opportunities of these firms.

5 Since the sample mean of Tobin's Q is 2.932, i.e., Ln (2.932) = 1.076, Ln(Tobin's Q) for financially hedged firms would be 0.129 + 1.076 = 1.205, which is equivalent to Tobin's Q of exp(1.205) = 3.337. Therefore the value premium of financial hedging (3.337 – 2.932)/2.932 = 13.8%.

6 As a robustness check, we scale the number of products-in-pipeline and the number of patents by the firm's total assets, and obtain qualitatively similar results.

Table 4

The Effects of Financial Hedging Interacted with Information Asymmetry, Growth Opportunities and Operational Hedging

	1	*2*	*3*	*4*	*5*	*6*
Dfinhedge (β_1)	0.129**	0.089	0.009	0.111	0.067	0.112
	(2.062)	(1.027)	(0.115)	(1.553)	(0.804)	(1.581)
*Dfinhedge * Forecast dispersion* (β_{21})		0.691***				
		(2.684)				
Forecast dispersion		−0.855***				
		(−3.805)				
*Dfinhedge * Intangibles* (β_{22})			0.544***			
			(2.648)			
Intangibles			−1.239***			
			(−6.427)			
*Dfinhedge * Nproduct-pipeline* (β_{23})				0.654***		
				(3.188)		
Nproduct-pipeline				0.011		
				(0.632)		
*Dfinhedge * Npatent* (β_{24})					0.069***	
					(3.183)	
Npatent					0.003*	
					(1.694)	
*Dfinhedge * Fophedge* (β_{25})						0.202**
						(2.071)
Fophedge						−0.316
						(−1.185)
Ddividend	−0.104	−0.023	−0.238***	−0.101	−0.078	−0.148
	(−1.404)	(−0.206)	(−2.900)	(−1.282)	(−0.875)	(−1.399)
ROA	2.263***	2.982***	1.813***	2.177***	2.243***	2.138***
	(8.488)	(5.442)	(6.839)	(8.120)	(6.388)	(6.856)
Firm Size	−0.027	−0.049**	0.013	−0.011	−0.006	−0.043**
	(−1.434)	(−2.402)	(0.726)	(−0.603)	(−0.250)	(−1.971)
R&D Intensity	3.490***	4.757***	2.623***	3.483***	3.675***	3.109***
	(11.396)	(8.093)	(8.799)	(10.008)	(8.536)	(9.006)

Table 4 (Continued)

	1	*2*	*3*	*4*	*5*	*6*
Capital Intensity	1.469*	0.735	0.406	1.546*	1.544	−1.118
	(1.879)	(0.568)	(0.547)	(1.936)	(1.549)	(−1.494)
Foreign Sales	−0.148*	−0.390***	−0.124	−0.165*	−0.078	0.794
	(−1.748)	(−3.165)	(−1.441)	(−1.897)	(−0.714)	(0.952)
Leverage	0.203	0.109	0.334**	0.251*	0.312*	−0.033
	(1.493)	(0.544)	(2.544)	(1.821)	(1.960)	(−0.365)
Advertising Intensity	−0.982	−1.149	0.157	−0.894	−1.993**	0.104
	(−1.371)	(−1.261)	(0.238)	(−1.181)	(−2.253)	(0.677)
RET Volatility	−3.996	−2.968	−5.554**	−3.200	−3.201	−3.278
	(−1.396)	(−0.606)	(−2.174)	(−1.140)	(−0.889)	(−1.038)
Intercept, SIC & year dummies	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	354	212	342	311	253	271
Adj. R^2	0.4709	0.5405	0.5403	0.4572	0.4529	0.4341
p-value of F-test ($\beta_1+\beta_{2i}=0$)		0.002	0.000	0.000	0.068	0.022

Notes:

This table reports the results of pooled cross-sectional time-series panel regressions for the impact of financial hedging on firm value conditional on the degree of information asymmetry and a firm's growth opportunities. The regression model specification is shown below:

$$Ln(Tobin'sQ) = \beta_0 + \beta_1 * Dfinhedge + \beta_2 * (Infoasymmetry/growth/Fophedge) + \beta_3 * \{Dfinhedge * (Infoasymmetry/growth/Fophedge)\} + \sum Control\ Variables + \varepsilon.$$

Ln (*Tobin's Q*) is the natural logarithm of *Tobin's Q* computed as the ratio of market value of assets to book value of assets. *Dfinhedge* is a dummy variable that takes a value of one if a firm uses financial derivatives, and zero otherwise. *Infoasymmetry* is proxied by forecast dispersion and intangibles. *Forecast dispersion* is the standard deviation of analyst earnings forecasts. *Intangibles* is the ratio of intangible assets to total assets. *Growth* is proxied by *N-product-pipeline* and *Npatent*. *Nproduct-pipeline* is the number of products under development. *Npatent* is the number of patents. *Fophedge* is a factor score variable based on all three proxies of operational hedging, including *Nopseg*, *Ngeoseg* and *Nforgsub*. *Nopseg* is the number of operating segments. *Ngeoseg* is the number of geographical segments. *Nforgsub* is the number of foreign subsidiaries of a firm. *Ddividend* is a dummy variable that equals one for firms paying dividends, and zero otherwise. *ROA* is net income scaled by total assets. *Firm size* is the natural logarithm of sales. *R&D intensity* is the ratio of total R&D expense to total assets. *Capital intensity* is the ratio of capital expenditures to total assets. *Foreign sales* is the ratio of foreign sales to net sales. *Leverage* is the ratio of book value of total debts to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *RET Volatility* is the standard deviation of daily stock returns during the previous calendar year. All the regressions include intercept, dummy variables for each calendar year and each 4-digit SIC code to control for time effect and refined industry effect. White's corrected *t*-statistic are reported in parentheses below each coefficient estimate, and *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

We estimate the following regression models to examine hypotheses H1–H2:

$$Ln(Tobin's\,Q) = \beta_0 + \beta_1{}^* Dfinhedge + \beta_2{}^* Infoasymmetry + \beta_3{}^* (Dfinhedge^* Infoasymmetry) + \sum Control\ Variables + \varepsilon, \tag{2a}$$

$$Ln(Tobin's\,Q) = \beta_0 + \beta_1{}^* Dfinhedge + \beta_2{}^* Growth + \beta_3{}^* (Dfinhedge^* Growth) + \sum Control\ Variables + \varepsilon, \tag{2b}$$

$$Ln(Tobin's\,Q) = \beta_0 + \beta_1{}^* Dfinhedge + \beta_2{}^* Ophedge + \beta_3{}^* (Dfinhedge^* Ophedge) + \sum Control\ Variables + \varepsilon. \tag{2c}$$

In particular, we include, as explanatory variables, interaction terms between the financial hedging variable and the proxy variables for information asymmetry and growth opportunities, respectively. The interaction term between financial and operational hedging is also included to examine whether the combined use of financial and operational hedging influences firm value.

Model (2) and (3) in Table 4 examine the impacts of information asymmetry. Model (2) shows that *Dfinhedge*Forecast dispersion* is significant and positive, while *Dfinhedge* itself is positive but statistically insignificant. It suggests that firms with greater forecast dispersion (greater information asymmetry) experience greater increase in firm value from financial hedging. In model (3), the interaction term *Dfinhedge*Intangibles* is positive and significant, while *Dfinhedge* itself is positive but insignificant. These results imply that the greater proportion of intangible assets (i.e., greater information asymmetry) a firm has, the greater is the increase in firm value from financial hedging. These results support hypothesis H1.

In model (4) and (5), we observe significant and positive coefficients of the interaction terms between financial hedging and growth opportunities: *Dfinhedge*Nproduct-pipeline* and *Dfinhedge*Npatent*. These results indicate that the larger the growth opportunities, the greater the extent to which financial hedging enhances firm value in the pharmaceutical and biotech industry. These results support hypothesis H2.

In model (6), we estimate equation (2c) and examine whether there is complementarity between financial and operational hedging. We use a factor score variable (*Fophedge*) that results from principal factors loading on three operational hedging variables: *Nopseg*, *Ngeoseg* and *Nforgsub*. We find a significant and positive coefficient for *Dfinhedge*Fophedge*, suggesting a complementary relationship between financial and operational hedging. That is, financial hedging enhances firm value particularly in firms that also adopt operational hedging. This result is consistent with our hypothesis H3.

(iii) Likelihood of Financial Hedging

The positive relationship between financial hedging and Tobin's Q supports our hypothesis that the use of financial derivatives increases firm value by reducing the volatility of internal cash flows and thereby mitigating the under-investment problem. However, it is possible that this result is driven by a reverse causality: firms with larger Tobin's Q may have more profitable investment opportunities and hence may have a greater incentive to hedge with financial derivatives. Thus it is likely that the decision on the use of financial derivatives is endogenous.

In this subsection, we estimate the following logit regression to examine the likelihood of financial hedging.

$$Dfinhedge = \alpha_0 + \alpha_1 {}^* \, Growth + \alpha_2 {}^* \, Ophedge + \sum Control\ Variables + \varepsilon, \qquad (3)$$

where the dependent variable, *Dfinhedge*, is a binary variable that takes a value of one if a firm reports the use of financial derivatives during the year, and zero otherwise. Firm's growth opportunities are proxied by R&D intensity and advertising intensity. We use a composite factor-score measure of operational hedging, as well as three individual operational hedging variables: (a) the number of foreign subsidiaries, (b) the number of geographic segments, and (c) the number of operating segments. As per the discussion in Section 4 (*ii*) and 3 (*ii*) (*f*), we include other control variables such as firm size, foreign sales ratio, leverage, tax loss carry-forward, dividends, year and four-digit SIC coded industry dummies.

The logit regression results are reported in Table 5. We find that R&D intensity and advertising intensity are positive and significant in all regressions. This suggests that in the pharmaceutical and biotech industry, firms with R&D and advertising intensity are more likely to use financial derivatives, in order to minimize their under-investment problem.

We utilize three individual proxy variables of operational hedging. When these measures are included individually in model (1)–(3), the coefficient estimates on the number of foreign subsidiaries, and the number of geographic segments, are all positive and statistically significant, while the number of operating segments is positive but insignificant. When all three variables are included together in model (4), the geographic segments and the number of foreign subsidiaries are significant and the operating segments are insignificant. As foreign sales ratio is included as an additional measure of operational hedging, it is also significant and positive. Looking at the results across all four equations, we find that geographic segments, foreign subsidiaries, and foreign sales variables are significant while operating segments are not. As expected, the factor score which aggregates individual operational hedging proxies is positive and significant.

Overall, we find a significant and positive relationship between financial and operational hedging, and this is true not only for an aggregate operational hedging score variable, but also for individual operational hedging proxies such as foreign sales and the number of foreign subsidiaries and geographical segments. These results support H3 that a firm's use of financial derivatives depends on its involvement in operational hedging in general. Allayannis, Ihrig and Weston (2001) find that operational hedging does not lower the firm's exchange risk for large industrial firms; however, on average, firms that are employing operational hedging strategies are more likely to use financial hedging which does reduce exchange rate risk.[7]

7 One caveat is that our measures of operational hedging merely reflect the presence of foreign currency exposure. To address this issue, we examine how each measure of operational hedging is related to the use of different types of derivatives (interest rate or FOREX or both). Pharmaceutical firms report the following four choices in using derivatives: both interest rate and FOREX derivatives, only interest rate derivatives, only FOREX derivatives, and not using derivatives at all. In Appendix E, we estimate a multinomial logistic regression. We use the observations of 'NO derivatives' as the base case and evaluate the other three

Table 5
Logistic Regressions Explaining the Use of Financial Derivatives

Variable	*1*	*2*	*3*	*4*	*5*
R&D intensity	4.112**	4.436***	3.627**	0.219*	0.380***
	(0.014)	(0.004)	(0.024)	(1.773)	(3.193)
Advertising intensity	8.507*	12.360**	9.265*	13.233***	16.216***
	(0.075)	(0.013)	(0.061)	(3.282)	(3.972)
Nforgsub	0.020**			0.014*	
	(0.035)			(1.732)	
Ngeoseg		0.574***		0.513***	
		(0.000)		(3.511)	
Nopseg			0.147	0.133	
			(0.206)	(1.166)	
Fophedge					1.048***
					(3.112)
Foreign sales				2.015***	3.522***
				(0.000)	(4.542)
Firm size	0.735***	0.747***	0.814***	0.862***	1.088***
	(0.000)	(0.000)	(0.000)	(5.146)	(5.539)
Ddividend	1.154***	0.426	1.108***	0.368	0.494
	(0.007)	(0.317)	(0.003)	(0.803)	(1.228)
Dtax	0.855**	0.237	0.764**	0.767*	0.990**
	(0.016)	(0.466)	(0.017)	(1.720)	(2.141)
Leverage	1.666**	1.022	1.002	0.977	0.910
	(0.048)	(0.200)	(0.184)	(1.149)	(0.961)
Intercept, SIC & year dummies	Yes	Yes	Yes	Yes	Yes
No. of Obs.	342	351	366	342	342
Pseudo R^2	0.4237	0.4272	0.3949	0.4351	0.4910

Notes:
This table reports the results for the following logistic models:

$$Dfinhedge = \alpha_0 + \alpha_1 * RDintensity + \alpha_2 * Adintensity + \alpha_3 * Fophedge + \alpha_4 * Foreign\ sales + \alpha_5 * Firm\ size$$
$$+ \alpha_6 * Ddividend + \alpha_7 * Dtax + \alpha_8 * Leverage + \alpha_9 * DSIC + \alpha_9 * Dyear + \varepsilon.$$

Dfinhedge, is a binary variable that takes a value of one if a firm uses financial derivatives, and zero otherwise. *R&D intensity* is the ratio of total R&D expense to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *Fophedge* is a factor score variable based on all three proxies of operational hedging, including *Nopseg*, *Ngeoseg* and *Nforgsub*. *Nopseg* is the number of operating segments. *Ngeoseg* is the number of geographical segments. *Nforgsub* is the number of foreign subsidiaries of a firm. *Foreign sales* is the ratio of foreign sales to net sales. *Firm size* is the natural logarithm of sales. *Ddividend* is a dummy variable that equals one for firms paying dividends, and zero otherwise. *Dtax* is a dummy variable that is equal to one if a firm incurs a net operating loss and zero otherwise. *Leverage* is the ratio of book value of total debts to total assets. All the regressions include intercept, dummy variables for each calendar year and each 4-digit SIC code to control for time effect and refined industry effect. *p*-values are reported in parentheses below each coefficient estimate, and *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

outcomes as alternatives to this choice. We find that the number of geographic segments and percentage of foreign sales are significantly positively related to the choice of using FOREX derivatives versus using no derivatives. However, the number of operational segment is significantly and positively related to the choice of using both types of derivatives. Furthermore, the number of geographic segments is also significantly and positively related to the use of interest rate derivatives only. As such, the positive association between operational hedging and the use of financial derivatives is not primarily driven by the notion that operational hedging may reflect the extent of foreign currency exposure.

Finally, the dividend payout dummy is a control variable and hence may not be a variable of major interest. However, dividends have been used as a measure of financial constraint, e.g., Allayannis and Weston (2001). The coefficient on *Ddividend* is positive in all the regressions and statistically significant in two out of five regressions. Thus the evidence is suggestive but inconclusive concerning whether firms facing difficulty in raising external capital engage in more financial hedging.[8]

(iv) Re-estimation of Tobin's Q with an Endogenous Financial Hedging

To take into account the endogenous choice of using financial derivatives in our basic valuation model with information asymmetry, growth, and operational hedging, we re-estimate the models in Table 4, using the predicted likelihood of the use of financial derivatives (*Pdfinhedge*). *Pdfinhedge* is estimated in the first stage, using model 5 of Table 5. This is equivalent to a two-stage instrumental variables approach where instruments are independent variables included in the first-stage model. The results in Table 6 are generally similar to those in Table 4. It remains the case that the interaction terms of financial hedging with each of the two proxies for information asymmetry and growth and with the factor score of operational hedging are significant and positive in all five cases. Hence, all three hypotheses supported in Table 4 carry over to Table 6.

To further account for the endogeneity of using financial derivatives as well as potential bi-directional impact between Tobin's Q and financial hedging, we also estimate the following simultaneous equation models of both Tobin's Q and *Dfinhedge* by the 3SLS technique:

$$\begin{aligned} Dfinhedge = {} & \alpha_0 + \alpha_1 {}^* Ln(Tobin's\ Q) + \alpha_2 {}^* Ophedge + \alpha_3 {}^* R\&DIntensity \\ & + \alpha_4 {}^* AdIntensity + \sum Control\ Variables + \varepsilon_1, \end{aligned} \tag{4}$$

$$\begin{aligned} Ln(Tobin'sQ) = {} & \beta_0 + \beta_1 {}^* Dfinhedge + \beta_2 {}^* InfoAsym(or\ Growth) \\ & + \beta_2 {}^* Dfinhedge {}^* InfoAsym(or\ Growth) + \beta_3 {}^* Ophedge \\ & + \sum Control\ Variables + \varepsilon_2. \end{aligned} \tag{5}$$

The results in Table 7 show that the likelihood of using financial derivatives is not significantly affected by Tobin's Q, suggesting that the causality may not run from Tobin's Q to financial hedging. In a simultaneous system equation model that allows a potential bi-directional impact, we still find that financial hedging leads to significantly higher firm value. Consistent with the results in Table 4, we also find that *Dfinhedge* Intangibles* and *Dfinhedge* Nproduct-pipeline* are positive and significant in equation (5). In sum, these results from endogenous estimations confirm our earlier results, suggesting that financial hedging enhances firm value, and more so for firms with more severe information asymmetry and better growth opportunities. And the

8 We have also used the Kaplan and Zingales (1997) index as an alternative measure of financial constraints, and the results are mixed. Bates, Kahle and Stulz (2009) find that R&D intensive firms rely more on their internal cash flows and hold larger amounts of cash. Similarly, Opler et al. (1999) report that firms with greater growth opportunities tend to hold more cash to avoid financing squeeze in slack times. An implication is that financial hedging and holding cash reserves are alternative methods of managing financial risk for firms facing growth. This contrasts with Froot, Scharfstein and Stein (1993) that costly external financing may induce financial hedging for firms with growth prospects. The present result on the impact of the financial constraints variable may reflect these competing theories.

Table 6
Estimation of Tobin's Q by the Two-Stage Instrumental Variables Method

	1	*2*	*3*	*4*	*5*
Pdfinhedge (β_1)	0.460**	0.076	0.216	0.189	0.599***
	(2.379)	(0.441)	(1.321)	(0.987)	(2.639)
Pdfinhedge * *Forecast dispersion* (β_{21})	0.990**				
	(2.317)				
Forecast dispersion	−1.036***				
	(−2.943)				
Pdfinhedge * *Intangibles* (β_{22})		0.959***			
		(3.534)			
Intangibles		−1.388***			
		(−6.520)			
Pdfinhedge * *Nproduct-pipeline* (β_{23})			0.781***		
			(3.226)		
Nproduct-pipeline			−0.034**		
			(−2.005)		
Pdfinhedge * *Npatent* (β_{24})				0.074***	
				(2.659)	
Npatent				−0.002	
				(−1.454)	
Pdfinhedge * *Fophedge* (β_{25})					0.344*
					(1.901)
Fophedge					−0.287
					(−1.614)
Ddividend	0.076	−0.187**	−0.036	−0.042	−0.054
	(0.785)	(−2.407)	(−0.505)	(−0.490)	(−0.699)
ROA	3.278***	2.074***	2.332***	2.445***	1.254***
	(7.878)	(9.044)	(9.689)	(7.621)	(4.802)
Firm Size	−0.109***	−0.024	−0.044*	−0.044	−0.065**
	(−3.916)	(−0.937)	(−1.702)	(−1.364)	(−2.074)
R&D Intensity	5.609***	3.176***	3.828***	4.158***	3.581***
	(10.062)	(8.938)	(10.046)	(9.074)	(10.397)

Table 6 (Continued)

	1	*2*	*3*	*4*	*5*
Capital Intensity	−0.336	−0.276	0.592	0.959	2.309***
	(−0.316)	(−0.413)	(0.827)	(1.022)	(2.753)
Foreign Sales	−0.717***	−0.172*	−0.200*	−0.188	−0.382***
	(−3.764)	(−1.668)	(−1.771)	(−1.369)	(−2.943)
Leverage	−0.133	0.213	0.115	0.113	−0.204
	(−0.658)	(1.395)	(0.720)	(0.599)	(−1.279)
Advertising Intensity	−0.311	0.224	−0.547	−0.448	−1.167*
	(−0.424)	(0.374)	(−0.840)	(−0.471)	(−1.705)
RET Volatility	−2.084	−5.295**	−2.861	−3.854	−3.905
	(−0.452)	(−2.314)	(−1.136)	(−1.134)	(−1.347)
Intercept, SIC & year dummies	Yes	Yes	Yes	Yes	Yes
No. of Obs.	302	339	342	258	342
Adj. R^2	0.6162	0.4568	0.4817	0.4784	0.5001
p-value of F-test ($\beta_1+\beta_{2i}=0$)	0.0003	0.0000	0.0001	0.0910	0.0002

Note:
This table reports the results of the pooled cross-sectional time-series panel regressions regarding the impact of financial hedging on firm value conditional on the degree of information asymmetry, a firm's growth opportunities and operational hedging, using a two-stage instrumental variable method. The second stage regression model specification is shown below:

$$Ln(Tobin'sQ) = \beta_0 + \beta_1 * Pdfinhedge + \beta_2 * (Infoasymmetry/growth/Fophedge) + \beta_3 * \{Pdfinhedge * (Infoasymmetry/growth/Fophedge)\} + \sum Control\ Variables + \varepsilon.$$

Ln (*Tobin's Q*) is the natural logarithm of *Tobin's Q* computed as the ratio of market value of assets to book value of assets. *Pdfinhedge* is the predicted probability of financial hedging from the first stage of estimation using Model 5 in Table 5. *Info asymmetry* is proxied by *forecast dispersion* and *intangibles*. *Forecast dispersion* is the standard deviation of analyst earnings forecasts. *Intangibles* is the ratio of intangible assets to total assets. *Growth* is proxied by *N-product-pipeline* and *Npatent*. *Nproduct-pipeline* is the number of products under development. *Npatent* is the number of patents. *Fophedge* is a factor score variable based on all three proxies of operational hedging, including *Nopseg*, *Ngeoseg* and *Nforgsub*. *Nopseg* is the number of operating segments. *Ngeoseg* is the number of geographical segments. *Nforgsub* is the number of foreign subsidiaries of a firm. *Ddividend* is a dummy variable that equals one for firms paying dividends, and zero otherwise. *ROA* is net income scaled by total assets. *Firm size* is the natural logarithm of sales. *R&D intensity* is the ratio of total R&D expense to total assets. *Capital intensity* is the ratio of capital expenditures to total assets. *Foreign sales* is the ratio of foreign sales to net sales. *Leverage* is the ratio of book value of total debts to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *RET Volatility* is the standard deviation of daily stock returns during previous calendar year. All the regressions include intercept, dummy variables for each calendar year and for each 4-digit SIC code to control for time effect and refined industry effect. White's corrected *t*-statistics are reported in parentheses below each coefficient estimate, and *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 7
Simultaneous Equation Models (3SLS procedure)

Variable	*1* *Dfinhedge*	*2* *Ln(Tobin's Q)*	*3* *Dfinhedge*	*4* *Ln(Tobin's Q)*	*5* *Dfinhedge*	*6* *Ln(Tobin's Q)*	*7* *Dfinhedge*	*8* *Ln(Tobin's Q)*
Dfinhedge		0.147*		0.101		0.062		0.097
		(1.720)		(1.060)		(0.700)		(1.100)
Ln(Tobin's Q)	0.052		0.071		0.069		0.090	
	(0.720)		(0.856)		(0.833)		(1.120)	
Dfinhedge * *Forecast dispersion* (β_{21})		0.209***						
		(3.153)						
Forecast dispersion		−0.614***						
		(−2.786)						
Dfinhedge * *Intangibles* (β_{22})				0.751**				
				(2.360)				
Intangibles				−1.852				
				(−1.490)				
Dfinhedge * *Nproduct-pipeline* (β_{23})						0.989**		
						(2.110)		
Nproduct-pipeline						−0.038		
						(−1.140)		
Dfinhedge * *Npatent* (β_{24})								0.108**
								(2.006)
Npatent								−0.004
								(−1.260)
Fophedge	0.097	−0.004	0.089	−0.004	1.047*	−0.004	0.087	−0.004
	(1.210)	(−0.110)	(1.184)	(−0.110)	(1.811)	(−0.110)	(1.018)	(−0.110)
Ddividend	0.248***	−0.173*	0.225**	−0.185**	0.211**	−0.203**	0.232***	−0.198**
	(2.880)	(−1.870)	(2.512)	(−1.950)	(2.1980)	(−2.260)	(2.711)	(−2.130)
Dtax	0.668**		0.702**		0.671**		0.699**	
	(2.032)		(2.202)		(2.191)		(2.196)	
ROA		1.730***		2.586***		2.145***		2.114***
		(5.560)		(6.760)		(7.260)		(6.830)
Firm Size	0.096***	0.015	0.091***	−0.015	0.087***	0.039	0.098***	0.037
	(4.790)	(0.580)	(4.581)	(−0.540)	(4.543)	(1.380)	(4.889)	(1.330)
R&D Intensity	0.953***	2.776***	1.031***	4.132***	0.981***	3.511***	0.950***	3.439***
	(2.610)	(5.810)	(2.801)	(8.110)	(2.640)	(7.960)	(2.610)	(7.510)

Table 7 (Continued)

Variable	1 Dfinhedge	2 Ln(Tobin's Q)	3 Dfinhedge	4 Ln(Tobin's Q)	5 Dfinhedge	6 Ln(Tobin's Q)	7 Dfinhedge	8 Ln(Tobin's Q)
Capital Intensity		1.060		1.643*		1.504*		1.538*
		(1.280)		(1.820)		(1.840)		(1.850)
Foreign Sales	0.384***	−0.195*	0.401***	−0.135	0.379***	−0.126	0.390***	−0.130
	(3.420)	(−1.650)	(3.562)	(−1.050)	(3.366)	(−1.110)	(3.451)	(−1.110)
Leverage	0.153	−0.523***	0.130	0.217	0.149	0.267	0.167	0.233
	(1.080)	(−3.350)	(1.011)	(1.170)	(1.068)	(1.520)	(1.112)	(1.310)
Advertising Intensity	1.157*	0.949	1.184**	−0.048	1.149*	−0.949	1.166*	−0.843
	(1.900)	(1.480)	(1.975)	−(0.070)	(1.824)	(−1.270)	(1.932)	(−1.040)
RET Volatility		1.486		−5.070		−3.221		−3.648
		(0.400)		(−1.240)		(−0.920)		(−1.000)
Intercept, SIC & Yr. Dummies	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	302	302	339	339	342	342	258	258
Adj. R^2	0.420	0.551	0.434	0.560	0.417	0.549	0.433	0.562

Notes:
In this table, we report the results of estimation of a simultaneous system of equations using 3-SLS procedure with following specification:

$$Dfinhedge = \alpha_0 + \alpha_1 * Ln(Tobin'sQ) + \alpha_2 * RDintensity + \alpha_3 * Adintensity + \alpha_4 * Fophedge + \alpha_5 * Foreign\ sales + \alpha_6 * Firm\ size + \alpha_7 * Ddividend + \alpha_8 * Dtax + \alpha_9 * Leverage + \alpha_{10} * DSIC + \alpha_{11} * Dyear + \varepsilon.$$

$$Ln(Tobin'sQ) = \beta_0 + \beta_1 * Dfinhedge + \beta_2 * (Infoasymmetry/growth/Fophedge) + \beta_3 * \{Dfinhedge * (Infoasymmetry/growth/Fophedge)\} + \sum Control\ Variables + \varepsilon.$$

(2) *Dfinhedge*, is a binary variable that takes a value of one if a firm uses financial derivatives, and zero otherwise. Ln (*Tobin's Q*) is the natural log of *Tobin's Q* computed as the ratio of market value of assets to book value of assets. *R&D intensity* is the ratio of total R&D expense to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *Fophedge* is a factor score variable based on all three proxies of operational hedging, including *Nopseg*, *Ngeoseg* and *Nforgsub*. *Nopseg* is the number of operating segments. *Ngeoseg* is the number of geographical segments. *Nforgsub* is the number of foreign subsidiaries of a firm. *Foreign sales* is the ratio of foreign sales to net sales. *Firm size* is the natural logarithm of sales. Ddividend is a dummy variable that equals one for firms paying dividends, and zero otherwise. Dtax is a dummy variable for tax incentives of net operating loss and is equal to one if a firm incurs a net operating loss and zero otherwise. *Leverage* is the ratio of book value of total debts to total assets. *Info asymmetry* is proxied by *forecast dispersion* and *intangibles*. *Forecast dispersion* is the standard deviation of analyst earnings forecasts. *Intangibles* is the ratio of intangible assets to total assets. *Growth* is proxied by *N-product-pipeline* and *Npatent*. *Nproduct-pipeline* is the number of products under development. *Npatent* is the number of patents. *ROA* is net income scaled by total assets. *Capital intensity* is the ratio of capital expenditures to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *RET Volatility* is the standard deviation of daily stock returns during previous calendar year. All the regressions include intercept, dummy variables for each calendar year and each 4-digit SIC code to control for time effects and refined industry effects. All variables are as defined in Table 1 and Table 2. White's corrected *t*-statistics are reported in parentheses below each coefficient estimate, and *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

causality between financial hedging and Tobin's Q appears unidirectional – from financial hedging to Tobin's Q, not the reverse.

5. EXTENDED ANALYSES

We perform additional analyses in several ways. First, we decompose the aggregate financial derivative positions and estimate the value effects of foreign currency derivatives and interest rate derivatives separately. In addition, we use accounting variables as alternative measures of firm performance. Finally, we do several sundry sensitivity tests with respect to biotech firms, lagged relations between Tobin's Q and independent variables, and the impacts of outliers.

(i) Foreign Exchange Derivatives versus Interest Rate Derivatives

In Section 4, we considered the use of financial derivatives in the aggregate, without separating the different kinds of derivative contracts. Following Allayannis and Weston (2001) and others, we now separate foreign exchange derivatives from interest rate derivatives and run separate regressions for firms that use either foreign exchange derivatives or interest rate derivatives. In this sample, there are 129 firm-year observations where firms report the use of foreign exchange derivatives and there are 89 firm-year observations where interest rate derivatives are reported to be used.[9] For purposes of comparison, we also exactly replicate the models used by Allayannis and Weston (2001) with the same control variables. Specifically, in this section we use the natural log of assets as firm size, the ratio of R&D investment to firm assets as R&D intensity, the ratio of capital investment to firm sales as a proxy for growth opportunities, and the ratio of advertising to firm assets as a proxy of consumer goodwill. A diversification dummy, which takes a value of one if a firm operates in more than one industrial segment otherwise zero, is also included in the model. Also we employ a firm fixed-effect model to control for unobservable firm characteristics that may influence the firm value.

The results from pooled OLS and firm fixed-effect panel regressions are presented in Table 8. While the coefficient estimate on *Dfinhedge* is positive and marginally significant in OLS regression, it is insignificant in fixed-effect regression. However, only about 10% of the firms in the sample show changes in *Dfinhedge* over time. That is, we have little time series variation in *Dfinhedge,* which makes it difficult to test our hypothesis based on the firm fixed-effect model in the pooled time series and cross-sectional panel regressions.

More importantly, the coefficients of *Dfinhedge_Forex* are positive and significant in both OLS and firm fixed-effect regressions. In contrast, the coefficients on *Dfinhedge_Interest* are statistically insignificant. This shows that the value enhancement due to financial hedging in our sample stems more from hedging activities against the foreign exchange risk rather than the interest rate risk, which reflects the international nature of US pharmaceutical and biotech firms.

9 In some cases, it is not clear from the description whether the firm used interest derivatives or foreign derivatives. Those cases are excluded from this analysis.

Table 8

Hedging and Firm Value: Foreign Currency versus Interest Rate Derivatives

	Dependent Variable: Ln (Tobin's Q)					
	OLS			*Firm Fixed Effect*		
Dfinhedge	0.104*			−0.007		
	(1.711)			(−0.105)		
Dfinhedge_Forex		0.122**			0.189**	
		(1.968)			(1.999)	
Dfinhedge_Interest			−0.016			−0.030
			(−0.240)			(−0.392)
ROA	2.265***	2.270***	2.228***	1.270***	1.141***	1.180***
	(9.030)	(7.922)	(6.918)	(6.666)	(5.310)	(4.634)
Firm size	−0.008	−0.001	0.019	−0.356***	−0.328***	−0.384***
	(−0.492)	(−0.027)	(0.937)	(−6.286)	(−5.470)	(−4.774)
R&D intensity	3.289***	3.177***	3.372***	1.636***	1.437***	1.581***
	(10.410)	(8.955)	(7.329)	(5.127)	(4.303)	(3.208)
Advertising intensity	−0.804	−1.206	−1.179	−0.984	−2.923	−4.622
	(−1.173)	(−1.261)	(−1.090)	(−0.472)	(−1.128)	(−1.503)
Capital intensity	0.014	0.013	0.014	0.006	0.003	0.005
	(1.106)	(1.063)	(1.074)	(0.395)	(0.188)	(0.270)
Foreign sales	−0.163*	−0.149	−0.159	−0.025	−0.161	−0.045
	(−1.764)	(−1.452)	(−1.422)	(−0.213)	(−1.224)	(−0.319)
Ddividend	−0.012	−0.024	0.030	−0.076	−0.093	−0.014
	(−0.146)	(−0.256)	(0.267)	(−1.208)	(−1.280)	(−0.158)
Leverage	0.173	0.134	0.162	−0.263	−0.091	−0.162
	(1.286)	(0.929)	(1.080)	(−1.495)	(−0.469)	(−0.694)
Nopseg	−0.143***	−0.188***	−0.159**	−0.009	−0.011	−0.001
	(−2.834)	(−3.190)	(−2.589)	(−0.123)	(−0.139)	(−0.009)
Intercept, SIC/firm & year dummies	Yes	Yes	Yes	Yes	Yes	Yes
No. of Obs.	351	293	293	351	293	293
Adj. R^2	0.4384	0.4399	0.3922	0.4193	0.4384	0.4086

Notes:
This table reports the results of pooled cross-sectional time-series panel regressions and fixed effect regressions for the impact of using interest rate derivatives and foreign exchange derivatives on firm value. The regression model specification is shown below:

$$Ln(Tobin's Q) = \beta_0 + \beta_1 * (Dfinhedge/Dfinhedge\_Forex/Dfinhedge\_Interest) + \sum Control\ Variables + \varepsilon.$$

Ln (*Tobin's Q*) is the natural log of *Tobin's Q* computed as the ratio of market value of assets to book value of assets. *Dfinhedge*, is a binary variable that takes a value of one if a firm uses financial derivatives, and zero otherwise. *Dfinhedge_Forex* is a dummy variable that takes a value of one if a firm uses exchange rate financial derivatives, and otherwise zero. *Dfinhedge_Interest* is a dummy variable that takes a value of one if a firm uses interest rate derivatives, and otherwise zero. *ROA* is net income scaled by total assets. *Firm size* is the natural logarithm of sales. *R&D intensity* is the ratio of total R&D expense to total assets. *Advertising intensity* is the ratio of advertising expenditures to total assets. *Capital intensity* is the ratio of capital expenditures to total assets. *Foreign sales* is the ratio of foreign sales to net sales. *Ddividend* is a dummy variable that equals one for firms paying dividends, and zero otherwise. *Leverage* is the ratio of book value of total debts to total assets. *Nopseg* is the number of operating segments. We include intercept, 4-digit SIC dummies, and dummy variables for each calendar year. White's corrected *t*-statistics are reported in parentheses below each coefficient estimate, and *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

Table 9

Accounting Returns as an Alternative Measure of Performance

Variable	*ROE*	*Lead ROE*	*ROA*	*Lead ROA*
Dfinhedge	0.035**	0.037**	0.016*	0.019*
	(2.212)	(2.166)	(1.675)	(1.943)
Firm size	−0.004	−0.003	−0.000	0.001
	(−0.977)	(−0.590)	(−0.212)	(0.663)
Nopseg	0.008*	0.005	−0.002	0.000
	(1.801)	(0.983)	(−0.689)	(0.003)
R&D Intensity	−0.448***	−0.467***	−0.386***	−0.407***
	(−2.678)	(−3.667)	(−4.331)	(−4.518)
Capital Intensity	0.615***	0.715***	0.243**	0.252**
	(3.401)	(3.935)	(2.481)	(2.165)
Foreign Sales	−0.027	−0.028	−0.004	0.006
	(−1.119)	(−1.145)	(−0.251)	(0.382)
Leverage	−0.112***	−0.075*	0.036*	0.054**
	(−3.499)	(−1.934)	(1.749)	(2.139)
RET Volatility	−5.967***	−5.903***	−3.856***	−2.963***
	(−7.052)	(−6.446)	(−6.288)	(−5.422)
Dbiotech	−0.029**	−0.034**	−0.026***	−0.027***
	(−2.110)	(−1.992)	(−3.041)	(−2.845)
Intercept & Yr. Dummies	Yes	Yes	Yes	Yes
No. of Obs.	343	287	343	287
Adj. R^2	0.441	0.444	0.589	0.526

Notes:
This table employs *ROE*, *Lead ROE*, *ROA* and *Lead ROA* as alternative measures of firm performance. The regression model specification is shown below:

$$Performance = \beta_0 + \beta_1 * Dfinhedge + \sum Control\ Variables + \varepsilon.$$

Performance is proxied by *ROE/Lead ROE/ROA/Lead ROA*. *ROE* is operating income scaled by the market value of equity. *Lead ROE* is the ROE of a firm in year t+1. *ROA* is operating income scaled by total assets. *Lead ROA* is the ROA of a firm in year t+1. *Dfinhedge* is a dummy variable that takes a value of one if a firm uses financial derivatives, and zero otherwise. *Firm size* is the natural logarithm of sales. *Nopseg* is the number of operating segments. *R&D intensity* is the ratio of total R&D expense to total assets. *Capital intensity* is the ratio of capital expenditures to total assets. *Foreign sales* is the ratio of foreign sales to net sales. *Leverage* is the ratio of book value of total debts to total assets. *RET Volatility* is the standard deviation of daily stock returns during previous calendar year. *Dbiotech* is a dummy variable equal to one for biotech firms and zero otherwise. All the regressions include intercept, dummy variables for each calendar year and each 4-digit SIC code to control for time effect and refined industry effect. White's corrected *t*-statistics are reported in parentheses below each coefficient estimate, and *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

(ii) Accounting Returns as an Alternative Measure of Firm Performance

While we find financial hedging increases Tobin's Q, which is a forward-looking market-based firm performance measure, it would also be of interest to examine whether financial hedging affects short-term accounting performance as well. In Table 9, we find a strong and consistent positive relationship between the use of financial derivatives and the contemporaneous or lead ROE and ROA. The coefficient estimates on *Dfinhedge* are positive and significant in all the regressions. It reiterates our finding that financial hedging enhances firm performance regardless of whether a market-based or accounting-based measure of performance is used. Interestingly, the dummy for biotech firms is negative and significant at the 10% level, indicating that the accounting performance is lower for biotech firms than for pharmaceutical firms.

(iii) Other Sensitivity Tests

We conduct additional sensitivity tests to check for the robustness of our results. To control for broader industry effects of biotech firms, we include an indicator variable for biotech firms in our regressions in Table 4. In untabulated results, we find no difference in primary regressions for inclusion of this control. In addition, we also use one-year lead Tobin's Q as a measure of firm performance in Table 4 and find results consistent with our hypothesis that the use of financial derivatives is positively associated with firm value. We also correct for any form of clustering of standard errors within firms, including serial correlation. Our results remain the same.

6. CONCLUSION

The pharmaceutical and biotech industry provides us with a unique sample to test the performance implications of hedging suggested by the information asymmetry hypothesis à la Froot, Scharfstein and Stein (1993). Heavy investment in R&D, unique product development risk, and international competition afford the pharmaceutical and biotech firms with severe information asymmetry as well as high growth opportunities. Given these characteristics, pharmaceutical and biotech firms are particularly susceptible to the under-investment problem stemming from information asymmetry.

In this study, we examine the information asymmetry hypothesis by investigating the interrelationship between financial and operational hedging and the firm performance in the pharmaceutical and biotech industry. Existing studies have focused on financial hedging in industries that are commodity-based and do not address the impact of information asymmetry. We find that firms with severe information asymmetry and high growth prospects are more likely to use financial derivatives. We estimate a hedging premium of about 13.8%, which compares with no hedging premium for the oil and gas firms reported by Jin and Jorion (2006) and 2% for oil refiners by MacKay and Moeller (2007), and is greater than the figures documented for multinationals by Allayannis and Weston (2001). This is consistent with our argument that pharmaceutical and biotech firms are more susceptible to information asymmetry and under-investment problems, thereby obtaining greater benefit from financial hedging.[10] In addition, we find that the combined use of financial and operational hedging enhances firm performance. More importantly, we find that firms with more severe under-investment problems – those with greater information asymmetry, larger growth opportunities or financing constraints – generally experience greater value enhancement through financial hedging. Our results support the information theory of corporate hedging by Froot, Scharfstein and Stein (1993) and suggest that the source of value enhancement stems from the fact that hedging helps relieve the under-investment problem due to information asymmetry and allows firms to take advantage of positive NPV projects.

10 Carter, Rogers and Simkins (2006) report a hedging premium of about 10% for airline firms. Compared to the pharmaceutical and biotech firms, the airline firms may not have as much information asymmetry, but under-investment is believed to be severe as well.

APPENDIX A
Three Largest Companies in Assets in each 4-digit SIC Coded Industry

SIC Code (2833): Medicinal Chemicals and Botanical Products

1. Cambrex Corp.
2. Philipp Brothers Chemicals
3. Savient Pharmaceuticals Inc.

SIC Code (2834): Pharmaceutical Preparations

1. Pfizer Inc.
2. Sanofi Aventis
3. Johnson and Johnson

SIC Code (2835): In Vitro and In Vivo Diagnostic Substances

1. Dade Behring Holdings Inc.
2. Inverness Medical Innovations
3. Genencor Intl. Inc.

SIC Code (2836): Biological Products, Except Diagnostic Substances

1. Amgen Inc.
2. Biogen Idec Inc.
3. Genzyme Corp.

APPENDIX B
Summary Statistics of Subsamples from each 4-digit SIC Coded Industries

	SIC Code			
Variables	*2833*	*2834*	*2835*	*2836*
Assets (US$ million)	745.8218	14,595.19	410.4885	2,994.429
Tobin's Q	1.524	3.819	1.734	2.025
R&D Intensity	0.022	0.098	0.077	0.118
ROA	0.002	0.039	0.099	–0.019
Leverage	0.315	0.229	0.049	0.122
NOBS	36	197	51	114
No. of Firms	7	35	11	21

Note:
This table reports the mean value of firm characteristics variables for each subsample with distinct 4-digit SIC codes.

APPENDIX C
An Example of Derivative Disclosure – Bristol-Myers Squibb Co. in 2002

BRISTOL-MYERS SQUIBB COMPANY FY-2002 10-K report, submitted on 03/28/2003

Item 7A. QUANTITATIVE AND QUALITATIVE DISCLOSURES ABOUT MARKET RISK.

The Company is exposed to market risk due to changes in currency exchange rates and interest rates. To reduce that risk, the Company enters into certain derivative financial instruments, when available on a cost-effective basis, to hedge its underlying economic exposure. These instruments are also managed on a consolidated basis to efficiently net exposures and thus take advantage of any natural offsets. Derivative financial instruments are not used for trading purposes. Gains and losses on hedging transactions are offset by gains and losses on the underlying exposures being hedged.

Foreign exchange option contracts and forward contracts are used to hedge anticipated transactions. The Company's primary foreign currency exposures in relation to the US dollar are the euro, Canadian dollar, Japanese yen and Mexican peso.

The table below summarizes the Company's outstanding foreign exchange contracts as of 31 December, 2002. The fair value of foreign exchange option contracts is estimated by using the Black–Scholes model and is based on year-end currency rates. The fair value of option contracts and forward contracts should be viewed in relation to the fair value of the underlying hedged transactions and the overall reduction in exposure to adverse fluctuations in foreign currency exchange rates.

	Weighted Average Strike Price	*Notional Amount*	*Fair Value*	*Maturity*
	(US dollars in million, except currency rates)			
Foreign Exchange Forwards:				
Euro	$1.00	$915	$23	2003
Swedish Krona	9.13	51	(2)	2003
Swiss Franc	1.44	39	1	2003
South African Rand	9.67	13	1	2003
British Pound	1.44	3	—	2003
Total Forwards		$1,021	$23	
Foreign Exchange Options:				
Euro	$0.99	$573	$13	2003
Canadian Dollar	1.55	113	3	2003
Australian Dollar	0.55	68	2	2003
Total Options		$754	$18	
Total Contracts		$1,775	$41	

At 31 December, 2001, the Company held option contracts with an aggregate notional amount and fair value of US$ 485 million and US$ 24 million, respectively. These contracts primarily related to the right to buy Japanese yen, and the right to sell Canadian and Australian dollars. The Company also held foreign exchange forward contracts with an aggregate notional amount of US$ 902 million and fair value of US$ (1) million. These contracts primarily related to exposures in the euro, Mexican peso, Japanese yen and British pound.

The Company uses derivative instruments as part of its interest rate risk management policy. The derivative instruments used include interest rate swaps, which are subject to fair-value hedge accounting treatment. During 2002, the Company executed with five financial institutions several fixed to floating interest rate swaps to convert US$ 3.0 billion of the Company's fixed rate debt to be paid in 2006 and 2011 to variable rate debt. For the year ended December 31, 2002, the Company recognized a reduction of interest expense of US$ 23 million that reflects the benefit of the lower floating rate obtained in the swap agreement. SFAS No. 133 requires the revaluation, at fair value, of the swap contracts as well as the underlying debt being hedged. As such, the swap contracts and the underlying debt have been revalued resulting in an increase in the current assets and long-term debt of US$ 133 million. Swap contracts are generally held to maturity and are not used for trading or speculative purposes. The following table summarizes the interest rate swaps executed in 2002:

	Notional Amount of Underlying Debt	*Variable Rate Received*	*Maturity*	*Fair Value*
		(US dollars in millions)		
Interest Rate Contracts				
Swaps associated with 4.75% Notes due 2006	$1,500	1 month US $ LIBOR + 0.54%	2006	$83
Swaps associated with 5.75% Notes due 2011	1,500	1 month US $ LIBOR + 1.31%	2011	50
	$3,000			$133

The Company also has outstanding several interest rate and foreign currency swaps related to Japanese yen notes due through 2005. The aggregate fair value of these instruments as of December 31, 2002 and 2001 was US$ 1 million and US$ 3 million, respectively.

The Company had US$ 6,261 million and US$ 6,237 million of long-term debt outstanding at December 31, 2002 and 2001, respectively. See Note 15, Short-Term Borrowings and Long-Term Debt, and Note 17, Financial Instruments, to the consolidated financial statements for additional information.

The Company maintains cash and cash equivalents, time deposits and marketable securities with various financial institutions, in order to limit exposure to any one financial institution. These financial institutions are located primarily in the US and Europe.

APPENDIX D
Correlation Matrix

	Dfinhedge	*Tobin's Q*	*Size*	*R&D Intensity*	*ROA*	*Leverage*	*RET Volatility*	*Nforgsub*	*Ngeoseg*	*Nopseg*	*Foreign Sales Ratio*	*Intangibles*	*Forecast Dispersion*	*Npatent*	*Nproduct Pipeline*	*Ddividend*
Dfinhedge	1.000															
Tobin's Q	0.014	1.000														
Size	0.391	0.168	1.000													
RAD Intensity	0.092	0.243	−0.160	1.000												
ROA	0.217	0.334	0.436	−0.516	1.000											
Leverage	0.026	−0.376	−0.086	−0.171	−0.099	1.000										
RET Volatility	0.067	−0.177	−0.598	0.240	−0.542	0.254	1.000									
Nforgsub	0.145	0.093	0.636	−0.063	0.276	−0.106	−0.389	1.000								
Ngeoseg	0.218	0.100	0.269	−0.065	0.143	−0.046	−0.177	0.212	1.000							
Nopseg	0.027	−0.057	0.375	−0.200	0.251	−0.019	−0.342	0.156	0.241	1.000						
Foreign Sales Ratio	0.336	−0.112	0.125	−0.165	0.100	0.082	−0.089	0.139	0.298	0.174	1.000					
Intangibles	0.190	−0.044	−0.080	0.016	−0.124	0.077	0.140	−0.077	0.070	−0.200	−0.175	1.000				
Forecast Dispersion	0.016	−0.160	0.018	−0.030	−0.045	0.032	−0.034	−0.002	−0.016	0.021	0.053	0.193	1.000			
Npatent	0.012	−0.054	0.030	−0.039	0.006	−0.017	−0.113	0.017	−0.060	−0.088	0.055	−0.253	0.235	1.000		
Nproduct Pipeline	0.226	0.028	0.492	−0.029	0.192	−0.094	−0.308	0.470	−0.006	0.194	0.086	−0.071	−0.035	0.069	1.000	
Ddividend	0.285	0.050	0.606	−0.118	0.342	−0.096	−0.459	0.526	0.306	0.386	0.249	−0.235	0.042	0.002	0.303	1.000

Note:
This table presents the correlation matrix among variables used in the analysis.

APPENDIX E
Multinomial Logistic Regressions Explaining the Use of Interest Rate and FOREX Derivatives

Variable	*Both derivatives vs. NO derivatives*	*Only interest derivatives vs. NO derivatives*	*Only FOREX derivatives vs. NO derivatives*
R&D intensity	6.284**	6.158*	10.046***
	(2.084)	(1.717)	(4.070)
Advertising intensity	2.519	−9.574	11.896***
	(0.500)	(−1.001)	(2.870)
Nforgsub	0.016*	0.012	0.008
	(1.649)	(0.796)	(0.872)
Ngeoseg	−0.240	0.448*	0.815***
	(−1.106)	(1.802)	(4.234)
Nopseg	0.521***	0.001	0.185
	(2.962)	(0.006)	(1.122)
Foreign sales	1.627	1.147	2.446***
	(1.504)	(0.940)	(2.815)
Firm size	0.784***	0.658**	0.699***
	(3.568)	(2.294)	(4.227)
Ddividend	2.987***	−0.306	−0.066
	(4.148)	(−0.476)	(−0.113)
Dtax	−0.511	−0.069	0.190
	(−0.925)	(−0.103)	(0.385)
Leverage	3.678**	1.964*	−0.886
	(2.392)	(1.660)	(−0.833)
Intercept, SIC & year dummies	Yes	Yes	Yes
No. of Obs.	342	342	342
Pseudo R^2	0.4427	0.4427	0.4427

Note:
This table presents the coefficient estimates from a multinomial logistic regression explaining the four choices of using financial derivatives: using both interest rate and FOREX derivatives, using only interest rate derivatives, using only FOREX derivatives, and not using derivatives.

$$\begin{aligned}Dfinhedge = {} & \alpha_0 + \alpha_1 * RDintensity + \alpha_2 * Adintensity + \alpha_3 * Fophedge \\ & + \alpha_4 * Foreignsales + \alpha_5 * Firmsize + \alpha_6 * Ddividend + \alpha_7 * Dtax + \alpha_8 * Leverage \\ & + \alpha_9 * DSIC + \ \alpha_9 * Dyear + \varepsilon.\end{aligned}$$

We use the observations of 'NO derivatives' as the base case and evaluate the other three outcomes as alternatives to this choice. All the regressions include intercept, dummy variables for each calendar year and each 4-digit SIC code to control for time effects and refined industry effects. White's corrected *t*-statistics are reported in parentheses below each coefficient estimate, and *, ** and *** denote statistical significance at the 10%, 5% and 1% levels, respectively.

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