

What Motivates Banks to use Derivatives: Evidence from Taiwan

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Abstract

Banks are active users of derivatives. Using banks listed on the Taiwan Stock Exchange for which there is detailed derivatives information for the period 1998 to 2005, we examine the determinants of derivatives usage and its impact on bank risk. Using specific bank characteristic variables that proxy for the motivations and effects of banks participating in the derivatives market and end-quarter transaction volumes, we investigate the rationale for derivatives usage that are discussed in the literature. Using Probit and panel data methods and testing for endogeneity, we investigate whether risk management, informational and economies of scale arguments as well as agency and managerial explanations are good predictors of observed activity.

Our results support the evidence of prior studies that risk management, and informational and scale factors explain the use of derivatives. On the other hand, our findings do not show that the use of derivatives affects observable risks. We also observe a substitution effect which suggests a rational approach to the participation decision. However, we find no support for agency and managerial motives, which we partly attribute to the specific regulatory, legal, and cultural environment that exists in Taiwan.

JEL classification: C3; G32; M41

Keywords: Derivatives; Hedging; Risk management, Banks

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1. Introduction

Financial economists have long been interested in the reasons why firms engage in risk management. While the rationale for the corporate use of derivatives has been the subject of a number of studies, there is comparatively little research into the motivations for banks and other financial institutions to use derivatives. As intermediaries with highly-levered balance sheets, banks have large exposures to interest rate, commodity, and currency risks and need effective ways to manage these exposures. Derivatives provide an efficient tool for off-balance sheet risk management since they provide an easy means to hedge (manage) the residual risk from commercial operations. Using a unique Taiwanese dataset this paper examines the motivation for derivative use by banks.

The evidence for corporate use of derivatives suggests that non-financial firms primarily use the instruments to manage financial risks (Brown, 2001; Geczy, Minton and Schrand, 1997; Hentschel and Kothari, 2001; Mian, 1996; Nanse, Smith and Smithson, 1993). Financial theory also suggests that corporate risk management will have a positive effect on firm value in the presence of capital market imperfections such as financial distress and bankruptcy costs (Smith and Stulz, 1985), convex tax

rates, or underinvestment problems (Bessembinder, 1991; Froot, Scharfstein, and Stein, 1985; Smith and Watts, 1992). In addition, pervasive agency conflicts between managers and shareholders and other managerial factors, such as earnings management and speculation, also explain observed behavior (Brown 2001; Core, Guay, and Kothari, 2002; Kalay, 1992; Smith and Wakeman, 1985; Tufano, 1996). While the understanding of the corporate use of derivatives is relatively well-advanced, there is a dearth of research into the motivation for banks and other financial institutions to use derivatives. Colquitt and Hoyt (1997) examine corporate hedging behavior in the life assurance industry and find support for a number of the motives put forward for the corporate uses of derivatives. Also investigating insurance companies, Cummins, Phillips, and Smith (2001) find similar motives and explanations for derivatives usage that confirm and expand on the results of their earlier study (Cummins, Phillips, and Smith 1997). De Ceuster et al (2003) provide international evidence by using data for both life and general insurance companies in Australia. A number of other studies of derivatives use on different types of financial firms indicate the motivation is not dissimilar to that for corporate users (Koski and Pontif 1999; Schrand and Unal, 1998). Brewer, Jackson and Moser (1996) look at the incentives provided by the regulatory environment that might encourage risk-taking using derivatives but find that their sample of savings and loan companies do not show evidence of increased risk

Firm characteristics influence the extent of hedging activity. Flannery and James (1984) and Colquitt and Hoyt (1997) find that bank common stocks are sensitive to interest rate effects. In addition, banks with a larger element of international activities are more likely to face and accordingly manage their currency exposure (Allayannis and Ofek, 2001). Smith and Stulz (1985) predict that increases in option holdings

should be associated with less hedging. Corporate governance may also influence risk management decisions. It is argued that outside directors who are appointed to act in the shareholders' interests have an incentive to signal that they indeed do act in that way (Fama and Jensen, 1983; Mayers et al., 1997). Firms dominated by independent outside directors generally are considered to have better corporate governance and risk management attributes. Whidbee and Wohar (1999) find that banks' decision to use derivatives is related to the proportion of outside directors as a percentage of all directors. Less informed outsider board members may have concerns about derivatives use due to their impact on the bank's leverage and risk-taking.

Derivatives reduce the likelihood of financial distress by decreasing the variability in firm value, thus reducing the expected costs of financial distress (Smith and Stulz, 1985; Mayers and Smith, 1987). Sinkey and Carter (2000) provide similar evidence on the characteristics of banks that undertake risk management using derivatives which indicates that smaller banks are more likely to hedge. On the other hand, some studies argue that large firms have more resources to set up a hedging program and employ personnel with expertise in derivatives than do small firms and hence are more likely to use derivatives (Hoyt, 1989; Colquitt and Hoyt, 1997; Cummins et al. 1997; Cummins et al., 2001). In line with the scale and informational economies argument, Sinkey and Carter (2000) contend that affiliated banks have access to the resources necessary to be active derivative users. They find that affiliated banks are more likely to use derivatives due to the existence of barriers to entry in banks' derivatives activities. They also argue that banks that generate higher profitability from intermediation are more likely to undertake derivatives hedging programs to lock in profits, while those with lower profitability are more likely to assume risks or speculate using derivatives.

It has been suggested that alternative and less costly risk management activities may act as substitutes for the use of derivatives. First, maintaining higher liquidity could alleviate insolvency risk through lower dividend payouts or through having a higher current ratio and accordingly reduce the propensity of banks to hedge (Amihud and Murgia, 1997). Nance et al. (1993) indicate that firms could decrease the agency and expected financial distress costs associated with straight debt financing by issuing preferred stock.

Banks as intermediary institutions may use derivatives as a risk management tool to hedge on-balance sheet transactions. They may speculate on movements in interest rates, exchange rates, and commodity prices, although few would to openly admit this. The empirical evidence on the relation between derivatives use and corporate risk is mixed (Tufano 1996). Guay (1999) demonstrates that derivative use reduces corporate risk. Choi and Elyasiani (1997) show that there is a link between the volume of a bank's interest rate and foreign exchange rate derivatives contracts and the bank's interest rate and currency risks. Of interest to this study, they find that currency derivatives contracts are negatively related to bank risk. Sinkey and Carter (2000) find that banks with a higher likelihood of financial distress use derivatives to hedge risk. However, when looking at mutual funds, Koski and Pontiff (1999) show that risk exposure and return performance are unaffected by the use of derivatives. Also, Hentschel and Kothari (2001) argue that derivative use could increase or reduce corporate risk, but find no consistent evidence to support their argument.

Adkins, Cater, and Simpson (2007) investigate derivatives use and managerial incentives and find that managers who have a significant portion of their wealth

invested in the firm have an incentive to hedge corporate risks. In addition, they point out that the managerial labor market could form its perception of managers' capability based on firm performance, a factor which could also induce managers to undertake hedging (Cannella, Fraser and Lee, 1995). Sullivan and Strong (2007) find that earnings variation falls when managers have greater wealth concentration in their banks and when incentives to monitor increase, but also find that stock ownership by hired-managers can increase total risk. However, earlier papers by Saunders, Stock and Travlos (1990) and Whidbee and Wohar (1999) argue that as managers acquire more equity in a bank, the bank assumes more risk and uses less hedging. Hence there is little agreement concerning managerial motivation and banks' use of derivatives.

We believe that our study is the first to cover both the incentives for hedging with derivatives and its effects on entity risk for banks. Previous derivatives studies focus on either the determinants of corporate usage of derivatives (Nance et al., 1993; Goldberg et al., 1998; Heaney and Winata, 2005) or the derivatives impact on firm risk (Choi and Elyasiani, 1997; Guay, 1999; Hentschel, and Kothari, 2001). Combining the two issues in our study, we present a more complete picture of the operating and financial characteristics of banks that are motivated to use derivatives.

This study extends the literature on derivatives usage in three ways. First we investigate what factors prompt banks to use derivatives. As our dataset differentiates between trading and non-trading uses and the underlying assets and liabilities, including currency, interest rate, equity, commodity, and credit-related contracts, we are able to make new inferences about the nature of derivatives activity in our sample. We use this classification to investigate how fundamental characteristics and managerial variables explain the utilization of specific types of instruments. In

particular, we assess bank characteristics and participation/volume decisions using currency and interest rate contracts. We choose these particular contracts due to their relatively high trading volumes.

Second, we are able to control for the problem that derivative use may be endogenous. For instance, certain characteristics of a bank may simultaneously determine both the level of the utilization of derivatives and bank risk. Our models specifically address this problem and hence provide more robust tests.

Third, as we use quarterly reporting data, we are able to analyze both within-years as well as end-of-year reporting transactions. We are able to extend studies such as Cummins, et al., (1997), Hardwick and Adams, (1999), Cummins, et al., (2001), and Shu and Chen, (2003) which rely on annual data. Simply using year-end positions excludes derivatives positions taken and then closed out for window-dressing or tax considerations. We believe our data mitigates this problem in that we can distinguish between trading and non-trading derivatives activity. In addition, holding derivatives instruments for hedging purposes for less than one quarter is relatively rare in practice. So while we do not have access to daily derivatives positions and we cannot observe intra-quarter activity, our data helps mitigate the measurement bias seen in other studies.

Understanding how banks use derivatives is important. Whereas the use of exchange-traded commodity derivatives has a long history, financial derivatives have a relatively recent history only being introduced in the 1970s. In the case of Taiwan, interest rate and foreign exchange derivatives were only launched in 1998 on the Taiwan Futures Exchange and hence our study covers the period when Taiwanese banks started to have access to locally-traded derivatives.

First, we examine risk management motives using a range of bank-specific factors found in the literature to influence participation activity in derivatives, namely characteristics such as size, affiliation, foreign operations, and so forth. We then examine whether bank characteristics and agency and corporate governance variables explain why banks avoid observable risk. We also study whether alternatives to derivative instruments and technical expertise in derivatives affect the usage decision. Third, we examine the extent to which banks hedge against firm risks. In our analysis, we take account of the endogeneity problem that banks' characteristics may influence derivative usage and risk. The remainder of the paper proceeds as follows: Section 2 introduces the sample and data, and we explain our methodology. In Section 3, we present the empirical results from which we offer some conclusions and their implications in Section 4.

2. Data and Methodology

This study uses data on all Taiwanese domestic banks that are listed on the Taiwan Stock Exchange (TSE) and Gre Tai Securities Market (GTSM), the over-the-counter securities exchange, over the period 1998:Q2 to 2005:Q1, a total of 28 quarters. The information on derivative usage is acquired from various editions of the publication *Condition and Performance of Domestic Banks* filed with the Central Bank of China containing end-of-quarter records of notional values of derivatives categorized as either trading or non-trading. The quarterly data on firm-specific characteristics are collected from the *Taiwan Economic Journal* (TEJ) Data Bank and the financial

statements provided by the *Securities and Futures Institute* (SFI).³ We have had to omit branches and subsidiaries of foreign banks, unlisted domestic banks, and regional depository institutions due to lack of data. The final sample consists of a panel of 934 firm-quarter observations that relates to 34 banks in 1998:Q2 and increases to 35 in 2005:Q1. The variables used in our study are defined in Table 1.

[Insert Table 1 about here]

We use a probit model to examine the effects of firm-specific factors that influence participation in derivatives.⁴ This approach allows for the discreteness of participation decisions and employs a dummy variable which equals one for users and zero for nonusers.⁵ The probit model is structured as follows:

$$Z_{i,t} = F^{-1}(P_{i,t}), \quad (1)$$

and

$$P_{i,t} = F(Z_{i,t}) = \Phi(Z'_{i,t}\beta) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{Z_{i,t}} e^{-s^2/2} ds, \quad (2)$$

where $Z_{i,t}$ is the vector of explanatory variables, F^{-1} is the inverse of the cumulative normal probability function, $P_{i,t}$ is the probability that bank i in quarter t participates in derivatives activities, s is a standard normal variable and β is the vector of the parameters to be estimated.

³ The quarterly data on non-performing loans during 1998-1999 are only available for a small portion of banks in the TEJ Data Bank. As a result, we use the year-end values of non-performing loans, which were hand-collected from the annual financial reports offered by the *Taiwan Securities and Futures Information Center*, as substitutes for the incomplete quarterly information for this variable.

⁴ For robustness checks, we also conduct the empirical analysis using logit and OLS models, which we do not discuss in this paper. Although the parameter estimates vary somewhat from the results we report here, the main tenor of the statistical test results remains unchanged.

⁵ We use FXPAR for currency-related derivatives participation and IRPAR for interest-rate related participation.

Combining equations (1) and (2) a simple probit regression model, for each of our three dependent variables to be defined subsequently, takes the form:

$$P_{i,t} = F(Z_{i,t}) = F\left(\alpha + \sum_{k=1}^K \beta_k x_{k,i,t} + \nu_i + \tau_t + \varepsilon_{i,t}\right) \quad (3)$$

where $Z_{i,t}$ represents the derivatives participation of bank i at the end of quarter t and is a binary variable proxy that takes the value one for derivatives users and zero otherwise. x_{kit} is the value of the k^{th} explanatory variable for bank i in quarter t ; k is the index of explanatory variables and $k = 1, \dots, K$; i is the index of bank and $i = 1, \dots, N$; t is the index of quarter and $t = 1, \dots, T$; α is a constant term; ν_i and τ_t accounts for individual bank and time effects, and $\varepsilon_{i,t}$ is a classic error term.

In our model for the motivations for derivative usage, we use the same regressors as in equation (3) and estimate the following panel regression model:

$$D_{i,t} = \alpha + \sum_{k=1}^K \beta_k x_{k,i,t} + \nu_i + \tau_t + \varepsilon_{i,t} \quad (4)$$

where $D_{i,t}$ is the derivative use by bank i at the end of quarter t , measured as the quarter-end notional value of derivatives positions (hereafter QEP) normalized by market value of total assets.⁶ Two different measures of QEP are used: currency-related holdings (FXQEP), and interest rate-related holdings (IRQEP).

For our risk model, we assess the effects of participation and volume decisions on capital market risk, which we measure either as total risk (SDR), normalized total risk

⁶ Market value is defined as the sum of market value of common equity, which is computed from the product of the closing stock price at the last trading day of each quarter multiplied by the number of shares outstanding, plus book value of liabilities and preferred stock. We use as our numerator derivatives positions classified as non-trading (that is, held for hedging purposes).

(SDRN), systematic risk (BETA), or unsystematic risk (IDS). To this end, we regress our risk measure on the use of derivatives and several control variables. Drawing on the previous research on firm risk and the use of derivatives and controlling for other risk-related characteristics, we specify a participation dummy as a variable measuring bank participation in derivatives. The panel data method is applied to estimate the following model:

$$R_{i,t} = \alpha + \beta_1 Z_{i,t} + \beta_2 CV_{i,t} + \nu_i + \tau_t + \varepsilon_{i,t} \quad (5)$$

where $R_{i,t}$ is firm risk, $Z_{i,t}$ is a measurement of participation in derivatives contracting, and $CV_{i,t}$ refers to the set of control variables. Following the approach used by Hentschel and Kothari (2001), we also control for financial leverage (LEVER), market value of equity (EMV) and book to market ratio (BM).

Controlling for bank characteristics, we examine the effect of transaction volumes in the same way as our risk model but replace the participation dummy in equation (5) with our transaction volume measure to assess the effects of the level of derivatives usage on bank risk, again using a panel model:

$$R_{i,t} = \alpha + \beta_1 D_{i,t} + \beta_2 CV_{i,t} + \nu_i + \tau_t + \varepsilon_{i,t} \quad (6)$$

where $D_{i,t}$ is the level of derivative use proxied by FXQEP or IRQEP, depending on the model.

In order to examine the marginal effect of the transaction volume decision, we use the Hentschel and Kothari (2001) methodology and construct 11 volume-based portfolios in terms of the level of derivatives use for each quarter. Portfolio 0 encompasses

banks that do not use any derivatives. The remaining banks are divided into 10 portfolios with approximately equal number of banks in each. Portfolio 1 consists of the banks with the lowest level of derivative use, while portfolio 10 includes those with the highest level. The level of derivative use is proxied by QEP in equation (7).

Controlling for risk factors, we examine whether banks with different levels of derivatives use differ in their risk by using portfolio dummies. Particular attention is paid to the difference in risk between extreme users, i.e., banks with the highest and lowest derivatives usage.

$$R_{i,t} = \alpha + \sum_{m=1}^{10} \alpha_m P_{i,m}^{QEP} + \beta_2 CV_{i,t} + \nu_i + \tau_t + \varepsilon_{i,t} \quad (7)$$

where the portfolio dummy $P_{i,m}^{QEP}$ is assigned a value of one for bank i at the end of quarter t if the bank is in portfolio m and zero otherwise.

We start our analysis with both fixed-effects models (FEM) and random-effects models (REM) since we have no a priori case that what we observe conforms to a particular model. However, if the general tenor of the results remains unchanged, our results will be robust to either specification. In order to determine the most appropriate model, we employ the two-stage diagnostic procedure suggested by Greene (2003, pp. 298-303). First, the Lagrange Multiplier (LM) test of Breusch and Pagan (1980) is used to compare OLS estimation against FEM/REM; a large value for the LM test statistic favors FEM/REM. Second, the specification test by Hausman (1978) is used to test REM against FEM; a large value for the Hausman test statistic favors FEM. For brevity, we report results for the most appropriate model determined by using these two tests. In addition, we examine if heteroscedasticity exists in the error term using the White (1980) test. If it does, a heteroscedasticity-consistent

estimation by Greene (2003, pp. 316-317) is performed.

In our tests of the effects of the participation/level of derivatives usage on risk, we assume that derivatives participation/level is exogenous. However, as discussed, this may not be the case. Certain bank characteristics may jointly influence both derivatives usage and risk and thus may be potential sources of endogeneity. If so, our coefficient estimates from regressions will be biased. We use significant variables obtained from the determinants model as instruments, those correlated with the endogenous variable, but uncorrelated with the disturbances. We perform a Hausman (1978) test for the endogeneity of derivatives participation/level and a Granger (1969) causality test to explore the endogenous patterns within specifications of the risk model and reduce the likely effects of endogeneity by using a 2SLS regression.

We also address the potential problem of multicollinearity. This applies especially in the risk model where there might be correlation between the risk-management incentives and the hedging level. Since a linear relation might exist among more than two variables, we examine the variance inflation factors (VIFs) for each explanatory variable employed. As a rule-of-thumb, variables can be regarded as highly collinear if a VIF exceeds ten (Gujarati, 2004, p. 362). The VIFs range from 1.00 to 5.52, indicating that the degree of multicollinearity is not severe in this study.

3. Results

We present the results of our different models first by presenting the determinants

⁹ The choice of eight lags is arbitrary, mainly due to the limitation of the software used. Different numbers of lags also are tried. The tenor of the results remains unchanged.

that influence participation in derivatives activity before discussing the results for bank risks. Table 2 shows the probit analysis for the effects of firm-specific characteristic on banks' participation activities for currency-related and interest rate-related derivative instruments. The likelihood ratio test and the Lagrange multiplier test results indicate that the models provide a good statistical fit. In both currency- and interest rate-related models the coefficients on the foreign exchange exposure variable (FX), measured by the proportions of net income of offshore banking units, are positive and highly significant. This suggests that banks with higher foreign currency exposure are more likely to engage in derivatives activities. This is consistent with prior studies such as Goldberg et al., (1998) and Allayannis and Ofek, (2001), in that banks with a higher proportion of net income from overseas subsidiaries are likely to have a greater propensity to hedge foreign exchange risk with currency-related instruments. Our results also supports the claim made by Goldberg et al. (1998) that banks using interest rate derivatives are more multinational.

[Insert Table 2 about here]

We find that asset-liability mismatches as indicated by our gap measures (IGLIA) and (IGAST) provide partial validation that observable risks contribute to derivatives usage. The coefficient of one of the interest rate risk related variables (IGLIA) is weakly positively associated with the interest rate derivatives decision and is significant at the ten percent level. This finding lends support to the view that derivatives are being used to manage the risks faced by banks. On the other hand, the sign for IGAST is negative but statistically insignificant. These conflicting results suggest that banks are more likely to use interest rate derivatives when interest rate

sensitive liabilities outweigh assets. This might be attributable to the different implications for our measures of gap risk. Looking at how other risk measures affect the decision, the z statistics show that the measure CREDIT (the ratio of non-performing loans to total loans) is not associated with a higher likelihood of derivatives usage. In this, our results differ from those of Sinkey and Carter (2000) and the fact that IGLIA is weakly significant but CREDIT is not does not support Schrand and Unal's (1998) hypothesis of coordinated risk management. However, as discussed later, there may be local factors that affect derivatives activity and would explain the lack of significance in our results.

The significantly positive coefficients on the firm size variable (SIZE) support the proposition that derivatives usage is partly dependent on scale and informational economies. This finding is consistent with the results of Nance et al. (1993), Mian (1996), Colquitt and Hoyt (1997), Sinkey and Carter (2000) and Cummins et al. (2001). However this finding runs counter to the idea that banks hedge against costly financial distress (Smith and Shultz, 1985).

We find a significant positive relation between the issuance of preferred stock (PS) and the decision to participate in derivatives activities in both models. The evidence is contradictory to our expectation, as proposed by Nance et al., (1993), that banks control agency and expected financial distress costs arising from long-term financing through the issuance of preferred stock. But it is consistent with Froot et al. (1993) who argue that issuing preferred stock increases leverage and thus the underinvestment problem, which can be alleviated by hedging.

We find that our measures for internal diversification (HERFR for revenues and HERFLTL for long-term liabilities) have a significant effect on the participation

decision. HERFR is significant for the use of currency and interest rate derivatives and HERFLTL influences the decision on interest rate derivatives. Our results are consistent with the view that diversification provides an alternative or reduces the demand for derivatives instruments for hedging purposes. This finding lends some support to the view that banks are likely to seek to manage their risks by diversifying revenues rather than simply relying on financial hedging. Our other measures for diversification such as the ratio of non-operating to operating income (NOI) and diversification of costs (HERFC) are not found to be statistically significant. One possible explanation for this is that banks focus on balance sheet rather than income risk measures. Also it may be the case that these diversification variables are poor proxies for these factors.

We find that for interest related derivatives the participation decision is positively affected by the net interest margin (NIM). The significance of NIM could be indicative of the fact that, with higher earnings generated from lending activities, banks have a greater need for interest rate derivatives to hedge NIM generated income. That is, banks with above average net interest margin would desire to lock in their interest spreads through the use of interest rate contracts.

The estimated coefficient for liquidity (CR) is negative and significant at the ten percent level in the participation model for interest rate derivatives, while it is positive but insignificant in the model for currency derivatives. This finding lends only weak support to the financial distress cost argument that banks can reduce the likelihood of encountering financial distress and thereby reduce its expected costs. We also find that the dividend payoff (DIV) exerts a negative impact on currency derivatives participation. This finding is contrary to the results of prior studies (e.g., Kalay, 1982;

Nance et al., 1993) who suggest that firms could reduce the expected agency costs and financial distress costs by paying lower dividends to control the underinvestment problem. One possible explanation for the contradiction is that lower dividend payouts provide higher free cash flows, increasing the underinvestment problem.

Some of the firm-specific elements found to be important incentives for the hedging decision in the extant literature are insignificant in our probit analysis. For instance, unlike Smith and Stulz (1985) and Tufano (1996), there is no observable relationship between managerial ownership (MO) and the decision to use derivatives. Our results do not support the notion that, as their shareholdings increase, managers engage more in hedging using derivatives. Nor does this result provide support for the argument put forward by Whidbee and Wohar (1999) that in the banking industry managerial ownership is inversely related to hedging using derivatives. The coefficient on our corporate governance variable (GOV) is consistently negative, but insignificant at the 0.1 level. While we do not find any support that corporate governance is related to the use of derivatives, we recognize that a single variable may be inadequate given the conflicting views on the impact of corporate governance on derivatives activity. Nor do we observe in our model the expected significant positive association between growth options (GROWTH) and the decision to use derivatives. The estimated coefficient on GROWTH is consistently positive as expected, but insignificant at the 0.1 level. Overall, there seems little support for the idea that agency and managerial motives influence derivatives activity.

The affiliation variable (AFFIL) in our models are insignificant and have mixed signs. One possible explanation is that whether the affiliated bank uses derivatives largely depends on the parent company. If the parent bank is an active derivatives user,

the affiliated bank is better able to use derivatives than a bank without affiliation. However, this may not mean that the affiliated bank is more likely to use derivatives because its parent bank may be in charge of the risk management program.

As with the participation decision, our volume decision analysis uses two sets of equations estimated using panel data models for currency-related and interest rate-related derivatives holdings by quarter-end. These are shown in Panels A and B of Table 3. The White (1980) test results are significant at the 0.01 level, suggesting the present of heteroscedasticity in the error term and as a result, the heteroscedasticity-consistent estimation suggested by Greene (2003) is performed to derive White-adjusted *t*-statistics. The results from the LM and Hausman tests suggest that the most appropriate specifications for currency and interest rate derivatives are random-effects models. We test for endogeneity using the derivatives measures and risk metrics and carry out the Hausman test for each volume decision-related specification in the risk model using significant variables in the determinants model as instruments. The unreported results show that the currency-related positions are endogenously determined with unsystematic risk.

[Insert Table 3 about here]

To assess whether we have statistical support for the direction of causation between derivatives holdings and bank exposures as well as to examine the robustness of the findings of the Hausman test, we perform the Granger causality test using the quarterly mean values of each derivatives measure and risk metric that are lagged by eight quarters⁹. The unreported results indicate that firm risks generally do not Granger-cause the derivatives decision, and vice versa with the exception of the relationship between total risk/unsystematic risk and interest rate-related positions.

The F -test rejects the null hypothesis that firm risks (total risk/unsystematic risk) do not Granger-cause the interest rate-related position. Nevertheless, both test statistics for the reverse causality fail to achieve significance. These findings do not consistently corroborate our earlier results from the Hausman test in support of the endogeneity of currency derivatives decisions. The causal direction between currency derivatives usage and unsystematic risk is not evident. However, recognizing the endogenous nature of the relation, we apply the 2SLS regression to estimate the regression instead of the panel data approach.

As may be expected, there are fewer significant results in the volume decision models than in the participation models. One explanation for the differences is that the derivatives market may be dominated by a few large banks even though there are a large number of market participants. We find a strong positive relationship between holding company affiliation (AFFIL) and the volume decision, suggesting that affiliated banks use more derivatives than unaffiliated ones. This is consistent with the marginal costs hypothesis suggested by Cummins et al. (2001).

Our results accord with the prediction that derivatives use is inversely related to the availability of substitutes. The relationship between the extent of derivatives use and the alternative instruments, namely diversification of business operations (NOI), the diversification of revenues (HERFR)¹⁰, and diversification of long-term investments (HERFLTI), is negative and significant at the 0.01 and 0.05 level in the interest rate derivatives models. However, we do not find the same relationship for currency derivatives models. We attribute the differences between the two results to the greater opportunities available to our sample of banks to use alternatives to

¹⁰ Consistent with what we have evidenced in the probit model, the diversification measure represented by Herfindahl index of revenues is significantly negative in both specifications of quarter-end position.

derivatives in the case of local currency activities, whereas such opportunities are not so readily available in the case of currency-related business.

For currency volumes model, we find the coefficients for the issuance of preferred stock (PS) and credit risk (CREDIT) both contradict our predictions. The positive relationship between preferred stock issuance and derivatives use is consistent with the result we obtained from the probit model and provides further support for the hypothesis that, given that preferred stock reflects additional leverage, debt-constrained firms are expected to incur underinvestment costs and hence, more likely to hedge with derivatives. The coefficient on CREDIT is negative and significant at the 0.1 level, and suggests that as the probability of financial distress increases, managers utilize fewer derivatives. This finding is inconsistent with Sinkey and Carter (2000) who argue that banks use derivatives in response to credit risk. One possible explanation for our results is that Taiwanese banks with high credit risk are closely monitored by the supervisory authority. Given this, banks with a high percentage of non-performing loans would receive further supervisory attention if they use derivatives to any great extent. We should note that over the time period of our study the overall profitability of the banking industry deteriorated, due in large part to increases in non-performing loans. Hence banks with a higher percentage of non-performing loans generally have a higher probability of financial distress, receive greater regulatory supervision and may be deterred from using derivatives¹¹. Hence local factors may contribute to our contrary results.

Summarizing the previous discussions, our results support the view that banks with greater diversification in the form of business operations, revenues, and

¹¹ In 2001, the Taiwan government set up the Financial Restructuring Fund which provides funds to help banks write off non-performing loans to improve their profitability.

long-term investments and affiliation to a financial holding company are motivated to engage in derivatives activities to reduce observable risks.

Table 4, in Panels A through D, reports the effects of derivatives (currency-related and interest rate-related) participation on our different measures of firm risk (total risk, normalized total risk, systematic risk, and unsystematic risk). However, for brevity, we do not show the details of the results for control variables. The overall results show that none of the derivatives participation decisions significantly affect any of the bank risks with the exception of the effect of currency related participation on total risk. The significant and positive coefficient on the currency-related participation dummy supports the risk-taking hypothesis and provides evidence that the currency-related decision could increase the level of total risk, implying that the decision to use exchange rate related contracts might be driven by speculative rather than hedging incentives. In addition, it is worth noting that total risk (standard deviation of daily returns) is influenced by other economic and bank-specific characteristics.

[Insert Table 4 about here]

We report the influence of transaction volumes on bank risk in Table 5, Panels A to D. Consistent with the findings from the participation decision models, the overall results for the volume decision models indicate that the majority of transaction volume decisions have no effect on the capital market risk metrics except for the quarter-end interest rate position (IRQEP). The significantly negative coefficients on IRQEP show that the use of interest rate- related derivatives could effectively reduce total and unsystematic risks, despite the insignificance of interest rate-related

participation (IRPAR) in the model. As discussed earlier, the inconsistent results for IRQEP and IRPAR might be stemming from the fact that the interest rate derivatives market is dominated by a few large banks that have trading volumes large enough to influence the level of firm risk.

[Insert Table 5 about here]

Following Hentschel and Kothari (2001), we form eleven quarter-end position (QEP) ranked derivatives portfolios; QEP is defined as $Q_{i,t} / MV_{i,t}$, where $Q_{i,t}$ is the notional value of quarter-end derivatives position for which derivatives information is disclosed at the end of each quarter and $MV_{i,t}$ is the market value of assets, the sum of market value of outstanding equity and the book value of liability, measured at the end of each quarter for bank i in quarter t . Portfolio 0 comprises bank-quarter observations without any end-of-quarter derivatives holdings. According to the ranked level of QEP, we further cluster our derivatives-user observations into ten portfolios with an approximately equal number of bank quarters in each portfolio and employ dummy variables to respectively proxy each of the eleven portfolios. Portfolio 1 includes firm quarters with the lowest QEP and Portfolio 10 includes firm quarters with the highest QEP. Then we regress bank risk on these dummies and three control variables financial leverage (LEVER), market value of equity (EMV), and book-to-market ratio (BM). The unreported results indicate that most coefficients on derivatives portfolio dummies are statistically insignificant, supporting the implications of the previous joint analysis. Like Hentschel and Kothari (2001), we cannot find, for any risk metric, uniform marginal changes which bear out our expectation that the risk levels differ between extreme users, and low-level participants, or nonusers. Moreover, based on the findings of the marginal effect model, we can rule out the possibility that banks

might base their derivatives hedging decisions on speculative incentives since, according to the derivatives holdings and average change of derivatives positions shown in the intensive derivatives-users portfolios, there is no significantly positive relation between derivatives holdings and risk.

There are several caveats to the above results. First, due to the limitations of the derivatives disclosures under current accounting standards, quarter-end notional principal amount of derivatives positions, rather than mark-to-market information, are employed for the analysis. The notional value aggregates long and short positions, thereby ignoring the potential netting effect. However, in line with other studies on derivatives usage, it is still considered as a satisfactory measure of a bank's involvement in derivatives (e.g. Colquitt and Hoyt, 1997; Goldberg et al. 1998; Sinkey and Carter, 2000; Allayannis and Ofek, 2001). A readily available alternative construct which is clearly superior to notional value simply does not currently exist (Nguyen and Faff, 2002). Second, the endogeneity issue might not be fully addressed. In practice, there is no definitive approach to identifying appropriate instruments for the Hausman test and 2SLS regression (Maddala, 2001, pp. 354-359). Finally, this study might suffer from potential serial correlation of the error terms. Data for longer periods and data on more firms are needed to address such an econometric problem.

4. Conclusions

The rationale for the corporate use of derivatives is well established; that for banks and other financial institutions less so. In our study we analyze the determinants for the use of derivatives using a sample of Taiwanese banks. Adopting the approach used

by Goldberg et al. (1999) and Nguyen and Faff (2002) different determinants are identified for participation and volume decisions for currency and interest rate derivatives. Our results indicate that bank-specific characteristics do influence participation. As with other studies, we find that the propensity to use derivatives is positively related to bank size, currency exposure, issuance of preferred stock, while negatively related to diversification of revenues. These findings suggest scale and informational economies and greater currency exposure, which cannot be easily offset by alternative strategies, increase the need for off-balance sheet hedging. This helps explain the different results for interest rate or currency related activity. This suggests different motivations for these instruments.

In our results, we find some support for the substitution effect for our revenue diversification variable but the preferred stock issuance measure contradicts this finding. The interest rate volumes model results suggest that diversification of business operations, revenues, and long-term investments influence derivative volumes and indicate the existence of a substitution effect. So although somewhat inconsistent, our findings imply that the banks in our sample rationally consider all the alternatives when weighing up the decision to use derivatives. This is lent further credence by the fact that affiliated banks, with lower costs of entry, are found to utilize more interest rate related derivatives than unaffiliated ones.

We find some support for the motivations given in the literature for risk management using derivatives. However, we find little support for the risk-reduction hypothesis. In line with Hentschel and Kothari (2001), we find no concrete evidence that derivatives use has any effect on a bank's risk, proxied by total risk, normalized total risk, systematic risk and unsystematic risk.

We also find little support in our models for the agency and managerial arguments put forward to explain the uses of derivatives. Our variables for managerial ownership are largely insignificant, with the exception of the participation decision for currency derivatives. Nor do we find any significant result for our corporate governance proxy. The lack of significance may be due to the institutional, regulatory, legal, and social differences between this and other studies, but it is also the case that the direction of effect may be bank-specific and not well captured in our models. More remains to be done on this question. Current theories disagree on the outcome of managerial ownership and the effect of derivatives use. Hence this is an area that merits further study, especially given the different business and regulatory environment that exists for many banks, which current theories largely ignore. We think this may show up important interactions between banks' risk-taking and the legal-managerial-corporate governance-regulatory nexus.

Finally, our work has a number of implications for those interested in risk management in financial institutions, including regulatory authorities, practitioners, and stakeholders. First, some on-balance sheet hedging instruments, such as the diversification of revenues and long-term investments and liabilities, serve as alternatives to reduce bank risks. Second, we do not find much evidence that derivatives use either increases or decreases bank risks. This tends to suggest that banks do not use derivatives to modify their risks but that they are just alternative used to establish the desired level of risk-taking.

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Table 1 Definitions, measurement of variables and hypothesized signs for the determinants and risk models

Variable	Mnemonic	Definition
<i>Panel A: Derivatives usage</i>		
<i>Participation decision</i>		
Currency-related participation	FXPAR	Participant dummy variable taking the value one for participants, zero otherwise ^a
Interest rate-related participation	IRPAR	Participant dummy that equals one for participants and zero otherwise ^a
<i>Volume decision</i>		
Currency-related quarter-end position	FXQEP	End-of-quarter currency-related derivatives positions scaled by market value of total assets ^a
Interest rate-related quarter-end position	IRQEP	End-of-quarter interest rate-related derivatives positions scaled by market value of total assets ^a
<i>Panel B: Risk metrics</i>		
Total risk	SDR	Standard deviation of daily share returns ^b
Normalized total risk	SDRN	Standard deviation of daily share returns / standard deviation of daily market returns ^c
Systematic risk	BETA	Coefficient of the market model regression ^d
Unsystematic risk	IDS	Standard deviation of the error term from the market model ^e
<i>Panel C: Proxies of firm characteristics</i>		
<i>Hypothesis 1: Growth opportunity</i>		
Growth opportunity	GROWTH	Retention ratio ^f × return on equity
<i>Hypothesis 2a: Managerial ownership</i>		
Managerial ownership	MO	Managerial shareholdings as a percentage of all shares outstanding
<i>Hypothesis 2b: Corporate governance</i>		
Corporate governance	GOV	Independent outsider directors as a percentage of all directors
<i>Hypothesis 3: Avoidance of observable risks</i>		
Interest rate risk	IGAST	Interest rate sensitivity gap-to-net value ratio ^g
Interest rate risk	IGLIA	Interest rate sensitivity gap-to-net value ratio ^g
Currency risk	FX	Net income of offshore banking units / net income of parent bank
Credit risk	CREDIT	Non-performing loans ^h / total loans
<i>Hypothesis 4: Ability to involve in derivatives market</i>		
Firm size	SIZE	Natural logarithm of total assets
Affiliation to the holding firm	AFFIL	One for banks with affiliation of bank holding company and zero otherwise
Profitability	NIM	Net interest margin ⁱ / net income
<i>Hypothesis 5: Alternatives to derivatives instruments</i>		
Liquidity	CR	Current ratio
Dividend payout ratio	DIV	Cash dividends / net income
Issuance of preferred stock	PS	Book value of preferred stock/ Book value of all stocks
Business diversification	NOI	Non-operating income / operating income
Diversification of revenues	HERFR	Inverse of Herfindahl index of revenues ^{j,k}
Diversification of costs	HERFC	Inverse of Herfindahl index of costs ^{j,l}
Diversification of losses	HERFL	Inverse of Herfindahl index of losses ^{j,m}
Diversification of long-term investments	HERFLTI	Inverse of Herfindahl index of long-term investments ^{j,n}
Diversification of long-term liabilities	HERFLTL	Inverse of Herfindahl index of long-term liabilities ^{j,o}
<i>Hypothesis 6: Derivatives hedging against firm risk</i> (Control variables employed by Hentschel and Kothari, 2001)		
Financial leverage	LEVER	Book value of liabilities / market value of common equity
Market value of equity	EMV	Natural logarithm of the market value of common equity
Book to market ratio	BM	Book value of assets / market value of assets ^p

Notes: Table 1 lists the information on mnemonics, definitions, and expected relations for both determinants and risk models. All variables are measured on quarter-end basis during the sample period 1998:Q2-2005:Q1.

^a The derivative contracts for hedging purpose are classified into five subcategories based on the nature of underlying assets: currency-related, interest rate-related, equity-related, commodity-related, and credit-related contracts, respectively. Due to the interest rate-related and currency-related derivatives trading dominate those of other types, we utilize these two kinds of contracts for examining the derivatives hedging activities. In our study, the derivatives utilization is measured according to participation and usage decision of derivatives. As to derivative participation, those banks disclosing notional value of derivatives positions on quarterly financial statements are referred to as derivative participants proxied by participant dummy set equal to one for users, and zero otherwise. The decision on the extent of derivative usage is evaluated in terms of quarter-end position, proxied by $Q_{i,t} / MV_{i,t}$, where $Q_{i,t}$ is the notional value of quarter-end derivative position for which derivative information is disclosed for bank i in quarter t , and $MV_{i,t}$ is the market value of assets, the sum of market value of outstanding equity and the book value of liability, measured at the end of each quarter. The market value of outstanding equity is defined as the sum of market value of common stock, which is measured as the closing stock price at the last trading day of each quarter multiplied by the number of shares outstanding at the same date, and book value of preferred stock.

^b Total risk proxied by the standard deviation of daily return for bank i in a given quarter t is computed as $\sqrt{\left\{ \left[\frac{1}{(N-1)} \right] \sum_{j=1}^N (r_{i,j} - \bar{r}_i)^2 \right\}}$, where N is the number of trading days in a given quarter t , $r_{i,j}$ is the daily share return of bank i for the trading day j , and \bar{r}_i is the average daily stock return for bank i during quarter t .

^c Normalized total risk measured by the normalized standard deviation of daily return is computed as $\sqrt{\left\{ \left[\frac{1}{(N-1)} \right] \sum_{j=1}^N (r_{i,j} - \bar{r}_i)^2 \right\}} / \sqrt{\left\{ \left[\frac{1}{(N-1)} \right] \sum_{j=1}^N (r_{m,j} - \bar{r}_m)^2 \right\}}$, where N is the number of trading days in a given quarter t , $r_{i,j}$ denotes the daily return of bank i for the trading day j , \bar{r}_i is the mean daily return in quarter t , $r_{m,j}$ denotes the daily index return of Taiwan Stock Exchange Corporation Capitalization Weighted Stock Index (TAIEX), a proxy of the market return, for the trading day j , and \bar{r}_m is the mean daily index return of TAIEX during quarter t .

^d Systematic risk measured by beta for bank i in a given quarter t is computed as the estimate of $\beta_{i,t}$ in the Capital Asset Pricing Model (CAPM) based single-index model as follow:

$$r_{i,j} - r_{f,j} = \alpha_{i,t} + \beta_{i,t} (r_{m,j} - r_{f,j}) + \varepsilon_{i,j},$$

where, in each quarter t , $r_{i,j}$ denotes the daily stock return of firm i at the trading day j , $r_{f,j}$ is the risk free rate proxied by the daily interbank money market rate, $r_{m,j}$ is the market return represented by the daily TAIEX index return for the trading day j , and $\varepsilon_{i,j}$ is the residual term from the CAPM regression. The error term is uncorrelated with the return on the market portfolio, $r_{m,j}$.

^e Unsystematic risk evaluated by the standard deviation of error term of the single-index regression, $\varepsilon_{i,j}$, for bank i in a given quarter t is computed as $\sqrt{\left\{ \left[\frac{1}{(N-2)} \right] \sum_{j=1}^N \varepsilon_{i,j}^2 \right\}}$, where N is the number of trading days in a given quarter t .

^f The retention ratio is constructed by dividing the retained earnings by net income.

^g The level of mismatch between asset and liability evaluated by the interest rate sensitivity gap-to-net value ratio (IGAST, for interest rate sensitive assets greater than interest rate sensitive liabilities; IGLIA, for interest rate sensitive liabilities larger than interest rate sensitive assets) are formulated as follow:

$$\text{IGAST} = \begin{cases} \frac{\text{interest rate sensitive assets} - \text{interest rate sensitive liabilities}}{\text{book value of total equity}} & \text{interest rate sensitive assets} > \text{interest rate sensitive liabilities,} \\ 0 & \text{otherwise.} \end{cases}$$

$$\text{IGLIA} = \begin{cases} \frac{\text{interest rate sensitive liabilities} - \text{interest rate sensitive assets}}{\text{book value of total equity}} & \text{interest rate sensitive liabilities} > \text{interest rate sensitive assets,} \\ 0 & \text{otherwise.} \end{cases}$$

^h Non-performing loans are defined as the cluster of bad loans, overdue loans, receivables under collection, and loans under abnormal payment statuses.

ⁱ The net interest margin is defined as total interest income received less total interest expense paid, both of which are deflated by total operating income.

^j Suppose X consists of M components where each component denotes x_k and $k = 1, 2, 3, \dots, M$. The Herfindahl index is computed as $\sum_{k=1}^M (x_k / X)^2$ to measure the concentration of X .

^k Interest income, interest revenue from short-term bills, net gains on marketable securities, investment income accounted for under the equity method, recovery of unrealized losses on valuation of long-term investments, trust fee income, net gains on foreign exchange, commission and fee income, other operating revenues, proceeds from sale of property and equipment, and proceeds from bad loans are used to calculate Herfindahl index of revenues.

^l Interest expense, allowance for bad debts, commission and fee paid, brokerage securities transaction charges, cost upon credit card business, operating expenses, and operating taxes are used to calculate Herfindahl index of costs.

^m Realized and unrealized losses on long-term investments, trading security, currency, assets reassessment, disposal of properties, and disposal of collaterals assumed are used to calculate Herfindahl index of losses.

ⁿ Long-term investments in stocks, bonds, real estate, currency-related assets, and treasury stock are used to calculate Herfindahl index of long-term investments.

^o Long-term liability, financial debenture, appropriated loan fund, interbank borrowing, and advance from customs are used to calculate Herfindahl index of long-term liabilities.

^p The market value of assets is measured by the sum of market value of equity and the book value of liability.

Summary statistics from sample Table 2!!

Table 2
Probit analysis of the determinants explaining derivative participation, based on Eq. (3)

Variable	Expected sign	Currency participation		Interest rate participation	
		Coefficient	z-Statistic	Coefficient	z-Statistic
Constant		-4.4433	-3.6220***	-1.1718	-0.8850
GROWTH	+	0.0068	0.0750	0.1494	1.2030
MO	?	-21.6226	-1.3020	12.4467	0.6850
GOV	?	-0.7140	-0.3200	-12.6431	-1.5740
IGAST	+	-0.0167	-0.0880	-0.0589	-0.2760
IGLIA	+	0.0023	0.0810	0.0610	1.9580*
FX	+	5.2079	4.7790***	6.0628	4.3010***
CREDIT	+	-0.0757	-0.0530	-2.5915	-1.4410
SIZE	?	0.2809	4.4290***	0.2794	4.1610***
AFFIL	?	0.0082	0.0590	-0.2429	-1.5410
NIM	+	0.4830	0.8940	1.3892	2.3690**
CR	-	0.0003	0.0310	-0.0191	-1.7810*
DIV	+	-0.2865	-2.2220**	0.0908	0.8450
PS	-	2.6454	2.8020***	2.1339	2.0620**
NOI	-	0.4623	0.2470	2.3729	1.0930
HERFR	-	-1.2115	-2.4510**	-4.4991	-8.1150***
HERFC	-	0.3632	0.5240	-0.4858	-0.6210
HERFL	-	0.2566	1.1230	0.2114	0.8690
HERFLTI	-	-0.0467	-0.1790	0.0893	0.3040
HERFLTL	-	-0.3486	-1.3990	-1.4067	-4.9550***
Number of observations		934		934	
Likelihood ratio test ^a		157.8303***		386.5966***	
LM test ^b		390.0387***		364.5674***	
McFadden R^2		0.1275		0.3019	

Notes: Table 2 reports results of the probit analysis for participation decision in which the dependent variable equals one if the bank discloses notional principal of derivatives positions on quarterly financial statements, and zero otherwise over the period 1998:Q2-2005:Q1, for a total of 934 observations. The details of each variable are presented in Table 1. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

^a Significance suggests that coefficients of independent variables are jointly statistically different from zero.

^b Significance suggests that a regression relation does exist between the dependent and explanatory variables.

Table 3
Determinants model measuring factors affecting the level of derivative usage, based on Eq. (4)

Variable	Expected sign	Currency volume		Interest rate volume	
		Coefficient	z-Statistic	Coefficient	z-Statistic
Constant		-0.0001	-0.0050	0.0360	2.2770**
GROWTH	+	0.0005	0.2340	0.0005	0.3740
MO	?	-0.3893	-1.0890	0.2724	1.2530
GOV	?	-0.0489	-1.2130	-0.0130	-0.5270
IGAST	+	-0.0021	-0.6330	-0.0001	-0.0420
IGLIA	+	0.0002	0.3410	0.0001	0.2350
FX	+	0.0289	1.1250	-0.0101	-0.6460
CREDIT	+	-0.0001	-0.0050	-0.0246	-1.3000
SIZE	?	0.0012	0.9060***	0.0000	-0.0420
AFFIL	?	0.0008	0.2650	0.0167	9.4320***
NIM	+	0.0023	0.2100	0.0039	0.5960
CR	-	0.0001	0.5420	-0.0001	-0.4980
DIV	+	-0.0003	-0.1460	0.0014	1.1900
PS	-	0.1209	5.0020***	0.0113	0.7680
NOI	-	-0.0169	-0.4850	-0.0525	-2.4790**
HERFR	-	-0.0166	-1.7120*	-0.0253	-4.3010***
HERFC	-	-0.0038	-0.2860	-0.0079	-0.9730
HERFL	-	-0.0010	-0.2480	0.0026	1.0180
HERFLTI	-	0.0004	0.0610	-0.0114	-3.2730***
HERFLTL	-	0.0003	0.0570	-0.0020	-0.5570
Number of observations		934		934	
White test ^a		3.5418***		8.0401***	
LM test ^b		135.5400***		70.5200***	
Hausman test ^c / method ^d		0.0000	REM	0.0000	REM

Notes: Table 3 reports results of the panel data analysis for volume decision in which the dependent variable describing the extent of derivatives usage is measured by quarter-end position of derivatives utilization using quarterly data from 1998:Q2 through 2005:Q1, for a total of 934 observations. The details of each variable are presented in Table 1. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

^a Significance suggests the presence of heteroscedasticity in the error term and as a result, heteroscedasticity-consistent estimation suggested by (Greene, 2003, pp. 316-317) is performed to derive White-adjusted *t*-statistics.

^b Significance suggests a rejection of the null hypothesis that OLS is the correct specification and consequently application of the pooled regression technique is required (Greene, 2003, pp. 298-301).

^c Significance suggests that a fixed-effects model would be more appropriate and the random-effects model if otherwise (Greene, 2003, pp. 301-303).

^d To determine the most appropriate regression model for each specification, we follow a two-stage diagnostic procedure (Greene, 2003, pp. 298-303). We start with the LM test to explore the relative efficiency of the heterogeneous fixed/random-effects estimation against the homogeneous pooled OLS model. The significance of LM test statistic suggests that panel data models are more efficient than the pooled cross-sectional OLS model. In the second step, we conduct a Hausman specification test to decide which type of panel models—fixed- or random-effects—should be employed in our study.

Table 4
Effects of derivatives participation on firm risks, based on Eq. (5)

Variable	Equations				
	Expected sign	Currency participation		Interest rate participation	
		Coefficient	<i>t</i> -Statistic	Coefficient	<i>t</i> -Statistic
<i>Panel A: The effect of participation on total risk</i>					
FXPAR	?	0.1659	2.4560**		
IRPAR	?			0.0731	0.9670
Number of observations		926		926	
Adjusted R^2		0.1217		0.1168	
<i>F</i> -test ^e		7.7500***		7.4400***	
White test ^f		2.4258***		2.3836***	
LM test ^g		1.3500		1.6400	
Hausman test ^h / method ⁱ		0.0000	OLS	0.0000	OLS
<i>Panel B: The effect of participation on normalized total risk</i>					
	Expected sign	Currency participation		Interest rate participation	
		Coefficient	<i>t</i> -Statistic	Coefficient	<i>t</i> -Statistic
FXPAR	?	0.0327	0.6320		
IRPAR	?			0.0468	0.8050
Number of observations		926		926	
Adjusted R^2					
<i>F</i> -test					
White test		2.3557***		2.3116***	
LM test		4.4800**		4.5400**	
Hausman test / method		0.0000	REM	0.0000	REM
<i>Panel C: The effect of participation on systematic risk</i>					
	Expected sign	Currency participation		Interest rate participation	
		Coefficient	<i>t</i> -Statistic	Coefficient	<i>t</i> -Statistic
FXPAR	?	0.0223	0.7830		
IRPAR	?			0.0115	0.3540
Number of observations		926		926	
Adjusted R^2					
<i>F</i> -test					
White test		2.3330***		2.4187***	
LM test		477.7200***		492.0600***	
Hausman test / method		0.0000	REM	0.0000	REM

(continued on next page)

Table 4 (continued)
Effects of derivatives participation on firm risks, based on Eq. (5)

Variable	Equations				
	Expected sign	Currency participation		Interest rate participation	
		Coefficient	<i>t</i> -Statistic	Coefficient	<i>t</i> -Statistic
FXPAR	?	0.1261	0.0648*		
IRPAR	?			0.0128	0.0726
Number of observations		926		926	
Adjusted R^2		0.1612		0.1578	
<i>F</i> -test		10.4400***		10.2000***	
White test		2.4950***		2.4468***	
LM test		1.8000		2.2300	
Hausman test / method		0.0000	OLS	0.0000	OLS

Notes: This table reports results of the risk model for the participation decisions on firm risks, as specified in Eq (5), for the period 1998:Q2-2005:Q1. The details of each variable are presented in Table 1. For brevity, the estimates of the constant term and control variables are not tabulated but they are available upon request. The four different risk metrics specified as the dependent variable are total risk, normalized total risk, systematic risk, and unsystematic risk as defined in Panel D of Table 1. The influences of derivatives participation on these risks, in turn, are presented in Panels A-D. According to the nature of underlying assets, the non-trading participation decisions, measured by binary dummy variables assigned one for users and zero otherwise, are categorized into currency-related participation (FXPAR), and interest rate-related participation (IRPAR) within each panel. ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5
Effects of derivatives usage on firm risks, based on Eq. (6)

Variable	Equations			
	<i>Panel A:</i> <i>Dependent variable: Firm risk measured by total risk</i>		<i>Panel B:</i> <i>Dependent variable: Firm risk measured by normalized total risk</i>	
	Currency Extent	Interest rate Extent	Currency Extent	Interest rate Extent
	Expected sign	Coefficient	Coefficient	Coefficient
FXQEP	?	0.0381		-0.7349
IRQEP	?		-7.0471***	1.1365
Number of observations		926	926	926
Adjusted R^2		0.1159		
F -test		7.3800***		
White test		2.3275***	2.3775***	2.2410*** 2.8446***
LM test		2.2500	4.5900**	4.7800** 4.1700**
Hausman test		0.0000	4.2000	0.0000 0.0000
Method		OLS	REM	REM REM

Variable	Equations			
	<i>Panel C:</i> <i>Dependent variable: Firm risk measured by systematic risk</i>		<i>Panel D:</i> <i>Dependent variable: Firm risk measured by idiosyncratic risk</i>	
	Currency Extent	Interest rate Extent	Currency Extent	Interest rate Extent
	Expected sign	Coefficient	Coefficient	Coefficient
FXQEP	?	-0.0280		9.6406
IRQEP	?		0.6431	-6.3735***
Number of observations		926	926	926
Adjusted R^2				0.0969
F -test				6.2700***
White test		2.3559***	2.4508***	2.3918*** 2.4837***
LM test		492.0700***	471.9800***	3.7100*
Hausman test		0.0000	0.0000	0.0000
Method		REM	REM	2SLS REM

Notes: This table provides estimation results of the risk model for the effects of volume decisions on firm risks, as specified in Eq (6), for the period 1998:Q2-2005:Q1. The details of each variable are presented in Table 1. For brevity, the estimates of the constant term and control variables are not tabulated but they are available upon request. The four different risk metrics specified as the dependent variable are total risk, normalized total risk, systematic risk, and unsystematic risk as defined in Panel D of Table 1. The influences of derivatives decision on these risks, in turn, are presented in Panel A-D. Within each panel, the derivatives decisions are categorized into two main types: quarter-end currency derivatives (FXQEP), and quarter-end interest rate derivatives (IRQEP). ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.