Underinvestment and Hedging: Firm Responses to Geopolitical Risk

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Abstract

This study investigates whether derivative cash flows mitigate underinvestment during periods of heightened geopolitical risk. Empirical evidence shows that firms with higher derivative cash flow ratios exhibit greater investment expenditures as the geopolitical risk index increases and are less likely to underinvest. Financing channels drive the mechanism through which hedging influences underinvestment. Specifically, hedging mitigates underinvestment by reducing a firm's cost of equity and the cost of bank loans. Moreover, the effect is more pronounced among firms with higher ex-ante underinvestment costs, greater foreign sales exposure, high-tech classification, lower cash ratios, and longer board tenure.

Keywords: Corporate hedging, Underinvestment, Geopolitical risk

1. Introduction

Geopolitical risk is defined as "the risk associated with wars, terrorist acts, and tensions between states that affect the normal and peaceful course of international relations" (Caldara and Iacoviello, 2022). Over the past few decades, the sharp rise in global conflicts and geopolitical tensions has posed substantial threats to economic stability (Phan, Tran, and Iyke, 2022) and hindered stock market development (Khraiche, Boudreau, and Chowdhury, 2023). Cheng and Chiu (2018) document that increases in geopolitical risk lead to economic contraction and reduced consumption. Similarly, Clance, Gupta, and Wohar (2019) find a strong association between rising geopolitical risk and an increased probability of future recessions. Further evidence from capital markets suggests that geopolitical tensions significantly reduce capital flows to both advanced and emerging economies (Feng, Han, Vigne, and Xu, 2023), highlighting the destabilizing effects of such risk on global financial markets. These findings underscore the persistent and destabilizing macro-financial consequences of geopolitical uncertainty.

Beyond its macro-financial effects, prior research shows that geopolitical risk also significantly influences firm-level decision-making. It affects corporate cash-holding policies (Lee and Wang, 2021; Wang, Xiong, Mirza, Shao, and Yue, 2021; Wang, Wang, and Wu, 2024; Hasan, Alam, Paramati, and Islam, 2022), encourages more conservative capital structure choices (Yaghoubi, 2024; Shrestha, Philip, and Khaw, 2024), and shapes share repurchase activity (Adra, Gao, Huang, and Yuan, 2023). It also influences corporate innovation (Lee, Zhang, Yu, and Fang, 2023; Jia, Yang, and Zhou, 2022), lobbying behavior (Alam, Farjana, and Houston, 2024), tax avoidance (Haque, Pham, and Yang, 2023), firm valuation (Pringpong, Maneenop, and Jaroenjitrkam, 2023), and merger and acquisition activity (Rao, Koirala, Aldhawyan, and Corbet, 2023). These effects arise from the uncertainty imposed by geopolitical risk on corporate decision-makers (Kelly, Pástor, and Veronesi, 2016), the resulting disruption of business environments and capital allocation (Demir, Díez-Esteban, and García-Gómez, 2019), and the amplification of operational risk (Lai, Xiong, Zhu, Li, and Tan, 2023). These findings suggest that geopolitical risk has broad implications for corporate financial policy, including investment decisions.

Prior research has highlighted the impact of geopolitical risk on corporate investment, a core component of financial decision-making. Existing studies consistently demonstrate that heightened geopolitical risk significantly reduces corporate investment expenditures (Le and Tran, 2021; Lai et al., 2023; Wang, Wu, and

Xu, 2024; Xiong, Lu, and Kong, 2024). While these findings offer valuable insights into the adverse effects of geopolitical uncertainty, they open the question of how firms can strategically respond to mitigate such effects. In particular, there is limited empirical evidence on whether corporate hedging strategies can effectively alleviate underinvestment during periods of heightened geopolitical risk.

Hedging with derivatives is a widely adopted risk management strategy among firms exposed to geopolitical uncertainty (Giambona, Graham, Harvey, and Bodnaret, 2018). Beyond mitigating external shocks, Gay and Nam (1998) argue that firms hedge to avoid potential underinvestment. Prior studies suggest that hedging is particularly effective when external financing is costly or constrained (Haushalter, 2000; Allayannis and Ofek, 2001; Géczy, Minton, and Schrand, 1997). Given that geopolitical risk depresses corporate investment and that hedging has been shown to alleviate underinvestment, a critical question arises: can hedging strategies help firms sustain investment during periods of heightened geopolitical risk?

Motivated by this gap, this study examines whether corporate hedging mitigates underinvestment under geopolitical uncertainty. Empirical findings indicate that hedging reduces underinvestment in response to elevated geopolitical risk. Consistent with this, firms with higher realized derivative cash flow ratios are less likely to underinvest when geopolitical risk is high. The main result remains robust to endogeneity concerns, as confirmed by instrumental variables (IV) regression analysis and a Heckman two-step selection model.

To better understand this relationship, we investigate how hedging affects underinvestment during periods of elevated geopolitical risk. Specifically, we focus on the financing channel through which hedging may reduce external financing costs, enabling firms to maintain investment. Political uncertainty increases risk premiums demanded by investors, raising the cost of equity (Pástor and Veronesi, 2012; Pástor and Veronesi, 2013; Ali, Anik, Hasan, and Kamal, 2023; Ren, Cao, Liu, and Han, 2023; Fiorillo, Meles, Pellegrino, and Verdoliva, 2024), while firms exposed to uncertainty also face higher borrowing costs (Francis, Hasan, and Zhu, 2014). Hedging helps firms mitigate these financing frictions and sustain investment activity despite elevated geopolitical risk, as prior research shows that it reduces both the cost of equity and loan spreads (Gay, Lin, and Smith, 2011; Campello, Lin, Ma, and Zou, 2011). Taken together, these arguments suggest that hedging can alleviate external financing frictions and thereby help sustain investment during periods of heightened geopolitical risk.

This mechanism is supported by empirical evidence. During periods of heightened geopolitical risk, the derivative cash flow ratio is significantly associated with lower firm-level costs of equity. In addition, derivative cash flows exhibit a negative relationship with both short-term and long-term bank loan rates, suggesting that hedging reduces financing costs across multiple funding channels. Together, these findings confirm the role of financing frictions as a key mechanism linking geopolitical risk, hedging, and investment.

We further examine the cross-sectional heterogeneity in the effect of hedging on underinvestment. In particular, we test whether the ability of hedging to reduce the likelihood of underinvestment during periods of elevated geopolitical risk is stronger for firms that are more likely to face external financing constraints or have more investment-sensitive characteristics. Specifically, we assess whether the effect varies with firms' ex-ante underinvestment costs, foreign sales exposure, high-tech industry classification, cash holdings, and board tenure.

Empirical results show that the mitigating effect of hedging is more pronounced among firms with higher ex-ante underinvestment costs, greater foreign sales exposure, high-tech classification, lower cash ratios, and longer board tenure. These findings suggest that firms with greater financial vulnerability or heightened exposure to geopolitical uncertainty benefit more from risk management strategies in sustaining investment.

This study focuses on Taiwan as the empirical setting for three main reasons. First, Taiwan is pivotal in global supply chains, particularly in the high-tech and semiconductor sectors. As the world's leading producer of advanced semiconductors, Taiwan's economic activity is deeply embedded in global technology and manufacturing. Despite this strategic importance, empirical research on how to address investment shortfalls arising from geopolitical risk remains limited. Studying Taiwan, therefore, offers timely and globally relevant insights into how firms in geopolitically sensitive economies can sustain investment and contribute to global supply chain resilience. Second, geopolitical risks surrounding Taiwan inherently involve multiple major economies, particularly the United States and China. Taiwan operates in an exceptionally complex geopolitical environment shaped by escalating cross-strait tensions, the ongoing U.S.-China trade war, and accelerating global semiconductor demand. These dynamics expose Taiwanese firms to domestic and international geopolitical uncertainty, directly influencing their financial decision-making and risk-management strategies. Finally, Taiwan provides access to a uniquely detailed dataset

on corporate derivative usage. Since 2005, publicly listed firms have been legally required to submit standardized monthly reports on using financial derivatives to the Market Observation Post System (MOPS). These disclosures specify the types of instruments used, their intended purpose (trading or non-trading), the notional and fair values of the contracts, and both realized and unrealized profits or losses. Following Jankensgård and Moursli (2020), this study focuses on the reported realized gains and losses, which reflect the derivative-related cash flows central to our empirical analysis.

This study makes three primary contributions to the literature. First, to the best of our knowledge, it is among the first to examine whether corporate hedging mitigates underinvestment during periods of heightened geopolitical risk. In doing so, it contributes to the growing literature on corporate decision-making under geopolitical uncertainty. Our findings show that hedging significantly reduces underinvestment, with the cost of capital as a key transmission channel. Moreover, analyzing firm-level heterogeneity provides a more comprehensive understanding of the interaction among geopolitical risk, hedging effectiveness, and investment outcomes. This finding deepens our understanding of how firms adjust investment behavior in response to external political shocks. Second, while Lin and Smith (2007) argue that theory predicts hedging should mitigate underinvestment, empirical findings have been mixed, partly due to limitations in how hedging activity is measured or the contexts in which it is studied. By focusing on geopolitical risk, which represents a distinct and exogenous source of uncertainty, this study provides direct evidence that firms exposed to such risk can reduce underinvestment through hedging, thereby supporting the theoretical prediction. Finally, Jankensgård and Moursli (2020) are the first to use actual derivative cash flows, specifically realized gains and losses on hedging contracts, as a measure of hedging activity, and find that these cash flows play a crucial role in sustaining investment. However, their analysis is limited to the oil and gas industry. This study extends their framework to a wider range of industries and demonstrates that derivative-based cash flow measures are a valid and informative proxy for hedging activity across sectors. Such generalization enables us to empirically assess how hedging affects investment under geopolitical risk in a broader corporate context.

The remainder of the study is organized as follows. Section 2 reviews the related literature and develops the hypothesis. Section 3 describes the construction of variables, sample selection procedures, and the empirical model. Section 4 presents the main results and addresses endogeneity concerns. Section 5 investigates the mechanisms through which hedging affects underinvestment. Section 6 explores firm-level heterogeneity using cross-sectional analyses. Section 7 concludes.

2. Literature review and research hypothesis

2.1. Geopolitical risk and investment

Geopolitical risk represents a critical and pervasive challenge for firms operating in an increasingly interconnected global economy. It influences various corporate financial decisions, including capital expenditures, cash holdings, capital structure, share repurchases, and innovation strategies. Investment forms the foundation of corporate growth and valuation, making it especially sensitive to geopolitical disruptions.

Prior studies have examined the adverse effects of geopolitical risk on corporate investment. Le and Tran (2021) provide a comprehensive analysis using data from emerging Asian economies between 1995 and 2018. Their findings reveal a consistently negative relationship between geopolitical risk and investment, although the effect is less pronounced in India and Turkey. Similarly, Wang, Wu, and Xu (2024) document a robust negative association between firm-level investment and geopolitical risk. These studies highlight geopolitical risk as a major macroeconomic shock that constrains corporate investment.

Extending these findings, Xiong, Lu, and Kong (2024) focus on bilateral conflicts and document their negative influence on corporate investment. Specifically, Lai et al. (2023) shed light on the distinct dynamics of domestic political risks, emphasizing that China's local, country-specific geopolitical risks predominantly suppress corporate investment. This evidence suggests that geopolitical risk is a powerful external constraint on corporate investment across global, bilateral, and domestic dimensions. These insights motivate further examination of whether firms can strategically mitigate such investment constraints, particularly through financial hedging.

2.2. Hedging and underinvestment

While geopolitical risk imposes investment constraints, corporate hedging provides a potential means of alleviating such pressures. Froot, Scharfstein, and Stein (1993) develop a model in which managers possess private information, leading to information asymmetry between internal and external capital providers. This asymmetry makes external financing more costly than internal funds, increasing the underinvestment risk. Their model suggests corporate hedging can alleviate

underinvestment by stabilizing internal cash flows and reducing the firm's reliance on costly external capital.

Hedging is particularly valuable for firms with significant growth opportunities and tight financing constraints, as it enhances their ability to fund value-creating investments internally. Several empirical studies have documented this relationship. Géczy, Minton, and Schrand (1997), Haushalter (2000), and Allayannis and Ofek (2001) find that firms use derivatives to mitigate underinvestment risk. Further evidence suggests that hedging reduces underinvestment costs when external financing is expensive (Gay and Nam, 1998; Géczy et al., 1997; Knopf, Nam, and Thornton, 2002).

When geopolitical risk is a major external constraint on investment, the cash flows generated through hedging activities may help firms sustain investment. We therefore propose the following hypothesis:

H1: Hedging mitigates underinvestment in response to elevated geopolitical risk.

3. Variable Construction, Sample Selection, and Model

3.1. Taiwan Geopolitical Risk Index

The Geopolitical Risk (GPR) Index, constructed by Caldara and Iacoviello (2022), measures adverse geopolitical events and their associated risks based on the monthly share of newspaper articles covering geopolitical tensions[1]. The index is constructed through keyword searches across ten prominent newspapers and classified into eight themes: war threats, peace threats, military buildups, nuclear threats, terror threats, the onset of war, the escalation of war, and terror acts.

This study employs the Taiwan Geopolitical Risk Index, a country-specific version of the GPR Index, which is based on articles that mention Taiwan in conjunction with these eight themes[2]. Following Alam, Farjana, and Houston (2024), we first compute the average Taiwan GPR over the 12 months of fiscal year *t*, and then define a binary variable, Geopolitical Risk Change, which equals one if the average GPR increases from year *t*–2 to *t*–1, and zero otherwise. A value of one thus indicates

[1] Available at https://www.matteoiacoviello.com/gpr.htm (Accessed on November 6, 2024)

[2] Numerous studies have employed country-specific GPR indexes to investigate the impact of geopolitical risk on corporate financial decisions (Lee et al., 2021; Wang et al., 2021; Wang, et al., 2024; Lai et al., 2023; Lee et al., 2023; Jia et al., 2022; Ren et al., 2023; Pringpong et al., 2023; Gupta, 2024; Li and Cheng, 2024).

a period of heightened geopolitical risk.

3.2. Derivative cash flow ratio

The main explanatory variable in this study is the derivative cash flow ratio. Jankensgård and Moursli (2020) are the first to use actual derivative cash flows, i.e., realized gains and losses on derivative contracts for hedging, as a proxy for firms' use of derivatives. This approach differs from earlier measures such as binary hedging indicators or hedge ratios. Unlike binary indicators or hedge ratios, which capture firms' hedging intentions or exposures at a point in time, realized derivative cash flows directly reflect the financial outcomes of hedging activity. Their findings demonstrate that derivative cash flows is a critical role in sustaining corporate investment.

We obtain derivative cash flow data from the Database of Derivatives Usage, compiled by the Taiwan Economic Journal (TEJ), which aggregates firm-level disclosures submitted to the Market Observation Post System (MOPS). Since 2005, publicly listed firms in Taiwan have been legally required to file standardized monthly reports on their financial derivative positions as of each month's end. These reports contain detailed information on the types of instruments used (forwards, futures, options, and swaps), their intended purpose (trading or non-trading), notional and fair values, margin requirements, option premiums, and both realized and unrealized gains and losses.

To construct the derivative cash flow variable, we calculate the average of each firm's monthly realized gains and losses from all non-trading derivatives over fiscal year *t*. The derivative cash flow ratio is then computed by scaling this amount by the firm's beginning-of-year total assets (TEJ Item #10). To mitigate the influence of outliers, the variable is winsorized at the 1st and 99th percentiles by year at the firm-year level.

3.3. Sample Selection

This study examines publicly traded firms listed on the Taiwan Stock Exchange (TWSE) and the Taipei Exchange (TPEx). The sample comprises 23,508 firm-year observations from 2006 to 2023. The analysis begins in 2006, as comprehensive data on realized gains and losses from derivative contracts only become available in that year. Financial firms are excluded from the sample. Firm-level accounting data, board characteristics, and governance variables are obtained from the TEJ. To mitigate the

influence of outliers, all continuous variables are winsorized at the 1st and 99th percentiles by year at the firm-year level.

3.4. Model

To test Hypothesis 1, we estimate the following fixed effects model:

$$\begin{aligned} investment\ \ expenditure_{i,t} &= \alpha_i + \beta_0 + \beta_1 \times Derivative\ \ cash\ \ flow\ \ ratio_{i,t} \\ &+ \beta_2 \times Derivative\ \ cash\ \ flow\ \ ratio_{i,t} \\ &\times Geopolitical\ \ risk\ \ change_{t-1} \\ &+ \beta_3 \times Geopolitical\ \ risk\ \ change_{t-1} \\ &+ \beta_4 \times Operating\ \ Cash\ \ Flow_t + Control\ \ variables_{i,t-1} \\ &+ Negative\ \ cashflow\ \ control_{i,t} \\ &+ Negative\ \ cashflow\ \ interactions\ \ controls_{i,t} + \varepsilon_{i,t} \quad (1) \end{aligned}$$

We expect a positive coefficient on the interaction term (β_2), consistent with the hypothesis that hedging attenuates underinvestment under rising geopolitical risk.

Following Jankensgård and Moursli (2020), we model investment as a function of contemporaneous derivative cash flow ratio and operating cash flow. Control variables include financial and governance characteristics drawn from Biddle, Hilary, and Verdi (2009) and Wang, Luo, Tian, and Yan (2020), including Tobin's Q, log total assets, price-to-book ratio (P/B), property, plant and equipment ratio (PPE), long-term debt ratio, cash ratio, return on assets (ROA), operating cycle, paying cash dividend indicator, loss dummy, firm age, institutional ownership, board size, ultimate controller ownership, CEO duality, and Big 4 auditor indicator.

In addition, consistent with Jankensgård and Moursli (2020), we control for control for negative cashflows and its interaction with operating cash flow and the derivative cash flow ratio[3]. Year fixed effects (Year FE) are excluded from the estimation, as geopolitical risk is uniform across all firms in a given year (Gulen and Ion, 2016; Nguyen and Phan, 2017; Lee and Wang, 2021). Instead, we include a linear time trend to capture potential shifts in firms' hedging behavior over time (Adra et al.,

[3] Several papers in the empirical literature recommend excluding negative-cash flow observations (e.g. Allayannis and Mozumdar, 2000). The argument is that in firms with negative cash flows investment cannot respond to further declines in cash flow because it is already at a minimum level, so the relation breaks down. In order to avoid data loss, and to avoid the censored regression bias from truncating the sample, a negative cash flow indicator variable is instead created which is then interacted with both derivative and operating cash flows.

2023). Definitions of all variables are provided in Table 1.

[Insert Table 1 here]

However, a reduction in investment expenditure does not necessarily indicate underinvestment. Analyzing investment efficiency presents the empirical challenge that a firm's optimal level of investment is an unobservable variable. Following the approach of Biddle, Hilary, and Verdi (2009) and Cutillas Gomariz and Sánchez Ballesta (2014), this study next directly models the association between hedging and the likelihood of underinvestment (or overinvestment) across different geopolitical risk periods.

$$investment\ \ expenditure_{i,t} = \beta_0 + \beta_1 \times Sales\ \ growth_{t-1} + \varepsilon_{i,t} \quad (2)$$

Eq. (2) is estimated for each industry-year based on the Taiwan Security Exchange industry classification for all industries with at least 20 observations in a given year. We then classify firms based on the magnitude of the residuals, which represent deviations from predicted investment, and use these classifications as the dependent variable. Firms are sorted into quartiles based on Eq. (2) residuals each year. Firm-year observations in the bottom quartile (i.e., the most negative residuals) are classified as underinvesting. In contrast, those in the top quartile (i.e., the most positive residuals) are classified as overinvesting. Observations in the middle two quartiles serve as the benchmark group.

I then estimate a multinomial logit model to predict the likelihood of a firm being in one of the extreme quartiles compared to the middle quartiles. H1 predict that firms with higher realized derivative cash flow ratio will be less likely to be in the bottom quartile of unexplained investment. Therefore, the coefficient of the derivative cash flow ratio is expected to be negative. The set of explanatory and control variables is identical to those used in the estimation of Eq. (1).

4. Empirical Results

4.1. Descriptive analysis

Table 2 reports the sample distribution across years and Taiwan Stock Exchange (TWSE) industry classifications. Over the sample period, the largest proportion of observations occurs in 2023 (6.9%), followed closely by 2022 (6.8%). The annual

distribution reflects a steady upward trend throughout the sample period. Regarding industry classifications, the Electronic Parts and Components sector constitutes the largest share of firm-year observations, representing 14.8% of the sample, followed by the Semiconductor sector at 10.5% and the Optoelectronic sector at 8.4%.

[Insert Table 2 here]

Table 3 presents descriptive statistics and group comparisons based on firms' derivative usage. Panel A reports summary statistics for the main explanatory, dependent, and control variables. The average investment expenditure for the sample is 5.1%. The primary explanatory variable, the derivative cash flow ratio for hedging, has a mean of zero and a maximum value of 0.8%, reflecting that 61.2% of the firms in the sample do not use derivatives. In an untabulated analysis restricted to derivative users, the number of observations decreases to 8,146, with total derivative cash flows amounting to 3.3 million and an average derivative cash flow ratio for hedging of 0.012%. Over the 18-year sample period, the geopolitical risk change variable equals one in 10 years, indicating that in those years, firms experienced an increase in geopolitical risk relative to the prior year.

Panel B of Table 3 compares firms based on derivative usage, classifying them as hedgers if derivative cash flows are nonzero and as non-hedgers otherwise. This partition allows for examining how firm characteristics differ between hedgers and non-hedgers. Derivative users exhibit higher investment expenditure rates, consistent with evidence from Jankensgård and Moursli (2020) indicating a strong positive relationship between derivative cash flows and capital expenditures. Hedging firms are larger, consistent with the idea that economies of scale facilitate the use of risk management tools. They also exhibit lower market valuations and generate higher operating cash flows relative to non-hedgers (Jankensgård and Moursli, 2020). In addition, hedging firms rely more on debt financing, which is consistent with hedging theory, as higher leverage increases the likelihood of financial distress and strengthens the incentive to hedge. By contrast, non-hedgers tend to hold more cash, which may reflect the use of internal liquidity as a substitute for financial hedging. Prior studies suggest that firms with stronger corporate governance are more likely to engage in hedging (Lel, 2012; Allayannis, Lel, and Miller, 2012), as reflected in higher institutional ownership, larger board size, lower ultimate controller ownership, and reduced CEO duality. The observed differences in financial and corporate governance characteristics are broadly consistent with prior literature on the determinants of hedging (Smith and Stulz, 1985; Nance, Smith, and Smithson, 1993; Froot, Scharfstein, and Stein, 1993; Géczy, Minton,

and Schrand,1997), suggesting that hedging firms exhibit systematically different profiles from those that do not.

[Insert Table 3 here]

Table 4 provides a detailed summary of derivative usage. Panel A reports descriptive statistics for firms with nonzero derivative cash flows, while Panel B compares derivative usage patterns between firms with positive versus negative derivative cash flows. Panel A of Table 4 reports summary statistics on derivative usage among firms with nonzero derivative cash flows. Forward contracts and swaps dominate the sample. Forwards exhibit the highest settled notional amount at approximately 7.49 billion and an outstanding notional amount of 2.03 billion, accompanied by moderate realized and unrealized gains of 3.97 million and 1.15 million, respectively. Swaps are the second most heavily used instrument, with a settled notional amount of 1.82 billion and an outstanding notional amount of 948.87 million, but they are associated with large unrealized losses averaging -3.20 million and realized losses of -1.39 million. Individual options and combination options represent a smaller share of total derivative usage. Futures, hybrid instruments, and other derivatives are used even less frequently across the sample.

Panel B of Table 4 compares derivative usage between firms with positive and negative derivative cash flows. In both groups, forward contracts are the most widely used derivative instrument, with settled notional amounts of 7.07 billion and 7.98 billion, respectively. Forward contracts also generate the largest realized gains and losses among all instruments, with gains of 30.54 million in the positive cash flow group and losses of -27.88 million in the negative group. Swaps are the second most commonly used derivative instrument, generating realized gains of 4.71 million in the positive cash flow group and realized losses of 8.71 million in the negative group, which are the second largest in magnitude after those associated with forwards. The results reveal substantial variation in both the extent of derivative usage and the associated gains or losses between firms with positive and negative derivative cash flows, most notably for forwards and swaps.

[Insert Table 4 here]

4.2. Baseline results

Table 5 presents the regression results of Eq. (1). As shown in column (1) for the

full sample, the interaction term coefficient between the derivative cash flow ratio and geopolitical risk change (β_2) is significantly positive, consistent with expectations. Following Biddle et al. (2009), we also perform a joint test to examine the sum of the coefficients on the main and interaction effects ($\beta_1 + \beta_2$), which captures the relationship between hedging and investment. The joint test also demonstrates a significantly positive result.

Columns (2) and (3) of Table 4 partition the full sample into subsamples based on changes in the geopolitical risk variable. In column (2), the derivative cash flow ratio is positive and statistically significant, suggesting that hedging amplifies corporate investment expenditures as the geopolitical risk index increases. By contrast, column (3) reveals that the derivative cash flow ratio is statistically insignificant during periods of lower geopolitical risk. Collectively, these empirical findings provide support for Hypothesis 1: Hedging mitigates underinvestment in response to elevated geopolitical risk.

[Insert Table 5 here]

This study builds on Biddle et al. (2009) and Cutillas Gomariz et al. (2014) by categorizing the sample into underinvestment, overinvestment, and benchmark groups. A multinomial logit model is then employed to estimate the likelihood of a firm being classified as underinvesting or overinvesting relative to the benchmark group. Table 6 presents the empirical results, with Columns (1) and (2) based on the full sample. In Column (1), the interaction term between the derivative cash flow ratio and changes in geopolitical risk is negative and statistically significant, indicating that firms with higher realized derivative cash flow ratios are less likely to underinvest during periods of elevated geopolitical risk. Furthermore, a joint test of the sum of the coefficients on the main effect and the interaction term ($\beta_1 + \beta_2$) yields a statistically significant result, providing support for Hypothesis 1. By contrast, in Column (2), the coefficient on the interaction term is statistically insignificant, and the joint test of the combined coefficients is similarly non-significant. This indicates that firms with higher realized derivative cash flow ratios do not exhibit a greater propensity for overinvestment. Columns (3) and (4) present results for the subsample where the geopolitical risk change equals 1, while Columns (5) and (6) correspond to the subsample where the geopolitical risk change equals 0. In Column (3), the derivative cash flow ratio coefficient is negative and statistically significant, indicating that during periods of elevated geopolitical risk, hedging reduces the likelihood of a firm becoming underinvested. However, this effect is statistically insignificant in Column (5), where

geopolitical risk remains low. Consistent with the findings in Column (2), the derivative cash flow ratio does not increase the likelihood of overinvestment, irrespective of whether geopolitical risk is elevated or low. These findings lend further support to Hypothesis 1.

[Insert Table 6 here]

4.3. Endogeneity test

4.3.1. IV-2SLS

Table 7 presents the results of an instrumental variables (IV) regression analysis designed to address potential endogeneity arising from omitted variable bias. The industry average of the derivative cash flow ratio is employed as the instrumental variable. The IV is statistically relevant to the derivative cash flow ratio, with Cragg-Donald F-statistics exceeding the weak instrument thresholds proposed by Stock and Yogo (2005), rejecting the null hypothesis of weak instruments (Cragg and Donald, 1993; Stock and Yogo, 2005). In the second stage, the coefficient of the interaction term between the derivative cash flow ratio and changes in geopolitical risk is significantly positive during periods of heightened geopolitical risk, consistent with the findings from the main regression analysis.

[Insert Table 7 here]

4.3.2. Heckman two-step model

Hedging strategies can be self-selected, raising concerns about potential selection bias. To address these concerns, and following Adam, Fernando, and Salas (2017), this study employs the Heckman two-step model to reflect this two-stage decision process and control for any selection bias associated with estimating the derivative cash flow ratio. Table 8 presents the results of a Heckman two-step estimation to account for potential selection bias in the decision to engage in hedging. Panel A reports the first-stage probit regression, which models the likelihood that a firm engages in hedging. We calculate an Inverse Mills ratio from the first stage results, which we include in the second stage regression to estimates its impact on the investment expenditure when geopolitical risk index scores increases. Panel B presents the second-stage results. The model also includes the full set of explanatory variables as specified in Equation (1). In both the OLS and firm fixed-effects specifications, the interaction term between the

derivative cash flow ratio and changes in geopolitical risk is significantly positive, consistent with the findings from the baseline regression.

[Insert Table 8 here]

5. Potential channel

Geopolitical risk's influence on financial markets directly affects the cost of capital. As geopolitical risk increases, stock price crashes become more frequent and volatile (Pástor and Veronesi, 2012; Fiorillo et al., 2024; Ren et al., 2023), driving external investors to demand higher risk premiums (Pástor and Veronesi, 2013; Ali et al., 2023), which in turn raises cost of equity (Carney et al., 2024). Consequently, the increased cost of equity driven by geopolitical risk leads to reduced corporate investment (Lai et al., 2023). Moreover, debt financing costs also rise. Francis, Hasan, and Zhu (2014) demonstrate that firms with greater uncertainty exposure face higher bank loan costs, while Bradley, Pantzalis, and Yuan (2016) show that heightened local policy risk increases firms' debt costs. Therefore, this heightened geopolitical risk perception ultimately drives up the overall cost of capital and consequently reduces corporate investment.

Hedging can reduce external financing costs. Froot, Scharfstein, and Stein (1993) theorize that hedging mitigates the underinvestment problem by enabling firms to pursue growth opportunities despite facing high external financing costs. By generating sufficient internal funds and lowering the cost of capital, hedging allows managers to follow an optimal investment policy. Based on this theory, Gay, Lin, and Smith (2011) find that the reduction in the cost of equity is driven by decreases in both market beta and SMB beta, indicating that firms use derivatives to mitigate financial distress risk. In addition, Campello, Lin, Ma, and Zou (2011) identify specific mechanisms by which hedging influences real and financial corporate outcomes, such as reducing financing costs through lower interest spreads. Similarly, Chen and King (2014) find that hedging lowers the cost of public debt by mitigating bankruptcy risk, agency costs, and information asymmetry. In summary, hedging mitigates underinvestment through the channel of alleviating external financing costs.

This section examines whether the mechanism of alleviating external financing costs explains why firms with higher derivative cash flow ratios are less likely to underinvest during periods of heightened geopolitical risk. The model designed to test this question is specified as follows:

$$
\begin{aligned}
&External\ \ financing\ \ costs_{i,t} \\
&\quad = \alpha_i + \beta_0 + \beta_1 \times Derivative\ \ cash\ \ flow\ \ ratio_{i,t} \\
&\quad + \beta_2 \times Derivative\ \ cash\ \ flow\ \ ratio_{i,t} \\
&\quad \times Geopolitical\ \ risk\ \ change_{t-1} \\
&\quad + \beta_3 \times Geopolitical\ \ risk\ \ change_{t-1} + Control\ \ variables_{i,t-1} \\
&\quad + Negative\ \ cashflow\ \ control_{i,t} \\
&\quad + Negative\ \ cashflow\ \ interactions\ \ controls_{i,t} + \varepsilon_{i,t} \quad (3)
\end{aligned}
$$

where external financing costs are measured using both the cost of equity and the cost of loans.

We follow the methodology of Gay et al. (2011) to estimate the cost of equity. First, to estimate the beta coefficients (b_i,s_i,h_i) for firm i in a given year, the following regression is conducted using the firm's daily returns:

$$R_{i,t} - R_{f,t} = a_i + b_i\left(R_{M,t} - R_{f,t}\right) + s_i SMB_t + h_i HML_t + e_t$$

where $R_{i,t}$ represents the return of firm i on day t in a given year, $R_{f,t}$ denotes the one-year time deposit interest rate of First Bank divided by 365, and R_M is the daily return on the TWSE Weighted Stock Index. The variables *SMB* and *HML* represent the difference in returns between small- and large-stock portfolios and the difference in returns between high- and low-book-to-market portfolios, respectively. The explanatory variables for the regression can be obtained from the TEJ Fama and French Daily Multi-Factor Market Database.

Next, for each firm-year, we estimate the annual risk premium, referred to as the cost of equity, using the following formula:

$$CE_i = E\left(R_{i,t}\right) - R_f = b_i\left[E(R_M) - R_f\right] + s_i E(SMB) + h_i E(HML)$$

where CE_i represents the cost of equity for firm i in a given year. The expectations values of the $R_M - R_f$, *SMB*, and *HML* are calculated as the arithmetic average of daily returns for each factor from January 5, 1999 (the data inception date of the TEJ database) to the end of the corresponding year. Following the methodology of Gay et al. (2011), the cost of equity estimates are then annualized by multiplying by 252 trading days.

As for the cost of loans, this study employs both short-term and long-term

borrowing rates obtained from the TEJ Listed and OTC Borrowing Details database as explanatory variables. If loans have floating or variable interest rates, the interest rate is calculated as the average of the minimum and maximum rates. If a firm has multiple loans in year *t*, a weighted average interest rate is computed based on the loan amounts.

Table 9 demonstrates that during periods of heightened geopolitical risk, the derivative cash flow ratio significantly reduces firms' cost of equity. Even during periods of diminished geopolitical risk, this relationship remains negative and statistically significant at the 5% level. Table 10 indicates that banks' short-term and long-term interest rates exhibit a negative relationship with derivative cash flows. Moreover, this negative relationship is more pronounced during periods of reduced geopolitical risk than during periods of heightened geopolitical risk. A possible explanation is that banks typically adopt more conservative lending practices during times of increased geopolitical uncertainty.

[Insert Table 9 here]
[Insert Table 10 here]

6. Cross-sectional heterogeneity of hedging effects

The baseline results indicate that firms with higher derivative cash flow ratios are less likely to underinvest during periods of heightened geopolitical risk. The heterogeneous impact of firm characteristics on this relationship is further examined by adopting the approach of Biddle et al. (2009) and Cutillas Gomariz et al. (2014) for subsample analyses. A multinomial logit model is estimated on the relevant subsamples to predict the likelihood of a firm falling into the underinvestment quartiles relative to the middle quartiles. Table 10 shows that for these subsamples—specifically, firms with higher ex-ante underinvestment costs, greater foreign sales exposure, classification in high-tech industries, lower cash ratios, and longer director and supervisor tenures—the negative coefficient on the derivative cash flow ratio is expected to be more pronounced.[4]

6.1. Ex-ante underinvestment costs

Froot et al. (1993) point out that the underinvestment problem is particularly

[4] Untabulated results indicate that the coefficient on the derivative cash flow ratio is statistically insignificant for the corresponding comparison groups: firms with lower ex-ante underinvestment costs, lower foreign sales exposure, non-high-tech classification, higher cash ratios, and shorter director and supervisor tenures during periods of heightened geopolitical risk.

severe for firms with significant growth and investment opportunities, especially when external financing is more expensive than internal cash flow. Under these conditions, returns from safe yet profitable investment projects tend to benefit creditors more than equity holders, leading firms to forgo valuable investment opportunities and incur higher underinvestment costs. Following Géczy et al. (1997), the interaction between growth opportunities (measured by the P/B ratio) and debt financing (represented by the long-term debt ratio) serves as a proxy for underinvestment costs. The sample is partitioned into two subsamples based on the industry-year median of these costs. Table 11 presents the results of the multinomial logit model estimating a firm's classification as underinvesting relative to the benchmark group during periods of heightened geopolitical risk across various subsamples. Column (1) displays the subsample of firms with relatively higher ex-ante underinvestment costs. The coefficient on the derivative cash flow ratio is significantly negative, indicating that among firms with higher ex-ante underinvestment costs, a higher derivative cash flow ratio is associated with a lower likelihood of underinvestment, thereby enhancing investment efficiency during periods of heightened geopolitical risk.

6.2. Foreign sales

Firms with higher export intensity are more affected by geopolitical risk. As their products are distributed worldwide, factors such as tariffs and currency exchange rate fluctuations further expose their sales revenues to the impact of geopolitical risk, consequently influencing their investment strategies. In this context, Géczy et al. (1997) suggest that firms with extensive foreign exchange exposure are more likely to use currency derivatives to hedge against such risks. Additionally, Bartram (2008) shows that hedging can significantly alleviate the exchange rate risks firms face due to foreign currency transactions and global competition. As a result, compared to firms with lower foreign sales, those with higher foreign sales have a stronger incentive to hedge against the shocks from geopolitical risk, thereby mitigating the risk of underinvestment. Therefore, we divide the sample into two subsamples based on the median of foreign sales. Column (2) of Table 11 presents the results for firms with higher foreign sales, where the coefficient on the derivative cash flow ratio is significantly negative. This suggests that, by engaging in hedging, these firms are less likely to underinvest when geopolitical risk increases.

6.3. High-tech firms

High-tech firms operating in global markets are uniquely exposed to a range of

uncertainties and challenges arising from geopolitical instability. These firms typically manage globally integrated supply chains and depend on advanced technological components sourced from regions that may be politically unstable. Consequently, high-tech firms are more vulnerable to the adverse impacts of geopolitical risk than firms in other industries (Shrestha et al., 2024). During periods of extreme geopolitical threats, investors tend to demand higher risk premiums for information technology firms (Ali et al., 2023), reflecting their heightened sensitivity to geopolitical uncertainty. Given that high-tech firms are more significantly affected by geopolitical risk, hedging strategies have a more pronounced effect on reducing underinvestment in these firms. The analysis of the high-tech firm subsample[5], presented in column (4) of Table 11, reveals that, as expected, the coefficient on the derivative cash flow ratio is significantly negative. In conclusion, hedging strategies mitigate underinvestment in high-tech firms due to their greater exposure to geopolitical uncertainty.

6.4. Cash ratio

Regarding firm heterogeneity, we consider the heterogeneous impact of cash holdings on the relationship between derivative cash flows and underinvestment when geopolitical risk increases. Froot et al. (1993) find that liquidity is negatively correlated with hedging activities. Firms with higher liquidity are better able to access external financing, thereby reducing underinvestment risks. In addition, a larger liquid asset base decreases bankruptcy risk, which in turn lowers both expected financial distress and agency costs. As a result, liquid assets can effectively substitute for financial hedging strategies (Nance, Smith, and Smithson, 1993; Géczy et al., 1997). As a result, firms with lower cash holdings have a stronger incentive to hedge against shocks arising from geopolitical risks compared to those with substantial cash reserves. In these firms, derivative cash flows play a more significant role in reducing the likelihood of underinvestment during periods of heightened geopolitical risk. To investigate this relationship, we partition the sample into subsets based on the median of cash ratio. Column (5) of Table 11 presents the results of heterogeneity analysis based on firms with lower cash ratio. The coefficients of derivative cash flows indicate that a higher derivative cash flow ratio is associated with a decreased likelihood of underinvestment for firms with lower cash ratio when geopolitical risk increases.

6.5. Director tenures

[5] High-tech firms include the following industries: Semiconductor, Computer and Peripheral Equipment, Optoelectronics, Communications and Internet, Electronic Parts and Components, Electronic Products Distribution, Information Services, and Other Electronics.

Directors with longer tenure are generally more risk-averse, as extended tenure is often associated with enhanced board stability and accumulated experience (Livnat, Smith, Suslava, and Tarlie, 2021). This greater risk aversion increases the likelihood that directors will adopt hedging strategies, thereby reducing the firm's exposure to underinvestment. Derivative cash flows are therefore expected to play a more significant role in mitigating underinvestment in firms with longer-tenured directors, particularly during periods of heightened geopolitical risk. Following Yeh (2019), and consistent with governance practices commonly observed in Taiwanese firms, we define board membership to include both directors and supervisors when constructing tenure-related variables. Based on this definition, we partition the sample according to whether the average board tenure is above or below the median. Column (6) of Table 11 presents the results for the subsample with longer board tenure. The coefficient on the derivative cash flow ratio is significantly negative, indicating that hedging strategies are more effective in alleviating underinvestment when board tenure is higher, as it reflects greater board stability and experience during periods of elevated geopolitical risk.

[Insert Table 11 here]

7. Conclusions

This proposal investigates whether hedging strategies mitigate underinvestment during periods of heightened geopolitical risk. Additionally, it further explores two potential mechanisms through which hedging influences underinvestment in response to increased geopolitical risk: the cash flow channel and the financing channel. Finally, the proposal performs cross-sectional analyses to examine firm heterogeneity in the impact of hedging on underinvestment during periods of heightened geopolitical risk.

The empirical results indicate that the derivative cash flow ratio increases corporate investment expenditure as the geopolitical risk index rises. Furthermore, firms with higher derivative cash flow ratios are less likely to underinvest during periods of heightened geopolitical risk. These findings support Hypothesis 1. Table 6 shows that during periods of heightened geopolitical risk, the derivative cash flow ratio significantly reduces the cost of equity and the bank's short-term and long-term loan rates. These findings support Hypothesis 2a and 2b. Finally, we find that the impact of hedging on underinvestment in response to geopolitical risk is more pronounced in firms with higher ex-ante underinvestment costs, greater foreign sales exposure, high-

tech classifications, lower cash ratios, and longer director tenure.

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Table 1
Variable definitions
All item numbers refer to annual data items from TEJ.

Variable	Definition
Investment expenditure	The sum of expenditures on property, plant, and equipment (#7324), research and development expenses (#3356), and net cash paid for acquisitions of other companies (#7350), minus proceeds from the sale of property, plant, and equipment (#7323), is then divided by beginning total assets (#10).
Derivative cash flow ratio	The fraction of derivative cash flows divided by beginning total assets (#10). Derivative cash flows is calculated as the annual average of realized gains from derivative contracts.
Geopolitical risk change	A dummy variable that takes the value of one if the yearly average of the Taiwan Geopolitical Risk Index increases from year *t* -2 to year *t* -1. The Taiwan Geopolitical Risk Index, developed by Caldara and Iacoviello (2022), is accessible at https://www.matteoiacoviello.com/gpr.htm. The original dataset is provided at a monthly frequency.
Operating cash flow	The fraction of operating cash flow (#7210) divided by beginning total assets (#10), minus the derivative cash flows ratio and the speculative cash flows ratio. The speculative cash flows ratio is defined as the ratio of derivative cash flows for speculative purposes to beginning total assets (#10). Derivative cash flows for speculative purposes is calculated as the annual average of realized gains from derivative contracts for speculation.
Non-user dummy	A dummy variable that takes the value of one if the firm does not use derivative, and 0 otherwise.
Tobin's Q	Market value of equity (#mv) plus the total assets (#10) minus the sum of the book value of equity (#2000) and deferred tax (#1515) divided by the book value of total assets (#10).
Log assets	Natural log of total assets (million, in New Taiwan dollar, #10) in year *t* -1.
P/B	Market value of equity divided by the book value of equity in year *t* -1. (R537)
PPE ratio	The fraction of property, plant, and equipment (#400) divided by total asset (#10).
Long-term debt ratio	The fraction of long-term debt (#1485 + #1421 + #1411 + #1441) to the sum of long-term debt (#1485 + #1421 + #1411 + #1441) and market value of equity (#mv).
Cash ratio	The fraction of cash and cash equivalents (#112) divided by property, plant, and equipment (#400) in year *t* -1.
ROA	The fraction is calculated as the sum of net income, and interest divided by the average total assets over the period. (#R101)
Operating cycle	The natural log of the sum of average collection days (#R609) and average inventory turnover days (#R611)
Paying cash dividend	A dummy variable that takes the value of one if the firm pays cash dividend (#7611) in year *t* -1 and zero otherwise.
Loss	A dummy variable that takes the value of one if profit from continuing operations (#3920) less than zero in year *t* -1 and zero otherwise.
Firm age	The number of years since the firm's listing year up to year *t* -1.
Institutional ownership	The fraction of common shares owned by institutional investors (#corp) in year *t* -1.
Board size	Natural log of the number of directors and supervisors on the board (#tots) in year *t* -1.
Ultimate controller holdings dummy	A dummy variable that takes the value of one if the fraction of common shares directly owned by the ultimate controller's individual holdings (#fld051), unlisted group companies' holdings, and group foundation holdings is more than 50% in year *t* -1.
CEO duality	A dummy variable that takes the value of one if the CEO and board chair are the same person (#dual) in year *t* -1, and zero otherwise.
Big4	A dummy variable that equals 1 if the firm's auditor is one of the big-four audit firms in year *t* -1, and 0 otherwise.
Sales growth	The change in sales from year *t* -2 to the year *t* -1. (#R401)
Time trend	A time trend variable defined as Time trend = year − 2005, where Time trend equals 1 for 2006, 2 for 2007, and so forth
Foreign sales	The foreign sales scaled by sales in year *t* -1.
Industry dummies	Industry dummies are based on Taiwan Security Exchange industry classification.
Cost of equity	The difference between its expected return and the risk-free rate based on the Fama and French three-factor model.
Cost of loan	The weighted average of long-term borrowing rates, calculated for syndicated loans or all loans.
Underinvestment costs	The interaction between the P/B ratio and the long-term debt ratio.
Investment in China	The total capital invested in China in year *t* -1.
Number of business segments	The number of business segments in the firm in year *t* -1.
Director and supervisor holdings	The fraction of common shares owned by directors and supervisors in year *t* -1.
Quick ratio	The fraction of quick assets scaled by the current liabilities in t-1.
R&D	The research and development expenditures scaled by the sales in year *t* -1.

Table 2
Sample distribution
The sample consists of an unbalanced panel of 23,508 firm-year level observations for the period 2006-2023, sourced from the TEJ database. This table presents the sample distribution by year and across the TWSE industry classifications.

year	Number of obs.	%	Industry	Number of obs.	%
2006	892	4.2%	Food industry	444	2.1%
2007	920	4.4%	Plastic industry	405	1.9%
2008	965	4.6%	Textile industry	839	4.0%
2009	988	4.7%	Electric machinery industry	1164	5.5%
2010	1010	4.8%	Iron and steel industry	719	3.4%
2011	1042	5.0%	Automobile industry	209	1.0%
2012	1042	5.0%	Building material and construction industry	1303	6.2%
2013	1093	5.2%	Shipping and transportation industry	18	0.1%
2014	1181	5.6%	Tourism and Hospitality	288	1.4%
2015	1220	5.8%	Other industry	1119	5.3%
2016	1240	5.9%	Chemical industry	626	3.0%
2017	1255	6.0%	Biotechnology and medical care industry	1242	5.9%
2018	1268	6.0%	Semiconductor industry	2198	10.5%
2019	1312	6.2%	Computer and peripheral equipment industry	1632	7.8%
2020	1326	6.3%	Optoelectronic industry	1755	8.4%
2021	1367	6.5%	Communications and internet industry	1270	6.0%
2022	1420	6.8%	Electronic parts and components industry	3117	14.8%
2023	1454	6.9%	Electronic products distribution industry	629	3.0%
Total	20,995	100.0%	Information service industry	493	2.3%
			Other electronic industry	1186	5.6%
			Cultural and Creative Industry	219	1.0%
			Green Energy and Environmental Services	35	0.2%
			Sports and Leisure	20	0.1%
			Household	65	0.3%
			Total	20,995	100.0%

Table 3 Summary statistics and mean differences by derivative cash flows

This table presents descriptive statistics and mean comparison tests for relevant variables. Panel A reports summary statistics for the full sample, which consists of an unbalanced panel of 20,995 firm-year observations from 2006 to 2023, obtained from the TEJ database. Panel B compares mean values between hedgers and non-hedgers, where firms are classified as hedgers if they report non-zero derivative cash flows in a given year and as non-hedgers otherwise. Statistical significance is based on two-sample *t*-tests. All variable definitions are provided in Table 1. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A Summary statistics

	N	Mean	SD	p25	Median	p75	Min	Max
Investment expenditure	20995	0.051	0.068	0.008	0.03	0.07	-0.185	0.425
Derivative cash flow ratio for hedging	20995	0	0.001	0	0	0	-0.006	0.008
Derivative cash flow ratio for speculation	20995	0	0	0	0	0	-0.001	0.002
Derivative cash flow for hedging	20995	856.033	19146.794	0	0	0	-203957.17	200479.67
Derivative cash flow for speculation	20995	85.606	960.822	0	0	0	-11828.6	11957.833
User dummy	20995	0.388	0.487	0	0	1	0	1
Geopolitical risk score	20995	0.069	0.078	0.022	0.043	0.066	0.013	0.308
Geopolitical risk score change%	20995	0.127	0.539	-0.322	0.273	0.516	-0.816	1.086
Geopolitical risk change	20995	0.579	0.494	0	1	1	0	1
Sales growth	20995	0.079	0.533	-0.12	0.016	0.159	-0.869	6.763
Operating cash flow	20995	0.053	0.106	-0.001	0.049	0.112	-0.406	0.456
Tobin's Q	20995	1.485	0.873	0.963	1.222	1.676	0.382	7.246
Log assets	20995	15.159	1.35	14.232	14.975	15.899	12.163	19.818
P/B	20995	1.798	1.375	0.96	1.41	2.13	0.2	11.53
PPE ratio	20995	0.186	0.166	0.05	0.139	0.279	0	0.771
Long-term debt ratio	20995	0.081	0.122	0	0.013	0.122	0	0.708
Cash ratio	20995	11.089	59.576	0.228	0.671	2.357	0.005	1240.304
ROA	20995	0.044	0.093	0.008	0.048	0.093	-0.455	0.394
Operating cycle	20995	5.025	0.852	4.604	4.951	5.286	1.892	9.278
Paying cash dividend	20995	0.764	0.425	1	1	1	0	1
Loss	20995	0.165	0.371	0	0	0	0	1
Firm age	20995	13.887	8.939	7	13	19	-4	58
Institutional ownership	20995	0.373	0.22	0.195	0.346	0.532	0.005	0.918
Board size	20995	2.181	0.204	1.946	2.197	2.303	1.609	2.996
Ultimate controller holdings dummy	20995	0.114	0.318	0	0	0	0	1
CEO duality	20995	0.349	0.477	0	0	1	0	1
Big4	20995	0.864	0.342	1	1	1	0	1
Negative cashflow control	20995	0.252	0.434	0	0	1	0	1
Negative cashflow control × operating cash flow	20995	-0.018	0.051	-0.001	0	0	-0.406	0
Negative cashflow control × derivative cash flows ratio	20995	0	0	0	0	0	-0.006	0.008
Cost of equity	20991	-0.01	0.022	-0.022	-0.008	0.004	-0.111	0.083
Cost of short-term loan	13581	0.018	0.01	0.011	0.016	0.022	0	0.067
Log cost of short-term loan	13580	-4.139	0.564	-4.483	-4.137	-3.807	-9.21	-2.698
Cost of long-term loan	10544	0.019	0.008	0.014	0.018	0.023	0	0.064
Log cost of long-term loan	10537	-4.035	0.519	-4.242	-4.017	-3.767	-8.764	-2.75
Underinvestment cost	20995	0.108	0.189	0	0.021	0.167	0	4.912
Foreign sales ratio	17153	63.65	32.753	38.05	74.59	92.66	0	100
Investments in China	16065	2436739.5	12071277.7	138195	497024	1471254	0	487700000
Tech firm dummy	20995	0.585	0.493	0	1	1	0	1

Table 3

Panel B Differences in means between hedgers and non-hedgers (based on whether derivative cash flow ≠ 0)

	Derivative cash flow ≠ 0	Derivative cash flow = 0	Difference
Investment expenditure	0.055	0.049	0.006 ***
Sales growth	0.063	0.087	-0.024 ***
Operating cash flow	0.067	0.047	0.02 ***
Tobin's Q	1.425	1.515	-0.09 ***
Log assets	15.758	14.867	0.891 ***
P/B	1.682	1.854	-0.172 ***
PPE ratio	0.186	0.186	0
Long-term debt ratio	0.089	0.077	0.012 ***
Cash ratio	4.931	14.084	-9.153 ***
ROA	0.058	0.037	0.021 ***
Operating cycle	4.839	5.115	-0.276 ***
Paying cash dividend	0.848	0.723	0.125 ***
Loss	0.105	0.194	-0.089 ***
Firm age	13.783	13.938	-0.155
Institutional ownership	0.408	0.357	0.051 ***
Board size	2.21	2.166	0.044 ***
Ultimate controller holdings dummy	0.063	0.138	-0.075 ***
CEO duality	0.294	0.375	-0.081 ***
Big4	0.914	0.84	0.074 ***
# of observation	6871	14124	

Table 4

Summary of derivative usage and comparison by cash flow direction

This table presents summary statistics on derivative usage for firms with nonzero derivative cash flows in Panel A. Panel B compares the usage patterns between firms with positive and negative derivative cash flows. FVTPL indicates contracts classified as fair value through profit or loss under IFRS 9. The lower number of firm-year observations for combination options and hybrid instruments designated at FVTPL reflects the fact that the corresponding reporting items were not introduced until 2009. All values are reported in thousands of New Taiwan dollars (NTD).

Panel A Derivative usage among firms with nonzero derivative cash flows

	Settled Notional Amount	Realized Gains/Losses	Outstanding Notional Amount	Unrealized Gains/Losses	Obs.
Forward	7487640.29	3970.79	2032806.99	1150.41	6871
Futures	34002.51	-15.41	9857.80	36.56	6871
Individual options	134540.71	-127.64	46130.82	-76.56	6871
Combination options	230556.41	39.57	47157.83	-96.27	5708
Swap	1824463.85	-1391.53	948871.20	-3195.15	6871
Others	13621.96	47.16	8965.59	3.42	6871
Hybrid instruments designated at FVTPL	95349.62	377.34	26353.11	78.32	5708

Panel B Comparison of derivative usage between firms with positive and negative derivative cash flows

	Firms with positive derivative cash flows					Firms with negative derivative cash flows				
	Settled Notional Amount	Realized Gains/Losses	Outstanding Notional Amount	Unrealized Gains/Losses	Obs.	Settled Notional Amount	Realized Gains/Losses	Outstanding Notional Amount	Unrealized Gains/Losses	Obs.
Forward	7073334.34	30540.27	2073060.88	-1288.52	3746	7984277.12	-27878.57	1984553.85	4074.01	3125
Futures	25610.40	191.24	7899.38	29.77	3746	44062.29	-263.13	12205.40	44.70	3125
Individual options	141262.19	324.75	41750.30	-20.43	3746	126483.54	-669.92	51381.85	-143.86	3125
Combination options	309434.13	289.45	60718.10	-77.44	3226	128034.45	-285.22	29532.76	-120.74	2482
Swap	1923553.96	4712.87	881146.38	-888.40	3746	1705682.55	-8709.00	1030054.29	-5960.30	3125
Others	17005.57	76.92	7679.20	16.72	3746	9565.96	11.48	10507.60	-12.53	3125
Hybrid instruments designated at FVTPL	124557.85	526.85	35692.68	193.04	3226	57385.97	183.01	14213.94	-70.79	2482

Table 5

Hedging and investment expenditure during periods of geopolitical risk

This table presents the results of Equation 1. The dependent variable is investment expenditure, and the explanatory variables include the derivative cash flow ratio, geopolitical risk change, their interaction term, and control variables. Column (1) provides results for the full sample, while Columns (2) and (3) present subsample analyses for observations where the geopolitical risk change variable equals 1 and 0, respectively. The joint significance examines whether $\beta_1 + \beta_2 = 0$ with the corresponding F-value and p-value reported. All variable definitions are reported in Table 1. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
	Full Sample	geopolitical risk change = 1	geopolitical risk change = 0
Derivative cash flows ratio	0.069	1.506***	0.294
	(0.738)	(0.566)	(0.888)
Derivative cash flows ratio × Geopolitical risk change	1.593**		
	(0.806)		
Joint significance	**9.57**		
	(0.002)		
Geopolitical risk change	-0.000		
	(0.001)		
Operating cash flow	0.070***	0.082***	0.054***
	(0.009)	(0.011)	(0.014)
Tobin's Q	0.011***	0.011***	0.012***
	(0.003)	(0.003)	(0.004)
Log assets	-0.013***	-0.012***	-0.017***
	(0.002)	(0.002)	(0.003)
P/B	-0.002	-0.001	-0.005*
	(0.002)	(0.002)	(0.003)
PPE ratio	-0.017*	-0.020*	-0.004
	(0.009)	(0.011)	(0.013)
Long-term debt ratio	-0.054***	-0.041***	-0.071***
	(0.007)	(0.007)	(0.011)
Cash ratio	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)
ROA	0.007	-0.009	0.040**
	(0.010)	(0.011)	(0.018)
Operating cycle	0.002*	0.002	0.005**
	(0.001)	(0.002)	(0.002)
Paying cash dividend	0.008***	0.009***	0.006**
	(0.002)	(0.002)	(0.003)
Loss	-0.007***	-0.006***	-0.008***
	(0.001)	(0.002)	(0.002)
Firm age	0.002	0.000	0.004
	(0.002)	(0.002)	(0.004)
Institutional ownership	0.002	-0.001	0.001
	(0.006)	(0.007)	(0.009)
Board size	0.010**	0.014***	0.002
	(0.004)	(0.005)	(0.007)
Ultimate controller holdings	-0.005	-0.005	-0.002
	(0.004)	(0.004)	(0.005)
CEO duality	-0.002	-0.002	-0.001
	(0.002)	(0.002)	(0.002)
Big4	0.008	0.012**	0.000
	(0.005)	(0.005)	(0.007)
Constant	0.191***	0.158***	0.247***
	(0.032)	(0.033)	(0.048)
Observations	20995	12146	8849
Negative cashflow control	YES	YES	YES
Negative cashflow interactions controls	YES	YES	YES
Industry FE	NO	NO	NO
Firm FE	YES	YES	YES
Year FE	NO	NO	NO
Time trend	YES	YES	YES
Adjusted R-squared	0.544	0.550	0.559

Table 6

Multinomial logit analysis

A multinomial logit model is used to predict the likelihood of a firm being classified as underinvesting or overinvesting relative to the benchmark group. Columns (1) and (2) report results using the full sample. Columns (3) and (4) present results for the subsample where the geopolitical risk change equals 1, while Columns (5) and (6) show results for the subsample where the geopolitical risk change equals 0. The joint significance examines whether $\beta_1 + \beta_2 = 0$ with the corresponding chi-squared test statistic and p-value reported. All variable definitions are reported in Table 1. The marginal effects of the interaction between the Derivative Cash Flows Ratio and Geopolitical Risk Change are reported in square brackets. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Full sample	Full sample	geopolitical risk change = 1	geopolitical risk change = 1	geopolitical risk change = 0	geopolitical risk change = 0
	Underinvesting versus Benchmark	Overinvesting versus Benchmark	Underinvesting versus Benchmark	Overinvesting versus Benchmark	Underinvesting versus Benchmark	Overinvesting versus Benchmark
Derivative cash flows ratio	1.197	-20.051	-69.489**	-44.765	10.925	0.087
	(34.759)	(52.528)	(28.623)	(32.163)	(35.017)	(56.310)
			[-8.387]*	[-3.425]	[1.689]	[-0.573]
Derivative cash flows ratio × Geopolitical risk	-68.397*	-13.204				
	(39.254)	(48.933)				
	[-9.974]*	[1.588]				
Joint significance	6.16**	1.06				
	(0.013)	(0.302)				
Geopolitical risk change	0.001	0.010				
	(0.036)	(0.034)				
Operating cash flow	-2.511***	2.796***	-2.094***	3.302***	-3.042***	2.197***
	(0.437)	(0.345)	(0.522)	(0.425)	(0.570)	(0.465)
Tobin's Q	-0.394***	0.257**	-0.351***	0.191*	-0.483***	0.392***
	(0.111)	(0.101)	(0.124)	(0.113)	(0.153)	(0.137)
Log assets	-0.135***	-0.192***	-0.146***	-0.176***	-0.129***	-0.215***
	(0.039)	(0.039)	(0.041)	(0.042)	(0.047)	(0.045)
P/B	0.198***	0.046	0.159**	0.073	0.269***	-0.011
	(0.063)	(0.063)	(0.071)	(0.069)	(0.092)	(0.085)
PPE ratio	-1.905***	2.654***	-2.034***	2.661***	-1.796***	2.620***
	(0.256)	(0.228)	(0.285)	(0.258)	(0.308)	(0.255)
Long-term debt ratio	1.340***	-1.117***	1.215***	-1.088***	1.598***	-1.125***
	(0.284)	(0.286)	(0.321)	(0.329)	(0.350)	(0.363)
Cash ratio	0.000	-0.000	0.000	0.000	0.001	-0.001
	(0.000)	(0.001)	(0.000)	(0.001)	(0.001)	(0.001)
ROA	0.463	-0.802**	-0.103	-0.765	1.176**	-0.811
	(0.376)	(0.388)	(0.453)	(0.475)	(0.512)	(0.510)
Operating cycle	-0.271***	0.052	-0.260***	0.055	-0.299***	0.052
	(0.053)	(0.051)	(0.059)	(0.053)	(0.072)	(0.065)
Paying cash dividend	-0.186**	0.233***	-0.106	0.295***	-0.275***	0.159
	(0.076)	(0.084)	(0.088)	(0.099)	(0.100)	(0.108)
Loss	-0.053	-0.228***	-0.061	-0.161*	-0.026	-0.308***
	(0.071)	(0.078)	(0.086)	(0.093)	(0.098)	(0.105)
Firm age	0.017***	-0.021***	0.017***	-0.024***	0.019***	-0.015**
	(0.005)	(0.005)	(0.005)	(0.006)	(0.007)	(0.006)
Institutional ownership	0.317	0.262	0.342	0.310	0.302	0.191
	(0.202)	(0.188)	(0.215)	(0.203)	(0.241)	(0.223)
Board size	-0.266	-0.149	-0.342*	-0.192	-0.156	-0.105
	(0.181)	(0.176)	(0.194)	(0.189)	(0.216)	(0.215)
Ultimate controller holdings	-0.081	-0.487***	-0.033	-0.404***	-0.146	-0.604***
	(0.113)	(0.126)	(0.118)	(0.132)	(0.144)	(0.151)
CEO duality	0.067	0.055	0.062	0.048	0.078	0.061
	(0.068)	(0.069)	(0.073)	(0.076)	(0.085)	(0.083)
Big4	-0.323***	0.224*	-0.316***	0.185	-0.342***	0.263*
	(0.109)	(0.124)	(0.118)	(0.131)	(0.124)	(0.145)
Constant	2.802***	0.294	3.396***	0.314	2.080**	0.262
	(0.695)	(0.779)	(0.742)	(0.815)	(0.875)	(0.927)
Observations	20995	20995	12146	12146	8849	8849
Negative cashflow control	YES	YES	YES	YES	YES	YES
Negative cashflow interactions controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO
Year FE	NO	NO	NO	NO	NO	NO
Time trend	YES	YES	YES	YES	YES	YES
Pseudo R-squared	0.145	0.145	0.149	0.149	0.147	0.147

Table 7
IV-2SLS
This table presents the results of IV-2SLS. All variable definitions are reported in Table 1. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	Periods of heightened geopolitical risk		Periods of diminished geopolitical risk	
	First stage	Second stage	First stage	Second stage
	Dependent variable: Industry-level average of the derivative cash flows ratio	Dependent variable: Investment expenditure	Dependent variable: Industry-level average of the derivative cash flows ratio	Dependent variable: Investment expenditure
	(1)	(2)	(3)	(4)
Industry-level average of the derivative cash flows ratio	0.76668***		0.82725***	
	(0.097097)		(0.08344)	
Derivative cash flows ratio		10.436***		4.918
		(3.658)		(3.818)
Operating cash flow	-0.00026	0.085***	-0.00008	0.054***
	(0.00017)	(0.011)	(0.00016)	(0.013)
Tobin's Q	-0.00001	0.011***	-0.00003*	0.012***
	(0.00002)	(0.003)	(0.00002)	(0.004)
Log assets	-0.00002	-0.011***	0.00001	-0.017***
	(0.00002)	(0.002)	(0.00002)	(0.003)
P/B	0.00001	-0.001	0.00002	-0.005**
	(0.00001)	(0.002)	(0.00001)	(0.002)
PPE ratio	0.00004	-0.020*	0.00009	-0.004
	(0.00008)	(0.010)	(0.00009)	(0.012)
Long-term debt ratio	0.00013	-0.042***	-0.00003	-0.070***
	(0.00009)	(0.007)	(0.00010)	(0.010)
Cash ratio	0.0000002*	0.000	0.00000	0.000
	(0.00000)	(0.000)	(0.00000)	(0.000)
ROA	0.00007	-0.009	0.00012	0.040**
	(0.00011)	(0.010)	(0.00011)	(0.016)
Operating cycle	0.00000	0.002	-0.00001	0.005**
	(0.00001)	(0.002)	(0.00002)	(0.002)
Paying cash dividend	-0.00002	0.009***	0.00003	0.006**
	(0.00002)	(0.002)	(0.00002)	(0.002)
Loss	-0.00002	-0.006***	0.00004	-0.008***
	(0.00002)	(0.002)	(0.00002)	(0.002)
Firm age	-0.00002**	0.000	0.00000	0.004
	(0.00001)	(0.002)	(0.00001)	(0.004)
Institutional ownership	0.00002	-0.001	-0.00006	0.002
	(0.00009)	(0.006)	(0.00008)	(0.008)
Board size	-0.00006	0.014***	0.00016*	0.002
	(0.00007)	(0.005)	(0.00008)	(0.007)
Ultimate controller holdings	0.00005	-0.005	0.00000	-0.002
	(0.00004)	(0.004)	(0.00004)	(0.004)
CEO duality	0.00005**	-0.003*	0.00000	-0.001
	(0.00002)	(0.002)	(0.00002)	(0.002)
Big4	-0.00001	0.012***	0.00000	0.000
	(0.00004)	(0.005)	(0.00003)	(0.006)
Observations	12036	12036	8800	8800
Negative cashflow control	YES	YES	YES	YES
Negative cashflow interactions controls	YES	YES	YES	YES
Industry FE	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES
Year FE	NO	NO	NO	NO
Time trend	YES	YES	YES	YES
Centered R-squared		0.055	0.071	0.071
Cragg-Donald Wald *F*-statistic	274.858		301.679	
Kleibergen-Paap Wald rk *F* statistic	62.347		98.295	
Stock-Yogo weak ID test critical values at 10% IV size	16.38		16.38	

Table 8

Heckman two-step model - Step 1

This table reports the Step 1 results of the Heckman two-step model. All variable definitions are reported in Table 1. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel A First step	
Log assets	0.319***
	(0.030)
Paying cash dividend	0.178***
	(0.047)
Long-term debt ratio	0.063
	(0.220)
ROA	0.342
	(0.240)
PPE ratio	-0.240
	(0.189)
Number of business segments	0.003
	(0.014)
Foreign sales	0.005***
	(0.001)
Quick ratio	-0.017
	(0.011)
P/B	-0.056***
	(0.018)
Institutional ownership	0.129
	(0.159)
R&D ratio	-0.345
	(0.239)
Director and supervisor holdings	-0.136
	(0.228)
Constant	-4.756***
	(0.517)
Observations	17124
Negative cashflow control	NO
Negative cashflow interactions controls	NO
Industry FE	YES
Firm FE	NO
Year FE	YES
Time trend	NO
Pseudo R-squared	0.158

Table 8

Heckman two-step model - Step 2

This table reports the Step 1 results of the Heckman two-step model. Column (1) reports the results from the OLS model, while Column (2) presents the findings from the fixed effects model. All variable definitions are reported in Table 1. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

Panel B Second step	(1)	(2)
	OLS	Fixed effect
Derivative cash flows ratio	-1.181	-0.110
	(0.867)	(0.676)
Derivative cash flows ratio × Geopolitical risk change	1.788**	1.472*
	(0.850)	(0.751)
Geopolitical risk change	-0.000	0.000
	(0.001)	(0.001)
Operating cash flow	0.130***	0.075***
	(0.012)	(0.010)
Tobin's Q	0.019***	0.008**
	(0.004)	(0.003)
Log assets	-0.001	-0.014***
	(0.001)	(0.002)
P/B	-0.002	-0.001
	(0.002)	(0.002)
PPE ratio	0.078***	-0.010
	(0.007)	(0.010)
Long-term debt ratio	-0.036***	-0.061***
	(0.006)	(0.008)
Cash ratio	-0.000	0.000
	(0.000)	(0.000)
ROA	-0.043***	-0.008
	(0.014)	(0.012)
Operating cycle	0.005***	0.001
	(0.002)	(0.002)
Paying cash dividend	0.004**	0.007***
	(0.002)	(0.002)
Loss	-0.012***	-0.007***
	(0.002)	(0.002)
Firm age	-0.001***	0.004*
	(0.000)	(0.002)
Institutional ownership	0.000	-0.000
	(0.005)	(0.007)
Board size	0.004	0.008
	(0.004)	(0.005)
Ultimate controller holdings	-0.009***	-0.003
	(0.003)	(0.005)
CEO duality	-0.001	-0.002
	(0.002)	(0.002)
Big4	0.009***	0.007
	(0.003)	(0.007)
IMR	0.003***	0.001
	(0.001)	(0.001)
Constant	-0.022	0.215***
	(0.019)	(0.040)
Observations	17124	17124
Negative cashflow control	YES	YES
Negative cashflow interactions controls	YES	YES
Industry FE	YES	NO
Firm FE	NO	YES
Year FE	NO	NO
Time trend	YES	YES
Adjusted R-squared	0.314	0.550

Table 9

The cost of equity and derivative cash flow

This table reports the estimation results of Eq. (3). The dependent variable is cost of equity, and the explanatory variables include the derivative cash flow ratio, geopolitical risk change, their interaction term, and control variables. Column (1) presents the results for the full sample, while Columns (2) and (3) provide subsample analyses for observations during periods of heightened geopolitical risk (where the geopolitical risk change variable equals 1) and reduced geopolitical risk (where the geopolitical risk change variable equals 0), respectively. The joint significance examines whether $\beta_1 + \beta_2 = 0$ with the corresponding F-value and p-value reported. All variable definitions are reported in Table 1. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)
	Full Sample	Periods of heightened geopolitical risk	Periods of diminished geopolitical risk
Derivative cash flows ratio	-0.542*	-0.752***	-0.788**
	(0.281)	(0.221)	(0.341)
Derivative cash flows ratio × Geopolitical risk change	-0.246		
	(0.312)		
Joint significance	15.58		
	(0.0001)		
Geopolitical risk change	0.0004*		
	(0.0002)		
Operating cash flow	-0.001	0.007*	-0.011**
	(0.003)	(0.004)	(0.005)
Tobin's Q	-0.002***	-0.004***	0.000
	(0.001)	(0.001)	(0.001)
Log assets	-0.002***	-0.002***	-0.001
	(0.000)	(0.001)	(0.001)
P/B	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.001)
PPE ratio	0.003	0.005*	0.005
	(0.002)	(0.003)	(0.003)
Long-term debt ratio	0.002	0.006**	-0.006**
	(0.002)	(0.002)	(0.003)
Cash ratio	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)
ROA	-0.001	0.006*	-0.010**
	(0.003)	(0.004)	(0.005)
Operating cycle	0.001***	0.002***	0.000
	(0.000)	(0.001)	(0.001)
Paying cash dividend	-0.000	0.001	-0.002***
	(0.001)	(0.001)	(0.001)
Loss	0.000	-0.001*	0.002***
	(0.000)	(0.001)	(0.001)
Firm age	-0.000	-0.001	-0.000
	(0.001)	(0.001)	(0.001)
Institutional ownership	0.000	0.004**	-0.008***
	(0.002)	(0.002)	(0.003)
Board size	-0.004***	-0.008***	-0.000
	(0.001)	(0.002)	(0.002)
Ultimate controller holdings	0.001	-0.000	0.002
	(0.001)	(0.001)	(0.002)
CEO duality	-0.001	-0.001	-0.001
	(0.000)	(0.001)	(0.001)
Big4	-0.003***	-0.003***	-0.003*
	(0.001)	(0.001)	(0.002)
Constant	0.010	0.020*	-0.012
	(0.008)	(0.011)	(0.014)
Observations	20991	12145	8846
Negative cashflow control	YES	YES	YES
Negative cashflow interactions controls	YES	YES	YES
Industry FE	NO	NO	NO
Firm FE	YES	YES	YES
Year FE	NO	NO	NO
Time trend	YES	YES	YES
Adjusted R-squared	0.439	0.440	0.425

Table 10

The bank loan rate and derivative cash flow

This table reports the estimation results of Eq. (3). The dependent variable is the bank's short-term and long-term interest rates, and the explanatory variables include the derivative cash flow ratio, geopolitical risk change, their interaction term, and control variables. Column (1) presents the results for the full sample, while Columns (2) and (3) provide subsample analyses for observations during periods of heightened geopolitical risk (where the geopolitical risk change variable equals 1) and reduced geopolitical risk (where the geopolitical risk change variable equals 0), respectively. The joint significance examines whether β1 + β2 = 0 with the corresponding F-value and p-value reported. All variable definitions are reported in Table 1. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	Bank's short-term rates			Bank's long-term rates		
	(1)	(2)	(3)	(4)	(5)	(6)
	Full Sample	Periods of heightened geopolitical risk	Periods of diminished geopolitical risk	Full Sample	Periods of heightened geopolitical risk	Periods of diminished geopolitical risk
Derivative cash flows ratio	-62.445***	-14.556*	-76.200***	-42.145***	-12.216*	-45.945***
	(15.581)	(8.238)	(20.915)	(10.454)	(7.107)	(15.192)
Derivative cash flows ratio × Geopolitical risk change	44.534***			27.013**		
	(14.989)			(11.760)		
Joint significance	4.86			4.43		
	(0.0276)			(0.0355)		
Geopolitical risk change	0.120***			0.102***		
	(0.007)			(0.009)		
Operating cash flow	0.097	0.192	0.040	0.181*	0.188*	0.147
	(0.101)	(0.128)	(0.197)	(0.102)	(0.106)	(0.229)
Tobin's Q	-0.045**	-0.051*	-0.078**	-0.029	-0.077***	0.044
	(0.022)	(0.028)	(0.039)	(0.022)	(0.021)	(0.059)
Log assets	0.013	0.011	-0.026	-0.013	-0.014	-0.027
	(0.020)	(0.019)	(0.031)	(0.018)	(0.017)	(0.036)
P/B	0.058***	0.046***	0.065***	0.034***	0.035***	0.017
	(0.011)	(0.015)	(0.021)	(0.011)	(0.011)	(0.030)
PPE ratio	0.257***	0.247***	0.177	0.204***	0.117	0.244
	(0.085)	(0.089)	(0.138)	(0.078)	(0.073)	(0.152)
Long-term debt ratio	0.058	0.216***	-0.035	-0.039	0.060	-0.113
	(0.065)	(0.063)	(0.143)	(0.068)	(0.048)	(0.158)
Cash ratio	0.000	0.000	0.000	0.000***	0.000***	0.001**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ROA	0.296***	-0.117	0.691***	0.294***	0.131	0.381**
	(0.086)	(0.101)	(0.157)	(0.084)	(0.088)	(0.175)
Operating cycle	0.056***	0.047***	0.060***	0.048***	0.052***	0.029
	(0.013)	(0.012)	(0.023)	(0.013)	(0.011)	(0.029)
Paying cash dividend	-0.105***	-0.074***	-0.126***	-0.093***	-0.077***	-0.104**
	(0.019)	(0.018)	(0.040)	(0.018)	(0.017)	(0.041)
Loss	0.038***	-0.056***	0.198***	0.056***	-0.024*	0.210***
	(0.014)	(0.015)	(0.026)	(0.017)	(0.014)	(0.038)
Firm age	-0.031	-0.006	-0.092	-0.028	-0.040**	0.014
	(0.027)	(0.015)	(0.089)	(0.024)	(0.018)	(0.048)
Institutional ownership	-0.121*	-0.177***	0.086	-0.109*	-0.142**	0.014
	(0.066)	(0.062)	(0.121)	(0.065)	(0.061)	(0.125)
Board size	-0.191***	-0.231***	-0.011	-0.097**	-0.126***	0.034
	(0.045)	(0.047)	(0.083)	(0.045)	(0.042)	(0.092)
Ultimate controller holdings	-0.008	-0.050	0.042	0.028	-0.000	0.075
	(0.033)	(0.032)	(0.056)	(0.031)	(0.033)	(0.073)
CEO duality	-0.031*	-0.036**	-0.008	-0.010	-0.030*	0.037
	(0.017)	(0.018)	(0.028)	(0.018)	(0.016)	(0.038)
Big4	-0.080**	-0.094**	-0.072	-0.069*	-0.087**	-0.027
	(0.036)	(0.037)	(0.052)	(0.037)	(0.035)	(0.064)
Constant	-3.764***	-3.751***	-3.074***	-3.429***	-3.252***	-3.604***
	(0.323)	(0.310)	(0.662)	(0.318)	(0.270)	(0.680)
Observations	13580	7810	5770	10537	6150	4387
Negative cashflow control	YES	YES	YES	YES	YES	YES
Negative cashflow interactions controls	YES	YES	YES	YES	YES	YES
Industry FE	NO	NO	NO	NO	NO	NO
Firm FE	YES	YES	YES	YES	YES	YES
Year FE	NO	NO	NO	NO	NO	NO
Time trend	YES	YES	YES	YES	YES	YES
Adjusted R-squared	0.281	0.330	0.273	0.290	0.511	0.186

Table 11
Multinomial logit analysis: Comparing "underinvestment" versus "benchmark" during periods of heightened geopolitical risk

A multinomial logit model is used to predict the likelihood of a firm being classified as underinvesting relative to the benchmark groupduring periods of heightened geopolitical risk. All variable definitions are reported in Table 1. Marginal effects for the derivative cash flows ratio are reported in square brackets. Heteroskedasticity consistent standard errors clustered at the firm level are reported in parentheses. *, **, and *** represent statistical significance at the 10%, 5%, and 1% levels, respectively.

	(1)	(2)	(3)	(4)	(5)	(6)
	Higher underinvestment cost	Higher foreign sales	Higher investment in China	High-tech firms	Lower cash ratio	Higher director tenures
Derivative cash flows ratio	-110.210**	-84.077***	-110.797***	-87.549***	-115.115***	-97.884**
	(47.000)	(32.143)	(33.585)	(32.371)	(40.523)	(41.051)
	[-13.048]*	[-10.366]**	[-14.2232]***	[-10.434]*	[-12.926]**	[-11.58647]*
Operating cash flow	-2.491***	-2.032***	-2.743***	-2.403***	-2.439***	-1.864**
	(0.817)	(0.666)	(0.668)	(0.619)	(0.815)	(0.741)
Tobin's Q	-0.436**	-0.244	-0.316**	-0.388**	-0.220	-0.433**
	(0.195)	(0.152)	(0.140)	(0.191)	(0.187)	(0.218)
Log assets	-0.159***	-0.200***	-0.200***	-0.156***	-0.296***	-0.118**
	(0.056)	(0.049)	(0.050)	(0.057)	(0.055)	(0.056)
P/B	0.150	0.143	0.138*	0.153	0.070	0.143
	(0.092)	(0.092)	(0.081)	(0.110)	(0.101)	(0.125)
PPE ratio	-2.151***	-2.083***	-1.953***	-1.975***	-2.826***	-2.145***
	(0.351)	(0.339)	(0.336)	(0.407)	(0.409)	(0.412)
Long-term debt ratio	0.932**	1.527***	1.074***	1.422***	1.312***	0.742
	(0.413)	(0.388)	(0.383)	(0.457)	(0.381)	(0.462)
Cash ratio	0.000	-0.000	0.000	0.001	-0.602***	0.000
	(0.001)	(0.000)	(0.000)	(0.001)	(0.151)	(0.001)
ROA	-0.079	-0.392	0.047	0.002	0.049	0.129
	(0.747)	(0.542)	(0.587)	(0.582)	(0.706)	(0.728)
Operating cycle	-0.240***	-0.159**	-0.297***	-0.266***	-0.276***	-0.292***
	(0.086)	(0.063)	(0.071)	(0.101)	(0.077)	(0.087)
Paying cash dividend	-0.009	-0.101	0.027	-0.027	-0.100	-0.018
	(0.120)	(0.112)	(0.114)	(0.115)	(0.120)	(0.133)
Loss	-0.072	-0.135	0.018	-0.046	-0.131	-0.022
	(0.118)	(0.118)	(0.111)	(0.107)	(0.117)	(0.123)
Firm age	0.021***	0.025***	0.018***	0.027**	0.022***	0.013*
	(0.007)	(0.007)	(0.006)	(0.011)	(0.007)	(0.007)
Institutional ownership	0.222	0.489*	0.332	0.284	0.319	0.262
	(0.291)	(0.268)	(0.266)	(0.298)	(0.295)	(0.308)
Board size	-0.716***	-0.535**	-0.200	-0.155	-0.342	-0.197
	(0.247)	(0.247)	(0.230)	(0.268)	(0.246)	(0.271)
Ultimate controller holdings	-0.168	-0.239	-0.160	0.065	-0.141	-0.167
	(0.174)	(0.150)	(0.154)	(0.193)	(0.175)	(0.176)
CEO duality	-0.080	0.110	0.150	0.095	-0.024	0.046
	(0.100)	(0.093)	(0.091)	(0.096)	(0.097)	(0.105)
Big4	-0.563***	-0.261*	-0.258*	-0.362**	-0.312**	-0.238
	(0.145)	(0.148)	(0.149)	(0.181)	(0.148)	(0.177)
Constant	4.732***	3.804***	3.849***	5.840***	5.946***	2.578**
	(1.063)	(0.897)	(0.913)	(1.132)	(1.039)	(1.060)
Observations	5746	7084	7467	7005	6127	6043
Negative cashflow control	YES	YES	YES	YES	YES	YES
Negative cashflow interactions controls	YES	YES	YES	YES	YES	YES
Industry FE	YES	YES	YES	YES	YES	YES
Firm FE	NO	NO	NO	NO	NO	NO
Year FE	NO	NO	NO	NO	NO	NO
Time trend	YES	YES	YES	YES	YES	YES
Pseudo R-squared	0.182	0.164	0.174	0.128	0.171	0.157