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Innovating Through Uncertainty: How Firms Buffer Geopolitical Risk to Sustain Financial Performance

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Abstract

This study investigates the impact of geopolitical risk (GPR) on corporate financial performance and examines whether innovation can mitigate the adverse effects of GPR. Using panel data on Taiwanese listed firms from 2012 to 2024, the analysis employs a fixed-effects regression model as the main estimation method, complemented by generalized estimating equations (GEE) and several additional robustness checks. To address potential endogeneity concerns, a two-stage least squares (2SLS) approach is applied, using GPR indices from Hong Kong and South Korea as instrumental variables. The empirical results show that GPR exerts a significantly negative effect on corporate financial performance. Moreover, innovation moderates this relationship, effectively reducing the detrimental impact of GPR. However, this mitigating effect was time-sensitive. Innovation implemented within the previous year continued to buffer the negative impact of GPR, whereas innovations older than two years no longer exhibited a significant moderating effect. These findings are robust across various alternative model specifications and estimation techniques. Based on these results, this study suggests that firms should strengthen and prioritize innovation activities to enhance resilience against geopolitical uncertainty. CEOs are encouraged to advance product and process innovation early in the development cycle to build strategic buffers before products enter the market. Additionally, policymakers can support corporate innovation through targeted measures such as tax incentives for high-technology equipment and streamlined procedures for patent acquisition.

JEL classification: G01, G30, G32.
Keywords: Geopolitical risk, Uncertainty, Innovation, Taiwan, Dragon countries.

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1. Introduction

Uncertainty—such as geopolitical risk (GPR), defined as the inability of individuals to predict the likelihood of future events—reflects the uncertainty faced by consumers, managers, and policymakers regarding potential outcomes (Bloom, 2014). Geopolitical risk refers to threats arising from wars, terrorist acts, and tensions among states, which influence international relations, trade, and economic stability (Caldara & Iacoviello, 2022). Bohl et al. (2017) further conceptualize GPR as the potential disruption of political–economic conditions that support human welfare, originating from interconnected political, economic, and natural systems. Political risks emerge from interactions among competing political actors, economic risks stem from market volatility, and natural risks arise from environmental changes, even when such changes are indirectly caused by human activity.

Recent geopolitical events have created high levels of uncertainty that significantly affect firms, including global market downturns, rising trade protectionism (Ou et al., 2023), the Brexit referendum, the U.S.–China trade wars (2018 and 2025), the rise of ISIS leading to energy market instability, the Russia–Ukraine war resulting in surging commodity prices, and the COVID-19 pandemic which disrupted global consumption and supply chains. How firms can build resilience to such uncertainties has become an increasingly important question (Ou et al., 2023). As Wang and Wang (2024) emphasize, GPR has heightened global economic instability, demonstrating the need to better understand its consequences.

A growing body of research shows that GPR has significant adverse effects on both macroeconomic and microeconomic conditions. Prior studies document detrimental effects on microeconomics, such as household portfolio (Sun & Li, 2025); and macroeconomics, such as economic growth (Akadiri et al., 2020; Wang et al., 2024), oil prices (Bouoiyour et al., 2019; Qin et al., 2020), GDP growth (Akadiri et al., 2020; Caldara & Iacoviello, 2022), consumption and employment (Bloom, 2007; Cheng & Chiu, 2018), and overall global financial stability (Phan et al., 2022). Central banks, financial institutions, investors, and corporate managers increasingly regard GPR as a major factor influencing business operations and financial performance (Caldara & Iacoviello, 2022; Sandra & Kim, 2022), and consider it a key determinant of economic decision-making (Demir & Ersan, 2017).

Innovation, however, is inherently risky, idiosyncratic, unpredictable, and long-term in nature, making it more susceptible to failure (Cui et al., 2023). It involves transforming existing knowledge and resources into new products or processes (Guan et al., 2021). Bhattacharya et al. (2017) describe innovation as a specialized intangible investment that yields future benefits but differs from other intangible assets due to its long horizon and high uncertainty. Recent geopolitical developments have further underscored the strategic importance of innovation for global firms. Innovation promotes competitive advantage and long-term economic growth (Solow, 1957; Tajaddini & Gholipour, 2020; Tian et al., 2022; L. Zhou & Chen, 2024), enhances firm survival (Wen et al., 2022; H. Zhou et al., 2023), and improves enterprise value (H. Zhou et al., 2023). Notably, Pandit et al. (2011) find that innovative firms exhibit higher productivity and lower volatility in future operating performance.

The relationship between uncertainty—including GPR—and innovation has received limited attention and remains theoretically ambiguous. Some studies argue that rising GPR restricts firms' access to essential foreign technology and equipment, thereby hindering innovation (Jia et al., 2022). According to real option theory, heightened uncertainty increases the value of waiting, encouraging firms to delay innovation investments due to macroeconomic instability, information asymmetry, and higher financing costs (Jia et al., 2022; Wang & Wang, 2024; William &

Fengrong, 2022). Innovation, which involves significant sunk costs and long-term commitments, becomes even more sensitive to uncertainty (Cui et al., 2023). Recent empirical evidence supports a negative relationship between uncertainty and innovation (William & Fengrong, 2022; Cui et al., 2023; Tian et al., 2022).

Conversely, growth option theory suggests that uncertainty can increase investment—particularly innovation—when it enlarges the potential upside (Bloom, 2014). Increased uncertainty may heighten competitive pressure, incentivizing firms to innovate in order to differentiate their products and maintain market share (Guan et al., 2021). Wang and Wang (2024) find that although GPR creates technological barriers, it can also stimulate innovation by intensifying competition. Pan (2018) notes that the negative effect of GPR may be weaker in industries with intense product market competition. Under strategic growth options, firms in competitive industries invest more in innovation even during uncertain periods (Vo & Le, 2017). Aghion et al. (2005) similarly argue that competition raises the incremental returns from innovation, encouraging greater R&D investment. Empirical evidence shows that uncertainty may, in some cases, promote innovation (Liu & Gao, 2024; Stein & Stone, 2010).

Given these theoretical ambiguities and mixed empirical findings, an important question arises: Does innovation mitigate the detrimental effect of GPR on financial performance? Despite its importance, this question has received limited scholarly attention.

This study contributes to the literature in three ways. First, it examines whether innovation attenuates the adverse effect of GPR on corporate financial performance. Second, it investigates the lagged effects of innovation to assess the persistence of its mitigating role. Third, this study uses Taiwan GPR Index and incorporates GPR indices from other "Dragon countries" with similar structural characteristics to strengthen the empirical analysis. Specifically, the Hong Kong GPR Index and South Korea GPR Index are used, with each index measured as the average of twelve months within a fiscal year. The rationale for using these instruments is that Hong Kong, South Korea, and Taiwan represent third rapidly industrializing economies in East Asia with high growth rates and strong export performance.

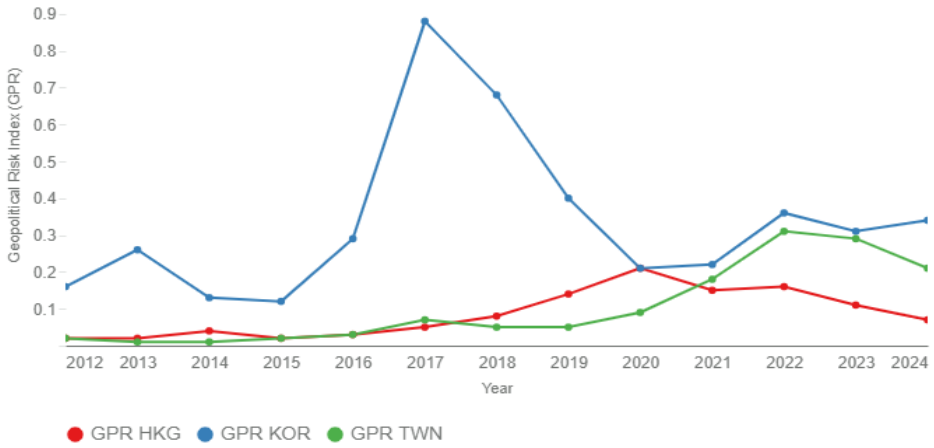

Figure 1: Geopolitical Risk (GPR) Index : HKG, KOR, TWN (2012-2024).

The remainder of this study proceeds as follows. Section 2 provides the literature review. Section 3 describes the data and methodology. Section 4 presents the empirical results and discussion. Section 5 concludes.

2. Literature Review

Caldara and Iacoviello (2022) conceptualize geopolitical risk (GPR) as the occurrence or escalation of threats arising from wars, terrorism, and tensions among states and political actors that disrupt peaceful international relations. GPR reflects the ability of states to control and compete over territory; when such uncertainty cannot be resolved, business operations and cycles are adversely affected, thereby undermining corporate financial performance (Caldara & Iacoviello, 2022; Gupta, 2023). Higher GPR is associated with an increased probability of economic disasters and lower expected GDP growth (Akadiri et al., 2020; Caldara & Iacoviello, 2022).

Baker et al. (2016) show that uncertainty significantly influences macroeconomic performance by constraining managers' ability to forecast regulatory, fiscal, and monetary policy changes. Ozdemir et al. (2023) highlight that uncertainty reduces or delays consumer demand for goods and services, thereby lowering firms' revenues. Prior studies also show that uncertainty increases firms' cost of capital and business operations (Çolak et al., 2017; Ou et al., 2023) and weakens sales performance. Yung and Root (2019) further find that uncertainty increases earnings management practices, which in turn influences firm value.

Based on prior studies, the first hypothesis is formulated:

H1: Geopolitical risk (GPR) reduces corporate financial performance.

Guan et al. (2021) define innovation as the use of knowledge and materials to create, improve, or transform products, technologies, strategies, management practices, and business models. Accordingly, innovation reflects the novelty of products and processes (Prajogo, 2006). Innovation contributes to advancements in product and process technologies (Lieberman & Montgomery, 1988). Lööf and Heshmati (2006) argue that innovation represents new or substantially improved goods and services for both firms and markets, and innovative firms are characterized by positive innovation-related investment and sales. Innovation is a long-term process that typically requires technology development and implementation supported by employee costs, equipment purchases, and material expenditures (Wang et al., 2017).

From a resource-based view, firms must possess intangible resources that are difficult for competitors to imitate in order to sustain competitive advantage (Cho & Pucik, 2005). The capability to innovate and deliver high-quality products or services constitutes an important intangible resource. This capability positively affects financial performance and enables firms to earn superior profits (Artz et al., 2010) by enhancing productivity and creating new products or services (Hai et al., 2022). Innovation improves productivity (Ren et al., 2023) and overall financial performance. Chouaibi (2021) finds that highly innovative firms are more likely to achieve stronger financial profitability and secure more stable financial positions.

Innovation investment is a strategic decision that enhances productivity, performance, and future market share (Jia et al., 2022). It also improves corporate reputation and investor trust, as generating new products and services through innovation strengthens corporate image and increases investor willingness to invest (Cui et al., 2023). From the perspective of strategic growth options, innovation reduces production costs and enables firms to expand at lower marginal cost relative to competitors, thereby generating future competitive advantage (Kulatilaka & Perotti, 1998). Bhattacharya et al. (2017) similarly view innovation as a long-term intangible investment that yields future financial benefits.

More successful innovators exhibit superior future operating performance. Innovation stabilizes future performance by raising revenues through new product sales and reducing operating costs through efficiency gains; innovative firms display higher performance and lower performance uncertainty (Pandit et al., 2011). Coad et al. (2016) argue that innovation enhances performance because new products or increased productivity through technological advancements expand market share. Warusawitharana (2015) also demonstrates that innovation produces economically and statistically significant improvements in profits and firm value, and such effects are persistent. Launching innovative products allows firms to operate in less competitive environments, thereby generating higher profits (Artz et al., 2010). Firms possessing intangible innovative capabilities develop valuable, rare, inimitable, and differentiated products (Sher & Yang, 2005), which strengthen competitive advantage (Awwad et al., 2025). Commercialized new products increase profits and market share, and such gains outweigh the marginal costs of innovation (Hai et al., 2022).

Innovation is shaped by both internal and external factors, including uncertainty (Aghion & Jaravel, 2015). Although innovation is inherently uncertain, it is still positively associated with firm performance. Speed is critical: firms must develop and commercialize innovations more quickly than competitors (Prajogo, 2006), especially in uncertain environments. Uncertainty often slows productivity, hiring, and investment, but innovation may respond differently due to adjustment costs.

Strategic growth option theory suggests that delaying investments—including innovation—creates opportunities for competitors. Thus, firms must act quickly to preserve market share (Kulatilaka & Perotti, 1998). GPR may therefore stimulate innovation as firms attempt to seize growth opportunities and outperform competitors (Jia et al., 2022; Pan, 2018). Market competition, particularly in highly competitive industries, motivates firms to increase innovation expenditures (Tajaddini & Gholipour, 2020). Wang and Wang (2024) show that GPR intensifies competitive pressure and promotes corporate innovation. The cost of innovation becomes lower than the cost of losing market position. The value of waiting approaches zero if competitors are innovating and launching new products (He et al., 2020).

Uncertainty is both a risk and an opportunity (Guan et al., 2021). Firms that choose not to innovate risk losing market opportunities to competitors, while innovation improves future profitability and competitive advantage. Market fluctuations and heightened competition during uncertain periods make innovation increasingly essential (Liu & Gao, 2024). Firms with greater exposure to GPR face higher threats and thus need to innovate proactively to reduce dependence on unstable external resources and to secure resilient operational pathways (Cui et al., 2025).

Uncertainty generally suppresses capital investment, hiring, and advertising, but it encourages innovation spending (Stein & Stone, 2010). Firms considering early innovation investment gain opportunities for future expansion. In non-monopolistic markets, innovation is a core engine of growth and survival (Guan et al., 2021; Zhou & Chen, 2024). Under real-option logic, firms that delay innovation risk forfeiting first-mover advantages to competitors (Weeds, 2002). Firms under competitive pressure invest more in innovation, particularly when facing higher uncertainty (Vo & Le, 2017). Early investment in innovation helps firms secure competitive advantage and pre-empt competitors' moves (Atanassov et al., 2024).

Although no consensus exists regarding the relationship between uncertainty and innovation (Guan et al., 2021), only a limited number of studies examine the mediating role of innovation in the GPR–financial performance relationship (He et al., 2020; Pan, 2018). Innovation improves profitability (Love et al., 2009) and insulates firms from market tensions. Its positive effects are

particularly strong for firms exposed to fluctuating market conditions, intense competition, or hard-to-innovate industries (Atanassov et al., 2024). Multiple studies show that innovation enhances financial performance (Artz et al., 2010; Prajogo, 2006; Chouaibi, 2021; Awwad et al., 2025).
Based on prior studies, the second hypothesis is proposed:

H2: Innovation positively moderates the relationship between GPR and financial performance

3. Data, Variable Definition, and Methodology of The Study

This study employs data on geopolitical risk (GPR), Taiwanese firms' financial statements, the USD/TWD exchange rate, and Taiwan's annual inflation from 2012 to 2024. All firm-level financial statement data, exchange rate data, and inflation statistics were obtained from the Taiwan Economic Journal (TEJ) database. The GPR data were sourced from the global geopolitical risk index developed by Caldara and Iacoviello (2022), available on their official database. Consistent with common practice in empirical studies, financial-sector firms—including banks, insurance companies, securities firms, and leasing and financing institutions—were excluded because their financial structures and regulatory environments differ substantially from non-financial firms.
The dependent variable is Return on Assets (ROA), which serves as a proxy for corporate financial performance. The primary independent variable is Taiwan's GPR index, constructed by Caldara and Iacoviello (2022). Their index quantifies geopolitical risk by computing the share of newspaper articles that reference adverse geopolitical events—including conflict, tension, war, or terrorism—across leading international newspapers, including those covering Taiwan. The index is designed to capture the intensity and dynamics of geopolitical risk that may affect economic and financial outcomes. Following Gupta (2023), this study measures GPR as the twelve-month average of the monthly GPR index for each fiscal year, denoted as GPRMEAN.
Consistent with Wang et al. (2017) and Jia et al. (2022), innovation is proxied by research and development (R&D) intensity, defined as the ratio of R&D expenditure to total sales. This measure captures firms' commitment to innovation investment relative to their operational scale. R&D intensity is measured as the ratio of R&D expenditure to sales revenue because geopolitical risk influences market conditions and demand, which directly affect firms' sales performance. As a result, sales revenue is more sensitive to geopolitical shocks than alternative scaling measures such as total assets or total expenditures, making the R&D-to-sales ratio a more appropriate indicator for capturing firms' innovative effort under geopolitical uncertainty.
The study includes a set of firm-level and macroeconomic control variables, including net income ratio, operating expense ratio, cash flow ratio, current ratio, debt-to-equity ratio (DER), net operating cycle, logarithm of total assets, the USD/TWD exchange rate (FOREX), and Taiwan's annual inflation rate (INFLATION).

Table 1: Variable Definition

Variable	Variable Symbol	Variable Definition
Financial performance	ROA	Ratio of net income to total asset
Uncertainty	GPRMEAN	Geopolitical risk index constructed by Caldara & Iacoviello (2022)
Innovation	INNO	Proportion of R&D expense to total revenue
Net income ratio	NIR	Ratio of net income to total revenue
Operating expense ratio	OPXR	Measure the proportion of various expense to operating income
Cash flow ratio	CASH	Measure whether the cash flow generated by operating activities to current liabilities
Current ratio	CURR	Ratio of current asset to current liabilities
Debt to equity ratio	DER	Ratio of total debt to total equity
Net operating cycle	NETOPC	Measuring how long it takes for a firm to generate cash inflows from its operating cycle
Total asset	LnTA	Refers to total amount of asset owned by enterprise
Foreign exchange	FOREX	Foreign exchange of USDTWD
Inflation	INFLATION	The value of Taiwan inflation

This study winsorizes all continuous variables at the 2nd and 98th percentiles to mitigate the influence of extreme outliers on the empirical results, except for GPRMEAN, FOREX, and INFLATION, which are retained in their original form due to their macroeconomic nature. The baseline econometric model used to test the first hypothesis is specified as follows:

$$ROA_{it} = \alpha_{it} + \beta GPRMEAN_{it} + \lambda Control_{it} + \mu_{it} + \delta_{it} + \varepsilon_{it} \quad (1)$$

where ROA_{it} denotes the return on assets of firm i in year t; $GPRMEAN_{it}$ is the annual average geopolitical risk index; $Control_{it}$ represents the vector of firm-level and macroeconomic control variables; μ_{it} captures unobserved firm-specific effects; δ_{it} represents time-specific effects; and ε_{it} is the idiosyncratic error term.

Furthermore, this study examines whether innovation moderates the effect of geopolitical risk on corporate financial performance. To evaluate this moderating relationship, the following model is estimated:

$$ROA_{it} = \alpha_{it} + \beta_1 X_{it} + \beta_2 GPRMEAN_{it} + \beta_3 INNO_{it} + \lambda Control_{it} + \mu_{it} + \delta_{it} + \varepsilon_{it} \quad (2)$$

Where X_{it} denotes the interaction term $GPRMEAN_{it}$ x $INNO_{it}$ and $INNO_{it}$ represents innovation measured by R&D spending to total revenue.

4. Result and Discussion

4.1 Descriptive Statistic

Table 2: Descriptive Statistic

Table 2.Descriptive Statistic

Variable	Obs	Mean	Std. dev.	Min	Max
ROA	12,347	4.503852	7.068903	-14.92	22.64
GPRMEAN	12,553	.1006716	.1028276	.01	.3
INNO	9,461	4.695969	6.159055	.08	30.67
NIR	12,496	6.189039	15.55391	-58.69	44.08
OPXR	12,497	18.48564	16.16452	2.37	84.87
CASH	12,315	30.22232	46.6117	-84.82	181.33
CURR	12,357	257.4124	230.363	58.48	1314.23
DER	10,748	57.4804	60.28261	.55	300.19
NETOPC	12,130	194.958	385.5805	-33.85	2224.16
LnTA	12,553	16.0579	1.501509	13.4998	20.19817
FOREX	12,553	.0076354	.0516557	-.075	.109
INFLATION	12,553	.0131678	.0100319	-.0006	.0271

Source : TEJ by processed

Table 2 presents the descriptive statistics of all variables used in the regression analysis. The mean, standard deviation, minimum, and maximum values of ROA are 4.503852, 7.068903, –14.92, and 22.64, respectively. These values indicate that ROA exhibits substantial variation, and the minimum value of –14.92 suggests that some firms are experiencing losses. The variable GPRMEAN has a mean of 0.1006716 and a standard deviation of 0.1028276, implying relatively low dispersion and suggesting that geopolitical risk remains fairly stable over the sample period. The INNO variable has a mean, standard deviation, minimum, and maximum of 4.695969, 6.159055, 0.08, and 30.67, respectively, indicating a high degree of variability in firms' innovation activities. Descriptive statistics for the remaining control variables are also reported in Table 2.

4.2 Fixed Effect Regression Result

Table 3 reports the fixed-effects regression results. Column (1) shows that GPRMEAN has a coefficient of –4.001 with a p-value of 0.000, indicating that geopolitical uncertainty has a statistically significant negative effect on firm financial performance at the 1% level. Consistent with Caldara and Iacoviello (2022), geopolitical risk reflects deteriorations in international peace due to events such as wars, terrorism, and interstate political tensions. These disruptions adversely affect international trade, financial markets, and the overall business cycle, ultimately harming firm performance (Caldara & Iacoviello, 2022; Gupta, 2023). Because geopolitical uncertainty is largely unavoidable (He et al., 2020), its negative impact tends to spread across all firms in a country regardless of size or financial condition.

Column (2) of Table 3 examines whether innovation moderates the relationship between geopolitical uncertainty and firm performance. The interaction term GPRMEAN x INNO has a coefficient of 0.204 and a p-value of 0.008, indicating a positive and significant moderating effect at the 1% level. This suggests that innovation mitigates the detrimental impact of geopolitical uncertainty on financial performance. Uncertainty typically suppresses product and service demand, as consumers postpone or reduce spending (Ozdemir et al., 2023). Innovation can counter this by enabling firms to introduce new products or reduce operating costs (Pandit et al., 2011).

New product offerings can expand market share and increase revenues (Hai et al., 2022), while cost-reducing innovations allow firms to offer more competitively priced goods and services. These combined effects help sustain or even enhance consumer demand, thereby improving firm financial performance despite heightened uncertainty.

Table 3.Basic Regression of GPRMEAN and INNO

	(1)	(2)
	ROA	ROA
GPRMEAN	-4.001***	-3.989***
	(0.000)	(0.000)
NIR	0.303***	0.366***
	(0.000)	(0.000)
OPXR	0.0403***	0.124***
	(0.000)	(0.000)
CASH	0.0162***	0.0129***
	(0.000)	(0.000)
CURR	-0.00154***	-0.00251***
	(0.000)	(0.000)
DER	-0.0217***	-0.0205***
	(0.000)	(0.000)
NETOPC	-0.00125***	-0.000593
	(0.000)	(0.223)
LnTA	0.653***	0.439***
	(0.000)	(0.001)
FOREX	7.233***	9.617***
	(0.000)	(0.000)
INFLATION	17.96***	13.03**
	(0.002)	(0.034)
GPRMEANxINNO		0.204***
		(0.008)
INNO		-0.377***
		(0.000)
_cons	-7.082***	-3.640*
	(0.000)	(0.089)
N	10554	8111
R^2	0.480	0.547

Source : TEJ by processed *p*-values in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

As reported in Table 3, the coefficient on the interaction term between geopolitical risk (GPRMEAN) and innovation (INNO) is 0.204. Given that the standard deviation of INNO is 6.159 (see Table 2), a one-standard-deviation increase in innovation mitigates the adverse effect of geopolitical risk on return on assets (ROA) by approximately 1.256 percentage points (0.204 × 6.159 = 1.256). This result indicates that innovation serves as a moderating factor that weakens the negative impact of geopolitical risk on firm performance.

4.3 Robustness Test

Based on Ou et al. (2023), this study conducts several robustness tests: (1) replacing the measures of geopolitical risk and innovation, (2) excluding macroeconomic variables to remove the influence of external economic conditions, (3) altering the sample period to assess the stability of the results, and (4) applying generalized estimating equation (GEE) as an alternative statistical methods to verify the consistency of the findings.

Table 4: Robustness Test

	(1)	(2)	(3)	(4)
	ROA	ROA	ROA	ROA
GPRMEDIANxINNO	0.197**			
	(0.011)			
INNO	-0.376***		-0.393***	-0.345***
	(0.000)		(0.000)	(0.000)
GPRMEDIAN	-3.339***			
	(0.000)			
NIR	0.366***	0.370***	0.367***	0.344***
	(0.000)	(0.000)	(0.000)	(0.000)
OPXR	0.124***	0.0666***	0.124***	0.127***
	(0.000)	(0.000)	(0.000)	(0.000)
CASH	0.0128***	0.0138***	0.0128***	0.00918***
	(0.000)	(0.000)	(0.000)	(0.000)
CURR	-0.00252***	-0.00301***	-0.00247***	-0.00236***
	(0.000)	(0.000)	(0.000)	(0.000)
DER	-0.0205***	-0.0202***	-0.0208***	-0.0277***
	(0.000)	(0.000)	(0.000)	(0.000)
NETOPC	-0.000605	-0.000367	-0.000683	-0.00260***
	(0.214)	(0.453)	(0.164)	(0.001)
LnTA	0.406***	0.252*	0.359***	1.261***
	(0.002)	(0.068)	(0.008)	(0.000)
FOREX	8.981***	9.969***		6.361***
	(0.000)	(0.000)		(0.000)
INFLATION	8.238	14.66**		29.46***
	(0.154)	(0.018)		(0.000)
GPRMEANxRDINTENSITY		26.29**		
		(0.035)		
RDINTENSITY		-31.12***		
		(0.000)		
GPRMEAN		-4.438***	-0.895*	-4.864***
		(0.000)	(0.095)	(0.000)
GPRMEANxINNO			0.228***	0.168*
			(0.003)	(0.057)
cons	-3.115	-0.246	-2.366	-16.21***
	(0.144)	(0.912)	(0.272)	(0.000)
N	8111	8118	8111	5256
R^2	0.547	0.540	0.539	0.513

Source : TEJ by processed *p*-values in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.4 Replacing The Measurement Of Geopolitical Risk and Innovation

This study re-estimated the baseline model using the median geopolitical risk index (GPRMEDIAN) to verify whether the results are sensitive to alternative GPR measures. Table 4, Column 1 shows that the coefficient and p-value of GPRMEDIAN are –3.339 and 0.000, indicating a negative and statistically significant relationship with ROA at the 1% level. The interaction term GPRMEDIAN x INNO yields a coefficient of 0.197 with a p-value of 0.011, demonstrating a positive and significant moderating effect of innovation at the 5% level.

In addition, Table 4, Column 2 presents the results using R&D intensity (RDINTENSITY) as an alternative proxy for innovation. R&D intensity is R&D spending to total assets. The coefficient and p-value of GPRMEAN x RDINTENSITY are 26.29 and 0.035, indicating a positive and significant moderating effect. These findings confirm that the main conclusions remain robust when alternative measures of geopolitical risk and innovation are used.

4.5 Excluding Macroeconomic Factors

To exclude the influence of external macroeconomic conditions, the regression analysis was re-estimated without macroeconomic variables such as foreign exchange rates and inflation. Table 4, Column 3 shows that the coefficient and p-value of GPRMEAN x INNO are 0.228 and 0.003. The magnitude and statistical significance closely mirror the results reported in Table 3, Column 2, where macroeconomic controls were included. This confirms that the moderating role of innovation is not driven by macroeconomic conditions, and the original findings remain robust.

4.6 Changing the Sample Period

After Taiwan held its election in January 2024, the geopolitical risk increased . To test the stability of the results under a period of heightened geopolitical pressure, this study re-estimated the model using data from 2017 to 2024. Table 4, Column 4 shows that the coefficient and p-value of GPRMEAN x INNO are 0.168 and 0.057, indicating a positive and significant impact at the 10% level. This result suggests that the moderating effect of innovation persists even during periods of intensified geopolitical tension, supporting the robustness of the main finding.

4.7 Changing the Statistical Method

This study further employed the Generalized Estimating Equations (GEE) approach as an additional robustness test. GEE, introduced by Liang and Zeger (1986), extends the generalized linear model and is particularly well-suited for longitudinal or panel datasets. It accounts for both within-entity and between-entity variability, yielding robust standard errors and producing efficient and unbiased parameter estimates in the presence of correlated observations (Ballinger, 2004; Madanoglu & Ozdemir, 2019). Its ability to model intra-group correlation structures enhances the accuracy of coefficient estimates. Accordingly, GEE is widely regarded as a reliable approach for analyzing longitudinal economic and financial data (Schneper & Guillén, 2004).

Table 5, Column 1 shows the coefficient and p-value of GPRMEAN are –3.074 and 0.000, indicating a negative and significant relationship with ROA at the 1% level. Column 2 reveals that the interaction term GPRMEAN x INNO has a coefficient of 0.134 and a p-value of 0.077, showing a positive and significant moderating effect at the 10% level. These results further confirm that the main conclusions remain robust across alternative estimation techniques.

Table 5: GEE

	(1)	(2)
	ROA	ROA
GPRMEAN	-3.074***	-3.538***
	(0.000)	(0.000)
NIR	0.304***	0.364***
	(0.000)	(0.000)
OPXR	0.0237***	0.0656***
	(0.000)	(0.000)
CASH	0.0182***	0.0147***
	(0.000)	(0.000)
CURR	-0.00155***	-0.00205***
	(0.000)	(0.000)
DER	-0.0199***	-0.0194***
	(0.000)	(0.000)
NETOPC	-0.000896***	-0.000958**
	(0.000)	(0.015)
LnTA	0.235***	0.241***
	(0.000)	(0.000)
FOREX	6.973***	9.651***
	(0.000)	(0.000)
INFLATION	17.07***	13.88**
	(0.004)	(0.027)
GPRMEANxINNO		0.134*
		(0.077)
INNO		-0.134***
		(0.000)
_cons	-0.291	-0.541
	(0.763)	(0.614)
N	10554	8111
R^2		

Source : TEJ by processed *p*-values in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

4.8 Endogeneity Issue

To address potential endogeneity arising from omitted variable bias, this study employs an instrumental variable approach. Following Ou et al. (2023), a two-stage least squares (2SLS) estimation is conducted using geopolitical risk (GPR) indices from other countries as instruments. Specifically, the Hong Kong GPR Index and South Korea GPR Index are used, with each index measured as the average of twelve months within a fiscal year. The rationale for using these instruments is that Hong Kong, South Korea, and Taiwan represent third rapidly industrializing economies in East Asia with high growth rates and strong export performance.

Moreover, Hong Kong has been under Chinese sovereignty since 1997 and operates as a Special Administrative Region with a high degree of autonomy. Political developments and policy interventions by the Chinese government in Hong Kong are therefore interpreted as reflections of China's broader political strategy. Given China's stated objective of reunification with Taiwan, political actions affecting Hong Kong are perceived in Taiwan as potential signals of Beijing's future approach toward Taiwan. Consequently, Taiwanese policymakers, investors, and the public may fear that political developments observed in Hong Kong could similarly occur in Taiwan in

the event of annexation. This perception increases Taiwan's geopolitical risk environment, leading to a positive spillover effect from Hong Kong's geopolitical risk to Taiwan's geopolitical risk.
Rising military tensions on the Korean Peninsula, particularly between South Korea and North Korea, contribute to heightened geopolitical uncertainty across East Asia. This conflict extends beyond the two Koreas, as the United States provides security support to South Korea while China tends to align diplomatically with North Korea. The involvement of major powers increases the risk of broader regional escalation. Given China's objective of reunification with Taiwan and the United States' opposition to such actions, heightened tensions on the Korean Peninsula raise concerns that regional conflict could expand to the Taiwan Strait. Consequently, escalating geopolitical risk in South Korea contributes to increased geopolitical risk perceptions in Taiwan.
Table 6, Column 1 shows that the coefficient and p-value of GPRMEAN are –3.621 and 0.001, respectively, indicating a negative and statistically significant impact on ROA at the 1% level. Column 2 reports that the interaction term GPRMEAN x INNO has a coefficient of 0.210 and a p-value of 0.016, demonstrating a positive and significant moderating effect at the 5% level. These results confirm that the main findings remain robust after accounting for potential endogeneity using the 2SLS approach.

Table 6: Instrumental Variable

	(1)	(2)
	ROA	ROA
GPRMEAN	-3.621***	-4.144***
	(0.001)	(0.002)
NIR	0.303***	0.366***
	(0.000)	(0.000)
OPXR	0.0400***	0.125***
	(0.000)	(0.000)
CASH	0.0161***	0.0129***
	(0.000)	(0.000)
CURR	-0.00155***	-0.00250***
	(0.000)	(0.000)
DER	-0.0217***	-0.0205***
	(0.000)	(0.000)
NETOPX	-0.00125***	-0.000590
	(0.000)	(0.226)
LnTA	0.631***	0.446***
	(0.000)	(0.002)
FOREX	7.004***	9.694***
	(0.000)	(0.000)
INFLATION	15.48*	13.87
	(0.061)	(0.107)
GPRMEAN*INNO		0.210**
		(0.016)
INNO		-0.378***
		(0.000)
_cons	-6.724***	-3.756
	(0.002)	(0.102)
N	10554	8111
R^2		

Source : TEJ by processed *p*-values in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7 presents the results of the lagged innovation analysis. Column 1 shows that the coefficient and p-value of the interaction term GPR x L1INNO are 0.139 and 0.089, respectively, indicating a positive and statistically significant impact on financial performance at the 10% level. L1INNO represents the one-year lag of innovation, or the effect of innovation implemented one year prior. This result suggests that innovation from the previous year can still mitigate the detrimental impact of GPR on financial performance, although its effect is weaker than that of current-year innovation (0.204).

Column 2 reports that the interaction term GPR x L2INNO has a coefficient of 0.0916 and a p-value of 0.288, indicating a positive but statistically insignificant impact on financial performance. L2INNO represents innovation from two years prior, suggesting that the effect of innovation from two years ago is insufficient to mitigate the negative impact of GPR.

Column 3 shows that the interaction term GPR x L3INNO has a coefficient of –0.0606 and a p-value of 0.496, indicating a negative and statistically insignificant effect. L3INNO represents innovation from three years prior. This result implies that innovation from three years ago not only fails to mitigate the adverse effects of GPR but may even exacerbate them.

The diminishing effect of lagged innovation over time may be attributed to the increased likelihood that competitors have replicated the firm's innovations, particularly those that generate substantial sales and profits. Consequently, the mitigating impact of innovation on GPR diminishes as the innovation ages.

Table 7: The Lag of INNO

	(1)	(2)	(3)
	ROA	ROA	ROA
GPRMEANxL1INNO	0.139*		
	(0.089)		
L1INNO	-0.0688**		
	(0.016)		
GPRMEAN	-5.002***	-4.560***	-2.263**
	(0.000)	(0.000)	(0.011)
NIR	0.354***	0.324***	0.311***
	(0.000)	(0.000)	(0.000)
OPXR	0.0393***	0.0221**	0.0256**
	(0.000)	(0.021)	(0.011)
CASH	0.0126***	0.0131***	0.0116***
	(0.000)	(0.000)	(0.000)
CURR	-0.00195***	-0.00106*	-0.00108*
	(0.000)	(0.059)	(0.071)
DER	-0.0214***	-0.0252***	-0.0273***
	(0.000)	(0.000)	(0.000)
NETOPX	-0.000829	-0.00101*	-0.00231***
	(0.111)	(0.071)	(0.000)
LnTA	0.366**	0.947***	1.741***
	(0.017)	(0.000)	(0.000)
FOREX	9.695***	8.247***	4.351***
	(0.000)	(0.000)	(0.000)
INFLATION	23.01***	24.14***	17.85***
	(0.000)	(0.000)	(0.008)
GPRMEANxL2INNO		0.0916	
		(0.288)	

L2INNO		0.0979***	
		(0.001)	
GPRMEANxL3INNO			-0.0606
			(0.496)
L3INNO			0.130***
			(0.000)
_cons	-2.189	-11.91***	-24.71***
	(0.370)	(0.000)	(0.000)
N	7521	6858	6191
R^2	0.521	0.494	0.480

Source : TEJ by proceed *p*-values in parentheses * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

5. Conclusion

This study examined the impact of geopolitical risk (GPR) on firm financial performance and the moderating role of innovation in alleviating its adverse effects. Using annual financial data of Taiwanese firms from 2012 to 2024, the results consistently indicated that GPR exerted a significant negative impact on firm performance. Furthermore, innovation, measured by R&D intensity (R&D expenditure relative to sales), effectively mitigated the detrimental effect of GPR on corporate financial outcomes. However, this mitigating effect was time-sensitive. Innovation implemented within the previous year continued to buffer the negative impact of GPR, whereas innovations older than two years no longer exhibited a significant moderating effect. Innovations from three years prior and earlier were ineffective in reducing the adverse consequences of geopolitical risk. This pattern suggested that the protective benefits of innovation diminished over time, likely due to competitive imitation, particularly when successful innovations were rapidly adopted by rivals and their profitability advantages eroded.

These findings carry important implications for firm managers, CEOs, and policymakers. CEOs should recognize that proactive investment in innovation can serve as a strategic tool to reduce the adverse effects of geopolitical uncertainty. Governments can further support corporate innovation through targeted policies, such as tax incentives for importing high-technology machinery and facilitating patent protections for new innovations.

The study has some limitations. The analysis covers only the period from 2012 to 2024, and longer time series data could provide even more robust results. Future research could explore additional factors or mechanisms that help firms mitigate the detrimental effects of GPR on financial performance

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