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MARKET COMPETITION AND INNOVATION PREMIUM BEFORE AND AFTER THE FINANCIAL CRISIS: EVIDENCE FROM TAIWAN

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Abstract

This study explores the influence of innovation and market competition on stock returns in Taiwan before and after the 2008 financial crisis. This study offers marginal contributions to the important topic of innovation investment which is a vital driver of competitiveness and growth. The study employs Fama Macbeth regression and a sorting portfolio to examine a sample of 121,913 firm-month observations from 1991 to March 2021. A Two-Stage Least Squares estimation is also employed to address unobserved endogeneity issues. The empirical findings suggest that innovation premiums persist in Taiwan. However, the findings also report that higher market concentration reduces stock returns in Taiwan. The results support the information asymmetry theory and the resource-based view theory. This study can support policymakers and managers in developing innovative activities sustainably in emerging markets, while also helping individual investors to optimize their investment portfolios.

Keywords: Innovation premium; market competition; financial crisis; cross-sectional stock returns; Taiwan.

JEL classification: G21, G22

1. INTRODUCTION

Several studies have confirmed a statistical relationship between expenditures on R&D and their pivotal role in driving a company's economic growth and success over a long period. Both theoretical and empirical research shows that organizations with high R&D intensity take on more risk and generate better future stock returns (Eberhart et al., 2004). Innovation and upgrading of technology play an essential role in increasing the volatility of stock returns, while less-imitated resources are a great advantage for businesses regarding competition.

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Specifically, Gharbi et al. (2014) and Duong et al. (2023) show that R&D investment improves a firm's growth opportunities. Moreover, successful R&D efforts can lead to the development of new products and better services, improving performance, and gaining an advantage over market rivals, which can drive future revenue growth. Investors may perceive companies with high R&D intensity as having strong growth potential, which could positively impact stock returns.

A competitive advantage shows that when firms use their initiative to create exclusive products, the concentration level in the market is low, creating a sustainable competitive advantage. This advantage might positively impact stock returns if investors perceive the company as better positioned for future market demands. Gallagher et al. (2015) found that average stock returns were positively correlated with market concentration. A sustainable competitive advantage typically develops as a company expands, capturing market share and having industry advantages that positively affect stock returns. However, Hou and Robinson (2006) and Gu (2016) have discovered that companies operating in sectors with high concentration levels have diminished stock returns.

Gharbi et al. (2014) and Hou et al. (2022) examine the relationship between R&D and stock returns in different stock markets. Gallagher et al. (2015) and Hou and Robinson (2006) also find the influence of market competition on stock returns in many nations. Still, studies need to analyze the influence of R&D and market competition on Taiwan stock returns, especially before and after the 2008 financial crisis. Therefore, our study has a marginal contribution to the existing studies by closing this research gap.

We carry out this study in Taiwan for the following reasons. We analyze market competition on R&D premiums in Taiwan since it is among the most potential in Southeast Asia and presents considerable investment opportunities to boost national innovation. Our descriptive statistics also report that the listed firms in Taiwan increased by 23.9% regarding R&D investments from 2010 to 2020. Taiwan is an emerging market and one of the leading countries in producing electronic components and equipment (Liu & Hsu, 2006). Therefore, it is worth testing whether innovations empower stock returns in Taiwan.

Moreover, Duong et al. (2021) demonstrate that Taiwan possesses unique microstructures that differ from other markets. Individual investors predominantly control Taiwan's stock market, while transaction costs are also low in Taiwan compared to other nearby countries. Moreover, the daily volatility and liquidity of the Taiwan stock market are incredibly high, implying higher limits on arbitrage. Therefore, investors may not fully capture the R&D premium from the Taiwan stock market.

Finally, The Taiwan Fair Trade Commission (TFTC) has enacted the Competition Laws Taiwan Fair Trade Act (TFTA) to restrict competition and unfair competition. Due to continuous innovations in industries and competitive behaviors, businesses should encourage independence to compete more equitably by investing in R&D and making superior products in an emerging market.

Stock data were collected from the Taiwan Economic Journal (TEJ) for listed firms in Taiwan. TEJ utilizes IFRS financial statement information between March 1991 and March 2021. Following Gu (2016), R&D expenditure was scaled by market equity to estimate R&D intensity. Following Gaspar and Massa (2006), the Herfindahl-Hirschman index was calculated by summing the squared market shares of all businesses in the industry. Market shares are determined by dividing a firm's sales by industry sales. We follow Duong et al. (2022) in utilizing cross-sectional regressions and portfolio sorting procedures to test the impact of R&D intensity and market competition on stock returns.

This study extends prior literature for the following reasons. The research is among the first attempts to test the relationship between innovation and market competition in Taiwan. Yu et al. (2020) and Xiang et al. (2020) also investigated the effect of R&D intensity on stock returns. However, Yu et al. (2020) employed a ratio of R&D over total assets to quantify innovation conducted in developed countries such as the U.S. stock market. Xiang et al. (2020) estimated R&D intensity by the ratio of R&D to sales revenue. This study differs from Yu et al. (2020) and Xiang et al. (2020) by estimating R&D intensity by R&D/MV in Taiwan, an emerging economy in Asia. Finally, the study implements the Two-Stage Least Squares estimation to solve unobserved endogeneity issues.

The remaining portion of the research begins with Section 2, which serves as an exposition of the theoretical background. Section 3 focuses on the data and methodology, while Section 4 presents the findings and discussion. Finally, Section 5 concludes the study.

2. LITERATURE REVIEW

2.1. Theory

The resource-based view (RBV) identifies a company's resources and the resource potential at its disposal, thereby representing its sustainable competitive advantage. Valuable, rare, and low-imitability resources are a great advantage for businesses to compete and succeed. Innovation is crucial to creating a competitive advantage in the new competitive environment. Moreover, technology "upgrades" play a big part in increasing stock return volatility. Research to create new products is available to businesses to achieve better operational efficiency. Innovations generate a higher value than other businesses in the same industry. "More innovative" companies will have higher stock returns than others. The RBV theory is necessary for this study as it can explain the increase in stock returns due to the growth in firms' research and development activities.

A competitive advantage shows that a business has a higher ability to create products and services for customers when compared to the same products in other businesses. Simply put, it requires businesses to make optimal use of available resources and to globalize service production. The HHI index measures the level of concentration in the market. When enterprises use their innovations to create exclusive products compared to other enterprises in the same industry, the concentration level in the market is higher, leading to low competition and creating a sustainable competitive advantage. When the market is more perfectly competitive, the product brings credibility to customers; then, the stock return will increase. Liu and Mantecon (2017) showed that a competitive advantage typically develops as a company expands, capturing market share and gaining advantages in its industry. A sustainable competitive advantage is a positive factor affecting stock returns.

2.2. R&D and Stock Returns

Gharbi et al. (2014) demonstrated that R&D has a positive relationship with the stock return of companies in high-tech industries but negatively impacts low-tech groups. R&D activities create information asymmetry about the company's possibilities for future development and expose the company's stock to potential risk. Hou et al. (2022) assert that increased investment in R&D is associated with higher stock returns in worldwide stock markets. They emphasize the significance of intangible assets in the international pricing of assets, particularly in most developed countries. Eberhart et al. (2004) and Duong et al. (2023) suggest that investing in intangible assets such as innovation provides substantial value for companies with promising growth opportunities, particularly in high-technology sectors.

Xiang et al. (2020) show a negative association between R&D intensity and stock returns. Changes in R&D spending have a detrimental impact on investors. Furthermore, Leung et al. (2020) argue that the inherent uncertainty around the potential future advantages of R&D investments could lead to mispricing in an inefficient market.

Hypothesis 1: R&D intensity positively affects stock returns in Taiwan.

2.3. Market Competition and Stock Returns

Hou and Robinson (2006) and Sharma (2011) contend that firms operating in industries with high concentration levels, meaning less competition, experience lower stock returns in the U.S. market. These studies report that industries have more significant barriers to entry, which protect firms against financial distress risks. Moreover, these firms have a lower innovation risk as they undertake less innovative activities than their competitors in industries with lower concentration levels. Gu (2016) also reports that high firms operating in industries with greater competition tend to achieve higher expected returns than those with high concentrations.

On the contrary, Gallagher et al. (2015) investigate the effects of sector concentration on stock returns in the Australian market. Their findings revealed that companies operating in industries characterized by lower levels of competition tend to exhibit notably elevated stock returns compared to their counterparts in more competitive sectors. Gallagher et al. (2015) also contend that firms operating in industries with lower levels of competition can create monopoly rents. However, Ryu et al. (2017) demonstrate that there is an insignificant relationship between market competition and stock returns in the Korean market. Therefore, the following hypothesis is proposed:

Hypothesis 2: Market competition has a positive relationship with stock returns in Taiwan.

Firstly, Taiwan is an emerging market and one of the leading countries in producing electronic components and equipment. Aiming to research the causes of Asia's economic growth, Duong et al. (2021) also show that Taiwan has unique microstructures that differ from other markets. Besides this, The Taiwan Fair Trade Commission (TFTC) has enacted Competition Laws Taiwan Fair Trade Act (TFTA). Consequently, this study aims to see how businesses compete in R&D investments after the law was enacted and revised before and after the 2008 financial crisis. These reasons explain why our research postulates such hypotheses for Taiwan.

3. Data and Methodology

3.1. Data

Stock data were collected from the Taiwan Economic Journal (TEJ) for all listed firms. TEJ uses International Financial Reporting Standards (IFRS) financial statement data from 1991 to March 2021. To calculate R&D intensity, firms with negative R&D expenses were excluded, following Chan et al. (2001). In addition, we follow Fama and French (1992) and Duong et al. (2023) in eliminating firms in the utility and financial sectors as these firms have higher leverage ratios than other firms. To ensure the accessibility of all accounting variables, we adopt the methodology of Duong et al. (2022) by aligning accounting data from fiscal year t - 1 through returns from July of year t to June of year t + 1. Moreover, we follow Zhang et al. (2015) by winsorizing all predictive variables at the 0.5% and 99.5% levels to mitigate outlier problems. Accordingly, the final sample consisted of 121,913 firm-month observations taken from 1991 to March 2021.

3.2. Variable Definitions

We follow Gu (2016) in estimating R&D intensity by dividing the annual R&D spending in fiscal year t by the firm's market equity at the end of fiscal year t. Leung et al. (2020) and Hou et al. (2022) demonstrated that R&D spending on market equity has strong return predictability and higher abnormal returns than other metrics such as R&D expenses on total assets or sales. This finding emphasizes the necessity for more research into this R&D-to-market anomaly.

According to Gaspar and Massa (2006), we estimate market concentration by the Herfindahl-Hirschman index, which involves adding up the squared market shares of all businesses (measured as their sales divided by total industry sales). All variables are discussed in Appendix A.

3.3. Research Methodology

We follow Duong et al. (2022) and Duong et al. (2023) in utilizing cross-sectional regressions and portfolio sorting techniques to analyze the influence of R&D intensity on expected stock returns. To begin, we employ the Fama and Macbeth (1973) estimations to analyze the impact of R&D intensity (RDM), market concentration (HHI), mispricing (MIS), book-to-market ratio (BM), SIZE, leverage (LEV), and total assets growth (TAG), on stock returns cross-sectionally for the entire sample, before and after the financial crisis of 2008.

Additionally, Two-Stage Least Squares (TSLS) estimations were also employed to address unobserved endogeneity issues and heterogeneity assumptions. TSLS helps address endogeneity by using instrumental variables to remove the correlation between the endogenous explanatory variable and the error term, ensuring that the estimates are unbiased and consistent. Moreover, TSLS using instrumental variables is applied to the model to solve the reverse causality. Two-year-lagged R&D variables were used as instrumental variables. Tung and Binh (2022) and Bellemare et al. (2017) suggested that the lagged R&D was a useful instrument in their studies. The first-stage equation in the TSLS regression and relevant test statistics can be used to assess the relevance of the instrumental variables. In the first stage of regression, the F statistic is over the threshold of 10 (Prob F-statistic < 0.001), and the R^2 statistic is high (0.94). In addition, the Sargan test of overidentifying restrictions was used to confirm the validity of the instruments. The statistics determine if the instruments are valid and uncorrelated with the error term. The Sargan test (p = 0.253) shows that the instruments are valid.

Subsequently, we conduct univariate and bivariate portfolio sorting to calculate the outcomes based on value-weighted and equal-weighted measures. After controlling for other variables, we determined the return differences between the tercile with the lowest R&D intensity and the tercile with the highest R&D intensity. Positive return differences indicate the ongoing existence of the R&D premium.

3.4. Model Constructions

Model 1 was constructed to test the impact of R&D intensity on cross-sectional stock returns, following Chan (2001). Meanwhile model 2 examines the association between market power and stock returns. We employed monthly firm-level cross-sectional regressions, run as follows:

$$R_{i,t} = \beta_0 + \beta_1 RDM_{i,t-1} + \varepsilon_{i,t-1} \qquad (1)$$

$$R_{i,t} = \beta_0 + \beta_1 HHI_{i,t-1} + \varepsilon_{i,t-1} \qquad (2)$$

Fama and French (1992) proposed that tiny companies with a high book-to-market (BM) ratio have a tendency for elevated future returns and a history of underperformance, so we add BM and SIZE into model 3. Following Khoa et al. (2020) and Lam and Wei (2011), adding leverage (LEV) and total assets growth (TAG) to stock returns. We followed Chen et al. (2010), Cakici et al. (2017), and Hai et al. (2020), in constructing the mispricing index into model 3 based on nine indicators. These indicators include the book-to-market equity ratio (BM), size (SIZE), net operating assets (NOA), gross profitability premium (GPP), return on equity (ROE), return on assets (ROA), R&D intensity (RDM), total asset growth (TAG) and leverage (LEV). Model 3 examines the impact of R&D intensity and market concentration on stock returns after controlling for other variables.

$$R_{i,t} = \beta_0 + \beta_1 RDM_{i,t-1} + \beta_2 HHI_{i,t-1} + \beta_3 BM_{i,t-1} + \beta_4 SIZE_{i,t-1} + \beta_5 LEV_{i,t-1} + \beta_6 TAG_{i,t-1} + \beta_7 MIS_{i,t-1} + \varepsilon_{i,t-1} \quad (3)$$

Where $R_{i,t}$ is the return on stock i in month t. Variable definitions are explicitly described in Appendix A.

We followed Tung and Binh (2022) and Bellemare et al. (2017) in employing two-year lagged variables of RDM as instrumental variables. The first-stage specification using instrumental variables was as follows:

$$RDM_{i,t-1} = \emptyset_1 + \emptyset_2 RDM_{i,t-2} + \varepsilon_{i,t-1} \quad (1)$$

where the outcome variable, the variable $RDM_{i,t-2}$ is the one-year lagged variable of $RDM_{i,t-1}$.

The corresponding second-stage equation is as follows:

$$R_{i,t} = \beta_0{}' + \beta_1{}' RDM_{i,t-1} + \beta_2 HHI_{i,t-1} + \beta_3 BM_{i,t-1} + \beta_4 SIZE_{i,t-1} + \beta_5 LEV_{i,t-1} + \beta_6 TAG_{i,t-1} + \beta_7 MIS_{i,t-1} + \varepsilon_{i,t-1} \quad (2)$$

4. Empirical Findings

4.1. Descriptive Statistics

Table 1 shows the descriptive statistics for all variables. The average values for RDM and HHI are 0.019 and 0.02, respectively. Binh and Tung (2020) also showed that the average

Table 1 Descriptive Statistics

Variable	N	Mean	Std Dev	10^{th} Pctl	Median	90^{th} Pctl
LnMV	121,913	15.200	1.499	13.453	15.055	17.124
LnBM	121,913	0.067	0.835	-0.964	0.142	1.029
LnSIZE	121,913	15.256	1.490	13.536	15.108	17.186
RDM	121,913	0.019	0.048	0.001	0.007	0.046
HHI	121,913	0.020	0.065	0.000	0.000	0.037
LEV	121,913	0.103	0.099	0.007	0.073	0.244
TAG	121,913	0.095	0.231	-0.095	0.048	0.331
MIS	121,913	0.552	0.218	0.222	0.556	0.889

Notes. The table illustrates descriptive statistics of eight variables. The data sample includes 121,913 firm-month observations between 1991 and March 2021. Appendix A contains detailed explanations for all variables.

value of RDM was 0.20 on the Vietnam Stock Exchange from 2010 to 2018. Karamshahi et al. (2018) indicated that the mean of HHI is 0.086 on the Tehran Stock Exchange. Setyawan et al. (2022) gave the average value of HHI 0.099 for the Indonesian market. Therefore, it can be said that Taiwan generally has a lower mean of RDM and HHI than other countries.

4.2. Pearson Correlation Matrix

Table 2 presents the correlation matrix of the independent variables in the model. The correlation associations between the variables exhibit both positive and negative impacts. No multicollinearity issue is detected between the independent variables as all correlation coefficients are less than 0.8 (Tran et al., 2022).

Table 2 Pearson Correlation Matrix

Variable	RDM	HHI	MIS	LnBM	LnSIZE	LEV	TAG
RDM	1.000						
HHI	-0.035***	1.000					
	(<0.001)						
MIS	-0.231***	0.133***	1.000				
	(<0.001)	(<0.001)					
lnBM	0.276***	0.090***	-0.206***	1.000			
	(<0.001)	(<0.001)	(<0.001)				
lnSIZE	-0.380***	-0.012***	0.344***	-0.462***	1.000		
	(<0.001)	(<0.001)	(<0.001)	(<0.001)			
LEV	-0.048***	0.091***	0.463***	0.053***	0.050***	1.000	
	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)		
TAG	0.014***	-0.065***	-0.130***	0.017***	0.028***	0.029***	1.000
	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	

Notes. This table provides the correlation coefficients for independent variables for the convenience of our analysis. The data sample consists of 121,913 firm-month observations between 1991 and March 2021. Appendix A contains detailed definitions for all variables.

4.3. The Results of the Fama-Macbeth Regressions

Table 3 Firm-Level Cross-Sectional Return Regressions

Intercept	RDM	HHI	MIS	LnBM	LnSIZE	LEV	TAG	ADJRSQ	Wald Test (Prob.)
Panel A: Full sample									
0.835*	9.644***							0.009	
(2.01)	(5.02)								<0.001
1.092**		-1.962						0.009	
(2.59)		(-1.50)							0.011
1.018	2.928*	-1.866*	-0.715*	0.518***	0.019	0.369	-0.332	0.069	
(0.78)	(1.71)	(-1.90)	(-1.67)	(4.82)	(0.22)	(0.60)	(-1.28)		<0.001
Panel B: Before the Financial Crisis 2008									
-0.612	4.060*	-2.435	-0.790	0.532***	0.119	0.487	-0.106	0.098	
(-0.27)	(1.77)	(-1.50)	(-1.10)	(3.05)	(0.77)	(0.47)	(-0.25)		<0.001

Table 3 (Continued)

Intercept	RDM	HHI	MIS	LnBM	LnSIZE	LEV	TAG	ADJRSQ	Wald Test (Prob.)
Panel C: After the Financial Crisis 2008									
2.925***	1.604	-1.201	-0.628	0.501***	-0.098*	0.232	-0.597**	0.035	
(2.69)	(0.62)	(-1.23)	(-1.54)	(4.44)	(-1.66)	(0.40)	(-2.27)		<0.001

Note. Table 3 reports the estimation results from Fama-MacBeth regressions. The sampling period is between 1991 and March 2021, including 121,913 firm-month observations. Appendix A displays detailed definitions for all variables. The symbols ***, **, and * correspond to the significance levels of 1%, 5%, and 10%, respectively. The T-values are enclosed in parentheses.

Table 3 presents a positive impact between R&D intensity and stock returns. These results demonstrate that a percentage increase in R&D intensity increases stock returns by 2.928 percent cross-sectionally. Hou et al. (2022) and Gharbi et al. (2014) also implied that firms with greater growth potential benefit from R&D investments. Companies with a high R&D intensity assume greater risk and are anticipated to generate better returns because of the information asymmetry on the company's future. The findings support the theory of the resource-based view.

Additionally, Table 3 shows that Taiwan's market competition and stock returns are negatively correlated. Our analysis predicts a 1% increase in HHI and a 1.164 percent decrease in stock returns. Our result is consistent with those of Sharma (2011) and Hou and Robinson (2006), who found that businesses operating in highly concentrated markets experience fewer stock returns, are shielded from intense competition, and exhibit lower levels of innovation.

4.4. Two-Stage Least Squares (TSLS) Estimation

Following Nguyen et al. (2024), Duong et al. (2023), and Let et al. (2023), we performed the Wald test and Durbin-Wu-Hausman test to check for heterogeneity assumptions and endogeneity issues. Fama-MacBeth regression indicated violation of heterogeneity assumptions (see Table 3), while the RDM, BM, SIZE, LEV, TAG, and MIS were also found to be endogenous, which can lead to biased findings (see Table 4). Therefore, we followed Liu et al. (2021), Le et al. (2023) and Sima et al. (2023) in performing TSLS regressions to address the lack of heterogeneity assumptions and endogeneity issues. The TSLS estimation results are reported in Table 5.

Table 4 Durbin–Wu–Hausman Test Results

Variables' residuals	Coefficient	P-value
Res-RDM	-1.736**	0.039
Res-HHI	0.898	0.643
Res-MIS	-1.845***	<0.001
Res-LnBM	0.414***	<0.001
Res-LnSIZE	0.0001***	0.0004
Res-LEV	1.118**	0.026
Res-TAG	-0.867***	<0.001

Notes. Table 4 presents the results of the endogeneity test. The findings indicate that the variables RDM, BM, SIZE, LEV, TAG, and MIS are endogenous. The symbols ***, **, and *, denote 1%, 5%, and 10% significance levels, respectively.

Table 5 Regression Results Using TSLS Estimations

Variables	Model 1	Model 2	Model 3	Before 2008	After 2008
RDM	11.608***		2.919**	2.359	8.551***
	(<0.001)		(0.021)	(0.342)	(<0.001)
HHI		-0.769*	-1.168**	-0.281	-1.438***
		(0.098)	(0.014)	(0.813)	(0.004)
MIS			-1.008***	-0.656	-1.226***
			(<0.001)	(0.260)	(<0.001)
LnBM			0.402***	0.379***	0.470***
			(<0.001)	(<0.001)	(<0.001)
LnSIZE			-0.077***	-0.107*	-0.043
			(0.004)	(0.070)	(0.152)
LEV			0.516	0.635	0.471
			(0.201)	(0.477)	(0.287)
TAG			-0.594***	-0.637**	-0.485***
			(<0.001)	(0.019)	(0.010)
R-squared	0.320	0.319	0.322	0.379	0.283
Prob (F-statistic)	<0.001	<0.001	<0.001	<0.001	<0.001
Instrument rank	355	355	355	208	157
N	121,913	121,913	121,913	43,042	78,871

Notes. Table 5 reports the Two-Stage Least Squares (TSLS) regression estimation results. The sampling period is between 1991 and March 2021, including 121,913 firm-month observations. The symbols ***, **, and * denote the significance levels of 1%, 5%, and 10%, respectively.

Table 5 reports a positive impact between R&D intensity and stock returns after controlling for other variables. These results demonstrate that a percentage increase in R&D intensity increases stock returns by 2.919 percent cross-sectionally. Hou et al. (2022) emphasize the importance of intangible investments in asset pricing for most developed countries. Gharbi et al. (2014) also imply that R&D investments add value to organizations with more growth opportunities. Firms involved in high R&D intensity take on more risk and are expected to achieve higher returns due to information asymmetry about the company's prospects. This discovery suggests that firms that invest heavily in R&D-intensive activities should use efficient disclosure strategies to minimize information asymmetry and prevent excessive fluctuations in stock returns. Market reactions to R&D-related news, such as announcements of breakthroughs, collaborations, or successful trials, can also influence stock returns. Positive news can increase investor confidence and, consequently, higher stock returns. Our result aligns with Gharbi et al. (2014) and Hou et al. (2022), the resource-based view theory, and hypothesis 1.

Table 5 illustrates a negative link between market competition and stock returns in Taiwan. Our research indicates a one percent rise in HHI and a 1.168 percent decline in stock returns, showing that a company with a high HHI is in a monopoly industry with little competition. Hence, companies that pay little attention to R&D investment retain a competitive advantage. Sharma (2011) and Hou and Robinson (2006) find that businesses operating in highly concentrated markets experience fewer stock returns, are shielded from intense competition, and exhibit lower levels of innovation. Therefore, investors anticipate fewer stock returns in line with the lower innovation risk and the lower challenge that these companies must confront. Our result is consistent with Sharma (2011) and Hou and Robinson (2006) and supports hypothesis 2.

The results shown in Table 5 also indicate that the book-to-market ratio (BM) has a significant positive affect on stock returns while the SIZE effect is substantially negative. A high book-to-market ratio indicates that the market perception of a company's value is still low, which can signal excellent investment opportunities for investors. Besides this, our findings also show that mispricing (MIS) hurts stock returns. Overreaction by investors may result in the overpricing of favorable information or the underpricing of negative information. To prevent overvaluing a firm with substantial investments, investors must thoroughly understand the agency issue of overinvestment and its potential impact on its future profitability. The result aligns with Duong et al. (2022) and Titman et al. (2004).

We also tested the relationship between R&D intensity, market concentration, and stock returns before and after the 2008 crisis. The results shown in Table 5 report that the R&D premium persisted only after the financial crisis. Organizations with high R&D intensity take on more risk and generate better future stock returns, while R&D investments contribute more value to organizations with greater growth opportunities after the crisis. Nevertheless, the influence of market concentration on stock returns disappeared before the financial crisis of 2008.

As economies began to recover from the financial crisis, R&D intensity gradually rebounded. Yang and Huang (2013) also state that there is a tendency for R&D intensity to grow during periods of economic expansion. Due to strong economic growth, companies could allocate more financial resources to innovation and R&D operations. For companies operating in many industries this innovation often led to encountering fierce rivalry, necessitating ongoing investment in research and development to sustain their position as market leaders. Competitive forces compel corporations to augment their research and development expenditures to distinguish their goods, enhance quality, and maintain a competitive edge over competitors in rapidly evolving sectors to take advantage of expansion opportunities. Besides this, many firms adopted open innovation models, collaborating with external partners, universities, and research institutions to share costs and access a broader pool of ideas and expertise.

4.5. Results of Robustness Testing Employing Univariate Portfolio Analysis

Table 6 Average Returns of Portfolios Sorted by R&D Intensity

Panel A: All period		
Portfolio	VW portfolio	EW portfolio
Low	0.745	0.568
2	0.849*	0.988**
High	1.377***	1.613***
High - Low	0.632*	1.045***
t value	(1.72)	(6.14)
Alpha Different	-0.015	0.376***
t-value	(-0.11)	(2.69)
Panel B: Before the Financial Crisis 2008		
Portfolio	VW portfolio	EW portfolio
Low	0.918	0.461
2	0.824	0.964
High	1.414**	1.731***
High - Low	0.496	1.270***
t value	(0.77)	(4.63)

Table 6 (Continued)

Alpha Different	-0.226	0.486
t-value	(-0.39)	(0.97)
Panel C: After the Financial Crisis 2008		
Portfolio	VW portfolio	EW portfolio
Low	0.542	0.693
2	0.879	1.016*
High	1.334**	1.475***
High - Low	0.791***	0.782***
t value	(2.96)	(4.31)
Alpha Different	0.023	0.372
t-value	(0.18)	(2.56)

Notes. Table 6 reports the univariate sorting returns by R&D intensity. The sample period is between 1991 and March 2021. The symbols ***, **, and * denote the 1%, 5%, and 10%, significance levels respectively. T-values are enclosed in parentheses.

This section describes the implementation of the univariate portfolio analysis which involved sorting stocks with the lowest R&D intensity into the first tercile (low) and highest R&D intensity (high) portfolios into the third tercile. Table 6 shows the value-weighted and equal-weighted average monthly returns for each R&D intensity portfolio, with the third tercile having the highest stock returns. The results also show the positive and statistical monthly and risk-adjusted return differences for value-weighted and equal-weighted portfolios. The empirical results are consistent with those of Plyakha et al. (2012) and Malladi and Fabozzi (2017), who state that the EW portfolio outperforms the VW portfolio with regards to average returns.

To test coefficients before and after the 2008 crisis, a two-sample t-test was implemented with the value-weighted and equal-weighted values. The results show no significant differences in the coefficients between the pre-crisis and after-crisis periods, for the value-weighted or equal-weighted data. Therefore, the difference between the data sets is a numerical difference which is not statistically significant, meaning the difference is insignificant.

The monthly return differences between the lowest and highest R&D intensity for all periods are 0.63% and 1.04% per month for VW and EW, respectively. These findings suggest that investors can generate high profits by purchasing stocks from firms with a high level of R&D investment and selling stocks of firms with a low level of R&D investment. Inventors may be inclined to pay a premium for stocks exhibiting high R&D intensity since companies with high R&D intensity undertake greater risks and are anticipated to attain higher returns. These results are consistent with those of Hou et al. (2022) and Gharbi et al. (2014).

We also tested the impacts of the financial crisis of 2008 on the arbitrary returns between the lowest R&D intensity and the highest R&D intensity. Malladi and Fabozzi (2017) and Plyakha et al. (2012) found that an equal-weighted portfolio performs better than a value-weighted one. The equal-weighted portfolio exhibits a higher total return than the value-weighted portfolio due to its increased allocation of tiny companies, low-priced equities, value stocks, and stocks with significant idiosyncratic volatility. Equal-weighted indexes exhibit more diversification than market capitalization-weighted indexes, potentially reducing risk. Equal-weighted funds prioritize value investing, a method often regarded as better by market experts and investors. Before the financial crisis of 2008, only the EW average return difference was significant at 1.27%, with a t-statistic value of 4.63.

After the financial crisis of 2008, the difference in average monthly returns between companies with the lowest and highest levels of R&D intensity is 0.79% for VW and 0.78%

for EW. All exhibit statistical significance. Nevertheless, the EW arbitrary return between before and after the 2008 financial crisis has a disparity, whereby this value decreases from 1.27% to 0.78%. These results indicate that the financial crisis 2008 had a detrimental impact on the average monthly return of firms with high R&D intensity because this crisis may have been more severe for innovative firms (Hall et al., 2016). Yang and Huang (2013) also show that R&D intensity rises during economic expansion. In order to take advantage of growth prospects, businesses may increase their R&D expenditures during economic booms. However, during economic downturns, such as the 2008 financial crisis, they may reduce their spending to save money and reduce financial risk.

4.6. Robustness Test by Employing Bivariate Portfolio Analysis

This section describes the implementation of the bivariate portfolio analysis to test whether the positive returns of R&D intensity remain stable. First, we divide stocks into tercile portfolios based on R&D intensity. Afterward, we classify stocks within each R&D intensity portfolio into terciles according to their BM, lnSIZE, HHI, LEV, TAG, and MIS. Table 5 reports the value-weighted (VW) and equal-weighted (EW) average monthly returns of tercile portfolios double-sorted by R&D intensity after controlling for BM, lnSIZE, HHI, LEV, TAG, and MIS.

Panel A shows the value-weighted average return differences between the highest R&D intensity and lowest R&D intensity portfolios for all periods were found to be 0.297%, 0.736%, 0.722%, 0.446%, 0.795%, and 0.728% per month, respectively. Meanwhile, the equal-weighted average return differences between the high R&D intensity and low R&D intensity portfolios for all periods were found to be 0.627%, 0.680%, 0.847%, 0.633%, 1.034%, and 0.970% per month, respectively. These results suggest that an R&D premium persists for all periods after controlling for firm characteristics.

Table 7 The Dependent Sorting between R&D Intensity and Firm Characteristics

Decile	BM	lnSIZE	HHI	LEV	TAG	MIS
Panel A: Full sample						
Portfolio			Value Weight Portfolio			
Low	1.125***	0.736*	0.614	0.836*	0.579	0.604
2	0.932**	0.928**	0.884**	0.868**	0.858**	0.883**
High	1.358***	1.350**	1.313***	1.045**	1.374***	1.332***
High - Low	0.297	0.736**	0.722***	0.446	0.795***	0.728***
t value	(1.18)	(2.17)	(3.25)	(1.51)	(3.19)	(2.79)
Alpha Different	-0.100	0.188	0.351**	-0.192	-0.057	-0.004
t-value	(-0.79)	(0.61)	(2.19)	(-1.19)	(-0.43)	(-0.03)
Portfolio			Equal Weight Portfolio			
Low	0.864**	0.758*	0.621	0.738*	0.570	0.575
2	0.992**	1.001**	1.029**	0.992**	0.968**	0.998**
High	1.429***	1.426**	1.502***	1.242**	1.605***	1.544***
High - Low	0.627***	0.680*	0.847***	0.633***	1.034***	0.970***
t value	(3.13)	(1.89)	(5.15)	(2.92)	(5.95)	(5.86)
Alpha Different	0.231*	0.128	0.519***	0.154	0.378***	0.398***
t-value	(1.71)	(0.43)	(3.39)	(0.92)	(2.71)	(2.80)

Table 7 (Continued)

Decile	BM	lnSIZE	HHI	LEV	TAG	MIS
Panel B: Before Financial Distress 2008						
Portfolio			Value Weight Portfolio			
Low	1.506**	0.779	0.772	1.122	0.569	0.659
2	0.908	0.871	0.861	0.881	0.836	0.892
High	1.420**	1.998**	1.323**	0.904	1.386**	1.347**
High - Low	0.040	1.149*	0.584	0.222	0.818**	0.687
t value	(0.10)	(1.77)	(1.59)	(0.40)	(2.03)	(1.61)
Alpha Different	-0.576	0.138	-0.161	-0.691	-0.395	-0.220
t-value	(-1.24)	(0.12)	(-0.26)	(-1.28)	(-0.67)	(-0.36)
Portfolio			Equal Weight Portfolio			
Low	0.940	0.647	0.583	0.766	0.466	0.483
2	0.961	0.974	1.051*	1.012	0.946	0.980
High	1.484**	2.108**	1.560***	1.211	1.695***	1.614***
High - Low	0.666*	1.226*	0.916***	0.727*	1.228***	1.131***
t value	(1.92)	(1.69)	(3.45)	(1.76)	(4.35)	(4.25)
Alpha Different	0.427	0.245	0.602	-0.010	0.415	0.514
t-value	(0.72)	(0.21)	(1.26)	(-0.02)	(0.78)	(0.97)
Panel C: After Financial Distress 2008						
Portfolio			Value Weight Portfolio			
Low	0.707	0.689	0.429	0.545	0.591	0.539
2	0.961*	0.994*	0.911*	0.853	0.883	0.871
High	1.286**	0.814	1.302**	1.168**	1.359**	1.315**
High - Low	0.578**	0.434	0.873***	0.623**	0.767***	0.776***
t value	(2.23)	(1.25)	(3.70)	(2.15)	(2.88)	(2.89)
Alpha Different	-0.036	0.223	0.419***	-0.138	-0.009	0.035
t-value	(-0.28)	(0.70)	(2.55)	(-0.81)	(-0.07)	(0.25)
Portfolio			Equal Weight Portfolio			
Low	0.779	0.878*	0.665	0.710	0.692	0.682
2	1.029*	1.032*	1.004**	0.970*	0.994*	1.020*
High	1.364**	0.860	1.438***	1.269**	1.500***	1.463***
High - Low	0.584***	0.281	0.772***	0.559***	0.808***	0.781***
t value	(3.21)	(0.87)	(4.14)	(2.66)	(4.46)	(4.38)
Alpha Different	0.224*	0.135	0.509***	0.158	0.382***	0.397***
t-value	(1.66)	(0.44)	(3.15)	(0.89)	(2.66)	(2.71)

Notes. Table 7 reports the bivariate sorting returns by R&D intensity and other variables. The sample period is between 1991 and March 2021. The symbols ***, **, and * denote the 1%, 5%, and 10% significance levels respectively. The T-values are enclosed in parentheses.

Panel B reports that the value-weighted return differences between the highest and lowest R&D intensity portfolios were positive and significant before the financial crisis of 2008 and after controlling for lnSIZE and TAG. Plyakha et al. (2012) and Malladi and Fabozzi (2017) found that equal-weighted portfolios outperform value-weighted portfolios.

Furthermore, the results for the equal-weighted returns were statistically more significant, with the average return differences between the highest and lowest R&D intensity after controlling for BM, lnSIZE, HHI, LEV, TAG, and MIS being 0.666%, 1.226%, 0.916%, 0.727%, 1.228%, and 1.131%, respectively. These findings indicate that before the financial crisis of 2008, investors could earn arbitrage profits by investing in large and dominant firms.

However, the average differences in returns, calculated using equal weights, between the highest and lowest R&D intensity after the financial crisis in 2008 are positive and statistically significant and were found to be 0.584%, 0.772%, 0.559%, 0.808%, and 0.781%, respectively, after controlling for BM, HHI, LEV, TAG, and MIS (except for lnSIZE). These findings indicate that the R&D premium disappears after controlling for the market value equity. Additionally, the empirical results show that an R&D premium existed for the entire period, both before and after the financial crisis of 2008, after controlling for the Herfindahl-Hirschman index (HHI). Nevertheless, double sorting reveals that average return differences were stronger before the financial crisis of 2008 and weaker after the financial crisis.

5. CONCLUSION

We are the first to investigate the influence of market competition on R&D premiums in Taiwan before and after the 2008 financial crisis, employing various estimation techniques, including Fama and Macbeth's (1973) regression, Two-Stage Least Squares estimations, and portfolio sorting methods to analyze the final sample with 121,913 firm-month observations. The results show that R&D intensity positively affects stock returns. The findings demonstrate the negative nexus between market competition and stock returns in Taiwan, and report that the R&D premium existed only after the financial crisis. Additionally, it is shown that the influence of market concentration on stock returns vanished before the financial crisis of 2008. Finally, it should be noted that these findings are robust, as analysis also employed a portfolio sorting method.

The findings suggest that individual investors employ suggested models and methods to optimize their investment portfolios and achieve high returns by buying shares of companies with higher R&D intensity and in high-competition industries. Markets respond positively to increased R&D spending as greater expected future earnings are indicated when the rise is considered additional value, which implicitly excludes excessive investment. By implication, if the signaling impact of changes on R&D spending profits is greater than the fluctuations, the negative relationship between returns and variation in R&D should be driven by discontinuous costs rather than excessive investment (Xiang et al., 2020).

The research also has practical implications for managers and policymakers. Gharbi et al. (2014) suggested that R&D activities cause information asymmetry for investors regarding a company's future potential, exposing the company's stock to potential risks. Therefore, managers who implement an effective communication strategy should disclose information that minimizes uncertainty about the product's likelihood of success and its expected earnings. Our findings indicate that RD premiums persist in the Taiwan stock market. Hence, policymakers focused on promoting sustainable economic expansion should strive to foster R&D investments by implementing efficient regulations (tax reduction, tax refunds, and tax incentives) for the company and avoiding cutting of R&D spending unnecessarily, even during periods of crisis (Sungthong & Meesook, 2023). Additionally, education is a field that plays a significant role in promoting innovation. As a result, greater investment in education is required to foster future innovations. These results also show that companies in industries with high concentration earn lower stock returns. Thus, policymakers and regulators should adopt policies to prevent large companies from merging, preventing monopolies from manipulating the market.

Although this study extends the growing asset pricing literature, it has data limitations as it focuses only on the Taiwan market. Furthermore, it should be noted that Taiwan is an emerging market; thus, the conclusions drawn from this research may not accurately represent the conditions seen in frontier and developed markets. As a result, it is recommended that subsequent research is conducted to delve into this topic on a global scale to generate a comprehensive understanding.

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Appendix A

Acronyms	Variable	Definition	References
Dependent variable			
RET	Stock returns	Net percentage change in close price over the previous month. Ret = (Close $price_{i,t}$ – Close $price_{t-1}$) / (Close $price_{t-1}$)	Duong et al. (2022); Duong et al. (2023)
Independent variables			
RDM	R&D intensity	R&D expenditure divided by market equity	Gu (2016)
HHI	Market competition	Summing the squared market shares of all businesses, measured as their sales divided by the total industry sales.	Gaspar and Massa (2006)
Control variables			
lnBM	Book-to-market ratio	We computed the book-to-market ratio for each month using the stock's market value in the preceding June of year t and the common stock's book values at the end of December of year t-1. We took the natural logarithm of the Book-to-Market ratio to scale down the range of B/M ratios, especially if there are extreme values. This transformation makes the data more manageable and less skewed, allowing for better comparison and analysis.	Duong et al. (2022).
lnSIZE	Size	At the end of month t-1, we use the firm's market equity (the market value is estimated by multiplying a stock's price by the number of shares outstanding) and then conduct a logarithmic transformation.	Duong et al. (2022).
LEV	Leverage	Long-term liability scaled by the total assets	Duong et al. (2023)
TAG	Total Asset Growth	TAG refers to the growth rate of a company's total assets (TA) from year t-1 to year t performed as follows: $TAG_{it} = (TA_{it}/TA_{it-1})-1$.	Lam & Wei (2011).
GPP	Gross Profitability Premium	The difference between sales and cost of sales is divided by total assets for the fiscal year ending in calendar year y-1, which is then assigned to July of year y to June of year y +1.	Van Hai et al. (2020)
NOA	Net Operating Asset	Calculated by dividing the difference between operating assets and operating debt for the fiscal year by the lagged total assets. This ratio is then assigned from July of year y to June of year y +1.	Van Hai et al. (2020)
ROA	Return On Assets	Calculated by dividing the net income by the average total assets.	Van Hai et al. (2020)
ROE	Return On Equity	Net income divided by the average total equity	Van Hai et al. (2020)
MIS	Mispricing	We classify all stocks into two separate groups. The BM, GPP, ROA, ROE, TAG, and RDM indicators will be assigned a value of 1 if they fall below their respective median values for all stocks in that month. Conversely, they will be assigned a value of 0 if they exceed their respective median values. The NOA, LEV, and SIZE indicators will be assigned a 1 (0) value if they are more significant than (less than) the median value of all stocks for that month. Subsequently, by assigning values of 1 and 0 to each stock based on nine indications, we compute the MIS index, which is the average value derived from the nine monthly indicators.	Chen et al. (2010), Cakici et al. (2017), and Van Hai et al. (2020)