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OWNERSHIP CONCENTRATION AND R&D INVESTMENTS? VARIATIONS BROUGHT BY FAMILY CONTROL IN TAIWAN

Irene Wei Kiong Ting
Faculty of Industrial Management,
Universiti Malaysia Pahang, 26600 Gambang, Pahang, Malaysia
ireneting75@gmail.com*

Qian Long Kweh
Institute of Management Technology,
Dubai International Academic City, 345006, Dubai, UAE
qlkweh@gmail.com

Huai-Chun Lo
Division of Finance, College of Management,
Yuan Ze University, Taiwan
hclo@saturn.yzu.edu.tw

ABSTRACT

This study finds that ownership concentration has a positive impact on R&D investments up to a critical point, after which the impact is reversed. Further, the study indicates that family control has a moderating effect on the nonlinear relationship between ownership concentration and R&D investments. More specifically, family-controlled firms are influenced by ownership concentration to a lower extent than non-family controlled firms. Consistent with most prior studies, this study shows that shareholders of a family-controlled firm are involved in the long-term decisions of the firm, and may thus invest in R&D innovation to seek long-term profit maximization in certain situations.

Keywords*:* Ownership concentration; R&D investments; Family control; Moderating effect; Excess control

INTRODUCTION

The effect of ownership is particularly interesting in the context of research and development (R&D) investments, given that "R&D was causing efficient firm scale to increase to the point where no individual, family, or group of managers would have sufficient wealth to own a controlling interest in major firms" (Holderness, 2014). This study examines the relationship between ownership concentration and R&D investments as well as the moderating effect of family control on the relationship. Prior studies (Chen, Li, Shapiro, & Zhang, 2014; Zhang, Li, Hitt, & Cui, 2007) document that ownership structure is related to a firm's R&D activities. Chang, Chung, and Mahmood (2006) and Baysinger, Kosnik, and Turk (1991), in particular, claim that shareholders with concentrated ownership prefer to make long-term R&D investments to increase the stability of the firm rather than seek short-term profit

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maximization. Similarly, Lee and O'neill (2003) find that ownership concentration in US firms is positively correlated with R&D investments.

Consistent with this argument, our empirical results indicate that R&D investments increase with ownership concentration up to a critical point, after which the relationship turns negative. The former observation confirms that blockholders' decision making in a concentrated ownership firm may be long-term oriented, which may encourage shareholders to make more R&D investments. The latter observation indicates that once a mass of blockholders' wealth is concentrated in a specific firm, the blockholders with highly concentrated ownership become risk averse (Dilling-Hansen, Madsen, & Smith, 2003) and are reluctant to spend on R&D investments. This finding is consistent with Cho (1998), who shows that a nonlinear relationship exists between insider ownership and R&D investments.

Prior studies on family-controlled companies argue that the preference to employ family members to hold positions as directors, supervisors and/or managers causes these firms to lose expertise, particularly in terms of R&D technologies. Such nepotism is common in family-controlled firms because family members own a majority of the shares (Tsai, Hung, Kuo, & Kuo, 2006) which allows them to act for their own benefit or at the cost of other shareholders' interests (Chu, 2009). Thus, family control in firms may result in less R&D investments (Choi, Zahra, Yoshikawa, & Han, 2015). However, Hamadi and Heinen (2015) document that family members would be associated with the firm for generations and their decisions regarding the firm would be long-term oriented. These confounding findings imply that family members may vary from one firm to another. Besides, the uniqueness of family-controlled companies in pursuing corporate goals also indicate that family-controlled companies are more heterogeneous as compared to non-family controlled firms. This study thus calls this intuition into question by examining the relationship between ownership concentration and R&D investments.

Taking family control as a moderator, we find a nonlinear, inverted U-shaped relationship between ownership concentration and R&D investments for non-family controlled firms. However, the potential impact of ownership concentration on R&D investments can be observed only minimally in family-controlled firms, suggesting that shareholders in family-controlled firms aim for long-term profit maximization (Anderson & Reeb, 2003; Schulze, Lubatkin, & Dino, 2003). More specifically, the findings indicate that family-controlled firms may have higher R&D investments as compared to non-family controlled firms, when ownership concentration is at an extremely low level or at an extremely high level. These results are in line with the findings of the study by Jaggi, Leung, and Gul (2009) that family control is a moderating element on the relationship between board independence and earnings management. In addition, Lo, Ting, Kweh, and Yang (2016) document the moderating role of family control on the relationship between ownership structure and financial leverage.

This study makes at least two contributions. First, rather than assuming that shareholders with a concentrated ownership deal with R&D investments in a linear way (Chang et al., 2006), this study empirically suggests a nonlinear relationship between ownership concentration and R&D investments; this relationship is particularly obvious in non-family firms. This study highlights the existence of risk aversion when ownership of a firm is highly concentrated in some blockholders.

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Second, this study clarifies the difference in R&D investments between family-controlled firms and non-family controlled firms. Our finding is consistent with the study by Hamadi and Heinen (2015), which indicates that there is no effect of ownership concentration on the performance of family-controlled firms. In contrast to prior studies (Choi et al., 2015), we prove that family-controlled firms may not always be reluctant to spend on R&D investments as compared to other types of companies. While family owners are conservative and risk averse (Schulze et al., 2003), they aim for long-term profit maximization and thus, would be willing to spend on R&D investments (Chang et al., 2006).

The following sections are organized as follows. The next part dicusses prior studies and develops hypotheses. The third part explains data and methodology, while the following one covers tests and results. The final part concludes this study.

PRIOR STUDIES AND HYPOTHESES DEVELOPMENT

Empirical studies on the ownership concentration-R&D relationship produce mixed results. Ortega-Argiles and Moreno (2009) agree that ownership concentration has a significantly negative relationship to R&D as the action of the managers in risky decisions are limited, thereby moving the firm away from the benefits of specialization. Consistently, Zeng and Lin (2011) suggest that firms with concentrated share ownership and inside ownership have lower R&D spending but state ownership has higher level of R&D spending for Chinese listed firms. This is due to the fact that state ownership provides incentives to closely monitor management and pursue long term goals, thus reducing agency cost and promotes R&D spending. Moreover, Karray and Kriaa (2009) indicate that ownership structure especially foreign controlled firms have a significant negative impact on R&D investment. State and foreign controlled firms are said to have less probability and motivation to innovate. While the former is subjected to bureaucracy and lack of communication that subsequently reduced the innovative incentives, the latter are motivated by weak cost of labour and often subcontracting to produce innovation. In contrast, Lee (2012) found that there is a positive effect of ownership concentration on R&D for the sample of 424 Korean manufacturing firms from 1999-2008.

The prediction about the overall effect of ownership on the R&D of a firm is unclear. Therefore, this study attempts to further investigate this relationship in Taiwan. We hypothesize the following:

Hypothesis 1: *Ownership concentration is significantly related to R&D.*

Despite the vital role that family businesses plays in the economy, little is known about how family ownership affects R&D of the firms. Hence, this papers makes the first attempt to test the moderating effect of family control on the relationship between ownership concentration and R&D. In other word, the study further establishes the fact that family ownership identity plays a significant role in determining the R&D, given the concentrated ownership which is lacking in literature.

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DATA AND METHODOLOGY

This study employs a large panel dataset comprising data related to firms that are publicly listed on Taiwan Stock Exchange for the period from 1999 to 2014. The data were extracted from the Taiwan Economic Journal (TEJ) database. The following criteria were applied to filter the data: first, the total assets of each observation must be at least NTD 1 billion to prevent the small firm effect; second, the observations must not have a missing value for any variable in our empirical models; third, the sample must not include financial institutions because they have different statutory requirements. The final sample, thus derived, in this study comprised 15,721 firm-year observations for analyses.

The following paragraphs describe the methodology used for the empirical analyses in this study. Specifically, we followed the tradition of empirical studies to examine the relationship between R&D investments and ownership concentration using regression analysis. Consistent with prior studies (for an example, Hovey, Li, & Naughton, 2003), two main measures were used to examine the impact of ownership concentration on R&D investments, *OC3 and OC5*, which represent the respective percentages of shares held by the top three (*OC3*) and top five (*OC5*) blockholders. To control for potential industrial differences and intertemporal effects, we subtracted *OC3* (*OC5*) from the median *OC3* (*OC5*) of the firm's corresponding industry in that year. Further, we added the value 1 to the industry-adjusted ownership concentration to prevent any negative ratio because the squared terms of both *OC3* and *OC5* have been used in our regression models.

For family control, a dummy variable that represents a firm controlled by a group of people who have a family relationship or share a common family name was used, following Lo et al. (2016). Based on the strict definition given by the TEJ, family-controlled firms are those in which (i) the positions of chairman and chief executive officer are held by family members; (ii) board seating rights are greater than 50 percent and outside directors are less than 33 percent of the total number of directors; (iii) board control rights are at least 33 percent and at least three family members hold positions as directors, supervisors and/or managers; and (iv) the block shareholdings held by the family shareholder(s) are more than the critical control level[1]. Finally, the dependent variable, *R&D*, was measured as R&D expenditures relative to total assets, in line with prior studies (Gavious, Hirsh, & Kaufman, 2015; Zeng & Lin, 2011).

To minimize the possible effect of endogeneity on ownership concentration (Chen, Cheung, Stouraitis, & Wong, 2005; Lee & O'neill, 2003), we used the two-stage least squares (2SLS) method to examine the relationship among ownership concentration, family control and R&D investments. At the first stage, this study regressed either *OC3* or *OC5* on family control, board-related features and firm-related features. At the second stage, this study utilized the predicted values of *OC3* and *OC5* as the testing variable of the ownership concentration. Therefore, the following equations were drawn up:

$$OC_{it} = \beta_0 + \beta_1 FamC_{it} + \beta_2 MB_{it} + \beta_3 Vol_{it} + \beta_4 FDir_{it} + \beta_5 IDir_{it} + \beta_6 Size_{it} + \beta_7 Age_{it} + \beta_8 ROA_{it} + \beta_9 CR_{it} + \sum_s \gamma_s Year_{s,it} + \sum_u \lambda_u Industry_{u,it} + \varepsilon_{it} \quad (1a)$$

[1] Critical control level is "the critical portion of shares which, if it is held as the largest bloc, has a certain degree of control, which is high enough for it to be said to dominate the company" (Cubbin & Leech, 1983, p. 358).

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$$R\&D_{it} = \beta_0 + \beta_1 OC_{it} + \beta_2 FamC_{it} + \beta_3 IDir_{it} + \beta_4 Size_{it} + \beta_5 Age_{it} + \beta_6 ROA_{it} + \beta_7 Profit_{it} + \beta_8 LTDR_{it} + \beta_9 CapI_{it} + \beta_{10} InvI_{it} + \beta_{11} CR_{it} + \sum_s \gamma_s Year_{s,it} + \sum_u \lambda_u Industry_{u,it} + \varepsilon_{it} \quad (1b)$$

where *R&D* is the ratio of R&D to total assets; *OC* can be either *OC3*, which is Top 3 ownership percentage or *OC5*, which is Top 5 ownership percentage; *FamC* is family control; *MB* is the ratio of market value to book value of equity; *Vol* is σROA_t in the industry; *FDir* is the ratio of foreign directors to total directors; *IDir* is the ratio of independent directors to total directors; *Size* is the natural logarithm of total assets; *Age* is the natural logarithm of years of establishment; *ROA* is the ratio of earnings before interests and taxes to prior-year total assets; *Profit* is the ratio of continuing operations' income after taxes to total sales; *LTDR* is the ratio of long term debt to total assets; *CapI* is the ratio of fixed assets to total assets; *InvI* is the ratio of inventory to total assets; and *CR* is the ratio of current assets to current liabilities. The control variables are included based on prior studies including Chen et al. (2014), Zhang et al. (2007), Chang et al. (2006), Baysinger et al. (1991), and Lee and O'neill (2003).

To examine the moderating effect of family control on the relationship between ownership concentration and R&D investments, we include an interaction term of *OC* and *FamC*. Specifically, we estimate the following equation:

$$R\&D_{it} = \beta_0 + \beta_1 OC_{it} + \beta_2 FamC_{it} + \beta_3 OC \times FamC_{it} + \beta_4 IDir_{it} + \beta_5 Size_{it} + \beta_6 Age_{it} + \beta_7 ROA_{it} + \beta_8 Profit_{it} + \beta_9 LTDR_{it} + \beta_{10} CapI_{it} + \beta_{11} InvI_{it} + \beta_{12} CR_{it} + \sum_s \gamma_s Year_{s,it} + \sum_u \lambda_u Industry_{u,it} + \varepsilon_{it} \quad (2)$$

TESTS AND RESULTS

Table 1 shows the descriptive statistics for the explanatory variables of our sample. The table shows that *R&D* investments account for nearly 2 percent of the sample firms' total assets. The means and medians of *OC3* and *OC5* are close to one, reflecting that they are industry-adjusted indicators. Mean family control (*FamC*) indicates that around 62 percent of the sample firms are family-controlled. The average market to book (*MB*) ratio of the sample firms is 157 percent, while the mean volatility (*Vol*) is 0.11. In terms of board composition, the proportion of foreign and independent directors on the board is approximately 2 percent and 14 percent, respectively. The average firm size (*Size*) is 8.64 (logged value), indicating average total assets of approximately NTD 5.653 billion. The average logged value of 3.09 for years of establishment (*Age*) shows that the sample firms have been in business for 22 years. With respect to return on assets (*ROA*), the reported mean value is 0.07. Mean *Profit* indicates that the total income after taxes from continuing operations of the sample firms is 3 percent on average. The average total long-term debt to total assets ratio (*LTDR*) for the observed period is around 11 per cent. Furthermore, around 30 percent and 17 percent of the sample firms' total assets are made up of fixed assets (*CapI*) and inventories (*InvI*), respectively. The average current ratio (*CR*) of 2.50 suggests that NTD 1 of the sample firms' current liabilities is covered by NTD 2.50 of their current assets.

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Table 1: Descriptive statistics (N = 14,573)

Variable	Mean	Median	Q1	Q3	S.D.
R&D/total assets (*R&D*)	0.02	0.01	0.00	0.03	0.03
Top 3 ownership percentage (*OC3*)	1.02	1.00	0.90	1.13	0.17
Top 5 ownership percentage (*OC5*)	1.02	1.00	0.90	1.12	0.16
Family control (*FamC*)	0.62	1.00	0.00	1.00	0.48
Market value/book value of equity (*MB*)	1.57	1.21	0.80	1.88	1.41
σROA_t in the industry (*Vol*)	0.11	0.10	0.08	0.13	0.04
Foreign directors/total directors (*FDir*)	0.02	0.00	0.00	0.00	0.07
Independent directors/total directors (*IDir*)	0.14	0.00	0.00	0.29	0.17
Natural logarithm of total assets (*Size*)	8.64	8.39	7.69	9.27	1.27
Natural logarithm of years of establishment (*Age*)	3.09	3.18	2.75	3.53	0.58
Net income/total assets (*ROA*)	0.07	0.06	0.02	0.12	0.12
Continuing operations' income after taxes (*Profit*)	0.03	0.04	0.01	0.10	2.67
Long term debt/total assets (*LTDR*)	0.11	0.08	0.02	0.17	0.11
Fixed assets/total assets (*CapI*)	0.30	0.29	0.16	0.43	0.19
Inventory/total assets (*InvI*)	0.17	0.14	0.08	0.21	0.15
Current assets/current liabilities (*CR*)	2.50	1.73	1.29	2.53	5.20

Note: *OC3* is Top 3 ownership relative to total outstanding shares, which is defined as *OC3* subtracts median *OC3* of the industry plus one to avoid having any negative values. OC5 is Top 5 ownership relative to total outstanding shares, which is defined as OC5 subtracts median OC5 of the industry plus one to avoid having any negative values. *FamC* = A dummy variable equals one if company *i* is family-controlled, and zero otherwise.

In Table 2, all the observations of the study have been grouped in two categories, based on family control and the level of R&D investments. The findings indicate that family-controlled firms have significantly lower *R&D* and *MB* ratio compared to those of non-family controlled firms (0.0163 vs. 0.0311 and 1.4600 vs. 1.7119, respectively). Morck and Yeung (2003) claim that family-controlled firms prefer to maintain their control on firms, which may conflict with focusing on R&D investments. Morck and Yeung (2004) further emphasize that family owners are not well-equipped with advanced or complex technology, suggesting that new development or changes may be perceived as a threat by them. These findings corroborate the findings of Sirmon, Arregle, Hitt, and Webb (2008), Chen and Hsu (2009) and Muñoz-Bullón and Sanchez-Bueno (2011) who agree that family-controlled firms and R&D investments are significantly and negatively related. Because owner-managers have a strong preference for control (Goffee & Scase, 1985), family-controlled firms may entail higher ownership concentration to maintain their decision-making authority in the firm.

Furthermore, a firm is more likely to be a non-family controlled firm in the groups of higher volatility, higher proportion of foreign directors and independent directors, higher *ROA* and current ratio. The mean difference tests also indicate that family-controlled firms are significantly larger in firm size, older in terms of firm age, and more profitable; further, they have more fixed assets and inventories over total assets compared to non-family controlled firms. Overall, most of the differences are statistically significant at the conventional levels.

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Table 2: Sub-group analysis

	Grouping by *FamC*				Grouping by *R&D_Dum*			
Variable	Family	Non-Family	Difference	*t*-stat	High	Low	Difference	*t*-stat
R&D	0.0163	0.0311	-0.0149	-26.04***				
OC3	1.0414	0.9885	0.0529	19.34***	1.0160	1.0275	-0.0116	-4.21***
OC5	1.0367	0.9889	0.0478	17.67***	1.0136	1.0242	-0.0107	-3.93***
MB	1.4600	1.7119	-0.2519	-10.90***	1.7713	1.3925	0.3788	16.31***
Vol	0.1016	0.1135	-0.0119	-18.51***	0.1083	0.1049	0.0033	5.16***
FDir	0.0129	0.0252	-0.0123	-10.26***	0.0207	0.0155	0.0052	4.24***
IDir	0.1189	0.1670	-0.0482	-17.53***	0.1594	0.1256	0.0338	12.17***
Size	8.6861	8.6131	0.0730	3.48***	8.5670	8.7033	-0.1364	-6.48***
Age	3.2064	2.9351	0.2712	28.96***	3.0362	3.1451	-0.1089	-11.36***
ROA	0.0633	0.0766	-0.0133	-6.90***	0.0581	0.0420	0.0160	8.97***
Profit	0.0388	0.0161	0.0226	0.53	0.0404	0.0229	0.0175	0.39***
LTDR	0.1244	0.0967	0.0277	14.77***	0.0965	0.1244	-0.0278	-15.10***
CapI	0.3249	0.2706	0.0544	17.52***	0.2886	0.3147	-0.0261	-8.44***
InvI	0.1705	0.1596	0.0110	4.43***	0.1565	0.1802	-0.0237	-9.64***
CR	2.3251	2.6685	-0.3434	-4.12***	2.6082	2.4056	0.2026	2.35**

Note: Refer to Table 1 for the definitions of the variables. ** and *** denote the significance levels at 5% and 1%, respectively.

With respect to the comparison based on R&D levels, a firm with higher R&D investments is more likely to have a higher *MB* ratio, greater volatility, higher proportion of foreign directors and independent directors, larger ROA, greater profitability and higher current ratio, of which the mean differences tests are all significant at the conventional levels. Conversely, this univariate analysis reveals that firms with low R&D investments have significantly higher ownership concentration compared to that of firms with high R&D investments. In addition, firms with low R&D investments tend to have significantly larger firm size, higher firm age, higher fixed assets to total assets, and more inventories over total assets than firms with high R&D investments.

As stated earlier, this study adopts the two-stage least squares (2SLS) method to address the endogeneity issue with respect to the relationship between ownership concentration and R&D investments. Panel A of Table 3 reports the 2SLS regression results using *OC3* as the dependent variable at stage 1 and *R&D* as the dependent variable at stage 2. At stage 1, this study regresses ownership concentration on family control and additional variables. The empirical evidence at stage 1 depicts a significantly positive relationship between family control and ownership concentration. This result is consistent with Lo et al. (2016), asserting that ownership concentration and family control are simultaneously influenced by one another.

At stage 2, the empirical findings show that ownership concentration positively influences R&D investments. This result is consistent with Lee (2012) who argues that shareholders with concentrated ownership are usually long term-oriented because their profits depend on the firm's long-term survival. More specifically, blockholders have incentives to spend on R&D investments.

This study further examines the moderating effect of family control on the relationship between ownership concentration and R&D investments. A significant moderating effect of family control exists in the link between ownership concentration and R&D investments, whereby the coefficient on *OC3 x FamC* is -0.0968. Interestingly, the positive coefficient on

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OC3 (0.0740) and the negative interaction variable (-0.0968) suggest that the slope for family control is close to zero. The untabulated F-test that examines the net effect of family control confirms the result at the conventional 5 percent significance level. Overall, this finding indicates that the effect of family control on R&D investments is less influenced by ownership concentration.

Further, this study uses squared *OC3* to test a possible nonlinear relationship between ownership concentration and R&D investments. The positive coefficient on *OC3* (0.5303) and the negative coefficient on $OC3^2$ (-0.2163) conclude that a nonlinear relationship exists between ownership concentration and R&D investments. The results imply that at a low level of ownership concentration, as ownership concentration increases, blockholders are willing to spend more on R&D investments. However, after a critical point, blockholders with more ownership concentration invest in R&D on a decreasing curve owing to their risk aversion.

Another interesting result was found regarding the effect of moderating coefficients on *OC3 x FamC and* $OC3^2$ *x FamC*, being significantly negative (-0.6179) and significantly positive (0.2518), respectively. Again, the results demonstrate the moderating role of family control, where *FamC* moderates the non-linear relationship between ownership concentration and R&D investments. The untabulated F-test indicates the net values of *OC3* and *OC3 x FamC* are approximately zero (F-statistics = 0.18). A consistent result was obtained for the net values of $OC3^2$ and $OC3^2$ *x FamC* (F-statistics = 0.14). These results indicate that the relationship between ownership concentration and R&D investments is represented by an inverted U-shaped curve for non-family controlled firms; however, the effect is minimal for family-controlled firms. More specifically, while R&D investments of non-family controlled firms are influenced by ownership concentration, the effect of ownership concentration is less pronounced among family-controlled firms. These results suggest that R&D investments in family-controlled firms are higher than those in other firms on average in two scenarios—when the ownership concentration is at a low level and when the ownership concentration at a high level.

Following Lean, Ting, and Kweh (2015), Ehikioya (2009), and S. Lee (2012), we use *OC5* as an alternative measure of ownership concentration. The estimations are shown in Panel B of Table 3, and the results are qualitatively similar to those in Panel A of Table 3.

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Table 3: 2SLS regression results – ownership concentration (N = 14,573)

Panel A: Ownership concentration = *OC3*								
Dependent Variable	Stage 1: *OC3*		Stage 2: *R&D*					
Variable	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat
Intercept	1.0995	67.88***	0.1075	13.84***	-0.0114	-0.96	-0.2529	-3.02***
OC3			0.0362	3.81***	0.0740	7.01***	0.5303	3.41***
OC3xFamC					-0.0968	-8.12***	-0.6179	-2.74***
$OC3^2$							-0.2163	-2.95***
$OC3^2xFamC$							0.2518	2.37**
FamC	0.0695	24.98***	-0.0086	-10.43***	0.0906	7.40***	0.3586	3.00***
MB	0.0058	5.40***						
Vol	0.3485	19.30***						
FDir	-0.0476	-0.79						
IDir	-0.0132	-12.48***	-0.0015	-6.61***	-0.0009	-3.73***	-0.0007	-2.49**
Size	-0.0189	-6.83***	-0.0096	-18.01***	-0.0075	-13.06***	-0.0072	-12.25***
Age	0.0787	6.33***	-0.0001	-0.04	-0.0063	-2.58***	-0.0079	-3.17***
ROA	0.0003	0.62	-0.0002	-1.77	-0.0002	-1.73*	-0.0002	-1.77*
Profit			-0.0238	-8.97***	-0.0231	-8.74***	-0.0228	-8.57***
LTDR			-0.0279	-16.71***	-0.0259	-15.55***	-0.0261	-15.66***
CapI			-0.0170	-7.29***	-0.0155	-6.67***	-0.0157	-6.74***
InvI			0.0002	3.40***	0.0002	3.28***	0.0002	3.34***
CR	0.0710	7.61***	0.0111	6.01***	0.0070	3.61***	0.0059	2.87***
Fixed effects	Yes		Yes		Yes		Yes	
Adj. R^2	0.0858		0.2441		0.2530		0.2534	

Panel B: Ownership concentration = *OC5*								
Dependent variable	Step 1: *OC5*		Step 2: *R&D*					
Variable	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat	Estimate	*t*-stat
Intercept	1.1262	70.68***	0.0172	1.55	-0.0127	-1.08	-0.1967	-2.65***
OC5			0.0409	4.46***	0.0733	7.24***	0.4207	3.06***
OC5×FamC					-0.0827	-7.47***	-0.5374	-2.80***
$OC5^2$							-0.1646	-2.55**
$OC5^2×FamC$							0.2190	2.41**
FamC	0.0643	23.46***	-0.0087	-11.26***	0.0758	6.69***	0.3105	3.07***
Control Variables	Yes		Yes		Yes		Yes	
Fixed effects	Yes		Yes		Yes		Yes	
Adj. Rsq.	0.0932		0.2500		0.2508		0.2531	

Note: Refer to Table 1 for the definitions of the variables. *, **, and *** denote the significance levels at 10%, 5% and 1%, respectively. Fixed effects include year and industry.

Although ownership concentration is widely used in existing studies to measure the level of concentrated ownership, for ensuring the robustness of the test, this study further employs excess control (*EC*) as another proxy of ownership concentration (Cubbin & Leech, 1983). Higher excess control implies a higher level of ownership concentration, and owners with a significant amount of shareholding may take aggressive actions over managerial decisions. According to Lee (2012), excess control is calculated as the difference between ownership controlled by the ultimate controlling shareholders and the critical level of ownership that ensures the retention of controlling rights.[2] We calculate ownership as the sum of the percentage of direct and indirect shares held by the ultimate controlling shareholders. This formula could be a better measure of ownership concentration because it represents the amount of shares owned by individual investors and large blockholders. Therefore, we replicate the estimations in Table 3 by using excess control. The results in Table 4 reconfirm the existence of a nonlinear relationship between excess control and R&D investments, which is also moderated by family control.

[2] Readers are requested to refer to footnote 1 for the definition of critical control level.

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Table 4: 2SLS non-linear regression results – excess control (N = 14,573)

Dependent Variable	Stage 1/DV = *EC*		Stage 2/DV = *R&D*	
Variable	Estimate	*t*-stat	Estimate	*t*-stat
Intercept	1.0184	74.13***	-2.1626	-7.85***
EC			3.4531	7.17***
ECxFamC			-2.1049	-3.83***
EC^2			-1.2562	-5.94***
EC^2xFamC			0.9768	4.11***
FamC	0.0679	28.77***	1.0764	3.39***
Control variables	Yes		Yes	
Fixed effects	Yes		Yes	
Adj. R^2	0.1513		0.2613	

Note: *EC* = Ownership – critical control level in percentage + 1, whereby ownership indicates the sum of percentage of direct and indirect shares held by the ultimate controlling shareholders. *, **, and *** denote the significance levels at 10%, 5% and 1%, respectively. Fixed effects include year and industry.

CONCLUSION

By using the 2SLS regression method, we show that a nonlinear inverted U-shaped relationship exists between ownership concentration and R&D investments. This implies that ownership concentration influences a firm's R&D investments, and thus, this effect should be highlighted in innovation improvements. Our analyses suggest that shareholders with concentrated ownership increase their R&D investments up to a critical point. However, after the critical point, R&D investments decrease with an increase in ownership concentration owing to risk aversion. Moreover, the two abovementioned relationships are moderated by family control.

Overall, this study has broad implications for literature on this topic. First, this study shows that the relationship between ownership concentration and R&D investments is nonlinear. Furthermore, this study provides empirical evidence that family control may not always entail low levels of R&D investments, as compared to other types of companies. In addition, the findings suggest that investors may consider investing in firms with family involvement because family-controlled firms consider the firms as their long-term belongings for several generations and seek long-term profit maximization.

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