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CASH HOLDINGS AND R&D INTENSITY WITH DIFFERENT CONTROLLING SHAREHOLDERS

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ABSTRACT

Introduction/Main Objectives: This research aims to examine the effects of cash holdings on a firm's R&D intensity. We further examine how that relationship may be varied across different controlling shareholders. For robustness reasons, we test it in a developing market and a developed market. **Background Problems:** Economics and business theories state that research and development (R&D) is susceptible to financing constraints due to the lack of collateral value and asymmetric information issues. This argument has been extensively debated with no consensus being reached. Therefore current study focuses on the examination of R&D and cash holding and the role of controlling shareholders. **Novelty:** The current study considers the importance of controlling shareholders on the relationship between cash holding and R&D intensity. We expect that different controlling shareholders will have different constraints on R&D financing. **Research Methods:** This study focuses on a sample of public listed companies in Malaysia and Singapore from the year 2012 to 2018, and estimates the model under a two-step GMM panel regression to eliminate the endogeneity issue. **Finding/Results:** The results show that cash holdings have significant effects on the intensity of R&D. However, that relationship is different across countries and across controlling shareholders. Malaysia's foreign firms will increase their R&D's intensity when their cash holdings are high. Meanwhile, Singaporean family firms will reduce the intensity of their R&D when their cash holdings are high. Overall the findings confirm the hypothetical alignment of the agency theory and also the resource-based view theory. **Conclusion:** Our findings surmise that higher cash holdings cause a lower R&D intensity due to the cash management decisions by managers. A firm with high leverage tends to reduce its R&D intensity when cash holdings are high, and vice versa. This behavior can be found in all the controlling shareholders.

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INTRODUCTION

Economics and business theories state that research and development (R&D) is susceptible to financing constraints due to the lack of collateral value and asymmetric information issues (Brown et al., 2012; Hall et al., 2016; Peia & Romelli, 2022). This argument has been extensively debated with no consensus being reached. On the one hand, if financing constraints are binding in a firm, R&D will not be a priority, hence leaving it depressed (Brown et al., 2012; Boeing et al., 2022; Peia & Romelli, 2022). Other findings report that R&D has no significant relationship with the financial structure (Bond & Meghir, 1994). Furthermore, the evidence in this research area reports that financing frictions affect R&D and leave different financing effects on R&D initiatives. For example, financing constraints on R&D are much stronger for US firms compared to European firms, which is intriguing considering the capital market in the US is at least as developed as those in Europe (Brown et al., 2012; Hall et al., 2016; Peia & Romelli, 2022).

Thus far, most of the existing literature on this topic is based on developed markets; either in the US or Europe, and there are only a few pieces of research on the effects of cash holdings on the R&D of firms in emerging markets, especially from the Southeast Asia region where the controlling shareholder has a significant relationship with agency costs. Comparatively, the managerial behavior in Southeast Asia might be different from that in developed countries due to the dominance of family-owned businesses, which could provide different views of the constraints on R&D financing. In other words, the effect of access to finance on R&D's intensification for firms in Southeast Asia may differ from that in developed countries due to the unique characteristics of managerial behavior in family-controlled firms that dominate the Southeast Asia region. Building on these theoretical assumptions, this research aims to examine the effects of cash holdings on R&D within the Southeast Asian context.

This current research highlights the constraints on R&D financing by using two major theories: (1) The resource-based view theory (RBV) and (2) the agency theory. The RBV argues that a firm with higher cash holdings has better R&D intensity compared to those with lesser cash holdings. This theory further explains that having higher R&D leads the firm to achieve a competitive advantage.

Meanwhile, the agency theory argues that the different interests between the shareholders and the managers may affect the cash holdings in a company and thus influence its R&D financing. Agents (managers) from a family firm may be more cautious with R&D spending compared to the non-family managers. This may be due to the fact that family firm managers are usually family members. Hence, they will be more conservative with the firm's cash management (Anderson & Reeb, 2003; Rocco, Ponomareva, & Pittino, 2018; La Rocca & Cambrea, 2019). On the other hand, non-family firm managers may have a level of self-interest in making strategic decision-generating higher R&D expenditures, even though their financing sources are limited. This implies that in a region such as Southeast Asia, where family firms dominate the businesses, controlling shareholders might give a new perspective about the constraints on R&D financing.

This study highlights two crucial matters that distinguish this current research from other previous findings like He and Wintoki (2016). The first is the controlling shareholders, who act as the moderators in the relationship between financing sources and R&D. Prior studies in this area focus on the direct effect of cash holdings on R&D's intensity, yet there is still no

consensus about it. We argue that controlling shareholders may play an important role in moderating that relationship for the Asian context. We hypothesize that different controlling shareholders will have different constraints on R&D financing. Additionally, previous studies have attempted to introduce other moderating variables to reveal the direction of the constraints on R&D financing, such as the CEO's characteristics as a moderator (Yin, Hai, & Chen, 2019) government connections, (Cull, Li, Sun, & Xu, 2015), CEO's optimism (Huang-Meier, Lambertides, & Steeley, 2016), and incentives (Chen, 2017). However, to our knowledge, there has been no attempt to treat the controlling shareholders as moderators.

Second, as mentioned above, we chose Southeast Asia as our sampling frame because family firms dominate this region ((Fang et al., 2022; Amin & Liu, 2020). Another reason is that this region comprises two distinguished markets: the developed and developing markets. We take Singapore as the representative of the developed market. Meanwhile, Malaysia is the developing market. Theoretically, the cash holdings policy toward innovation among developed markets will not be different from that of others. However, previous research found different results between the US, Europe, and Japan (Bhagat & Welch, 1995; Brown et al., 2012; Hall et al., 2016; Peia & Romelli, 2022). Therefore, we purposely take Singapore to enrich the literature for this area, especially for the context of a developed market that family firms dominate. Our comparison findings between Malaysia and Singapore can be used to compare the constraints of R&D financing between developed and developing countries.

This current research studies a panel data set of R&D financing for Malaysian and Singaporean listed firms over the period from 2012 to 2018. The summary statistics show that R&D investment is higher in Singapore, compared to Malaysia. The mean values of cash holdings and cash flows are similar for both countries, where the cash holdings were 0.12 and 0.18 for Malaysia and Singapore respectively.

Malaysia has around 66% of the family-owned firms in our sample, it is higher than the Singaporean family owned firms, at 52%. Interestingly, the mean values of the interaction between the family firms and cash holdings are the same for Malaysia and Singapore.

To exploit the constraint of R&D financing, we modify a dynamic structural model by Bond, Edmans, and Goldstein (2012). We estimate the model using a panel system GMM Generalized Method of Moments) that accounts for unobserved firm-specific effects and addresses all the financial variables' potential endogeneity. The instrumentation and one-lagged provide rectification for possible reverse causality and endogeneity, as Wintoki et al. (2012) suggested. The detailed information related to the estimation model is provided in Section 3.

The first research objective is to investigate the effect of cash holdings on the R&D of Malaysian and Singaporean firms by simultaneously controlling for the period and country effect in the model. The second objective of this study is to examine the moderating effect of the controlling shareholders on the relationship between cash holdings and R&D in Malaysian and Singaporean firms. Thirdly, this research draws an argument between agency costs and the efficient internal capital market.

In sum, this research replicates the method developed by Brown, et al. (2012) by using measures such as R&D's intensity and cash flows. This study extends the method to a new empirical specification, and the model along with the variables, are all modified. The contribution of this research is threefold. First, the study of emerging countries is added to the

literature on this area of research. Besides that, the empirical findings of the cash holdings' effect on R&D in Malaysian and Singaporean firms is documented and interpreted. Moreover, the important role of the controlling shareholders is established by investigating the relationship between cash holdings and the R&D of firms.

LITERATURE REVIEW

1. Cash Holding and R&D Intensity

Previous findings have extensively documented that cost is the most important feature of R&D (Hartono & Kusumawardhani, 2018; Brown et al., 2012; Himmelberg & Petersen, 1994). R&D activities are massive investments consisting of payments to highly skilled employees and extensive capital expenditure. In a transitory shock to finance, a firm tends to adjust its R&D expenditure rather than retrench or divest the unit (Cherkasova & Kurlyanova, 2019; Lee & Roh, 2020). Aligned with the resource-based view theory, a financing source is an important resource for R&D activities (Fuller, 2018).

Theoretically, the cash holdings policy has a significant association with the intensity of a firm's R&D (He & Wintoki, 2016). Cash holdings act as insurance or protection for the firm's financing activities. A company with larger cash holdings is less likely to retrench, divest, or default (Utami et al., 2017; Cherkasova & Kurlyanova, 2019; Lee & Roh, 2020). When a deposit outflow occurs, a company with excess cash holdings can use the reserves to cover the outflow without encountering any extra costs, such as the cost of borrowing from other financial institutions like banks.

In the context of cash holdings and R&D, Wang, Wei, and Zhang (2014) surmise that greater cash holdings result in greater R&D success. This is because companies with greater cash-to-assets ratios have more patents and patent citations for a given amount of research and development expenditure. As the firm has more significant cash holdings, the managers have less stress or concerns about taking investment opportunities. Managers have more confidence to invest in more innovative projects, which will improve the R&D of the firm.

Other empirical findings have found the same conclusion about the positive effect of cash holdings on R&D smoothing. For example, Lyandres and Palazzo (2016) report that cash holdings are positively related to companies' R&D efficiency, with relatively low costs of external funds. Low costs of external funds mean that a firm has enough cash holdings, or excess cash reserves, that enable it to save the cost of external funds, such as borrowing from other financial institutions or banks. With more cash holdings, the R&D efficiency of the firm will be higher. Baldi and Bodmer (2018) support this by arguing that when cash holdings increase, R&D smoothing will also increase. Thus, this study hypothesizes:

H1: Higher cash holdings reduce the constraints on R&D financing.

2. Controlling Shareholders and R&D Intensity

Controlling shareholders are the shareholders who own the majority of the shares in the firm, which can be either an individual shareholder with more than half of the company's shares or a group of shareholders who together own the majority of the outstanding shares (Ladime & Brahmana, 2021; Brahmana et al., 2019). Controlling shareholders have more voting rights on company decisions, including R&D decisions (Lewellyn & Bao, 2021). Therefore, the ownership structure is an important issue for the investors (Ariyono & Setiyono, 2020; Soejono, 2010; Wardhana & Tandelilin, 2011).

Different controlling shareholders have different agency issues. A firm controlled by a family tends to have more agency costs when executing strategic decisions than a non-family business (Soejono, 2010; Liu & Tian, 2012; Yıldız et al., 2021). This agency issue is also found in the relationship between controlling shareholders and R&D investment (see (Lewellyn & Bao, 2021).

Previous studies addressed agency issues as the explanation for the negative effect of controlling shareholders on R&D investment. For example, Hoskisson et al. (2002) show the potential conflict between the owners (principal) and their managers (agent). The targeted R&D investment level from the owners can be different from the target of the managers, due to financing issues. This conflict influences the growth, as well as the R&D, of the company. Lewellyn & Bao (2021) test the controlling shareholder effect on the performance of R&D activities on 11,262 firms from 35 countries. They found that different controlling shareholders have different conclusions, due to different levels of agency costs. Thus, this research hypothesizes:

H2: Different controlling shareholders have a different effect on the constraints of R&D financing; in which the intensity of the R&D of family-controlled firms is significantly different from that of non-family firms in both countries; and the intensity of the R&D in foreign-controlled firms is significantly different from that in non-foreign firms, in both countries.

3. Moderating Role of Controlling Shareholder on the Constraint of R&D Financing

Intriguingly, the R&D literature has no consensus about the relationship between cash holdings and R&D smoothing. On the one hand, the empirical findings surmise a negative relationship between cash holdings and R&D activities (Beladi, Deng, & Hu, 2021). On the other hand, the empirical findings support a positive effect (Lyandres & Palazzo, 2016; Wang et al., 2014). One explanation for these mixed findings is the agency costs incurred by the controlling shareholders (Lewellyn & Bao, 2021). The controlling shareholders of a family business tend to influence the actions and decisions of the managers (Brahmana, Setiawan, & Hooy, 2019; Setiawan, Aryani, Yuniarti, & Brahmana, 2019; Suprianto, Rahmawati, Setiawan, & Aryani, 2019), causing the managers to invest in low-return projects (Anderson et al., 2012; Choi et al., 2015; Brahmana et al., 2019; Yıldız et al., 2021).

The non-consensus between cash holdings and the R&D of a company implies that there should be a moderating variable to strengthen the relationship. Managers of family firms are usually family managers, leading to lower agency costs (Anderson et al., 2012). Managers from the foreign-owned firm are usually professionals, which leads to alignment (Lewellyn & Bao, 2021). With a higher agency cost, the cash holdings' impact on R&D smoothing will serve a manager's self-interest rather than value creation. This explains why the managers do not inform the controlling shareholders about R&D investment activities and outputs.

As our research setting is Southeast Asia, where family firms dominate, it serves as a good experiment to test the moderating effect of controlling shareholders on the relationship between cash holdings and R&D. We develop the moderating by using the agency theory's framework. Hence, we hypothesize:

H3: Having controlling shareholders as moderators strengthens the constraints on R&D financing).

METHOD, DATA, AND ANALYSIS

1. Model Specification

We build our model following the specifications of the model by Bond and Meghir (1994), which was later modified by He and Wintoki (2016). The model held profitability, cash flow, growth and leverage as the baseline for dynamic R&D. Similar to He and Wintoki (2016), this baseline model was derived under the assumption of there being no financing friction with R&D financing. The estimation model was run under the panel GMM model to tackle the endogeneity issue following Wintoki et al (2012). This "system" GMM model, which was developed for panel models by Blundell and Bond (1998) allowed us to address the potential endogeneity of all the financial variables in differences and levels, using lagged levels as instruments for the regression in differences and lagged differences as instruments for the regression in levels.

Our model included the firm-specific effect (α_i) to control for all the unobserved time-variant determinants of R&D at the firm level that were constant over the sample period. The model also included a time-specific effect (σ_t) to control for aggregate changes that could affect the demand for R&D. The correlation of those two specific effects to the error terms of the model's specification was tested under the Breusch-Pagan LM test and the Hausman test.

To answer the main research objective, we added controlling shareholder into our model's specification (1). The interaction between controlling shareholder and financing sources was the moderating effect. We followed the procedure from Dawson (2014). We defined the controlling shareholders in two ways: First, those who have businesses which were controlled by family members; second, those who have businesses which were controlled by foreigners.

The estimation model was built theoretically from the finance literature. According to the RBV theory, strategic resources constitute the main part of any strategic decision, such as R&D's intensity. Empirically, R&D's intensity was determined by profitability, sales, cash flow, growth, size, and age. The latter, the size and age did not contribute anything to the variance of our estimation. When we dropped these two variables, it also did not affect the goodness of the model. Hence, we took profitability, sales, cash flow, and growth to be the estimation model. As earlier discussed, we followed He and Wintoki (2016) and added the main effect, which was cash holdings. Finally, the moderating effect of the controlling shareholders (family-owned and foreign owned) was included, heeding the agency theory framework. The full estimation model was as follows:

$$
\begin{aligned}
R\&D_{i,t} \; = \beta_0 + \; & \beta_1 \mathrm{R\&D}_{i,t-1} + \\
& \beta_2 \Delta\mathrm{CashHoldings}_{i,t} + \\
& \beta_3 \Delta\mathrm{CashHoldings}_{i,t-1} + \beta_4 \mathrm{DFAM}_{i,t} + \\
& \beta_5 \mathrm{DFOR}_{i,t} + \beta_6 (\Delta\mathrm{CashHoldings} * \\
& \mathrm{DFAM})_{i,t} + \beta_7 (\Delta\mathrm{CashHoldings} * \\
& \mathrm{DFOR})_{i,t} + \beta_8 \mathrm{Profitability}_{i,t} + \\
& \beta_9 Sales_{i,t-1} + \beta_{10} \mathrm{CashFlow}_{i,t} + \sigma_t + \\
& \alpha_i + \varepsilon_{i,t} \qquad (1)
\end{aligned}
$$

The financial variables were defined and measured by following previous major research into this area. For R&D spending, it was measured by the total R&D expenditure for firm i in the period t. In a model with no financial friction, lagged sales would enter the Euler condition of this model if there was imperfect competition. Meanwhile, total cash flow (CashFlow) was also included with contempo-raneous and one lagged. Cash holdings were the ratio of cash and marketable securities over total assets. We took the change in cash holdings as

the factor constraining R&D financing. Lastly, profitability was measured by the ratio of net income to total assets.

We followed the procedure from Ladime and Brahmana (2021), and Brahmana et al. (2019) to construct the controlling shareholders. The controlling shareholders were measured by taking the highest direct control stated in the annual report. This data were provided in the section with the "list of substantial shareholders" in it. Theoretically, substantial shareholders meant ownership greater than 5%. However, 5% ownership did not follow the criteria of controlling shareholders, where they should have the largest shareholding with more than 50% (Claessens et al., 2002; Claessens et al., 2006). For the family-owned variable (DFAM), it was defined as a company that was controlled by a family. We scored "1" if it was family-owned, otherwise "0." The same procedure was applied for the foreign-owned variable (DFOR), where it was given "1" if it was foreign-owned, or "0" if not. We did not take state-owned firms as the third controlling shareholders because the numbers of state-owned firms in our sampling frame was trivial.

Appendix A shows the summary of the variables' definitions.

2. Data and Sample

This research comprised listed firms from the Malaysian Stock Exchange and Singaporean Stock Exchange. We expected that stronger constraints on R&D financing would be found for Malaysian listed firms compared to Singaporean listed firms. To achieve this objective, we pooled all the Malaysian listed firms into one sample, and the Singaporean listed firms into another data pool. We set the criteria for our sampling, which were non-financial firms which consistently reported their R&D expenditure over the period from 2012 to 2018. Overall, we collected 73 Malaysian listed firms and 92 Singaporean listed firms that did disclose their R&D expenditure. Interestingly, our sample's filtering found that most companies were from the communications equipment sector, IT services sector, technology hardware sector, electronic equipment sector as well as semiconductor equipment sector. There were only a few companies from the manufacturing industries sector. There was no company from the trading and service sector which reduced our sample significantly because Malaysia and Singapore are dominated by trading and service industries. The data were collected from annual reports.

RESULT AND DISCUSSION

1. Descriptive Statistics

Table 1 consists of two panels. Panel A displays the summary statistics for all the variables for Malaysian listed firms, meanwhile, Panel B displays the summary statistics for all the variables for Singaporean listed firms. Overall, the sample exhibited characteristics comparable to those in prior studies. The mean values of the cash holdings were 12% and 18% for Malaysian and Singaporean firms, respectively. This was similar to those reported by He and Wintoki (2016), and Lyandres and Palazzo (2016). Given that ours was a sample of firms in developing and developed countries, this was consistent with the evidence that firms in developing countries like Malaysia tended to be more aggressive with their cash holding policies, meanwhile, firms in a developed country, like Singapore, tended to hold more cash.

For the R&D's intensity variety, Table 1 shows the mean values of 0.01 and 0.13 for the Malaysian and Singaporean samples, respectively. The huge gap between Malaysia and Singapore confirmed that the characteristics of the institutional settings between developing and

developed countries were significantly different. In a developing country like Malaysia, R&D is not an organizational culture, and it is treated as an additional process. Meanwhile, Singaporean firms realize the importance of R&D to achieve their competitive advantage.

Additionally, Table 1 also confirms our postulation about the domination of family firms in Southeast Asia. Panel A shows that 67% of observations were family firms in Malaysia. It also shows that 21% of the observations were foreign firms. For the Singaporean context, Panel B shows that 52% of the observations were family firms, and 40% of the sample were foreign.

2. Regression Evidence

Table 2 reports the estimates from panel regressions explaining firm-level cash holdings and innovation with different controlling shareholders for each of the two markets (Malaysia and Singapore). We first ran a diagnostic test, such as the individual effect test, the Hausman test, and autocorrelation, multicollinearity, normality, and heteroscedasticty tests, heeding the recommendation of Petersen (2008). All the specifications were two-step GMM panel regressions with a robust standard-error clustered by firms. This was to deal with endogeneity concerns.

The results are shown in Table 2. Columns [1], [2], and [3] are the findings from the Malaysian sample. Columns [4], [5], and [6] are the findings from the Singaporean sample. A small note from our analysis is that columns [1] and [4] were the baseline models, and columns [2] and [5] were the cash holding models. The main study results are in column [3] and column [6], and we analyzed the findings using these two columns.

Table 1. Summary Statistics

Panel A: Descriptive Statistics of Malaysian Listed Firms

Variable	Mean	Std. Dev.	Min	25th	75th	Max
RND	0.01	0.05	0	0	0.23	0.79
CASH_HOLD	0.12	0.13	0	0.03	0.61	0.73
GROWTH (%)	0.20	0.41	-0.16	0.24	3.56	4.22
ROA (%)	-0.21	1.10	-14.77	-6.20	6.68	15.201
CASHFLOW (LN)	3.87	4.25	0	0	8.19	11.77
SALES (LN)	10.17	2.83	0	9.44	11.62	14.62
DFAM	0.67	0.47	0	0	1	1
DFOR	0.21	0.41	0	0	1	1

Panel B: Descriptive Statistics of Singaporean Listed Firms

Variable	Mean	Std. Dev.	Min	25th	75th	Max
RND	1.35	6.46	0	0	22.15	93.6
CASH_HOLD	0.18	0.14	0	0.08	0.24	0.83
GROWTH (%)	0.13	3.74	-53.58	-2.6	1.93	42.90
ROA (%)	-0.16	2.07	-39.01	-1.24	0.37	14.60
CASHFLOW (LN)	3.52	4.44	0	0	8.18	14.33
SALES (LN)	11.19	2.68	0	10.21	12.67	18.35
DFAM	0.52	0.5	0	0	1	1
DFOR	0.4	0.49	0	0	1	1

Note that: the mode values for DFAM and DFOR are 1 and 0, respectively
Source: Stata, 2022

Columns [3] and [6] revealed the negative effect of cash holdings on R&D's intensity (β= -2.21 SE= 0.7010 for Malaysia. β= -2.33 SE= 1.0028 for Singapore). The findings were intriguing, considering the direction of the relationship was negative, which implied that higher cash holdings led to a lower R&D intensity. In other words, when a firm had higher cash reserves, the manager might reduce the intensity of the R&D.

One interpretation is that, in the context of cash management, cash holdings affect the R&D's intensity mainly due to the financing gap. Due to the capital structure of those companies being more in debt, firms prefer to pay their debts first, rather than taking investment opportunities. Thus, this may not be surprising considering most of the listed companies in this region experienced or learned from the debt crisis during the 1997 monetary crisis. Therefore, when their cash holdings were higher, Malaysian and Singaporean firms tended to reduce their R&D expenditure.

The controlling shareholders' variables in columns [3] and [6] produced various conclusions. For family-controlled (DFAM), the family-controlled group outperformed the R&D intensity of the non-family group. In Malaysia, the power of significance from family-controlled firms was statistically at the 10% level (β= 0.16), implying the effect was almost virtual. In Singapore, the relationship was statistically significant at the 5% level (β= 1.84). Overall, we concluded that the R&D intensity of family-controlled firms was significantly different from that of non-family firms in both countries.

For foreign-controlled (DFOR), it showed that only Malaysian foreign firms in Malaysia had a negative relationship with R&D's intensity, but the same effect was not found in Singapore. It meant that the R&D intensity of Malaysian foreign-owned firms was significantly lower than that of their non-foreign counterparts. Meanwhile, there was no significant difference in the R&D intensity between Singaporean foreign-owned firms and non-foreign-owned firms. These findings were consistent with Anwar and Sun (2013).

For the main objective, we used the interaction terms to examine whether the effect of cash holdings on R&D's intensity was strengthened by the controlling shareholders. We found that different controlling shareholders have different effects on the cash holdings - R&D intensity relationship. In Malaysia, the family firms had no moderating effect on the cash holdings and R&D's intensity relationship. This implied that no matter whether the controlling shareholders' firm was family-owned or non-family owned, the cash holdings' effect on R&D's intensity between these two groups was indifferent. In Singapore, the family firms had weakened the cash holdings' effect on R&D's intensity. It surmised that the non-family firms in Singapore outperformed the family-owned firms in the cash holdings and R&D intensity relationship.

The findings for foreign controlling shareholders had a different conclusion from the family-owned firms above. In Malaysia, the positive effect of cash holdings on R&D intensity would be strengthened when the controlling shareholder was a foreigner or international investor. Malaysian foreign-owned firms might channel their cash for a relatively higher R&D intensity, compared to non-foreign firms.

Table 2. Panel Regression Results for Cash Holdings and R&D Intensity Relationship

	Malaysia			Singapore		
	[1]	[2]	[3]	[4]	[5]	[6]
$R\&D_{T-1}$	0.11***	0.11***	0.11***	-0.92***	-1.22***	-1.23***
	(0.0001)	(0.0001)	(0.0002)	(0.0823)	(0.1239)	(0.1340)
CASH_HOLD		-2.58***	-2.21***		-7.85***	-2.33**
		(0.1535)	(0.7010)		(1.0443)	(1.0028)
DFAM			0.16*			1.84**
			(0.0843)			(0.8224)
FAMCASH			-0.98			-9.84**
			(0.7181)			(3.9013)
DFOR			-0.22*			-0.25
			(0.1147)			(0.7003)
FORCASH			1.23*			0.62
			(0.7323)			(3.9267)
LSALES	0.00*	0.01***	0.02***	0.63**	1.26***	1.33***
	(0.0027)	(0.0050)	(0.0058)	(0.2855)	(0.2652)	(0.2456)
LCF	0.02***	0.05***	0.05***	-0.01**	0.07***	0.05***
	(0.0004)	(0.0010)	(0.0010)	(0.0043)	(0.0223)	(0.0164)
ROA	0.01***	-0.01***	-0.01***	0.15***	0.18***	0.14***
	(0.0007)	(0.0006)	(0.0011)	(0.0495)	(0.0418)	(0.0388)
GROWTH	0.14***	0.18**	0.14*	-0.01	-0.01	-0.01
	(0.0466)	(0.0696)	(0.0813)	(0.0097)	(0.0115)	(0.0107)
CONSTANT	0.37***	0.34***	0.21*	-6.69**	-12.43***	-14.30***
	(0.0486)	(0.0818)	(0.1130)	(3.3476)	(3.0574)	(2.8581)
AR(1)	0.037	0.021	0.013	0.007	0.020	0.028
AR(2)	0.141	0.248	0.067	0.161	0.135	0.124
SARGAN	0.558	0.082	0.142	0.382	0.097	0.059

Note: The value stated is the coefficient value. Standard errors are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Source: Stata, 2022

In Singapore, the foreign-owned firms had no moderating effect on the relationship between cash-holdings and R&D's intensity. It meant that the cash holdings' effect of Singapore-listed firms on their R&D's intensity was not due to different controlling shareholders. The result was consistent with the previous research which addressed leverage costs as the explanation for the negative effect of cash holdings (Ismail, Ibrahim, Yusoff, & Zainal, 2010). Foo and Foo (2000) also support the result that cash is a strong motive for technology-based companies in Singapore to invest in R&D projects.

3. Robustness Check I: Sub-Sampling Approach

For robustness, we divided our samples into (i) family and non-family, and (ii) foreign and non-foreign. The purpose was to tackle the inquiry about whether the variance between cash-holdings and R&D's intensity would be different if the sample was divided following the controlling shareholder. Then, we re-ran the estimation models but dropped the controlling shareholder variable from the estimation model. We did post-estimation tests, such as testing for autocorrelation and the Sargan test for overidentifying

restrictions, and the results showed AR(1) had p-values lower than 0.05 and AR(2) and the Sargan test had p-values higher than 0.05. For brevity, we did not report the results. Table 3 reports the results.

The conclusions of our sub-sampling approach were similar to the earlier findings. In Malaysia, cash holdings had no significant effect on R&D's intensity for both family and non-family groups. However, we found a negative relationship between cash holdings and R&D's intensity in Singaporean family and non-family groups. The magnitude power of cash holdings in the Singaporean non-family group sample was relatively higher than in the family group.

When we did sub-sampling for the foreign and non-foreign groups, the results were intriguing. Cash holdings had a negative impact on R&D's intensity in both foreign firms and non-foreign firms. The negative effect of cash-holdings on R&D's intensity was also found in both Malaysian and Singaporean firms. The differences in cash holdings' coefficient values between foreign firms and non-foreign firms were distinctive, implying the significant difference in cash holdings' power between those two sample groups.

In short, the robustness tests surmised that the relationship between cash holdings and R&D's intensity would be different following the controlling shareholders. This effect was also varied across countries. For Malaysian firms, cash holdings were an important factor for the foreign-owned firms' R&D intensity. For Singaporean firms, cash holdings were an important factor for the family-owned firms' R&D intensity.

Table 3. Robustness Test for Cash Holding and R&D Intensity According to Controlling Shareholder Group

	Malaysia				Singapore			
	Non-Fam	Fam	Non-For	For	Non-Fam	Fam	Non-For	For
$R\&D_{T-1}$	0.95***	0.11***	0.87***	0.11***	-3.20***	0.76**	0.18***	-3.30***
	(0.0162)	(0.0018)	(0.0172)	(0.0004)	(0.3556)	(0.2951)	(0.0226)	(0.3608)
CASH_HOLD	0.04	-0.56	-1.0468***	-3.32***	-9.87***	-2.14***	-0.90***	-7.85***
	(0.0781)	(1.0195)	(0.3452)	(0.3452)	(3.0948)	(0.6951)	(0.3011)	(3.4705)
LSALES	0.02**	0.02**	0.02**	0.02**	-1.49	0.26	0.06	-0.22
	(0.0079)	(0.087)	(0.0082)	(0.0077)	(1.5818)	(0.3184)	(0.0951)	(1.4494)
LCF	0.01	0.01	0.06***	0.01***	0.21***	0.01	-0.01	0.24***
	(0.0012)	(0.0121)	(0.0024)	(0.0039)	(0.0671)	(0.0065)	(0.0037)	(0.0694)
ROA	-0.02*	-0.02*	-0.01***	-0.03***	-0.65*	3.47**	0.06	-0.37
	(0.0122)	(0.0110)	(0.0012)	(0.0012)	(0.3826)	(1.7054)	(0.1106)	(0.3776)
GROWTH	-0.01	0.19	0.08	0.08	-0.05	0.07	0.01	-0.06
	(0.1159)	(0.1404)	(0.0870)	(0.0870)	(0.0495)	(0.0464)	(0.0111)	(0.0501)
CONS	-0.02	0.2	0.38***	0.38***	2.01**	-2.46	-0.19	1.97
	(0.0375)	(0.1732)	(0.1305)	(0.1305)	(1.0413)	(3.8431)	(1.1798)	(1.0089)

Note: This table presents the estimation results for the sub-sampling. The value stated is the coefficient value. Standard errors are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Source: Stata, 2022

4. Robustness Check II: the Moderating Effect Plot

This research further examined the size of the significant moderating effect by plotting the interaction effect. We followed Dawson (2014) in portraying the effect and made two interaction effect figures. The first figure, Panel A of Figure (1), is graphical for the interaction effect between foreign-owned and the cash holdings of Malaysian listed firms. Panel B shows the interaction effect between family-owned and the cash holdings of Singaporean listed firms.

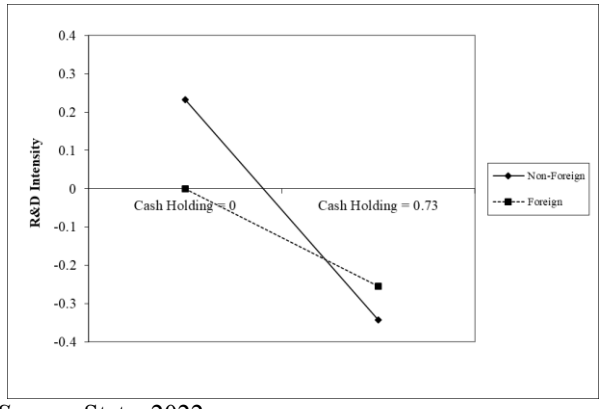
Panel A shows non-foreign firms started with high R&D intensity, compared to foreign-owned firms. As their cash holdings increased, the R&D intensity of non-foreign firms decreased fast, and it declined faster than the R&D intensity of foreign firms. At the maximum value of the cash holdings, the R&D intensity of non-foreign firms had a lower value than the R&D intensity of foreign firms. This graph confirmed that the controlling share-holders of foreign firms weakened the cash holdings for the R&D's intensity. It also surmised that non-foreign firms also had an issue of declining cash holdings for the R&D's intensity.

Panel B reports Singaporean family-owned firms started with high R&D intensity with zero cash holdings. Meanwhile, non-family firms started with a very low R&D intensity. When the cash holdings increased, family firms massively reduced their R&D's intensity. The R&D intensity of the family firms had a lower level than the R&D intensity of the non-family firms at the maximum cash holdings level. This figure concluded that the family-owned controlling shareholders would weaken the relationship between controlling shareholders and cash holdings.

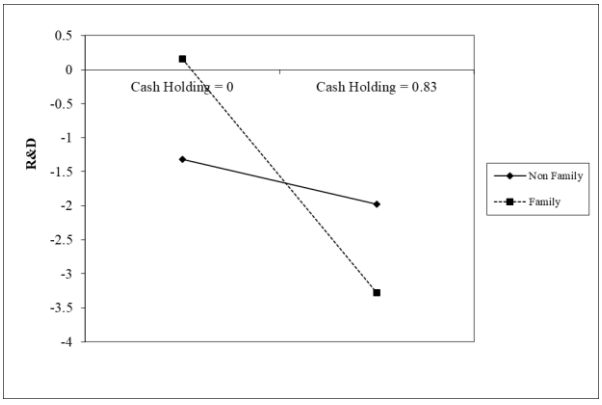
In sum, our figure (panels A and B) surmised that the R&D's intensity would decline significantly when the cash holdings increased. The controlling shareholders would speed up that decreasing R&D's intensity. In Malaysia, foreign-owned firms were the group that significantly influenced that association. Meanwhile, family-owned firms significantly affected the relationship between cash holdings and R&D's intensity in Singapore.

Figure 1. Graphical Plot of Controlling Shareholder Moderating Effect

Panel A Cash Holding and R&D Intensity in Malaysia



Panel B: Cash Holding and R&D Intensity in Singapore



Source: Stata, 2022

5. Robustness Check III: Changes of R&D Intensity

We performed a third robustness check to address the concern about cash holdings' effect on the changes in R&D's intensity. First, we re-estimated the full model using a change-in-variable regression, where we took the delta of R&D's intensity as the dependent variable. These R&D intensity changes were specified in terms of annual changes, which were also applied in much of the R&D's financing research (Lyandres & Palazzo, 2016). Due to concomitant variations, we used sub-sampling data rather than the full sample with dummy variables as the moderators. Table 4 reports the results.

In Malaysia, cash holdings only had a positive impact on foreign-owned firms. This surmised that higher cash holdings led to greater changes in R&D's intensity. Meanwhile, cash holdings did not significantly affect changes in R&D's intensity in other controlling shareholder groups. In Singapore, cash holdings had negative impacts on changes in the R&D's intensity, except for the non-family group. Higher cash holdings meant fewer changes in the R&D's intensity for family-owned firms, but not for non-family firms. Further, we found a positive relationship between cash holdings and changes in the R&D's intensity for both foreign-owned firms and non-foreign-owned firms. Note that the findings in Table 4 have a similar conclusion with our earlier findings in Table 3.

6. Robustness Check IV: Leverage and Size Effects

We performed another robustness check to address our argument related to the leveraging effect. First, we divided our full sample into a low and high-leverage groups for each country. The threshold for the low and high groups was the median value. Then, we re-estimated the full model for each sub-group. Table 5 presents the results. The results in columns [1] and [2] report the low-leverage group and the high-leverage group of Malaysian firms, respectively. Meanwhile, the results of the low-leverage group and the high-leverage group for the sample from Singapore are reported in columns [3] and [4], respectively.

Table 4. Robustness Test for Cash Holding and Changes in R&D Intensity

	Malaysia				Singapore			
	Fam	Non-Fam	For	Non-For	Fam	Non-Fam	For	Non-For
CASH_HOLD	-0.1551	0.115	0.1354**	0.1591	-0.1605*	-0.1227	0.152*	0.1294*
	(0.1589)	(0.3069)	(0.0648)	(0.2225)	(0.0896)	(0.1613)	(0.0909)	(0.0747)
LSALES	0.0133*	0.0096*	0.0091*	0.0221*	0.0004	0.017**	0.0043**	0.0078**
	(0.0076)	(0.0049)	(0.0049)	(0.0124)	(0.0058)	(0.0085)	(0.0021)	(0.0039)
LCF	0.0006	0.002	0.0007	0.0044*	0.0036**	0.0082*	0.0092**	0.0057*
	(0.0049)	(0.0084)	(0.0058)	(0.0025)	(0.0018)	(0.0048)	(0.0045)	(0.0030)
ROA	-0.0165***	-0.2465*	-0.0163**	-0.3021**	-0.1762***	-0.0126***	-0.0806*	-0.1712***
	(0.0029)	(0.1479)	(0.0078)	(0.1481)	(0.0041)	(0.0032)	(0.0437)	(0.0045)
GROWTH	0.003	0.0157	0.003	0.0115	-0.1046***	-0.0209	-0.0213	-0.1044***
	(0.0100)	(0.0414)	(0.0057)	(0.0386)	(0.0025)	(0.0280)	(0.0340)	(0.0028)
CONS	-0.1421*	0.0778	-0.0986*	0.1167	-0.0194	0.0172	0.0418	0.0112
	(0.0799)	(0.0719)	(0.0593)	(0.1225)	(0.0690)	(0.1043)	(0.1368)	(0.0655)

Note: This table presents the estimation results for changes in R&D. The value stated is the coefficient value. Standard errors are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Source: Stata, 2022

Table 5 reveals that each leverage group had a different conclusion. For the low leverage group, cash holdings had a positive relationship with R&D's intensity. This meant higher cash holdings led to a higher R&D intensity. Firms with low leverage tended to re-invest their cash in R&D. Given that the firms were from the high-leverage group, the conclusion was altered again. In Malaysia, the cash holdings of high-leverage firms had a negative effect on R&D's intensity. For the high-leverage group of Singaporean firms, higher cash holdings decreased the R&D's intensity. It confirmed our argument that firms in Singapore and Malaysia would shift their cash holdings by decreasing their R&D investment, due to their financial issues. When the firms had no leverage issues, their cash holdings had a positive association with R&D's intensity.

In terms of the controlling shareholders, Table 5 reports that low-leverage family-owned firms in Malaysia outperformed (relatively speaking) the R&D intensity of non-family firms. However, this effect did not occur in the Malaysian high-leverage firms. This cash holdings effect did not exist for Malaysian foreign firms in either the low-leverage or high-leverage groups. For the Singaporean context, the controlling shareholders' effect on R&D's intensity was statistically significant in family-owned firms with high-leverage and in foreign-owned firms with low-leverage. Singaporean family-owned firms that had high leverage outperformed the R&D intensity of non-family firms. Meanwhile, Singapore's foreign-owned firms outperformed the R&D intensity of non-foreign firms.

Turning to the moderating effect, Table 5 shows that the interaction terms of the controlling shareholders and cash holdings were not significant when the leverage was high (for Malaysia) or when the leverage was low (for Singapore). Although our previous results reported a significant sign for the interaction between foreign-owned firms and cash holdings in Malaysia, our sub-sampling results documented that this effect had disappeared. Interestingly, the interaction term of family-owned firms and cash holdings in Malaysia, which was not statistically significant earlier, now had a positive effect on R&D's intensity. This implied that Malaysia's family-owned firms would have higher R&D intensity when their cash holdings were high, due to their low leverage condition.

From the agency theory's perspective, Malaysian firms' managers tended to reduce their R&D's intensity when their cash holdings were more extensive. However, the managers in foreign-owned firms would invest more in R&D when their firms had higher cash holdings. Our robustness test showed that it might be due to the cost of leverage, whereas managers would use cash for leverage.

In Singapore, the managers tended to reduce their firms' R&D intensity when their cash holdings were high. The managers of family-owned firms in this country would reduce the R&D's intensity significantly when the cash holdings were high. This tallied with the alignment hypothesis in the agency theory. This conclusion confirmed previous studies, such as those by Zemplinerová and Hromádková (2012) and Baldi and Bodmer (2018).

CONCLUSION AND SUGGESTION

This research concludes that the effect of cash holdings on R&D's intensity will be different under certain controlling shareholders. In developing countries like Malaysia, foreign firms outperform the R&D intensity of non-foreign firms when their cash holdings increased. In developed countries like Singapore, family firms have a significant role in the cash

Table 5. Robustness Test for Leverage Effect

	Malaysia		Singapore	
	LOW	HIGH	LOW	HIGH
$R\&D_{T-1}$	-0.1446***	-0.1530***	-0.1210***	-1.0840***
	(0.0016)	(0.0018)	(0.0129)	(0.1230)
CASH_HOLD	0.2846**	-2.9619***	1.6602*	-7.4155*
	(0.1242)	(1.0042)	(0.9223)	(4.2612)
DFAM	0.1861*	-0.2361	-0.0123	2.8452***
	(0.1080)	(0.1512)	(0.1490)	(0.5809)
FAMCASH	2.4416***	1.6856	1.7863	-14.3244***
	(0.4425)	(2.0021)	(1.4767)	(3.7623)
DFOR	0.1165	-0.1556	0.2679*	-0.3876
	(0.1569)	(0.3838)	(0.1423)	(0.7555)
FORCASH	-0.2997	0.3811	-2.1657	4.9976
	(0.4591)	(1.9642)	(1.4010)	(4.0498)
LSALES	-0.0054	0.1788	0.0099***	0.0013
	(0.1313)	(0.1938)	(0.0010)	(0.0029)
LCF	0.0207*	0.0184*	0.0442***	0.2014**
	(0.0113)	(0.0101)	(0.0046)	(0.0870)
ROA	0.0017	0.0821***	-0.0005	0.0911***
	(0.0019)	(0.0138)	(0.0020)	(0.0225)
GROWTH	-0.0005	-0.0018	-0.4578***	-0.0991***
	(0.0020)	(0.0029)	(0.0567)	(0.0243)
CONSTANT	0.1837	0.417	-0.1926	0.0112
	(0.1778)	(0.2716)	(0.1406)	(1.6676)

Note: This table presents the estimation results for the effect of leverage. The values stated are the coefficient values. Standard errors are reported in parentheses. ***, ** and * denote statistical significance at the 1%, 5% and 10% levels, respectively.

Source: Stata, 2022

holdings – R&D intensity nexus. The Singapore family firms had underperforming R&D intensity compared to the non-family firms when cash holdings increased. Additionally, our research shows that the cash holdings' effect on R&D's intensity will also be different following their leveraging level.

Our results indicate that R&D's intensity is not a top priority for firms in Asia, which has long been an intriguing question in the strategic management literature. In particular, we show that higher cash holdings will be used more for settling the leverage, and R&D intensity financing is only the "sideshow." Our study provides new micro-level helpful evidence for understanding the link between cash holdings and R&D's intensity within the Asia region. We also reveal that the conclusions from developing countries and developed countries about the relationship between cash holdings and R&D's intensity will have differences due to the controlling shareholders. The findings also enrich the body of knowledge by confirming the agency theory and the resource-based view theory.

However, all our conclusions need to be validated by further research using a different theoretical framework to verify other possible explanatory factors. For example, our research did not cater for managerial ability, which is well explained by the upper-echelon theory. We also did not cover the financing cost regime (the

gearing theory), in which the cash holdings' effect could be different due to the cost of capital's level. The temporal effect for each financing cost regime may enrich the literature. Additionally, cash holdings may have different impacts on R&D's intensity when there is greater competition or when there are government incentives. It can be an exciting extension in the future.

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APPENDIX

Appendix A Variable Definition

Dependent Variable		
Variables	Proxy	Formula
R&D	R&D expenditure	$\frac{R\&D\ expenses}{Total\ revenues}$
Main Effect		
Financing Source	Cash Holdings	$\frac{Cash\ and\ marketable\ securities}{Total\ assets}$
Moderating Variable		
Controlling Shareholder	Dummy variable of Controlling Shareholder	DFAM = 1 if the controlling shareholder is a family business, and 0 if otherwise DFOR = 1 if the controlling shareholder is foreign, and 0 if otherwise
Control Variables		
Profitability	Return on Assets	Net income to total assets
Cash Flow	Total Cash	Total net cash flow after tax
Sales	Total Sales	Natural logarithm of total sales for the year
Growth	Capex turnover	Total capital expenditure to sales