Nature of Company Ownership, the Dual Role of CEO and Board Chair, and R & D Investment Intensity

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Abstract

Purpose - This study examines the impact of company ownership nature and of the dual role of CEO and board chair on R & D investment intensity, as well as the moderating effect of this dual role. Most previous research focused on the impact of the dual role of CEO and board chair on firm performance.
Design/methodology/approach - This study uses A-share companies listed on the Shenzhen and Shanghai stock exchanges in China from 2008 to 2017. The univariate and the multivariate regression analysis were hired In order to analyze the data.
Findings - The results show that there is a significant negative relationship between state-owned companies and R & D investment intensity. In addition, there is a significant positive relationship between the dual role and R & D investment intensity. The effect of state ownership on R & D investment intensity is more negative when CEO-board chair duality exists. This means that in case of state-owned companies, if CEO serves as the board chair, the propensity to invest in R&D is further reduced.
Research implications or Originality - This is a pioneering study that considers the joint effect of state-owned companies and dual role on R & D investment intensity in the Chinese economy.

Ⅰ. Introduction

Science and technology are the key forces of economic development, and company's innovation is the core driving force for national development. For companies to grow, despite fierce competition, they must rely on core technology of their products and services. The development of the company is closely related to the ability to innovate the productivity of companies and therefore R&D investment intensity represents the innovation of the productivity of companies (Jin, Lei and Yu, 2016).

However, even if it does not conform to the classical theory of separation of corporate ownership and management, corporate governance is an important issue in corporate innovation. This study provides empirical evidence on two important variables of the corporate governance structure, nature of company ownership and the dual role of CEO and chair

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of board (COB), which affect the company's intensity of R&D investment. Furthermore, this study investigates the moderating effect of the dual role of CEO and COB on the nature of company ownership and R&D investment intensity.

China's listed companies are divided into two types: state-owned and non-state-owned companies. State-owned companies have a special status in China's economic system and are an important pillar of national economic development. The difference in the nature of ownership of these two types of enterprises leads to significant differences in many aspects, such as corporate governance issues and agency issues. The corporate governance of state-owned enterprises is a kind of "multiple entrust-agent." State-owned companies belong to the people, and the people are represented by the state. The state represents the government, and the government authorizes the relevant institutions or departments. In addition, in Chinese state-owned enterprises, there are many instances of multiple leadership positions, one-in-one control, and one-size-fits-all. Therefore, it is necessary to consider the nature of enterprise ownership and analyze its impact on the R&D investment intensity. Liddle (1997) and others believe that private companies have more innovation power and innovation efficiency. Lin, Chen and Qin (2013) assert that state-owned enterprises' innovation efficiency is significantly lower than that of non-state-owned enterprises. Zhou, Gao and Zhao (2017) find that state ownership in emerging economies enables a firm to obtain crucial R&D resources, but makes it less efficient to utilize these resources to generate innovation.

Conversely, the role of CEO and COB may have significant impact on the R&D investment intensity of company. Dual role of CEO and board chair (hereafter, "dual role") means that both these positions are occupied by the same person. The principal-agent theory believes that when a dual role exists, CEO has a greater power in the company, the independence of the board of directors is compromised, and the management decision-making cannot be supervised. In terms of corporate governance structure, many scholars regard the separation of two jobs as a better governance structure (Fama and Jensen, 1983). Tuggle et al. (2010) believe that the dual role can easily lead to omissions in supervision.

However, modern management theory argues that the dual role can increase management's controlling power, facilitating quick and effective decision-making. Brickley, Coles and Jarrell (1997) find that the dual role can improve companies' operational efficiency. Li and Tang (2010) find that dual role can increase the level of the CEO's risk management as they are more likely to invest in R&D projects with higher risks. Most of the previous research focuses on the impact of the dual role on firm performance, rather than its impact on R&D investment intensity.

The rest of this paper is structured as follows. In Section 2, literature is reviewed and research hypotheses established. In Section 3, the sample composition and research design is described. Section 4 explains the main empirical results with additional tests results. Finally, Section 5 presents the summary of the findings and limitations of this work.

II. Theoretical Analysis and Research Hypothesis

1. Company ownership and R & D intensity

Company ownership theory is the basis for studying modern company operating performance. The difference in company ownership will have a direct impact on the company's operating

performance.[1] State-owned companies of the Chinese economy are not an exception. Although state-owned companies are generally considered inefficient in operations, they play an important role in China's economy (Lin, Lu, Zhang and Zheng, 2020)

To make profits, state-owned companies focus more on risk control than non-state-owned companies, and seek stability, balance, and long-term development. Managers in state-owned companies are often appointed by government, and show inclination towards self-promotion. Therefore, large amounts of R&D investments with uncertain outcomes can be perceived as a potential risk rather than profit by state-owned company managers.

Even though state-owned companies are more likely to obtain state capital support, preferential policies, and financing channels, these are not the only factors that determine R&D investment. The absolute competitive advantage in the market, coupled with government support, may provide insufficient incentive for state-owned companies to improve their competitiveness. Because state-owned enterprises often have to bear the burden of economic growth and unemployment control, to achieve the government's goals, one cannot simply pursue business performance (Bai and Xu, 2005; Zhang, Zhang and Zhao, 2003). Companies pay attention to R&D and improve innovation capabilities, which can promote economic growth. However, due to limited resources, state-owned companies also need to control social issues such as unemployment rate thereby, some corporate resources are diverted to assume these social responsibilities that reduces R&D investment. Teng and Yi (2017) find that local governments are negatively correlated with R&D intensity and innovation performance.[2] Wang et al. (2018) find that managers with stronger political ties lead to reduction in R&D intensity in China's private-owned companies.

Conversely, in order to survive and grow in a fiercely competitive environment, non-state-owned companies need to master their core technologies to continuously improve and innovate. The managers or controlling owners of non-state-owned companies must bear all risks of the company, embodying the entrepreneurial spirit including innovation, strategic renewal, and risk activities (Miller, 1983; Guth and Ginsberg, 1990). Li and Xia (2008) argue that the R&D intensity of non-state-owned listed companies is significantly higher than that of state-owned companies. Based on the above studies, this study proposes the following hypothesis:

H1: The state-owned company has a negative effect on R&D intensity.

2. The dual role and R&D intensity

The leadership structure of the board of directors is an important part of corporate governance. There are two theories related to the organizational efficiency of the company, agency theory and behavioral organization theory. Agency theory believes that the dual role is

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1) Grossman and Hart (1986), Hart and Moore (1990) created the GHM theory, distinguishing between specific rights and residual rights. Specific rights refer to rights that are clearly stipulated in the contract, and residual rights are rights that are not explicitly stipulated. The residual rights of control comes directly from the ownership of material assets.

2) Teng and Yi (2017) also find that cental governments owned companies are the mail driving force for R & D activities. In contrast, Sadowski and Sadowski-Rasters (2006) found that foreign-founded enterprises's perform better in innovation in European countries.

not conducive to the improvement of organizational efficiency. Jensen and Meckling (1976) point out due to the opportunistic behavior of agents, the dual role is more likely to cause agency problems. Conversely, the organizational behavior theory believes that the dual role can prompt the company to make more efficient investment decisions. If a company wants to have core competitiveness, it cannot do without R&D and innovation. Managers are also required to have market acumen, make strategic decisions, and discover and seize market opportunities for timely innovation. If CEO serves as the chairman of the board of directors, the CEO can easily intervene in the board of directors' decision making, thereby reducing the restriction on company management and improving the efficiency of decision making. Therefore, the dual role can prompt the company to make more flexible innovation decisions (Lane, JR and Lubatkin, 1998).

Davidson et al. (2004) argue that investors have much higher expectations of financial performance from companies having a CEO with dual role because they believe that CEOs are more interested in investing in new products and technologies. Chen and Cheng (2011) and Kao and Chen (2020) provide evidence that CEO with dual role have a positive and significant effect on R&D. Based on the above studies, this study proposes the following hypothesis:

H2: The dual role of CEO and COB has positive effects on R&D intensity.

3. The joint effect of state-owned nature and dual role on R & D intensity

In order to examine the moderating effect of CEO duality on R&D intensity, we reviewed several studies. As mentioned, state-owned companies need to meet social responsibilities to adhere to various policy requirements, and consequently may not be able to make innovative R&D investment decisions for company growth.

In general, R&D activities have long business cycles, low success rates, and high risks; but if successful, companies can gain significant profits. Therefore, in R&D investment, decision making is very challenging and risky (Millet-Reyes, 2004). If the CEO and COB are separate, their different interests may inevitably result in conflicts of interest in R&D investment decisions. Baysinger and Hoskisson (1989) and Hoskisson et al. (2002) believe that CEOs often try to reduce R&D investments to avoid risks and take into account short-term financial performance. Dong and Gou (2010) believe that the CEO's discretion has a negative correlation with the R&D investment intensity. Lin, Lin and Song (2010) also argue that government-directed CEO appointments have a negative correlation with the R&D investment of state-owned companies. However, having CEOs of state-owned companies serving as COBs may strengthen the company control and eliminate inefficient constraints.

There is no study related to the moderating effect of CEO duality on the relationship between the state-owned companies and R&D intensity, but the following studies are noteworthy. Wang et al. (2018) investigated the impact of political ties and managerial overconfidence on R&D intensity using 1,293 Chinese companies from 2010 to 2014. They show that explicit political tie decreases firm-level R&D intensity, but greater managerial overconfidence increases R&D intensity. Moreover, managerial overconfidence positively moderates the relationship between political ties and R&D intensity to the extent of reversing negative relationship into positive. Jizi and Nehme (2018) examine the moderating role of CEO duality on the relationship between

Fig. 1. The Structure of Nature of Company Ownership, Dual Role of CEO and COB with R & D Investment Intensity
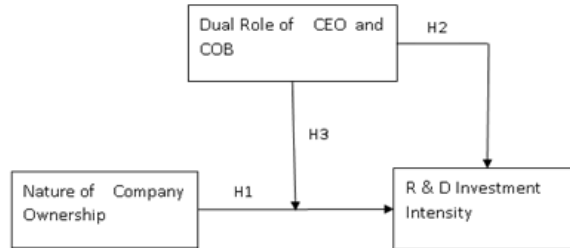
board monitoring and audit fees. They find positive impact of CEO duality on audit fees because the dual role increases the demand for higher audit quality. Based on the above discussion, this study proposes the following Hypothesis:

H3: The joint effect of state-owned company and CEO duality is related to R&D intensity.

Ⅲ. Research Design and Sample Selection

1. Research design

This study examines the impact of the nature of company ownership the dual role on R&D investment intensity. The following regression models test the H1 predication of a negative relation between state-owned nature of the company and R&D investment intensity:

$$RDS(RDT) = \alpha + \beta_1 OWSH + \beta_2 TOP1 + \beta_3 LEV + \beta_4 SALES \\ + \beta_5 AGE + \beta_6 TOBINQ_{t-1} + \beta_7 ROA_{t-1} + \beta_8 EGR \\ + \beta_9 TAGR + \beta_{10} SGR + \sum YEAR + \sum INDUS + \epsilon \ (1)$$

The dependent variable in this study is the intensity of R&D investment, i.e., RDS and RDT. There are three general measures of R&D investment intensity: R&D investment/gross sales, R&D investment/total assets, and R&D investment/total market value. Because there is a possibility of human manipulation of the total market value of enterprise, this study does not use the third indicator of R&D investment/total market value. This study selects two indicators: RDS (R&D investment/gross sales), RDT (R&D investment/total assets) to measure the intensity of R&D investment of the enterprise and ensure the stability of the results.

Equation (1) test variable is the nature of company ownership. OWSH denotes the nature of company ownership. This study uses dummy variables to indicate the nature of the company. State-owned companies are denoted as 1, whereas non-state-owned companies are denoted as 0. In Equation (1), the coefficient β1 investigates H1, that is, state-owned companies' decreases R&D investment.

The second hypothesis concerns whether there is a positive relation between the dual role

and R&D investment intensity. The following regression models test if the H2 predication of the dual role is positively correlated with R&D investment intensity:

$$RDS(RDT) = \alpha + \beta_1 DUAL + \beta_2 TOP1 + \beta_3 LEV + \beta_4 SALES \\ + \beta_5 AGE + \beta_6 TOBINQ_{t-1} + \beta_7 ROA_{t-1} + \beta_8 EGR \\ + \beta_9 TAGR + \beta_{10} SGR + \sum YEAR + \sum INDUS + \epsilon \quad (2)$$

The test variable in Equation (2) test is the dual role, which is indicated by DUAL. When the COB and CEO positions are filled by the same person, the value is 1, 0 otherwise. In Equation (2), the coefficient β1 investigates H2, i.e., CEO duality companies increase R&D investment.

The third hypothesis concerns the relationship between the joint effect of the state-owned nature of company and dual role on R&D investment intensity. The following regression models test the H3 predication of the joint effect of the state-owned nature and dual role on R&D investment intensity:

$$RDS(RDT) = \alpha + \beta_1 OWSH + \beta_2 DUAL + \beta_3 OWSH*DUAL \\ + \beta_4 TOP1 + \beta_5 LEV + \beta_6 SALES + \beta_7 AGE \\ + \beta_8 TOBINQ_{t-1} + \beta_9 ROA_{t-1} + \beta_{10} EGR + \beta_{11} TAGR \\ + \beta_{12} SGR + \sum YEAR + \sum INDUS + \epsilon \quad (3)$$

In Equation (3), the coefficient β3 investigates H3, i.e., CEO duality companies moderate the negative impact of state-owned ownership on R&D investment intensity.

This study selects several control variables following the previous studies (Lim and Goh 2016; Lee and Kim 2019; Byun 2019). TOP1 means equity concentration used by equity ratio of the largest shareholder of company, LEV means debt to asset ratio measured by total liabilities divided by total assets, SALES use natural log of gross sales at the end of the year, AGE indicates company age from establishment, TOBINQt-1 is the previous value of Tobin's Q, ROAt-1 is the previous value of return on assets, EGR means equity growth ratio, TAGR means total assets growth rate, and finally SGR means sustainable growth rate. In addition, year and industry dummy variables are used to control the unobservable effect of year and industry. Detailed variable definitions are provided in Appendix1.

2. Sample Selection

This study uses data of A-share companies listed on the Shenzhen and Shanghai stock exchanges in China from 2008 to 2017. Due to the existence of variables, the sample also contains data from 2007 and excludes: (i) financial listed companies; (ii) ST listed companies (ST refers to stocks that have been specially processed by listed companies in China to warn against the potential delisting risk); (iii) Data with incomplete information on our main indicators; and (iv) Companies that have been listed for less than 2 years. The data come from CSMAR database in China. In order to avoid influence of outliers, this study winsorizes all continuous variables for 1% tailing. Th study uses STATA 15.0 for data analysis, and the statistical significance of the reported regression coefficients is based on the heteroscedasticity consistent covariance matrix (White1980).

Table 1: Distribution of Samples by Year and by Industry

Panel A: Sample Distribution by Year		
Year	RDS	RDT
2008	1098	1095
2009	1160	1160
2010	1291	1291
2011	1591	1594
2012	1848	1846
2013	1988	1990
2014	1915	1916
2015	1994	2002
2016	2107	2104
2017	2351	2348
Total(Firm)	17343(2756)	17346(2755)
Panel B: Sample Distribution by Industry		
Industries	RDS	RDT
Agriculture, forestry, animal husbandry and fishery	298	299
mining industry	432	433
manufacturing	11147	11150
Electricity, heat, gas and water production and supply	631	631
Construction industry	441	441
Wholesale and retail trade	1052	1052
Transportation, warehousing and postal services	626	626
Accommodation and Catering	77	77
Information Transmission, Software and Information Technology Services	818	816
Real estate	871	871
Leasing and business services	196	196
Scientific research and technical services	110	109
Water, Environment and Public Facilities Management	174	174
Residential services, repairs and other services	23	23
education	7	7
Health and social work	31	31
Culture, sports and entertainment	180	181
Comprehensive	229	229
Total (Firm)	17343 (2756)	17346 (2755)

Table 1 Panel A shows the year distribution of the sample by dependent variables, RDS and RDT. Table 1 Panel B provides the distribution of sample companies across different industries, using China Securities Regulatory Commission's Industry Classification 2012 Edition.

3. Descriptive Statistics

Table 2 presents the summary statistics of the regression variables. Panel A provides descriptive statistics for the dependent variables that are based on pooled data over the years. The mean value and median of the ratio of R&D investment to gross sales are 2.51% and 1.30%, and the mean value and median of the ratio of R&D investment to total assets are 1.29% and 0.75%. The values are relatively small, indicating that the company's R&D investment intensity needs improvement. The minimum and maximum value of the ratio of R&D investment to gross sales is 0 and 21.36%, and the minimum and maximum value of the ratio of R&D investment to total

Table2: Descriptive Statistics for Variable Measures

Variables	N	Mean	Std	Min	Q1	Median	Q3	Max
Panel A: Dependent Variables								
RDS	17343	0.0251	0.0003	0.0000	0.0000	0.0130	0.0388	0.2136
RDT	17346	0.0129	0.0001	0.0000	0.0000	0.0075	0.0214	0.0830
Panel B: Test Variables								
OWSH	17346	0.4471	0.0038	0.0000	0.0000	0.0000	1.0000	1.0000
DUAL	17346	0.2315	0.0032	0.0000	0.0000	0.0000	0.0000	1.0000
Panel C: Control Variables								
TOP1	17346	0.3550	0.0011	0.0879	0.2392	0.3384	0.4751	0.7590
LEV	17346	0.4377	0.0015	0.0460	0.2749	0.4352	0.5963	0.9732
SALES	17346	21.3635	0.0102	17.6022	20.4333	21.2462	22.1735	25.3432
AGE	17346	14.9586	0.0395	3.0000	11.0000	15.0000	19.0000	28.0000
TOBINQt-1	17346	2.7316	0.0136	0.9211	1.5046	2.1669	3.3281	13.1587
ROAt-1	17346	0.0438	0.0004	-0.1985	0.0171	0.0400	0.0680	0.2181
EGR	17346	1.1632	0.0026	0.5414	1.0202	1.0688	1.1600	5.1565
TAGR	17346	0.1757	0.0023	-0.3087	0.0233	0.1059	0.2315	3.7659
SGR	17346	0.0557	0.0006	-0.4751	0.0191	0.0506	0.0913	0.4124

assets is 0 and 8.30%, indicating a large difference in the intensity of R&D investment between companies. Panel B and C provide descriptive statistics for test variables and control variables. The mean value of OWSH is 44.71%, indicating that less than half of total sample are state-owned . The mean value of DUAL is 0.2315. This means that 23.15% of the sample companies' CEOs are also the chair of the board of directors. The minimum and maximum value of TOP1 are 8.79% and 75.90%, showing that the equity ratio of the largest shareholder is quite different. In addition, the minimum and maximum value of TOBINQt-1 and ROAt-1 are, respectively, 0.9211 and 13.1587 and -0.1985 and 0.2181, indicating that the performance of each company varies greatly. The minimum and maximum values of LEV are 0.0460 and 0.9732, indicating that the difference in the debt to asset ratio between companies is also very large.

Table 3: Pearson Correlations of Regression Variables

	RDS	RDT	OWSH	DUAL	
Panel A : Pearson Correlations of Dependent Variables and Test Variables					
RDT	0.8162***				
OWSH	-0.3128***	-0.2765***			
DUAL	0.1960***	0.1673***	-0.2839***		
Panel B : Pearson Correlations of Regression Variable					
	TOP1	LEV	SALES	AGE	TOBINQt-1
RDS	-0.1213***	-0.3718***	-0.2714***	-0.1469***	0.3050***
RDT	-0.0826***	-0.3023***	-0.1024***	-0.1354***	0.2393***
OWSH	0.1895***	0.3061***	0.2992***	0.1791***	-0.2535***
DUAL	-0.0504***	-0.1528***	-0.1627***	-0.0948***	0.1446***
	ROAt-1	EGR	TAGR	SGR	
RDS	0.1270***	0.0153**	0.0420***	-0.0457***	
RDT	0.1759***	-0.0007	0.0123	0.0285***	
OWSH	-0.1517***	-0.0545***	-0.0944***	-0.0232***	
DUAL	0.0534***	0.0176**	0.0482***	-0.0065	

Note: *, **and*** indicate significance at 10%, 5% and 1% level, respectively

Table 4: Summary Statistics-Sample Split by RDS

Variables	low RDS Mean (N=9970)	High RDS Mean (N=7373)	Difference	t-test	p-value
OWSH	0.5969	0.2496	0.3473	48.4350***	0.0000
DUAL	0.1587	0.3271	-0.1685	-26.5737***	0.0000
TOP1	0.3691	0.3378	0.0313	14.2315***	0.0000
LEV	0.5017	0.3557	0.1460	50.2087***	0.0000
SALES	21.6469	21.0077	0.6392	31.9148***	0.0000
AGE	15.6495	14.0905	1.5590	19.6459***	0.0000
TOBINQt-1	2.3446	3.2200	-0.8753	-33.0055***	0.0000
ROAt-1	0.0383	0.0509	-0.0126	-17.8452***	0.0000
EGR	1.1566	1.1730	-0.0164	-3.0343***	0.0024
TAGR	0.1634	0.1928	-0.0294	-6.4351***	0.0000
SGR	0.0577	0.0536	0.0041	3.1457***	0.0017

Note: *, **and*** indicate significance at 10%, 5% and 1% level, respectively

Panel A of Table 3 shows the Pearson correlations of the dependent variables and test variables. RDS and RDT are positively and significantly correlated with each other. State owner-ship is negatively and significantly correlated with RDS and RDT, indicating that R&D investment intensity is generally low for state-owned companies. In contrast, DUAL is positively and sig-nificantly correlated with RDS and RDT, meaning that companies with dual role increase R&D investment. Panel B of Table 3 reports Pearson correlations between the test variables and con-trol variables. TOP1, LEV, SALES, AGE are negatively and significantly correlated with RDS, RDT and DUAL. The company's previous performance (TOBINQt-1, ROAt-1) positively and significantly correlated with RDS, RDT and DUAL. Similarly, EGR and TAGR are positively and significantly correlated with RDS and DUAL. SGR is negatively and significantly with RDS, but positively and significantly correlated with RDT. Multicollinearity problems are not found. However, all test variables and control variables are checked for multicollinearity by analyzing variance inflation factors (VIF). All VIFs are well below the suggestion value of 5 for the dependent variables RDS and RDT.

IV. Empirical Result

1. Univariate Tests

Table 4 shows the results of the univariate tests. After splitting the sample into high and low R & D investment intensity (RDS) groups, this study measures the mean difference of each group for t-tests. The results show that all research variables have a significant t-value. Test variables, OWSH and DUAL show that there is a large difference between low-RDS companies and high-RDS companies. In the low-R&D-investment group, 59.69% of companies are state-owned, but 15.87% are managed by CEO as COB. In the high-R&D-investment group, 24.96% of companies are state-owned, but 32.71% of companies are managed by the CEO as COB. Similarly, control

Table 5: Results of Regression of R & D investment intensity on nature of company ownership

Variables	(1) RDS		(2) RDT	
	Coeff.	t-value	Coeff.	t-value
CONS.	0.1249***	28.28	0.0137***	6.52
OWSH	-0.0021***	-4.87	-0.0012***	-5.32
TOP1	-0.0067***	-4.73	-0.0031***	-4.49
LEV	-0.0103***	-11.89	-0.0060***	-9.13
SALES	-0.0030***	-15.29	0.0006***	6.58
AGE	-0.0009***	-19.74	-0.0004***	-17.55
TOBINQt-1	0.0018***	9.19	0.0010***	12.24
ROAt-1	0.0196***	3.23	0.0210***	7.59
EGR	-0.0039***	-5.49	-0.0018***	-4.56
TAGR	0.0051***	5.95	-0.0005	-1.27
SGR	-0.0019	-0.75	0.0078***	5.74
YEAR	included		included	
INDUSTRY	included		included	
Prob>F	0.0000		0.0000	
Adj.R²	0.4305		0.3806	
N	17343		17346	

Note: *, **and*** indicate significance at 10%, 5% and 1% level, respectively

variables also show large differences between the low-and high-R&D-investment group. Compared to high-R&D-investment companies, low-R&D-investment companies are more likely to have a concentrated ownership structure, large leverage, larger SALES and longer ages. However, high- R&D-investment companies are more likely to exhibit higher performance and growth rate.

2. Multivariate Regression analysis

As mentioned before, Ordinary Least Squares (OLS) Regressions run using a robust standard error (White, 1980). There are many methods for diagnosing multicollinearity, and the more commonly used method is the variance inflation factors (VIFs) method. This study uses this method to test multicollinearity, all VIFs were lower than 5, there is no serious multicollinearity.

Table 5 presents the multivariate regression results of R & D investment intensity against company nature and ownership with the relevant control variables. Model (1) uses RDS as the dependent variable. Model (2) uses RDT as the dependent variable, and is shown to be more robust than Model (1).

In Table 5, Hypothesis 1 posits a negative relationship between state-owned companies (OWSH) and R&D investment intensity. Model (1) shows that OWSH is negatively significant for RDS (coefficient =-0.0021, t=-4.87). in Model (2), OWSH is negatively significant for RDT (coefficient =-0.0012, t=-5.32), providing strong support for Hypothesis 1. Partially consistent with the results of previous study (Teng and Yi, 2017), the state-owned companies in China have a negative effect on the R & D investment intensity. The regression results of control variables on R&D investment intensity are as follows. In both the regressions, the shareholding ratio of the largest shareholder of company (TOP1), debt to asset ratio (LEV), and company age

from establishment (AGE) are negatively significant, indicating that high leveraged and relatively mature companies with concentrated ownership tend to invest less in R&D. In all two regression, the previous value of Tobin's Q, (TOBINQt-1), and the previous value of return on assets (ROAt-1) are positively significant, indicating that profitable companies tends to invest more in R&D. However, the results of SALES, TAGR, and SGR vary by Model (1) and Model(2).

Table 6 presents the results of R & D investment intensity against the dual role with the relevant control variables. In order to test Hypothesis 2, DUAL is used as a test variable. As in Table 5, Model (1) uses RDS as the dependent variable. Model (2) uses RDT as the dependent variable and provides more robust results than Model (1).

In Table 6, a positive relationship is found between DUAL and R&D investment intensity, as predicted in Hypothesis 2. Model (1) shows that DUAL is positively significant for RDS (coefficient =0.0038, t=7.21). In Model (2), DUAL is positively significant for RDT (coefficient =0.0017, t=6.79), providing strong support for Hypothesis 2. Consistent with the results of previous studies (Chen and Cheng, 2011; Kao and Chen, 2020), the dual role has a positive effect on the R&D investment intensity of companies in China. The regression results of the control variables on R&D investment intensity are generally consistent with the results in Table 5.

To further analyze Hypothesis 1 and 2, this study adds interaction terms. In Table 7, Model (1) and (3) include the two main effect variables only, OWSH and DUAL, and Model (2) and (4) add the interaction term, OWSH*DUAL.

Table 7 presents the results of Hypothesis 3 of the joint effect of the state-owned ownership and CEO duality on R & D investment intensity. Hypothesis 3 predicts that the joint effect   positively moderates the effect of state ownership on R&D investment intensity. However, the effect of state ownership on R&D investment intensity is more negative when the dual role exists. Table 7 shows that the OWSH*DUAL is negatively significant in the second regression for RDS (coefficient =-0.0057, t=-5.56) and the OWSH* DUAL is negatively significant in the fourth regression for RDT (coefficient =-0.0026, t=-4.95). In order to further analyze the joint effect of DUAL and OWSH on R&D investment intensity, the sample is divided into two groups, SOEs (state-owned enterprises) and NON-SOEs (non-state-owned enterprises), for comparative analysis, as in Table 8. Table 8 clearly confirms that the positive effect of CEO duality on R&D investment intensity is only from non-state-owned companies. At the same time, it also clearly confirms that the positive effect of CEO duality on R&D investment intensity does not appear at all in state-owned companies.

Table 6: Results of Regression of R & D investment intensity on the dual role

Variables	(1) RDS		(2) RDT	
	Coeff.	t value	Coeff.	t value
CONS.	0.1241***	28.48	0.0140***	6.73
DUAL	0.0038***	7.21	0.0017***	6.79
TOP1	−0.0075***	−5.43	−0.0036***	−5.28
LEV	−0.0165***	−12.05	−0.0061***	−9.33
SALES	−0.0030***	−15.60	0.0006***	6.29
AGE	−0.0009***	−20.71	−0.0004***	−18.55
TOBINQ$_{t-1}$	0.0018***	9.09	0.0010***	12.15
ROA$_{t-1}$	0.0211***	3.51	0.0220***	8.01
EGR	−0.0038***	−5.43	−0.0017***	−4.53
TAGR	0.0051***	5.93	−0.0005	−1.17
SGR	−0.0017	−0.65	0.0079***	5.89
YEAR	included		included	
INDUSTRY	included		included	
Prob>F	0.0000		0.0000	
Adj.R²	0.4319		0.3814	
N	17343		17346	

Note: *, **and*** indicate significance at 10%, 5% and 1% level, respectively

Table 7: Results of Regression of the joint effect of the state-owned nature and dual role on R & D investment intensity

Variables	(1) RDS		(2) RDS		(3) RDT		(4) RDT	
	Coeff.	t value	Coeff.	t value	Coeff.	t value	Coeff.	t value
CONS.	0.1215***	27.41	0.1210***	27.32	0.0123***	5.81	0.0120***	5.72
OWSH	−0.0015***	−3.46	−0.0006	−1.36	−0.0010***	−4.18	−0.0006**	−2.31
DUAL	0.0035***	6.62	0.0049***	7.57	0.0015***	6.01	0.0021***	7.26
OWSH*DUAL			−0.0057***	−5.56			−0.0026***	−4.95
TOP1	−0.0068***	−4.85	−0.0073***	−5.17	−0.0032***	−4.58	−0.0034***	−4.87
LEV	−0.0163***	−11.89	−0.0161***	−11.81	−0.0060***	−9.12	−0.0059***	−9.04
SALES	−0.0029***	−14.81	−0.0029***	−14.83	0.0007***	6.96	0.0007***	6.97
AGE	−0.0009***	−19.46	−0.0009***	−19.41	−0.0004***	−17.27	−0.0004***	−17.23
TOBINQt-1	0.0017***	9.04	0.0017***	8.89	0.0010***	12.08	0.0010***	11.91
ROAt-1	0.0196***	3.24	0.0203***	3.36	0.0211***	7.62	0.0214***	7.74
EGR	−0.0038***	−5.36	−0.0037***	−5.20	−0.0017***	−4.44	−0.0017***	−4.31
TAGR	0.0049***	5.71	0.0048***	5.55	−0.0006	−1.47	−0.0007	−1.60
SGR	−0.0021	−0.80	−0.0022	−0.84	0.0077***	5.71	0.0076***	5.67
YEAR	included		included		included		included	
INDUSTRY	included		included		included		included	
Prob>F	0.0000		0.0000		0.0000		0.0000	
Adj.R²	0.4323		0.4331		0.3820		0.3828	
N	17343		17343		17346		17346	

Note: *, **and*** indicate significance at 10%, 5% and 1% level, respectively

Table 8: Results of Regression of the dual role on R & D investment intensity in two group (SOEs and Non-SOEs)

Variables	RDS		RDS		RDT		RDT	
	(1)SOEs		(2)Non-SOEs		(3)SOEs		(4)Non-SOEs	
	Coeff.	t value	Coeff.	t value	Coeff.	t value	Coeff.	t value
CONS.	0.0857***	17.10	0.1682***	23.30	0.0229***	7.90	-0.0006	-0.17
DUAL	-0.0010	-1.33	0.0038***	6.15	-0.0007	-1.56	0.0021***	7.38
TOP1	-0.0110***	-6.55	-0.0056***	-2.58	-0.0049***	-5.04	-0.0031***	-3.12
LEV	-0.0092***	-5.78	-0.0193***	-8.99	-0.0044***	-4.78	-0.0077***	-7.70
SALES	-0.0014***	-6.44	-0.0051***	-14.81	0.0002*	1.71	0.0012***	7.75
AGE	-0.0010***	-16.86	-0.0007***	-12.41	-0.0004***	-13.11	-0.0003***	-11.20
TOBINQt-1	0.0011***	4.89	0.0016***	7.54	0.0006***	4.77	0.0012***	13.01
ROAt-1	0.0205***	3.23	0.0280***	3.41	0.0135***	3.68	0.0254***	6.67
EGR	-0.0009	-0.89	-0.0048***	-3.99	-0.0005	-0.79	-0.0025***	-4.41
TAGR	0.0037***	3.11	0.0052***	3.60	0.0012*	1.74	-0.0017**	-2.48
SGR	0.0015	0.50	-0.0019	-0.44	0.0067***	3.93	0.0081***	4.03
YEAR	included		included		included		included	
INDUSTRY	included		included		included		included	
Prob>F	0.0000		0.0000		0.0000		0.0000	
Adj.R²	0.3426		0.4133		0.3247		0.3534	
N	7791		9552		7789		9557	

Note: *, **and*** indicate significance at 10%, 5% and 1% level, respectively

Ⅴ. Conclusion

This study uses the A-share listed companies of the Shanghai and Shenzhen stock exchange in China from 2008-2017 to study the relationship between the dual role of CEO and CBO and the nature of company ownership on R&D investment intensity. The study finds that the state-owned companies have a negative effect on the R & D investment intensity. In addition, the dual role can promote R & D investment intensity. However, the joint effect of the state-owned companies and dual role on R&D investment intensity is negative and there are no positive moderating effects of CEO duality on R&D investment intensity. If CEO serves as the CBO, the propensity to invest in R&D is further reduced. The effect of state ownership on R & D investment intensity is more negative when the CEO duality exists.

Based on the results, there are some policy implications. Government departments should guide state-owned companies to build a reasonable governance structure according to their own needs. Companies should rearrange their structure of management rights, promote innovation and development, and strengthen R & D investment. Innovation is an important way for a company to gain core competitiveness. Research has found that the dual role in state-owned companies can decrease the intensity of R & D investment. Thus, R & D investment of state-owned companies are supervised and managed by the independent board of directors, which affect the company's performance.

In addition, the dual role in state-owned companies may lead to arbitrary decisions. For state-owned companies, most COBs or CEOs are appointed by the government. It is particularly important to establish an environment that can mitigate short-term R & D failures and risks (Holmstrom, 1989; Manso, 2011). Therefore, it is reasonable to strengthen internal and external

supervision capabilities, and at the same time effectively supervise management, giving them more freedom of innovation.

This study divides the companies into state-owned and non-state-owned companies. In the future, it can be further sub-divided into central state-owned, local state-owned, private-owned, and foreign-owned companies.

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Appendix 1. Variable definitions

Variables	Definition
RDS	R & D Investment Amount / Gross Sales
RDT	R & D Investment Amount / Total Assets
DUAL	When the two positions of COB and CEO are held by the same person, the value is 1; otherwise, it is 0.
OWSH	State-owned companies take the value 1, otherwise 0
TOP1	Shareholding ratio of the largest shareholder
LEV	Total Liabilities / Total Assets
SALES	LN (Gross Sales At the End of the Year)
AGE	Company establishment year
$TOBINQ_{t-1}$	Tobin's Q lags one period Tobin Q =Market Cap/Tatal Asset
ROA_{t-1}	ROA lags one period ROA=Net Income/Total Assets
EGR	Total Owners' Equity at the End of Current Year / Total Owners' Equity at the End of Last Year
TAGR	(Total Assets at the End of Current Year – Total Assets at the End of Last Year) / (Total Assers at the End of Last Year)
SGR	ROE * Retaining Rate of the Income / (1– ROE * Retaining Rate of the Income)
YEAR	Year dummy
INDUS	Industry dummy