Full Length Research Paper

The moderating effects of chief executive officer (CEO) duality on the relationship between research and development (R and D) spending and firm performance

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This study aims to examine a moderating effect of chief executive officer (CEO) duality, possessing both roles of the principle and the agent in a firm, to some extent, on the relationship between research and development (R and D) spending and firm performance. To test whether the moderating effect is significant, three-stage hierarchical regression analysis method applied. Using a Chow test further determines CEO duality's effect varies in industries. Statistical data analysis provided diversified interesting outcomes. Two subgroup samples, the semiconductor electronics industry and the other electronics industry, had significantly supported research hypothesis based on agency theory, while the peripheral products industry was just insignificantly consistent with the view of agency theory. A Chow test of differences in R² between the semiconductor electronics industry and other two industries, namely peripheral products industry and other electronics industry, did not achieve a statistical significance at the 5% level, indicating that it was unable to accept the anticipated hypothesis. These results implied that though there was a negative effect of interaction term between CEO duality and R and D spending on firm performance, the interactive influence did not significantly alter any difference among industries.

Key words: Hierarchical regression, chief executive officer (CEO) duality, research and development (R and D) spending, Chow test, agency theory, resource dependent theory.

INTRODUCTION

According to agency theory, a potential conflict between the interests of professional managers and owners arises from the divergence of ownership and control in organizations (Berle and Means, 1932; Coase, 1937; Fama and Jensen, 1983; Marris, 1964). Managers may pursue their self-interests regardless of profit maximization of a firm, agency cost thus is formed (Berle and Means, 1932). Managerial self-interest may be represented in decisions, while managers proceed their actions pertaining efforts, risk exposure and time horizons (Jensen and Smith, 1985). These decisions may put forth potential losses of an owner wealth. To protect interests of owners, monitoring management actions is a substantially important function of corporate boards (Eisenhardt, 1989; Jensen and Smith, 1976; Mizruchi, 1983). Agency theorists insinuate that corporate boards may serve as an effective supervisor of managers and bring a better firm performance, when motives of managers are in line with owners’ concerns (Fama, 1980; Jensen and Meckling, 1976). Researchers usually explore a firm’s influence of monitoring mechanism on economic performance (Core et al., 1999; Dalton et al., 2003; Dalton et al., 1998; Hermalin and Weisbach, 1998).

1972; Pfeffer and Salancik, 1978). Accordingly, resource-based theorists infer that the dissimilarity of performance among firms can be clarified for the divergence of their resources (Barney, 1986; Dierickx and Cool, 1989; Mahoney and Pandian, 1992; Rumelt, 1984; Tece et al., 1997; Wernerfelt, 1984). Furthermore, a firm with its particular knowledge and specialty generally has a considerable promising to act as an origin of prolonged competitive advantages (Barney, 1991; Coff, 1997; Grant, 1996; Kogut and Zander, 1992; McGrath et al., 1996). Empirical studies commonly discuss that would there exist a relationship between the boards’ chairman and firm performance (Boyd, 1990; Dalton et al., 1999; DeCarolis and Deeds, 1999; D’Este, 2005; Gerski et al., 1993; Pfeffer, 1972; Roberts and Amit, 2003).

Indeed, the function of corporate boards not only supervises operations but also provides needed resources (Korn, 1999; Hillman and Dalziel, 2003), theoretically and empirically, which are in connection with firm economic performance as well (Hillman and Dalziel, 2003). Coordinating agency and resource–based theories is thus far important in a related topic for discussion. Reviewing previous works, the majority of proposition analyzed focus only on either regulation of board or provision of board. Recently, the subject becomes a popular and vital proposal that moderating effects of the interaction term between monitoring and incentive based upon firm governance mechanisms on the relationship between innovative assets and firm performance (He and Wang, 2009; Le et al., 2006). Yet, these researches reach different conclusions from the facts that statistical data derived from their empirical study of each other.

In the current study, it not only reinvestigate the above mentioned issue, but make an appropriately classification by industry for the total sample firms. Using hierarchical regression procedures as the analysis method, electronics industry firms listed on the Taiwan Stock Exchanges and the Gre-Tai securities market for the year of 2008 are included in this study. Based on area of expertise for the electronics industry, total electronics industry samples are divided into three subgroups, namely the semiconductor electronics industry, the peripheral products industry and the other electronics industry. Total electronics industry samples involved amount to 527 firms, of which including 117 firms of the semiconductor electronics industry, 99 firms of the peripheral products industry, and 311 firms of the other electronics industry. Partial results from this empirical study reveal that the two subgroup samples of the semiconductor electronics industry and the other electronics industry significantly support expected hypothesis; that is, there is a negative effect of interaction term between chief executive officer (CEO) duality and research and development (R and D) spending on firm performance.

The conceivable contributions to academics of the present study are as follows. First of all, it may shed light on the academic gap in the Taiwan emergent market, by advising the concepts regarding the case of aligning agency and resource–based theories. This paper may be one of pioneers to confer whether there is a significant effect of interaction term between CEO duality and R and D spending on firm performance. Secondly, it may clarify possible doubts derived from inconsistent outcomes in earlier papers through properly classifying the total samples by industries. None of papers reviewed thus far utilizes dividing samples into subgroups as analyzing procedures for the same research topic. The empirical processes of this work may provide a reference for academics.

LITERATURE AND HYPOTHESIS

Chief executive officer (CEO) duality and firm performance

Agency theory regards firms as systems of complex written and unwritten contracts among divergent individuals (Fama and Jensen, 1983). A firm's owner is characterized as the principal, and its managers, namely CEO, described as the agent. Fama (1980) proves that separation of firm owner and managers can be solved as an efficient form of economic group within the "set of contracts" view. CEO duality exists when the same person grasps both duties of chief executive officer and chairman of the boards in a firm (Rechner and Dalton, 1991). Through behaving as a chairman, CEO may obtain a broader authority and control (Hambrick and Finkelstein, 1987; Harrison et al., 1988; Patton and Baker, 1987), and then acquires ample influential power to secure more personal advantages (Finkelstein and D’Aveni, 1994). CEO duality would consequently gain much dominion “to advance their concerns rather than the benefits of owners” (Weisbach, 1988). Accordingly, agency theory would insinuate an opposite connection between CEO duality and firm performance. Yet, grounded in resource dependence theory (Pfeffer, 1972; Pfeffer and Salancik, 1978), corporate boards are a faculty to cope with outside connections and decrease surroundings’ uncertainty. Based upon this view, CEO duality might substantially ameliorate firm performance in definite settings. Previous studies concentrated on the relationship between CEO duality and firm performance have not thus far reached an accordant conclusion. Some researches imply that the relation amid CEO duality and firm performance presents toward a reversed direction (Berg and Smith, 1978; Florackis et al., 2009; Rechner and Dalton, 1991). Other scholars intimate that CEO duality forms a positive influence on firm performance (Boyd, 1995; Donaldson and Davis, 1991; Finkelstein and D’Aveni, 1994; He and Wang, 2009; Mallette and Fowler, 1992). Within this skeleton, they demonstrate that the connection between CEO duality
and firm performance may be either positive or negative. Therefore, CEO duality is expected to affect firm performance negatively or positively, depending on either agency theory or resource dependence theory, and thus this study hypothesize that:

H$_{1a}$ Upon agency theory, CEO duality is negatively correlated with firm performance  
H$_{1b}$ Upon resource dependence theory, CEO duality is positively correlated with firm performance

Research and development (R and D) spending and firm performance

Founded on resource dependence theory, there is a perhaps momentous unintended and accidental relation amid an executive's aptitude of firm resources and skills, and the preferable resources provisional decisions that are solitary to each respective firm (Barney, 1986; Castanias and Helfat, 1991; Connor, 1991; Coff, 1999; Dierickx and Cool, 1989; Hillman, 2003; Kor and Mahoney, 2005; Lippman and Rumelt, 1982; Mahoney and Pandian, 1992; Nelson and Winter, 1982; Penrose, 1959; Peteraf, 1993; Rumelt, 1984, 1987; Teece, 1980, 1982; Wernerfelt, 1984; Wang et al., 2009). Distinct intelligence gathers and evolution tactics lead to fundamental dissimilarity among firms from the viewpoint of extent of firm-specificity of their knowledge resources (Coff, 1997; Grant, 1996; Kogut and Zander, 1992; Wang et al., 2009).

Substantially, the hardship of duplicating other firms' R and D procedures or consequences impedes the spread of technical erudition among firms (Helfat, 1994; Wang et al., 2009).

Better coordinating of staffs' talents to R and D plans and assembles classically extends the fertileness of R and D inputs in originating energetic skills and supportable competitive advantages (Kor and Mahoney, 2005). A large number of studies have empirically examined and obtained a comparable research result that both R and D expenditure and firm performance exist a positive relationship (Abrahams and Sidhu, 1998; Belderbos et al., 2004; Branch and Chichirau, 2010; David et al., 2008; Ehie and Olibe, 2010; He and Wang, 2009; Hill and Snell, 1988; Lee and Shim, 1995; Parcharidis and Varsakelis, 2010; Pyykko, 2009; Tsai, 2004; Tsai and Wang, 2004; Wang et al., 2009; Wu and Tu, 2007). On this viewpoint, they show that the connections between R and D expenditure and firm performance may be positive.

Therefore, R and D expenditure is expected to affect firm performance positively, and thus this study hypothesize that:

H$_2$ Upon resource dependence theory, R and D expenditure is positively correlated with firm performance.

The moderating effects of interaction term between chief executive officer (CEO) duality and research and development (R and D) spending on firm performance

While resource dependence theory holds that matching firm-specific knowledgeable resources with its firm-specific human capabilities, a firm’s realistic performance may be divaricated nearly from its potential (Kim and Mahoney, 2005), agency theory handles the fitting governance of resource decisions (Kor and Mahoney, 2005). Firm resources may be misappropriated by managers; resource dependence theory has ignored the potential occurrence of agency theory for an interest conflict between managers and owners (Penrose, 1995). Various prior papers have implied that insomuch as the objectives and attempting attitudes of managers and owners are inconsistent, and accordingly managers incline to strengthen their benefits except to owners' concerns (Dalton et al., 2003; Eisenhardt, 1989; Fama, 1980; Hillman and Dalziel, 2003; Rediker and Seth, 1995; Shleifer and Vishny, 1997; Zahra and Pearce, 1989). Several corporate governance mechanisms may facilitate assurance; nevertheless, managers' decisions such as R and D expenditure would improve owners' wealth (Cui and Mark, 2002; Fama and Jensen, 1983; Shleifer and Vishny, 1997; Walsh and Seward, 1990; Xu and Zhang, 2004). Albeit some literature has explored the concept of moderating effects of corporate governance mechanisms on the relationship between R and D spending and firm performance, empirical studies in this area has thus, far been somewhat sparse (He and Wang, 2009; Kor and Mahoney, 2005; Le et al., 2006), and their empirical findings are mixed. As preceding mentioned arguments that CEO duality is expected to affect firm performance either negatively or positively, the relation between R and D expenditure and firm performance may be positive. To infer, the moderating effects of interaction term between CEO duality and R and D spending on firm performance may be negatively or positively, depending on either agency or resource dependence theories, and thus this study hypothesize that:

H$_{3a}$ Upon agency theory, the interaction term between CEO duality and R and D spending affects negatively firm performance  
H$_{3b}$ Upon resource dependence theory, the interaction term between CEO duality and R and D spending affects positively firm performance

The moderating effect of interaction term between chief executive officer (CEO) duality and research and development (R and D) spending on firm performance among industries

In view of empirical evidence that the moderating effects
of interaction term between CEO duality and R and D spending on firm performance is cloudy, the connected proposition of this field is worth further evaluating. Kor and Mahoney (2005) analyze the effect of the dynamics, management, and governance of R and D and marketing resource deployments on firm performance. Using 60 technology-based firms as analysis sample, parts of their research results show that institutional ownership boosts economic returns from marketing deployments, while diminishing returns from R and D spending. Accordingly, Le et al. (2006) confer the nature and significance of moderating effects of external monitoring on the relationship between R and D spending and firm performance. Their sample firms include 344 technology sector companies and 173 medical-related sector companies. The major portion of their results indicates that while institutional investors positively moderate the form of the R and D spending-performance relationship, independent outside board members influence the strength of that relationship. He and Wang (2009) discuss asymmetric moderating effects of monitoring- and incentive-based governance mechanisms on the relationship between innovative knowledge assets and economic performance. The total number of observations utilized for analysis was 736 manufacturing firms. Their empirical analysis provides that while CEO duality positively moderates the form of the R and D spending-performance relationship, outside blockholders negatively moderate that relationship.

From above mentioned studies, some pronounces governance mechanisms acting as a positively moderating effect, while other considers governance functions playing as a negatively moderating effect. To improve inconclusiveness generated from prior literature, this paper not only uses electronics industrial firms as the analysis sample, but total electronics industry samples are divided into three subgroups, namely the semiconductor electronics industry, the peripheral products industry and the other electronics industry. On account of specialty and sophistication of the electronics industry as a whole, the moderating effects of interaction term between CEO duality and R and D spending on firm performance vary with industries, and thus this study hypothesize that:

\[ H_4 \text{ The moderating effects of interaction term between CEO duality and R and D spending on firm performance vary with industries } \]

METHODS

Sample

This study attempts to discuss the moderating effects of interaction term between CEO duality and R and D spending on firm performance. Electronics industry firms listed on the Taiwan Stock Exchanges and the GreTai securities market are included in the study for the year of 2008. Based on the nature of specialty and sophistication of the electronics industry, total electronics industry samples are divided into three subgroups, namely the semiconductor electronics industry, the peripheral products industry and the other electronics industry. Related financial data needed is mainly gathered from the Taiwan Economic Journal dataset. Inappropriate data which is uneven or insufficient, and the financial industry whose accounting procedures far differs from the rest of industries, are excluded from the research sample. Total electronics industry samples involved in the study amount to 527 firms, including 117 firms of the semiconductor electronics industry, 99 firms of the peripheral products industry, and 311 firms of the other electronics industry.

Variable measurement

Both R and D spending and CEO duality are treated as independent variables. Many previous studies point out that R and D spending is positively or negatively related with firm performance (Cui and Mark, 2002; David et al., 2008; Ehie and Olibe, 2010; He and Wang, 2009; Ho et al., 2005; Parcharidis and Varsakelis, 2010; Tsai et al., 2004; Wang et al., 2009). The study extracts R and D expenses listed in the income statement of sample firms as the proxy of R and D spending of 2008. Some studies find that there is a positive relationship between CEO duality and firm performance (Chahine and Tohmé, 2009; He and Wang, 2009). Nevertheless, other studies suggest that CEO duality has a negative effect on firm performance (Jackling and Joli, 2009; Florackis et al., 2009). A well constructed CEO duality is defined as a general manager who serves concurrently as a chairman of the board. CEO duality is a dummy variable, equaling to 1 when a firm's CEO heads the board of directors as well, otherwise 0.

Evidence has proved that the interaction term between CEO duality and R and D spending has a positive effect on firm performance (He and Wang, 2008). The imperative goal of the study is to investigate if the interaction term between CEO duality and R and D spending would affect firm performance. R and D spending multiplied by CEO duality is thus, taken as the proxy of interaction term above mentioned.

Because R and D spending correlates closely with firm performance, especially for electronics industry firms, it is usually regarded as the source of firm's innovation (Griliches, 1990; Hall, 2000; Hall et al., 2005; Jaffe et al., 1993), and technological capability (Figueiredo, 2002; Duysters and Hagedoorn, 2000). R and D spending ordinarily let firms attain the improvement of efficiency and the enlargement of absorptive capacity, which on that occasion can guide firms to expand their value added (Cohen and Levinthal, 1990; Griliches, 1986). In line with previous studies (Goto and Suzuki, 1989; Lichtenberg and Siegel, 1991; Wakelin, 2001; Tsai and Wang, 2004; Tsai et al., 2008), value added is used as the proxy of firms' performance. Moreover, value added is a margin of profit which is computed by the gap between incomes of a firm and charge of a firm's substantial inputs (Tsai et al., 2008).

Some prior studies suggest that there is a positive relationship between firm size and innovative performance (Damanpour, 1991; Van de Ven and Poole, 1988; Boeker and Huo, 1998; Tsai et al., 2008). Whereas other studies adumbrate that, it is unable to prove the positive relationship between a firm's size and its innovative performance (Lichtenberg and Siegel, 1991). Furthermore, a firm's innovative performance decreases while its size increases (Acs and Audretsch, 1990). Referring from above studies, there is existent a significant relationship between a firm's innovative performance and its size, regardless of positiveness or negativeness. Therefore, it is necessary to contain various decisive control variables in the present study to furnish research models more integrated. Following prior papers (Lichtenberg and Siegel, 1991; Tsai and Wang, 2004; Tsai et al., 2008), both fixed capital and labor force
Table 1. Descriptive statistics and Pearson correlations for variables.

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>S.D.</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td><strong>Panel A</strong></td>
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<tr>
<td>Value added (1)</td>
<td>1,639,236</td>
<td>8,693,728</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fixed capital (2)</td>
<td>4,485,695</td>
<td>25,000,000</td>
<td>1</td>
<td>0.8**</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee (3)</td>
<td>819.89</td>
<td>2,186.96</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1*</td>
<td>-0.1</td>
<td>1</td>
</tr>
<tr>
<td>R and D (4)</td>
<td>387,736.5</td>
<td>1,410,101</td>
<td>0.5**</td>
<td>0.6**</td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>DUAL (5)</td>
<td>0.29</td>
<td>0.45</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1*</td>
<td>-0.1</td>
<td>1</td>
</tr>
<tr>
<td>RD * DUAL (6)</td>
<td>52,345.12</td>
<td>208,527.3</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1*</td>
<td>0.3**</td>
<td>1</td>
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<tr>
<td><strong>Panel B</strong></td>
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<tr>
<td>Value added (1)</td>
<td>2,019,115</td>
<td>14,044,181</td>
<td>1</td>
<td></td>
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<td></td>
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<tr>
<td>Fixed capital (2)</td>
<td>8,963,201</td>
<td>29,059,015</td>
<td>1</td>
<td></td>
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<tr>
<td>Employee (3)</td>
<td>1,249.17</td>
<td>3,023.75</td>
<td>0.8**</td>
<td>1</td>
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<tr>
<td>R and D (4)</td>
<td>806,304.3</td>
<td>2,492,667</td>
<td>0.6**</td>
<td>0.6**</td>
<td>1</td>
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<tr>
<td>DUAL (5)</td>
<td>0.25</td>
<td>0.43</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td>1</td>
</tr>
<tr>
<td>RD * DUAL (6)</td>
<td>79,739.90</td>
<td>310,199.70</td>
<td>0.1*</td>
<td>0.1</td>
<td>0.1</td>
<td>0.4**</td>
<td>1</td>
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<tr>
<td><strong>Panel C</strong></td>
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<tr>
<td>Value added (1)</td>
<td>2,187,623</td>
<td>5,288,922</td>
<td>1</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Fixed capital (2)</td>
<td>684,440.9</td>
<td>1,158,570</td>
<td>1</td>
<td></td>
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<td></td>
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<tr>
<td>Employee (3)</td>
<td>632.03</td>
<td>1,089.07</td>
<td>0.7**</td>
<td>1</td>
<td></td>
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<tr>
<td>R and D (4)</td>
<td>495,132.9</td>
<td>1,161,728</td>
<td>0.8**</td>
<td>0.7**</td>
<td>1</td>
<td></td>
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<tr>
<td>DUAL (5)</td>
<td>0.35</td>
<td>0.48</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td>1</td>
</tr>
<tr>
<td>RD * DUAL (6)</td>
<td>77,102.81</td>
<td>248,642.4</td>
<td>0.1</td>
<td>0.1</td>
<td>0.1</td>
<td>0.4**</td>
<td>1</td>
</tr>
<tr>
<td><strong>Panel D</strong></td>
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</tr>
<tr>
<td>Value added (1)</td>
<td>1,321,756</td>
<td>6,733,762</td>
<td>1</td>
<td></td>
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<td>Fixed capital (2)</td>
<td>4,011,276</td>
<td>37,514,062</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Employee (3)</td>
<td>718.20</td>
<td>2,056.18</td>
<td>0.9**</td>
<td>1</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>R and D (4)</td>
<td>196,081.6</td>
<td>717,997.8</td>
<td>0.5**</td>
<td>0.7**</td>
<td>1</td>
<td></td>
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</tr>
<tr>
<td>DUAL (5)</td>
<td>0.28</td>
<td>0.45</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.1</td>
<td>1</td>
</tr>
<tr>
<td>RD * DUAL (6)</td>
<td>34,157.98</td>
<td>131,987.4</td>
<td>0.1</td>
<td>0.1**</td>
<td>0.1*</td>
<td>0.4**</td>
<td>1</td>
</tr>
</tbody>
</table>

Note: Panel A, presented full electronics industry samples (N = 527); Panel B, presented semiconductor electronics industry samples (N = 117); Panel C, presented peripheral products industry samples (N = 99); Panel D, presented other electronics industry samples (N = 99); **, noted correlation was significant at the 0.01 level (two-tailed); *, noted correlation was significant at the 0.05 level (two-tailed). The unit of value added, fixed capital, and R and D was thousands in NT dollar; employee by the number of persons.

are involved in controls. Total fixed assets were considered as the proxy of fixed capital, and the sum of employee is the alternate of labor force.

RESULTS

Table 1 presented the descriptive statistics and correlation matrix for the major variables included in the present study. As shown in the correlation matrix, some of the correlations among explanatory variables and controls were significant and high enough to take on the possibility of multicollinearity. Reported in Tables 2, 3, 4 and 5, none of the variance inflation factor statistics exceeded the threshold value of 10 (Mason and Perreault, 1991; Neter et al., 1995), indicating that multicollinearity was no longer a remarkable problem. Observing the basic statistics of main variables discovered some interesting findings. In terms of each industry, the mean value of value-added for the peripheral products industry was significantly greater than both the semiconductor and other electronics industries, while the other electronics industry was the lowest one. The mean value of fixed capital, employee, and R and D expending for the semiconductor electronics industry were all the supreme of each industry. Indeed, the specialty of the semiconductor electronics industry was thus somewhat different from other industries, adumbrating that this industry might impersonate as a moderator.

The present study employed a three-stage hierarchical regression as the research analysis method (Le et al., 2006; Tsai et al., 2008; Kim et al., 2009). Based on the categorization of total samples, empirical results took in order, the electronics industry, the semiconductor electronics industry, the peripheral products industry, and the
other electronics industry, reported in Table 2, 3, 4 and 5 respectively. The first stage of analyzing procedure constructed Model 1, containing control variables covered fixed capital and employee. Model 2 of the following step added two leading influential factors of R and D spending and CEO duality. The interaction term, R and D spending multiplied by CEO duality, was finally entered into Model 3.

Results of Model 1 revealed some phenomena. Table 3 it indicated an insignificant and negative relationship between fixed capital and value added in semiconductor electronics industry ($\beta=0.13, p>0.1, R^2=0.43$). Whereas there was a significant and positive relationship between fixed capital and value added in both the peripheral products ($\beta=0.52, p<0.01, R^2=0.76$) and other electronics industries ($\beta=0.12, p<0.05, R^2=0.76$) reported in Tables 4 and 5. These outcomes suggested that of unique characteristics of both intense knowledge and capital for the semiconductor electronics industry was thus far apparently different from none of these characteristics for the both peripheral products industry and the other electronics industry.

In Model 2, evidence showed a significantly positive relationship between R and D spending and value added in each industry, namely the semiconductor electronics industry ($\beta=0.71, p<0.01, R^2=0.66$), the peripheral products industry ($\beta=0.69, p<0.01, R^2=0.91$), and the other electronics industry ($\beta=0.18, p<0.01, R^2=0.78$) in Table 3. While related statistics provided that of both CEO duality and value-added appeared an insignificant and negative relationship for the both peripheral products industry ($\beta=0.02, p>0.1, R^2=0.66$) in Table 3. While related statistics provided that of both CEO duality and value-added appeared an insignificant and negative relationship for the both peripheral products industry ($\beta=0.02, p>0.1, R^2=0.66$) in Table 3.
Table 4. Hierarchical regression results for peripheral products industry.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed capital</td>
<td>0.52(6.4)**</td>
<td>0.10(1.79)*</td>
<td>0.10(1.81)*</td>
<td>3.90</td>
</tr>
<tr>
<td>Employee</td>
<td>0.39(4.94)*</td>
<td>0.20(3.9)**</td>
<td>0.20(3.8)**</td>
<td>2.95</td>
</tr>
<tr>
<td>R and D</td>
<td>0.69(12.6)**</td>
<td>0.69(12.5)**</td>
<td>3.34</td>
<td></td>
</tr>
<tr>
<td>CEO duality</td>
<td>-0.01(-0.38)</td>
<td>-0.00(-0.193)</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>R and D * CEO duality</td>
<td>-0.01(-0.331)</td>
<td></td>
<td>1.28</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.76</td>
<td>0.91</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>Adj- R²</td>
<td>0.76</td>
<td>0.91</td>
<td>0.91</td>
<td></td>
</tr>
<tr>
<td>F-value</td>
<td>157.33</td>
<td>250.29</td>
<td>198.35</td>
<td></td>
</tr>
<tr>
<td>ΔR²</td>
<td>0.14</td>
<td>0.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔF</td>
<td>81.00</td>
<td>0.10</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: **, Noted predictive ability was significant at the 0.01 level (two-tailed); *, noted predictive ability was significant at the 0.05 level (two-tailed). Figures in parentheses were t-values.

Table 5. Hierarchical regression results for other electronics industry.

<table>
<thead>
<tr>
<th>Variables</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>VIF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed capital</td>
<td>0.12(1.8)*</td>
<td>0.23(3.3)**</td>
<td>0.20(2.9)**</td>
<td>6.88</td>
</tr>
<tr>
<td>Employee</td>
<td>0.76(11.20)*</td>
<td>0.52(6.4)**</td>
<td>0.56(6.8)**</td>
<td>9.62</td>
</tr>
<tr>
<td>R and D</td>
<td>0.18(4.6)**</td>
<td>0.18(4.7)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CEO duality</td>
<td>-0.02(-0.90)</td>
<td>0.01(0.33)</td>
<td>1.22</td>
<td></td>
</tr>
<tr>
<td>R and D * DUAL</td>
<td>-0.08(-2.7)**</td>
<td></td>
<td>1.27</td>
<td></td>
</tr>
<tr>
<td>R²</td>
<td>0.76</td>
<td>0.78</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>Adj- R²</td>
<td>0.76</td>
<td>0.77</td>
<td>0.78</td>
<td></td>
</tr>
<tr>
<td>F-value</td>
<td>496.11</td>
<td>271.15</td>
<td>232.20</td>
<td></td>
</tr>
<tr>
<td>ΔR²</td>
<td>0.01</td>
<td>0.005</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ΔF</td>
<td>11.70</td>
<td>7.69</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: **, Noted predictive ability was significant at the 0.01 level (two-tailed); *, noted predictive ability was significant at the 0.05 level (two-tailed). Figures in parentheses were t-values.

0.01, p>0.1, R²=0.91) and the other electronics industry (β=-0.02, p>0.1, R²=0.78) in Tables 4 and 5 respectively. The above results showed that the relationship between CEO duality and value-added seemingly varied depending on industrial specialty.

In line with the H₃a prediction, there was a significant and negative relationship between the interaction term, R and D spending multiplied by CEO duality, and value-added for the semiconductor electronics industry (β=-0.16, p<0.01, R²=0.68) and the other electronics industry (β=-0.08, p<0.01, R²=0.78) in Tables 3 and 5 respectively. Yet, for the peripheral products industry (β=-0.01, p>0.1, R²=0.91) in Table 4 only existed an insignificant and negative relationship between the interaction term, R and D spending multiplied CEO duality, and value-added.

The H₄ prediction proposed that the effect of interaction term between CEO duality and R and D spending on firm performance varied with industry differentiation. A Chow test of the difference in R² between the semiconductor electronics industry and the peripheral products industry did not achieve a statistical significance at the 5% level (F=1.66, p>0.05). Nor did the difference in R² between the semiconductor electronics industry and the other electronics industry achieve a statistical significance at the 5% level (F=2.31, p>0.05), using the same analysis procedure. These results implied that the effect of interaction term of CEO duality multiplied by R and D spending on firm performance did not significantly change in differences among industries.

CONCLUSIONS AND LIMITATIONS

This study examined the moderating effects of CEO duality on the relationship between R and D spending and firm performance. Using electronics industry firms listed on the Taiwan Stock Exchanges and the Gre-Tai securities market was as analysis sample firms. According to specializing and sophisticating traits for the electronics industry, total electronics industry samples are
divided into three subgroups, namely the semiconductor electronics industry, the peripheral products industry and the other electronics industry. Statistical facts revealed various interesting results. First, R and D spending had been proved to have a significantly positive effect on value added, demonstrating resource dependence theory could reasonably clarify the relationship between R and D spending and firm performance in Taiwan. This empirical result was consistent with a great number of prior researches (Branch and Chichirau, 2010; David et al., 2008; Ehie and Olibe, 2010; He and Wang, 2009; Parcharidis and Varsakelis, 2010; Pyykkö, 2009; Wang et al., 2009; Wu and Tu, 2007).

Secondly, the empirical evidence provided that the relationship between CEO duality and value added was thus far somewhat ambiguous. For the semiconductor electronics industry, CEO duality had been verified to have an insignificantly positive effect on value added, weakly accordant with resource dependent theory (Boyd, 1995; Finkelstein and D’Aveni, 1994; He and Wang, 2009; Mallette and Fowler, 1992). Whereas for the peripheral products industry, CEO duality had been confirmed to have an insignificantly negative effect on value added, it was feebly compatible with agency theory (Berg and Smith, 1978; Florackis et al., 2009; Rechner and Dalton, 1991).

Lastly, consistent with agency theory, the interaction term between CEO duality and R and D spending had been proved to have a significant and negative effect on value added for both the semiconductor electronics and other electronics industries, while it just had an insignificant and negative effect for the peripheral products industry.

The above findings were similar to prior literature (He and Wang, 2009; Kor and Mahoney, 2005). Moreover, a Chow test of the difference in R² between the semiconductor electronics industry and other two industries, namely the peripheral products industry and the other electronics industry, did not achieve a statistical significance at the 5% level, indicating unable to accept the anticipated hypothesis. These results suggested that the effect of interaction term of CEO duality multiplied by R and D spending on firm performance did not significantly vary from industry differentiation.

Beyond question, this study somewhat had its limitations. R and D spending was, above all, drawn just from R and D expenses listed in the income statements of a firm, ignoring its possible differences of over two-year research period. The above restriction mainly arose from this research period covering merely a single year of 2008, due to limited data resources.

Moreover, R and D spending had been largely considered as a major input for the electronics industry since this industry held the representative of the present study. Using electronics industry firms as analysis samples, empirical evidence thus could not make an inference for other non-electronics industries.

REFERENCES


