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Top management team characteristics, R&D investment and capital structure in the IT industry

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Abstract This paper is based on agency theory, resource-based and upper-echelons perspectives to examine the relationship between R&D investment and capital structure and the moderating effects of top management team (TMT) characteristics on the financing decisions of R&D investment in small and medium enterprises (SMEs). Using data for SMEs in Taiwan's IT industry, we find that (1) SMEs involved in R&D activities tend to have lower debt levels and (2) TMT characteristics exert considerable influence on the R&D investment-financial leverage relationship in SMEs. One important implication of the empirical evidence is that for SMEs trying to compete on the basis of innovation, the TMT characteristics significantly influence financing decisions. As innovative activities increase, the selection and development of top executives, who are responsible for choosing an optimal capital structure that could keep financial costs low while providing sufficient financial resources for maintaining a continuous, uninterrupted rate of R&D, is crucial for SMEs.

Keywords Top management team characteristics · R&D investment · Capital structure

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1 Introduction

In order to be successful in today's dynamic environment, businesses need to continuously invest substantial amounts into research and development (R&D) to achieve a competitive advantage (Schilling and Hill 1998). Nevertheless, R&D is a considerably risky long-term investment (Baysinger et al. 1991). Firms trying to compete on the basis of innovation need a capital structure that can continuously and uninterruptedly support R&D investment.

Generally, previous studies have suggested that in order to avoid the costs of debt requirements and maintain sufficient financial slack, firms prefer equity financing to debt to fund R&D activities. Some researchers argue that, owing to asset substitution, underinvestment and information asymmetry problems, debt holders of R&D firms are exposed to risks and will incorporate these problems into the yield they demand, which in turn increases the costs of debt

financing (Bah and Dumontier 2001; Ho et al. 2006). Some studies have suggested that R&D investment usually creates highly specialized and unique assets that cannot serve as collateral (Long and Malitz 1985; Vincente-Lorente 2001). Therefore, debt holders will require higher risk premiums; this consequently raises the transaction costs of debt financing (Williamson 1988; Kochhar 1996). Based on the resource-based view (RBV), some researchers argue that maintaining a continuous rate of R&D investment is a driver for firms to strengthen their competitive advantage (O'Brien 2003; Kor 2006). Financial slack (i.e., low leverage) can help ensure that firms have sufficient financial resources for the whole R&D process and can reduce uncertainty in operations (Nohria and Gulati 1996; O'Brien 2003).

Most previous studies on the R&D investment-capital structure relationship have examined only large firms (Himmelberg and Petersen 1994), and their empirical findings may not hold for smaller firms (Cassar and Holmes 2003). Barton and Matthews (1989) contend that modern financial theory based on the market's assessment of total stock valuation applies to large firms, whereas the financing decisions of smaller firms may be based more on personal managerial preference and risk-taking propensity. Top managers generally determine strategic choices in the organization, such as innovation and financial leverage (Bantel and Jackson 1989; Certo et al. 2006). If top managers in small firms have greater influence on corporate decisions, their idiosyncrasies are very likely to affect the financing decisions of R&D investment. This paper adopts Hambrick and Mason (1984)'s upper-echelons perspective to explore the moderating effects of top management team (TMT) characteristics on the R&D investment-capital structure relationship in smaller firms.

The information-technology (IT) industry in Taiwan provides an interesting example in which we can investigate the relationships among R&D investment, TMT characteristics and capital structure. First, Taiwan's manufacturing industry is mainly composed of small and medium enterprises (SMEs), and Taiwan's IT industry is widely regarded as the most predominant industry in the manufacturing industry (Yang and Huang 2005). Second, Taiwan's IT industry spends relatively more money on R&D than other industries (Tsai and Wang 2004). Using data from a sample of Taiwanese IT SMEs for the period 2000–2002, this paper uses agency theory, resource-based and upper-echelons perspectives to examine the links among R&D investment, TMT characteristics and capital structure. In contrast to previous studies, which have primarily focused on large firms and overlooked the TMT attributes involved in SME corporate decisions, the empirical results of this study should assist in understanding small firm financing decisions for innovative activities and the influence of TMT characteristics on the R&D investment-capital structure relationship.

Empirical analysis supports two main propositions: (1) SMEs involved in intensive R&D activities tend to have lower debt levels and (2) TMT characteristics exert considerable influence on the R&D-leverage relationship in SMEs. An important implication of the empirical evidence is that, for SMEs that rely on continuous investment in R&D for competitiveness, it is considerably important for boards and CEOs to select and develop top managers who will be able to choose an optimal capital structure that can keep financing costs low and provide sufficient financial resources for innovation.

2 Literature and hypotheses

2.1 Capital structure

Given certain simplifying assumptions, Modigliani and Miller (1958) propose that capital structure does not have an impact upon firm value. This famous capital structure 'irrelevance' proposition generated huge controversy at the time. By relaxing the tax-free assumption, Modigliani and Miller (1963) take the tax deductibility of interest payments into consideration and propose that the firm value increases with financial leverage. One interesting question is thus raised, that of why all firms are not levered to capacity in order to maximize firm value.

The costs of debt financing could act to offset the benefits of interest payments (Jensen and Meckling 1976; Andrade and Kaplan 1998; O'Brien 2003). These costs may arise from financial distress costs. As the financial leverage rises, so too does the probability that a firm will fail to meet its debt obligations. If the firm defaults, it is very likely to have to declare itself bankrupt and have to pay some costs associated with bankruptcy, such as legal and

administrative expenses. Additionally, the costs of debt financing may come from agency costs. Debt holders would generally demand protection by resorting to monitoring and bonding mechanisms if equity holders tended to expropriate wealth from them (Jensen and Meckling 1976). The agency costs of debt between debt holders and equity holders thus occur and could offset the tax benefits of debt. Nevertheless, the debt-monitoring hypothesis (Jensen 1986; Harris and Raviv 1990) suggests that greater leverage can serve as a bonding device against managerial discretion, because debt reduces the amount of free cash flow available to managers and pressures them to work harder, consume fewer perquisites and make better decisions (Zantout 1997). Accordingly, increased leverage may reduce the total agency costs of debt (O'Brien 2003).

The potential benefits and costs of debt financing have encouraged researchers to determine whether an optimal capital structure exists; however, the empirical results still remain contradictory. The static tradeoff theory of capital structure states that "firms borrow up to the point where the tax benefit from an extra dollar in debt is exactly equal to the cost that comes from the increased probability of financial distress" (Ross et al. 2000, p. 504). It is thus implied that there is an optimal capital structure that balances the benefits and costs of debt financing. Nevertheless, Myers and Majluf's (1984) pecking order theory argues that there is no well-defined optimal debt level for a firm. Owing to information asymmetry and the signaling problems associated with external sources of financing, firms prefer internal (i.e., retained earnings) to external funding, and debt to equity if retained earnings are not sufficient to fund projects.

The benefits and costs of debt financing may account for the differences in financing decisions made by large and small firms. Compared with large firms, small firms face lower marginal tax rates, higher bankruptcy costs and more difficulties in signaling business quality to creditors (McConnell and Pettit 1984; Balakrishnan and Fox 1993; Chaganti et al. 1996). Because they receive less tax benefit and bear higher financial risk and costs of debt, small firms generally have less debt than large firms (Barton and Matthews 1989). Additionally, protective covenants and monitoring devices asserted by debt holders can affect top management's decision-making control and flexibility (Modigliani and Miller 1958; Michaelas et al. 1999). Top managers of small firms and entrepreneurs who fear losing control and flexibility are more likely to assume small amounts of debt (Barton and Matthews 1989).

2.2 R&D investment and capital structure

Since Jensen and Meckling (1976) proposed that financing and investment decisions are interactive processes, the door has been opened for researchers to explore how the choice of investments, such as R&D investment, can influence a firm's capital structure. Prior work on this issue has focused mainly on four aspects: agency cost problems, asset specificity and uniqueness, information asymmetry problems and financial slack (Kale and Shahrur 2007).

Agency cost problems between debt holders and firms render debt financing of R&D investment more expensive and thus make debt prohibitive. Because R&D projects are very difficult to monitor and estimate, underinvestment and asset substitution detrimental to debt holders are more likely to occur (Bah and Dumontier 2001; Ho et al. 2006). For asset substitution, the agency problem arises when shareholders engage in high-risk investments and expropriate value from the debt holders (Jensen and Meckling 1976; Garvey and Mawani 2005). For underinvestment, the agency problem arises when shareholders bypass relatively safe, positive net present value opportunities at the expense of debt holders (Myers 1977). Bearing risks from the underinvestment and asset substitution problems, debt holders would require a higher risk premium, which in turn increases the costs of debt. In order to avoid the increased costs of debt, firms may use equity to fund R&D initiatives and will therefore have lower debt levels. In light of the above, Bah and Dumontier (2001) show that R&D-intensive firms have significantly lower debt levels. Similarly, numerous studies have proposed that firms with considerable growth opportunities (and, correspondingly, firms with significant R&D opportunities) prefer equity financing to debt (Myers 1977; Jensen 1986; Balakrishnan and Fox 1993; Ho et al. 2004).

Firms with a large stock of specific and unique assets cannot borrow as much as others. Long and Malitz (1985) argue that R&D investment creates intangible assets that are less capable of supporting

debt because these assets are largely non-tradable and cannot be used as good collateral for borrowing. Similarly, Williamson's (1988) transaction costs economics framework states that most highly specialized and unique assets are non-tradable and cannot serve as collateral. This increases governance costs and consequently raises the transaction costs of debt financing. In this vein, numerous researchers have found that firms lacking in specialized assets have lower transaction costs and thus will generally prefer debt financing (Kochhar 1996; Vincente-Lorente 2001), whereas highly specific R&D investments are associated with lower debt levels (Bah and Dumontier 2001).

The problem of information asymmetry in R&D between debt holders and firms may cause firms investing in R&D to opt to maintain lower levels of debt. According to Himmelberg and Petersen (1994) and Bah and Dumontier (2001), information asymmetries may be more severe in R&D firms for two primary reasons. First, the nature of R&D makes it difficult for capital suppliers to appraise innovative projects accurately. Second, managers generally withhold R&D information for confidentiality reasons, because information transmitted to capital suppliers may also convey useful technological knowledge to rivals. In the light of these two reasons, debt holders may overestimate the R&D risks and demand a premium that further increases the costs of debt (Singh and Faircloth 2005). In terms of equity financing, equity providers may demand high ownership stakes; accordingly, equity financing may dilute ownership control and reduce shareholder wealth (Wu et al. 2007). However, Weaver (1956) argues that control is likely to be diluted only if stock is sold to one person or a small group. With equity financing, the original owners or executives can still retain control if stock is sold to the public or a special stock/trust arrangement is made. Furthermore, equity financing provides managers with greater autonomy in project choice than debt financing (Dittmar and Thakor 2007). Moreover, R&D investments have highly uncertain outcomes. Using equity capital, a firm would not need to suffer liquidity pressure from making a loan payment as it would by using debt (Ou and Haynes 2006) and may reduce the risk of running out of cash while trying to compete on the basis of innovation. In brief, information asymmetries can increase the costs of debt, as well as the costs of equity. However, as R&D investments tend to have a highly uncertain future cash flow and generally create intangible assets, most R&D firms with limited tangible assets as a source of collateral find it more difficult to raise the required funds via debt financing as compared with equity financing. Additionally, to maintain decision-making flexibility and avoid liquidity pressure from making a loan payment, managers may consider equity, not debt, as the main source of funds in financing R&D.

Based on the resource-based view (RBV), some researchers have argued that firms dedicating large sums to R&D will not want to borrow much (Dierickx and Cool 1989; O'Brien 2003; Singh and Faircloth 2005). RBV states that competitive advantage can be strengthened to respond rapidly to unpredictable and changeable market conditions by continuously developing existing and creating new resources and capabilities (Barney 1991). Accordingly, maintaining a continuous, uninterrupted rate of R&D investment is essential for firms competing on innovation in order to be successful in the globally competitive market (O'Brien 2003; Kor 2006). Any interruptions or reductions in cash flow for R&D may be detrimental to (1) forming and accumulating the stock of R&D know-how (Dierickx and Cool 1989), (2) launching new products (Bromiley 1991) and (3) enhancing the knowledge base through making acquisitions (Karim and Mitchell 2000). According to O'Brien (2003), financial slack can help to provide insulation against cash flow fluctuation, ensure firms have sufficient financial resources to get new products to market and assist firms to expand their stock of knowledge via acquisitions. O'Brien also finds that R&D intensity is negatively associated with financial leverage, suggesting that firms trying to compete on the basis of innovation should choose capital structures that provide sufficient financial slack. Similarly, Singh and Faircloth (2005) find that R&D-intensive firms exhibit lower debt by arguing that greater leverage will lead to a lower amount of funds being available for R&D investment.

This risk differential associated with default, monitoring difficulties and information asymmetries between large and small firms may be significantly greater when the latter finance innovative investments (Cassar 2004; Wu et al. 2007). Bhagat and Welch (1995) find no relationship between R&D and debt ratio for large US firms, and a significant

negative relationship for smaller firms. Bhagat and Welch (1995) further suggest that smaller firms are very likely to be subject to severe financial distress costs and are more sensitive to their debt level when they increase R&D spending. The findings of Bhagat and Welch (1995) imply that smaller firms prefer not to assume large amounts of debt in order to safeguard their R&D investments. It thus follows that equity capital, not debt, is considered the natural financial instrument for high-technology entrepreneurs and small business firms to fund R&D initiatives. Ou and Haynes (2006) argue that, due to highly variable profits, severe information asymmetries and lack of collateral, high growth technology firms are more likely to depend on equity. Similarly, numerous previous studies have suggested that entrepreneurs and small business managers may be more inclined to use equity financing for growth and new investment (Chaganti et al. 1996; Ortqvist et al. 2006; Dittmar and Thakor 2007).

The above analysis indicates that to avoid the costs of debt requirements and to maintain sufficient financial slack, SMEs with higher levels of R&D should select a conservative capital structure (i.e., lower debt). Specifically, this paper proposes the following hypothesis:

Hypothesis 1 There is a negative relationship between R&D investment and financial leverage.

2.3 TMT characteristics and the R&D investment-financial leverage relationship

Previous studies on the R&D investment-capital structure relationship have almost invariably focused on large firms, but their empirical findings may not hold for smaller firms (Cassar and Holmes 2003). Unlike large firms, most small firms are not traded actively on a financial market. Levin and Travis (1987) point out that "(t)he owners' attitudes toward personal risk—not the capital structuring policies public companies use—determine what amounts of debt and equity are acceptable" (p. 30). Accordingly, Barton and Matthews (1989) infer that, unlike large firms focusing on the financial market-based perspective, the financing decisions of small firms are based more on personal managerial preferences. Furthermore, compared with large firms, small firms have simpler organizational structures and communication channels (Kor 2006). Miller (1991) thus argues that CEOs can have greater influence.

As top managers determine the strategic choices in an organization, such as innovation and financial leverage (Bantel and Jackson 1989; Certo et al. 2006), it is very likely that TMT characteristics and desires exert considerable influence on the R&D-leverage relationship, particularly in small firms. Below, this paper adopts Hambrick and Mason (1984)'s upper-echelons perspective and considers four visible characteristics of team compositions, including TMT tenure, age, education level and stock ownership, in order to explore whether and how TMT characteristics affect small firm financing choices for R&D investment.

2.3.1 TMT tenure

The average tenure of team members might affect their attitudes toward the financing choice for R&D investment. Past empirical research has argued that managers' tenure affects their willingness to take risky action (Scherer and Ross 1990; Barker and Mueller 2002). Managers with less tenure in the firm may lack legitimacy in the eyes of certain internal or external stakeholders (Miller 1993) and are therefore more likely to take risks and invest heavily in R&D in order to prove themselves as competent managers (Kor 2006). Accordingly, shorter tenured managers may be more willing to assume debt for R&D outlays even though debt financing is costly due to the asset specificity and uniqueness associated with R&D.

On the other hand, longer tenured managers may have a more risk-averse approach towards funding R&D initiatives because there is less pressure on them to prove themselves. They may operate the organization based on their own paradigm (Hambrick and Fukutomi 1991; Barker and Mueller 2002), may become reluctant to make changes (Grimm and Smith 1991) and are possibly less likely to make investment decisions that could keep the firm progressing over time (Miller 1991; Barker and Mueller 2002). Based on these points, longer tenured TMTs may emphasize stability (Barker and Mueller 2002) and avoid taking risks in strategic actions (Kor 2006). Additionally, longer tenured managers may be more experienced to recognize the bankruptcy risks associated with

higher leverage. Accordingly, they would tend to choose a more conservative capital structure that involves lower financial risk when financing R&D. Specifically, this paper hypothesizes the following:

Hypothesis 2 The negative relationship between R&D investment and financial leverage is stronger with respect to long-tenured TMTs.

2.3.2 TMT age

Managers' age may affect their attitude to risk. Younger managers will be more inclined to pursue risky strategies, whereas older managers tend to be more conservative (Hambrick and Mason 1984; Barker and Mueller 2002). Younger managers may have a more risk-taking approach for three major reasons. First, younger managers may be more capable of learning and integrating information in making decisions, and thus may have more confidence in decisions (Taylor 1975). Second, as they have received their education more recently, younger mangers have technological knowledge superior to that of older managers (Bantel and Jackson 1989). Third, younger managers may be apt to take risks because their financial and career security concerns are a long way away on the horizon (Vroom and Pahl 1971; Barker and Mueller 2002).

R&D spending is considerably risky, and its payoffs may be generated only in the long run, if at all. Therefore, with regards to funding R&D activities, older TMTs with the propensity to be risk-averse and with financial and career security concerns would tend to choose a more conservative capital structure, whereas younger TMTs may be more willing to use more debt. The specific hypothesis is as follows:

Hypothesis 3 The negative relationship between R&D investment and financial leverage is stronger with respect to older TMTs.

2.3.3 TMT education level

Higher levels of education are associated with greater cognitive ability (Wally and Baum 1994) and as such could lead to a better ability to tolerate ambiguity (Wiersema and Bantel 1992), to grasp new ideas (Barker and Mueller 2002), to learn new behaviors and to generate and implement creative solutions to complicated problems (Bantel and Jackson 1989). Following this line of reasoning, a number of empirical studies have argued that CEOs and top managers educated to higher levels are more capable of generating rich and complex ideas for problem-solving and thus have a tendency to more easily accept innovation (Kimberly and Evanisko 1981; Bantel and Jackson 1989; Barker and Mueller 2002).

According to previous research and the reasoning discussed above, more educated TMTs possess advanced knowledge and greater cognitive ability. This in turn could enhance their ability to tolerate ambiguity, to absorb new information and to analyze, solve and implement solutions to complex problems. Therefore, they may be quite confident of their decisions in R&D investment and would not need as much financial slack as less-educated TMTs. More specifically, more-educated TMTs would be less likely to opt for a conservative capital structure when financing R&D investment. This paper thus hypothesizes the following:

Hypothesis 4 The negative relationship between R&D investment and financial leverage is weaker with respect to more educated TMTs.

2.3.4 TMT stock ownership

Hambrick and Mason's (1984) upper-echelons perspective proposes that the financial position of top managers will affect their strategic choices in innovation and financial leverage. Agency theory also suggests that substantial at-risk wealth could motivate CEOs and top mangers to be more long-term oriented. Owing to their underdiversification, risk-averse managers generally have an incentive to under-leverage the firm (Haugen and Senbet 1981; Berger et al. 1997) and under-invest in R&D (Smith and Watts 1992). A higher level of stock ownership could align managerial objectives and shareholder objectives (Chen and Huang 2006) and motivate top managers to undertake risky investment (Wright et al. 2007). This consequently may mitigate the under-leverage and under-investment problems (Smith and Watts 1992; Nam et al. 2003). Additionally, owner managers may be more inclined to debt financing since it allows them to control dilution of ownership due to equity financing.

Pursuing this line of reasoning, TMTs with significant at-risk wealth would be prone to increase debt levels to fund R&D projects if they consider R&D investment essential for firm growth and shareholder wealth maximization. This paper thus hypothesizes the following:

Hypothesis 5 The negative relationship between R&D investment and financial leverage is weaker with respect to a high percentage of shares owned by TMTs.

3 Research methods

3.1 Sample

The study sample includes small and medium IT firms listed on the Taiwan Stock Exchange (TSE) and the Over-the-Counter Market (OTC) during the period 2000–2002. The IT industry was selected because of the high priority it affords R&D (Tsai and Wang 2004). Additionally, this paper is particularly interested in analyzing SMEs because SMEs have more innovative activities (Yang and Huang 2005) and are more likely to be influenced by TMT characteristics (Levin and Travis 1987; Wright et al. 2007). According to Aw (2002), the standard definition of an SME is a firm that employs 300 or fewer workers; hence, this was chosen as criterion for the SMEs analyzed in this study.

The financial data were taken from the Taiwan Economic Journal Data Bank. TMT demographics were collected from company annual reports, *The Manager Directory in Taiwan* and *Business Groups in Taiwan*, published by the China Credit Information Service, *Who's Who in the Republic of China* published by the Central News Agency, and *Who's Who in Finance and Economics in the Republic of China* published by Commercial Times. Firms were excluded if complete information on financial data or TMT characteristics was unavailable. The final sample consisted of 95 companies and generated 162 company-years of analyzable observations. The representativeness of the final sample was checked by comparing the mean of the total assets (firm size) of the final sample with that of the original data set. The χ^2-test result was insignificant, suggesting no significant bias in the original data set.

3.2 Measurement of variables

3.2.1 Dependent and independent variables

The dependent variable *Leverage* represents capital structure and is measured as the ratio of total debt to total assets (Bah and Dumontier 2001; Frye 2004). The independent variable *R&D Ratio* represents the firm-level investment in R&D and is scaled by total sales (Baysinger et al. 1991; O'Brien 2003).

3.2.2 Moderators

Consistent with other upper-echelons studies, the TMT is defined as including the very highest level of management and the next highest tier (Wiersema and Bantel 1992; Carpenter et al. 2004). This paper selects some of the most commonly examined attributes of top managers, including tenure with the team, age, education level attained and stock ownership. The two variables *Tenure* and *Age* are calculated by aggregating the values of a team's members and taking the mean (Wiersema and Bantel 1992; Carpenter 2002). Following a method used by other researchers (Bantel and Jackson 1989; Barker and Mueller 2002), *Education Level* is measured on a seven-point scale reflecting the highest level of education attained (1 = elementary school, 2 = junior high school, 3 = high school, 4 = 2-year college, 5 = 4-year university, 6 = master degree and 7 = Ph.D. degree). *Shareholding* is calculated as the total percentage of shares held by TMT members (Nam et al. 2003; Kor 2006).

3.2.3 Control variables

Numerous firm-level control variables are used in the analyses to account for alternative determinants of capital structure. The variable *Past Profitability* controls for accounting performance in the previous year, as measured by return on assets (Barton and Gordon 1988; Hovakimian et al. 2001). The total number of employees (logarithm is taken to correct for skewness) is included as a measure of *Firm Size* (Barker and Mueller 2002). The variable *Tangible Assets* is calculated by dividing the total property, plant and equipment by total assets (Hovakimian et al. 2001; O'Brien 2003). *Capital Intensity* is computed by dividing the total assets by total sales

(Barton and Gordon 1988; O'Brien 2003). *Firm age* is the number of years a firm has been in existence (Westhead and Storey 1997; Zahra 2003; Honjo and Harada 2006).

To control for the industry effects, a single dummy variable is created for each two-digit IT industry, leading to three dummy variables (coded 1 for one two-digit IT industry, 0 otherwise). SIC codes, obtained from the Directorate-General of Budget, Accounting and Statistics, Executive Yuan, R.O.C., are used to classify the sample firms into four two-digit IT industries: electronic products manufacturing, electronic parts and components manufacturing, integrated circuit design services, and software and systems design services.

3.3 Methodology

To control for the potential confounding effects of R&D investment and capital structure, a pooled regression with fixed-year effects is utilized as described below.

4 Empirical results

The means, standard deviations and Pearson product–moment correlations of the variables are presented in Table 1. In terms of the dependent and independent variables, the average leverage and R&D ratios are 37.23 and 5.53%, respectively. In terms of TMT characteristics, the average age of team managers is 51.65, and they have been employed as top managers for 5.67 years on average. The mean level of education attained by the sample top managers is somewhere between having an undergraduate and a master's degree. The average stock share that top managers have is 9.17%.

The matrix in Table 1 indicates that there is a significant correlation between R&D ratio and capital intensity (0.55), suggesting multicollinearity between these two variables. The variance inflation factors (VIF) of the independent and control variables were therefore calculated to test for the effects of multicollinearity in the regression analysis. These results (1.13–1.78) suggest the absence of multicollinearity.

$$\begin{aligned} Leverage_{it} = {} & \beta_0 + \beta_1(R\&D\,Ratio_{it-1}) + \beta_2(Past\,Profitability_{it-1}) + \beta_3(Firm\,Size_{it-1}) \\ & + \beta_4(Tangible\,Assets_{it-1}) + \beta_5(Capital\,Intensity_{it-1}) + \beta_6(Firm\,Age_{it-1}) \\ & + \beta_7(Industry\,Dummy_i) + \varepsilon_{it} \end{aligned} \tag{1}$$

To investigate the moderating effects of TMT characteristics on the R&D-leverage relationship, the following equation extended from Eq. 1 is utilized.

To control for firm and industry effects on capital structure, regression analyses were performed in a step-wise manner as reported in Table 2. Model 1

$$\begin{aligned} Leverage_{it} = {} & \beta_0 + \beta_1(R\&D\,Ratio_{it-1}) + \beta_2(Tenure_{it-1}) + \beta_3(Age_{it-1}) \\ & + \beta_4(Education\,Level_{it-1}) + \beta_5(Shareholding_{it-1}) \\ & + \beta_6(R\&D\,Ratio_{it-1}) * (Tenure_{it-1}) + \beta_7(R\&D\,Ratio_{it-1}) * (Age_{it-1}) \\ & + \beta_8(R\&D\,Ratio_{it-1}) * (Education\,Level_{it-1}) \\ & + \beta_9(R\&D\,Ratio_{it-1}) * (Shareholding_{it-1}) + \beta_{10}(Past\,Profitability_{it-1}) \\ & + \beta_{11}(Firm\,Size_{it-1}) + \beta_{12}(Tangible\,Assets_{it-1}) \\ & + \beta_{13}(Capital\,Intensity_{it-1}) + \beta_{14}(Firm\,Age_{it-1}) \\ & + \beta_{15}(Industry\,Dummy_i) + \varepsilon_{it} \end{aligned} \tag{2}$$

Table 1 Means, standard deviations and correlations

Variables	Mean	SD	1	2	3	4	5	6	7	8	9	10
1. Leverage (in %)	37.23	17.61	–									
2. R&D ratio (in %)	5.53	7.38	−0.21**	–								
3. TMT tenure	5.67	3.47	−0.03	−0.14	–							
4. TMT age	51.65	7.07	0.12	0.10	0.18*	–						
5. TMT education	5.25	0.86	0.01	0.32**	−0.15	0.09	–					
6. TMT shareholding (in %)	9.17	7.15	0.17*	−0.03	0.14	0.05	−0.17*	–				
7. Past profitability (in %)	3.25	13.55	−0.35**	−0.12	0.08	0.03	−0.05	0.02	–			
8. Firm size (in log)	5.09	0.50	0.02	−0.16*	0.01	−0.09	0.03	−0.05	0.14	–		
9. Tangible assets (in log)	2.65	0.81	0.08	0.14	−0.11	0.17*	0.15	0.26**	−0.23**	0.28**	–	
10. Capital intensity (in %)	1.99	2.24	−0.10	0.55**	−0.07	−0.01	0.10	0.02	−0.18*	0.01	0.18*	–
11. Firm age (in log)	2.63	0.49	−0.02	−0.12	0.07	−0.19*	−0.35**	0.05	−0.08	0.01	−0.02	0.20*

Note: † $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$. $N = 162$

examines the firm and industry effects and shows that about 16.08% of the variance in sample firms relative debt levels can be explained by these factors. In particular, higher past profitability ($p < 0.001$) is associated with decreased financial leverage. The integrated circuit design services industry ($p < 0.1$) has lower debt ratios compared with those of the electronic parts and components manufacturing industry.

Model 2 in Table 2 represents the regression model to which the R&D ratio has been added. The regression results demonstrate that R&D investment is significantly and negatively associated with leverage ($p < 0.05$).This finding lends support to hypothesis 1 and is consistent with the argument that to avoid the costs of debt requirements and to provide sufficient financial slack, SMEs making sizable R&D investments may have lower debt levels. The empirical evidence may further imply that equity financing, which provides the management with greater autonomy in decision-making and control than debt financing (Dittmar and Thakor 2007) and relieves the firm from liquidity pressure in making loan payments (Ou and Haynes 2006), could be the natural financial instrument for high-technology entrepreneurs and small business firms to fund growth and new investment, such as R&D (Himmelberg and Petersen 1994; Chaganti et al. 1996; Ortqvist et al. 2006; Ou and Haynes 2006; Dittmar and Thakor 2007).

According to Model 3 in Table 2, both TMT age and shareholding exert a positive direct effect on leverage. TMT tenure is not significantly related to leverage, despite its negative coefficient; TMT education level is also insignificantly related to leverage, despite its positive coefficient.

To examine the influence of TMT characteristics on the R&D-leverage relationship, a moderated multiple regression was conducted. To avoid the multicollinearity problem between predictor variables and the interaction terms that include these predictor variables, the R&D ratio and TMT characteristics are centered by their means, as suggested by Aiken and West (1991). As shown in Model 4, Table 2, the interaction of R&D ratio with TMT age is significantly negative (−0.07), thus suggesting that the negative R&D-leverage relationship becomes stronger with increasing TMT age. The empirical evidence is consistent with the argument that older top managers are associated with inflexibility, poor learning and analytical ability, and their risk-averse propensity would tend to lead them to choose a more conservative capital structure when financing R&D investment.

Model 4 also indicates that the interactions of R&D ratio with TMT education level and shareholding are significantly positive (+0.76 and +0.09, respectively) in relation to leverage. The positive and significant moderating effect of TMT education level

Table 2 Results of regression analysis

Variables	Model 1	Model 2	Model 3	Model 4
Controls				
Past profitability	−0.44***	−0.46***	−0.49***	−0.45***
	(−4.11)	(−4.36)	(−4.74)	(−4.39)
Firm size	1.96	0.73	2.92	5.67*
	(0.71)	(0.26)	(1.06)	(2.03)
Tangible assets	0.90	1.03	−1.83	−2.67
	(0.50)	(0.58)	(−0.97)	(−1.37)
Capital intensity	−0.95	−0.02	−0.01	0.22
	(−1.52)	(−0.03)	(−0.02)	(0.30)
Firm age	−2.52	−3.54	−2.01	−2.45
	(−0.89)	(−1.25)	(−0.70)	(−0.88)
Electronic products manufacturing	−3.71	−2.41	−2.23	−2.57
	(−1.06)	(−0.69)	(−0.64)	(−0.72)
Integrated circuit design services	−8.20†	−4.40	−6.23	−3.64
	(−1.89)	(−0.96)	(−1.36)	(−0.78)
Software and systems design services	7.16	7.52†	7.46†	7.23†
	(1.61)	(1.71)	(1.70)	(1.69)
TMT tenure			−0.50	−0.83*
			(−1.31)	(−2.13)
TMT age			0.45*	0.32†
			(2.39)	(1.72)
TMT education			1.65	2.85
			(0.97)	(1.58)
TMT shareholding			0.54**	0.66***
			(2.90)	(3.60)
Main effect				
R&D ratio		−0.53*	−0.55*	−0.97**
		(−2.25)	(−2.34)	(−2.87)
Moderated effects				
R&D ratio × TMT tenure				−0.11
				(−1.38)
R&D ratio × TMT age				−0.07†
				(−1.89)
R&D ratio × TMT education				0.76*
				(2.16)
R&D ratio × TMT shareholding				0.09**
				(2.79)
Adjusted R^2 (in %)	16.08	18.28	23.32	29.16
Change in adjusted R^2 (in %)	Na	2.20	5.04	5.84
F value	4.08***	4.27***	4.26***	4.49***

Note: † $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, two-tailed coefficient tests. $N = 162$. Standardized coefficients are presented with standard errors in parentheses

suggests that the negative R&D-leverage relationship becomes weaker when top managers are educated to higher levels. This evidence is consistent with the argument that a higher level of education could enhance top managers' ability to tolerate ambiguity, to absorb new information and to analyze, solve and implement the solutions to complex problems. This in turn enables them to be quite confident in their decisions regarding R&D investment, and they may not then require as much financial slack as

less-educated managers. Additionally, the positive and significant moderating effect of TMT shareholding suggests that the negative relationship between R&D investment and capital structure becomes weaker as the stock ownership of top managers increases. This evidence is consistent with agency theory arguments that top managers with a significant at-risk wealth may consider that spending money on R&D investment is essential for firm growth and shareholder wealth maximization and therefore would tend to take on more debt to fund R&D activities.

Model 4 shows that TMT tenure is negatively, but not significantly associated with the R&D-leverage relationship. Some previous studies have utilized subgroup analysis to investigate the effects of tenure (Miller 1991; Barker and Mueller 2002). To further examine the moderating effect of TMT tenure, this paper follows the method of Miller (1991) and splits the sample into short- and long-tenured subgroups according to median TMT tenure. Regression analysis was then performed using the variables from Model 2 in Table 2. The subgroup analysis reported in Table 3 shows that the R&D ratio exerts a negative and significant association with leverage in the long-tenure subgroup, but is insignificant in the short-tenure subgroup. The magnitude of coefficient (−0.74) of the long-tenure subgroup is lower than that of the short-tenure subgroup (−0.19), indicating that R&D investment is more negatively associated with leverage in the long-tenure subgroup. The empirical results suggest that TMTs prefer a more conservative capital structure when financing R&D investment as their tenure increases. The subgroup analysis results are consistent with the argument that as their tenures increase, top managers become more risk averse and tend to avoid anything that may endanger their wealth and jobs. Therefore, longer tenured managers may prefer a lower debt level, which involves lower financial risk, when financing R&D investment.

Table 3 Subgroup analysis based on TMT tenure

Variables	TMT Tenure ≤ median	TMT Tenure > median
R&D ratio	−0.19	−0.74*
	(−0.49)	(−2.41)
Past profitability	−0.31*	−0.62***
	(−2.16)	(−4.91)
Firm size	7.66†	−7.30*
	(1.88)	(−2.36)
Tangible assets	−4.55†	10.75***
	(−1.93)	(4.77)
Capital intensity	−2.02	0.24
	(−1.57)	(0.32)
Firm age	−0.59	10.68**
	(−1.33)	(3.01)
Industry		
Electronic products manufacturing	−4.19	−2.27
	(−0.83)	(−0.61)
Integrated circuit design services	−3.75	0.89
	(−0.58)	(0.17)
Software and systems design services	8.19	2.82
	(1.36)	(0.55)
Adjusted R^2 (in %)	23.85	51.88
F value	3.25**	8.94***
No. of observations	80	82

Note: † $p < 0.1$; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$, two-tailed coefficient tests. $N = 162$. Standardized coefficients are presented with standard errors in parentheses

5 Conclusion

Using data on SMEs in Taiwan's IT industry, this paper investigates SMEs' financing decisions with regard to R&D investment, with specific emphasis on assessing the role played by top managers. The empirical results indicate a negative relationship between R&D investment and leverage, suggesting that firms with R&D expenditures may prefer equity to debt financing in order to maintain financial slack and avoid the increased costs of debt resulting from the problems of asset substitution, underinvestment, information asymmetry and asset specificity. Furthermore, this paper provides evidence that top managers exert considerable influence on small firm financing decisions regarding R&D investment. Specifically, the negative R&D-leverage relationship becomes stronger in firms led by longer tenured or older top mangers and weaker in firms where top managers are more educated or have greater stock ownership. The empirical results thus suggest that longer tenured or older managers are conservative and tend to avoid any financial risk that may threaten their reputations and job security. Accordingly, they may prefer equity to debt when financing R&D activities. Additionally,

more educated managers may be more capable and confident in their decision-making, and managers with a higher ownership stake may have more incentives to maximize shareholder returns, and therefore would be more willing to adopt risky strategies. Accordingly, they are more likely to use debt for R&D investments.

This paper has undertaken to advance both theory and management practices. In terms of theory, rather than exploring the issue of the effect of a firm's investment decision on its financing decision from one single perspective, this paper tries to look more broadly at this issue from a cross-functional perspective. Most previous studies have been based on agency theory or resource-based perspectives to investigate the R&D investment-capital structure relationship (Bah and Dumontier 2001; O'Brien 2003). Although some researchers have pointed out the greater influence of top managers on corporate decisions (Barton and Matthews 1989; Miller 1991), to the best of our knowledge, no published papers have integrated the influence of TMT characteristics into the relationship between R&D investment and capital structure. This paper therefore leads to further understanding of the R&D investment–capital structure relationship from a cross-functional perspective that includes agency theory, resource-based and upper-echelons perspectives.

Many previous studies have investigated the issue of capital structure, primarily from the perspective of economic rationality. However, a firm's corporate strategy, such as investment and financing decisions, is developed by top executives, whose values and cognitive base may exert a great influence on the strategy. Integrating the upper-echelons perspective into the issue of capital structure enables us to discover that TMT composition (e.g., tenure, age and education levels) and incentive schemes (e.g., stock ownership) may affect a firm's risk propensity in strategy-making that, in turn, moderate financing decisions for R&D activities. Our findings thereby can expand upon previous research on the effects of executives on corporate decisions, particularly in the small business sector.

The empirical evidence of this study has several implications. First, our work suggests that, with diverse cognitive styles, backgrounds and risk-taking propensities, different team compositions would have significant moderating effects on the R&D-leverage relationship. Therefore, it could be considerably important for boards and CEOs in SMEs to select and develop appropriate people for top management positions who will make corporate decisions in the best interests of the company and shareholders. For instance, if R&D is important for organizational development and competitiveness, boards may need to appoint younger and/or more-educated people to the top positions. Additionally, boards may need to keep a close eye on the financing decisions for R&D investment made by longer tenured top managers and if necessary make appropriate adjustments to their incentives in a timely manner, such as making compensation contracts emphasizing long-term profitability.

Second, it may be hard to make adjustments in the composition of the top management team at times. In this case, a firm could encourage the incumbents to pursue further education or increase their connections with the external environment. For instance, a firm could encourage older or longer tenured managers to interact with customers, suppliers or competitors more frequently. This could help the managers to absorb new information and knowledge and become more familiar with the industry that their firm is in, which in turn affects their financing decisions for R&D investment. Additionally, as discussed earlier, incentives may affect managers' decision-making. SMEs may try to alter managers' financing decisions for R&D outlays by increasing their stock ownership in the short term.

Finally, strategic decision-makers could predict a competitor's moves based on the demographics of its top management. Given our findings, a firm could predict and analyze a competitor's investment and financing habits based on its TMT tenure, age, education level and stock ownership. This in turn could enable the firm to respond rapidly to any challenges and changes from its competitors and the organizational environment.

6 Limitations and future research

This paper has some major limitations. First, it focuses on the IT industry, so findings may not be able to be generalized to other industries. Second, measuring the cognitive styles and perceptions of top managers is admittedly problematic, and demographic variables

were therefore used instead of psychological measures. Further, it is very difficult to obtain complete personal information for top managers in Taiwan. The proxy measure and incomplete demographic data may thus limit the generalizability of the ratiocination and inquiries. Future studies could be enriched if researchers could collect more complete and in-depth data about the psychological attributes of top managers. Third, this paper studies TMT characteristics, such as average tenure, average age, average education level and total shareholdings only. Future studies could expand this line of research by exploring whether and how TMT heterogeneity may affect a firm's financing decisions with regard to R&D investment. Finally, this paper focuses primarily on how managers choose between debt and equity financing, but the issue of its resource base, for instance, internal vs. external financing, has been ignored. However, the relevant issue is worthy of our continued research.

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