Education, R&D and Firm Performance in Information Technology

Industries: An Empirical Examination

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Abstract

Education and research and development (R&D) investments are critical for enabling IT firms to remain at the forefront on innovation. Surprisingly, there is very little research on how education contributes to the profitability of IT firms and how this relationship is moderated by the firms’ investments in R&D. Using theories from human capital literature, we propose a model to measure how education and R&D investments impact firm performance. Our results suggest that both education and R&D investments are associated with a positive firm performance in IT industries. We also show that the interaction effects between R&D and education is positive, suggesting that IT firms which invest in highly skilled employees are in a better position to take advantage of R&D investments. Our results also suggest that higher levels of education such as masters are associated with higher returns to R&D investments than bachelors’. This paper adds several new insights to the literature on human capital and firm performance.

Keywords: Education, R&D, firm performance, human capital, innovation
1. Introduction

Rapid innovation has been the engine of technological change over the last decade. No other sector of the economy has witnessed this change more firsthand than the IT sector. Firms such as Apple, Microsoft, Intel, Motorola, and Google spend billions of dollars every year on developing new products and services. The fast pace of technological change makes it imperative for IT firms to innovate or get left behind by competitors. For example, in the late 1990s, Yahoo was the most popular search engine, but its dominance was short-lived as Google grabbed the mantle from Yahoo because of its superior search algorithm. AMD is making significant inroads in Intel’s dominance in the microprocessor market, and Apple is doing likewise with Microsoft in the PC operating system market. New technologies such as RFID, microblogging, and cloud computing are examples of potential ‘giant-killers’ on the horizon which threaten established IT companies.

Two factors which have become synonymous with technological innovation are research and development (R&D), and skilled workforce. Research and development (R&D) is the key to IT firms introducing new products and services to the market in a timely manner and ahead of their competitors. In IT industries, innovation enables a company to remain competitive in the ever-changing landscape of products and services. Therefore, the survival of firms in IT industries depends on their capability to innovate. For example, Cisco Systems, which is a market leader in data communication equipment, spends more than 16% of its revenues on R&D. Not only do IT firms invest in R&D to enhance their existing products (e.g., Microsoft launches new versions of the Windows operating system), but they also invest in dealing with new technological breakthroughs that have a disrupting effect on its existing products (e.g., technologies such as cloud computing threaten Microsoft’s desktop software model).

The other key factor which is essential to a firm’s innovation capability is the skill levels of its employees. Highly skilled workers who can keep pace with technological change are in a better position to innovate in IT industries. For example, Google’s unorthodox portfolio of human capital is its Ph.D.-

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centered culture because it views people with Ph.D. degree as more passionate towards research activities\(^2\). A skilled workforce is at the heart of any country’s IT sector\(^3\). The debate on the pressing need for skilled workforce in the IT industry has entered the policy-making domain with industry leaders such as Bill Gates lobbying the Congress to relax visa restrictions on educated foreign nationals who can work in IT related jobs\(^4\). They argue that these skilled employees are crucial to the US to maintain its standing as a global leader in information technological innovation. Recently, the US Dept of Homeland Security relaxed its visa policies for foreign science and engineering graduates so that they can work in the US for an additional period of 17 months after completing their education in the US\(^5\). The US government also provided for 20,000 additional work visas to foreign nationals who completed their masters or higher degrees in the US. In short, there is plenty of anecdotal evidence to suggest that educated employees are highly sought by firms in the IT sector.

While it is generally accepted educated employees are essential to IT firms, there exists a great diversity across the world in the role that educational institutions play in supplying talent to the IT firms. For example, in the US, there exist very close linkages between education and industry. Infact, the whole software industry was created by the establishment of computer science departments in US universities (Mowery, 1999). In addition, we can see that high tech industry clusters around leading universities, such as Stanford University near the Silicon Valley and MIT near Boston. On the other hand, in countries such as Japan, India and Taiwan, universities provide graduates with generic science and engineering background to meet workforce needs of IT firms and the firms provide on-the-job trainings to train impart skills (Hatakenaka 2008). Different companies also pursue different strategies while hiring educated

\(^3\) The Means to Compete: Benchmarking IT industry Competitiveness reported by The Economist Intelligence Unit [58].  
\(^5\) http://www.ice.gov/sevis/updates_postcompletion_opt.htm#8.
people. For example, Microsoft prefers to hire potential, so most part of its workforce comes from college graduates. However, PhDs are the important composition of Google’s workforce (Stross, 2004).

While prior literature examines the impact of education on firm productivity (Black and Lynch, 2001), there are several shortcomings in the current body of research. There are very few studies which examine the impact of employee education on the overall profitability of a firm. Employee education is also associated with significant costs for a company. For example, the human capital theory (Becker, 1965) suggests that employee compensation increases with education. Firms also need to keep and retain qualified employees through investing in human resource management practices (Huselid 1995). Also, highly skilled employees are also more easily employable elsewhere and the firm can face a higher turnover among these employees (Moore and Burke 2002). For example, it is well known that IT firms face a higher turnover compared to firms in other industries (Igbaria and Greenhaus 1992).

Another interesting topic which has not been explored is returns to masters and higher education levels compared to bachelors. In recent years, several countries have emphasized science and technology education and the number of people with advanced degrees in these fields in increasing. For example, the number of people with masters degrees in engineering increased four times from 1995 to 2001 in Taiwan, and the number of people with PhDs tripled in the same period (Figure 2a and 2b). However, an oversupply of people with higher education levels can lead to the problem of overeducation where firms hire people whose education qualifications exceed those required to do the job (Tsang, 1987). For example, it is not uncommon to find computer science masters and PhDs working as programmers in Russia and India. While prior research mainly measures education by a single variable (Bassanin and Scarpetta, 2002), this specification is not sufficient to capture the incremental impact of higher levels of education. Therefore, the question arises is whether there is an incremental benefit for higher levels of education such as Masters and PhD in IT firms.

Finally, there is very little research which explores the complementarities between R&D and employee education (Møen 2005). Prior research suggests that education is associated with a higher
capability to innovate or assimilate outside innovation (Nelson and Phelps, 1966), though empirical evidence in this area is lacking. The R&D Magazine reported in 2001 that employees with PhDs command a salary premium in R&D related jobs. While educated employees are considered vital to innovation, as had been suggested by industry leaders such as Bill Gates, evidence from countries such as India shows otherwise. Several top IT firms such as Microsoft, Texas Instruments, and Google have set up R&D operations in India, despite the large variance in the quality of its educated workforce. Experts suggest that the in-house training facilities setup by these firms contributes to the success of R&D in developing countries such as India (Wadhwa et al, 2008).

With this motivation, we propose the following research questions to address the above-mentioned gaps in literature.

1. What is the impact of employee education on firm performance in IT industries?
2. What is the incremental contribution of employees with masters and higher education levels to firm profitability, as compared to employees with bachelors’ degrees?
3. What is the impact of R&D on firm performance in IT industries?
4. How is the relationship between R&D and firm performance moderated by employee education?

We collect data on firm profitability, employee education, R&D investments and other financial indicators for IT firms in Taiwan for this study. Our main results are as follows: we show that education is positively associated with firm performance, suggesting that firms with highly skilled employees are more profitable. Our results suggest that firms which invest more in R&D are more profitable. Finally, we show that the relationship between R&D and firm profitability is moderated by the education level of the employees. Firms which employ a higher fraction of college educated individuals get a higher return on their R&D investments. A higher fraction of employees with higher education levels such as Masters and PhDs in a firm are associated with even higher returns on R&D investments.

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The main contributions of this paper are: we provide evidence of a positive relation between employees’ education level and firm profitability in IT industries. This is the first study, to the best of our knowledge, which estimates the moderating impact of education on the relation between R&D and firm performance. Finally, we also measure education at multiple levels and show that higher levels of education are associated with increasing returns to R&D.

The reminder of this paper is organized into four sections. In Section 2, we review the previous literature in workforce capital and R&D areas and develop our hypotheses. The research method is described in Section 3. In Section 4, we discuss the findings. A summary and conclusion is provided in Section 5.

2. Literature review and hypotheses

Human capital

Recent strategic management research contributes to the theory of the firm by proposing the resource-based view which states that the firm is a bundle of unique capabilities (Barney 1991; Mahoney and Pandian 1992). One key resource which is valuable, scarce and can help a firm retain its competitive advantage is human capital (Lado and Wilson 1994). Human capital theory suggests that people possess skills, knowledge, and abilities that provide economic value to firms (Tsang 1987). The characteristics of firm specific human capital, such as scarcity, non-substitutability, which requires a firm to incur heavy replacement costs make human capital more valuable to firms (Barney 1991). As has been extensively discussed in the human capital literature, organizations need to form a variety of human resource planning and work practices to manage human resources efficiently, such as recruiting talented employees, providing training and promoting opportunities, and developing compensation mechanisms (Malos and Campion 2000).

The rapid development of technology has increasingly driven the demand for skilled employees (Doms et al. 1997; Falk and Seim 2001). Therefore, complementary relationship between information technology and human capital may be an important factor to explain the shift toward skilled labor (Falk
and Seim 2001). The importance of skilled workers is even more significant in IT industries. As Ang et al. (2002) suggest, “IT jobs are complex, requiring knowledge of difficult technical concepts such as data modeling, process engineering, and design theory”.

There is little prior research which considers the impact of human capital on firm profitability. Prior literature finds that more educated workers will make other workers more productive (Moretti 2004). However, prior research in the information systems area also demonstrates that there are substantial costs associated with employees who have a higher education or work experience (Ang et al. 2002; Levina and Xin 2007).

Although human capital is measured in different ways (education, experience, and training) in prior research, education is often the most commonly used proxy for human capital (Carmeli and Tishler 2004). The seminal work on human capital theory by Becker (1964) suggests that level of education is a strong indicator of human capital. Apart from the human capital theory, other theoretical frameworks explain the positive impact of education. The sorting and signaling framework (Weiss, 1995) suggests that people who are ex-ante more intelligent opt for and are selected for higher education. Nelson and Phelps (1966) suggest that education enhances one’s ability to receive, decode, and understand information. Moreover, education can also strengthen ability, reduce uncertainty, and contribute to more efficient decision making (Griliches 2000). In technology intensive industries such as IT, the knowledge of employees is related to firms’ ability to develop new product and services, which is a critical determinant of firm performance and survival (Smith et al 2005).

In particular, education is becoming more important when there is a rapid technological change because schooling enhances employee skills that facilitate the gathering, processing, and interpreting of information (Bartel and Lichtenberg 1987). A feature of IT industries is that they are operate in an environment of uncertainty. Past research suggests that the gap between the productivity of educated and uneducated employees increases in an uncertain environment.
There is very little discussion on how masters and higher education levels impact firm profitability in IT industries at the firm level. While there is anecdotal evidence that employees with higher education levels such as Masters’ degrees command higher pay (Mithas and Krishnan 2008) and more promotion opportunities (Wright 1988), it is not clear whether firms optimally allocate these highly educated employees. In situations where there is oversupply of higher educated labor, firms may hire them for jobs which traditionally require lower education levels. Labor economics literature (Autor et al, 2003) suggests that computerization leads to a shift from non-skilled to skilled workers, but is silent about the incremental returns to higher skill levels. Mithas and Krishnan (2008) draw on prior theories to hypothesize that higher education levels such as Masters’ are likely to lead to a learning and productivity advantage due to accumulation of superior managerial competencies. Hunton et al. 2005 suggest that higher education contributes to success by increasing specific types of knowledge and enhancing ones’ ability to learn.

Therefore, we propose our first hypothesis on the relationship between employees’ education levels and firm performance. Further, we hypothesize that this relationship is not linear, but increases for higher levels of education.

H1a: Firms with a higher fraction of employees with college education are likely to be more profitable than firms with a higher fraction of employees with no college education.

H1b: Firms with a higher fraction of employees with higher education levels such as Masters and PhD degrees are more profitable than firms with a higher fraction of employees with Bachelors’ degree and lower levels.

R&D and firm performance

R&D is an important factor of productivity and several research articles have examined the role of R&D on firm performance (Griliches 2000, Oriani and Sobrero 2008). Two main literature streams explain the impact of R&D investments on firms. The learning literature suggests that an important benefit of R&D is
that it helps firms to develop absorptive capacity, which enables them to generate new knowledge (Cohen an Levinthal 1990). A firm’s absorptive capacity for learning, however, depends on its endowment of relevant technology-based capabilities (Mowery et al. 1996). R&D investment is the necessary condition for the creation of absorptive capacity (Tsai 2001). The knowledge management literature suggests that innovation occurs when a firm identifies the potential opportunities to fill the gaps in the industry positioning map, such as new customer segments, new customer needs, or new production methods (Markides 1997). In order to identify the innovation, a firm needs to search new opportunities by exchanging information and knowledge, building on current knowledge, synthesizing external knowledge with internal knowledge, and becoming a learning organization. Therefore, efficient knowledge exchange among functions internal and external to the firm is critically important to success (Moenaert et al. 1992). Roussel et al. (1995) suggest that R&D is the key to develop new knowledge within a firm.

The development of technological strength and accumulation of knowledge resulting from R&D efforts determine firm performance in high tech industries (Pegels and Thirumurthy 1996). Since IT industries are technologically intensive, innovation is the key to developing a source of sustained competitive advantage (Arora et al. 2001). Therefore, it is imperative for firms to increase their resource allocation to R&D investments so that their technological advantage over competitors is enhanced (Yanadori and Marler 2006). Therefore, our second hypothesis is that greater R&D investment will have positive impact on firm profitability for IT firms.

**H2: R&D intensity is positively associated with a higher firm profitability in IT industries.**

**Interaction terms: Education x R&D intensity**

R&D is closely related to human capital in a firm. Prior theoretical work (Aghion and Howitt 1998) suggests that human capital is complementary with R&D investments. Higher skills levels among firm employees are associated with a higher ‘economic competence’ (Eliasson 1990) or ‘absorptive capacity’ (Cohen and Levinthal 1990), both of which are critical for innovativeness.
Prior literature argues that R&D capital of firms is to a large extent embodied in the employees (Møen 2005). In high tech industries, R&D employees are more valuable because their efforts directly influence the organization’s innovation capabilities (Yanadori and Marler 2006). Human capital is also associated with innovation because it enhances the absorptive capacity of a firm (Negassi 2004). Therefore, for technology firms to take advantage of R&D investments, they should make complementary investments in human capital. As Møen (2005) suggests, skilled employees are better placed to leverage R&D investments to produce constant innovation and growth for a firm. Autor et al (2003) and Wolff (1996) suggest that IT firms need a strong base of human capital to remain at the forefront of innovation.

There has been little prior research which examines the interaction between R&D and education levels on firm performance. Ballot et al. (2001) used training as a proxy for human capital to explore the complementarities between human capital and R&D, but their results were inconclusive. They further speculate the education or experience and not training is likely to be the dominant variable which interacts with R&D, and recommend further studies in this area which use education or experience as a proxy for human capital. Lee et al. (2005) show that of all human capital variables, education has the greatest impact on R&D performance.

Therefore, we propose that the returns to R&D will be higher for firms with a higher fraction of educated employees. Moreover, it is has been established that the performance of Masters and Ph.Ds exceed those without these higher degrees in terms of R&D performance (Lee et al. 2005).

Therefore, our third hypothesis is:

\[ H3a: \text{The impact of R&D on profitability will be higher for firms which invest have a higher average level of education} \]

\[ H3b: \text{The moderating impact of education on the relationship between R&D and firm profitability will be higher for Masters and higher levels of education compared to undergraduates.} \]

In addition to the aforementioned factors that impact firm performance, we include additional variables as controls in our model. Executive compensation (Anderson et al. 2000), corporate governance
(Mehran 1995), corporate ownership (Dalton and Daily 2001), managerial discretion (Henderson and Fredrickson 1996), and salary expenses (Jemric and Vujcic 2002) all impact firm performance and are included as controls.

3. Research method and data

Empirical model

Our empirical model is shown in Figure 1. As discussed in the literature section, we examine the direct impacts of education and R&D investment on firm performance first. We then examine whether the relationship between workforce capital and firm performance will be moderated by the intensity of R&D investment.

We can express this mathematically in form of the following equation:

\[
ROA_i = \beta_0 + \beta_1 \text{GRADUATES}_{it} + \beta_2 \text{UNDERGRADS}_{it} + \beta_3 \text{RND\_INT}_{it} + \beta_4 \text{GRADUATES}_{it} \times \text{RND\_INT}_{it} \\
+ \beta_5 \text{UNDERGRADS}_{it} \times \text{RND\_INT}_{it} + \beta_6 \text{ADV\_INT}_{it} + \beta_7 \text{LAB\_INT}_{it} + \beta_8 \text{CAP\_INT}_{it} + \beta_9 \text{VOLATILITY}_{it} \\
+ \beta_{10} \text{AVG\_LABOR\_COST}_{it} + \beta_{11} \text{EXEC\_COMP}_{it} + \beta_{12} \text{STOCKHELD}_{it} + \beta_{13} \text{INDEPDIRECTOR}_{it} \\
+ \beta_{14} \text{BOARDSIZE}_{it} + \epsilon_{it}
\]  

We measure firm performance by the variable \( ROA \) which is the return on assets (Larcker et al. 2007). Employee education level is an important signaling mechanism of their level of competence (Spence 1973). Human capital theory also mainly looks at education as an important determinant of human capital (Becker 1975). We use two variables to measure the different levels of workforce capital – \text{GRADUATES} which is the fraction of employees with a Masters or PhD degree, and \text{UNDERGRADS} which is the
fraction of employees with only a Bachelors degree. The omitted variable here is the fraction of employees who do not have a college education. We measure R&D levels by the variable $RND_{INT}$ which is the total R&D expenditure divided by the total revenue.

We include the following control variables in our model. We add executive compensation ($EXEC\_COMP$) which is measured as the logarithm of the average of all forms of compensation, including salary, cash bonus, stock options, and other kinds of compensation received by the executives of the firm. We measure corporate governance by using three different variables, including board size ($BOARDSIZE$), board independence ($INDEPDIRECTOR$), and executive ownership ($STOCKHELD$). Board size is measured by logarithm of total number of board members. As for board independence, previous literature (Fama and Jensen 1983) finds that the greater ratio of outsiders on the board will enhance the corporate governance mechanism. Thus, we use the ratio of outside directors to total number of directors to measure board independence. Executive ownership is measured as the ratio of market value of stock share held by inside directors to total equity. Stock return volatility is also an important factor needed to be considered when designing compensation mechanism. In addition, stock return volatility is also an indicator of innovation activity, which represents high risk and unpredictable characteristics (Anderson et al. 2000). We measure volatility as the standard deviation of previous three years of firm stock returns ($VOLATILITY$). In addition, we use managerial variables such as advertising intensity ($ADV\_INT =$ ratio of advertising expense to total revenues), employee intensity ($LAB\_INT$=ratio of total number of employees to total revenues), and capital intensity ($CAP\_INT$ = ratio of total property, plant, and equipment to total revenues) as controls in our model. Finally, we also control for the salary received by employees in the firm ($AVG\_LABOR\_COST$), which is the average salary (in ‘000 New Taiwan dollars - denoted by T$) received by employees in the firm.\footnote{1 US dollar roughly equals 31 Taiwan dollars (in Aug 2008)} Table 1 shows the descriptive statistics of our data.

\begin{table}
\centering
\begin{tabular}{|c|c|c|}
\hline
Variable & Description & Value \\
\hline
$RND_{INT}$ & R&D expenditure divided by total revenue & 0.05 \\
$EXEC\_COMP$ & Logarithm of average compensation & 1.5 \\
$BOARDSIZE$ & Logarithm of total number of board members & 2.0 \\
$INDEPDIRECTOR$ & Ratio of outside directors to total number of directors & 0.6 \\
$STOCKHELD$ & Ratio of market value of stock share held by inside directors to total equity & 0.4 \\
$VOLATILITY$ & Standard deviation of previous three years of firm stock returns & 0.01 \\
$AVG\_LABOR\_COST$ & Average salary in ‘000 New Taiwan dollars & 5.0 \\
\hline
\end{tabular}
\end{table}
Sample

The data comes from Taiwan Economic Journal (TEJ) database which includes data from financial statements and corporate governance. We match the observations that for all variables employed in the study and delete those have missing values. After eliminating the missing values in our dataset, the total number of firm-year observations is 713, from 2000 to 2006. The final sample contains 11 kinds of IT sectors in Taiwan. The largest sector in our sample is the Electronic components sector, which represents 21.8% of sample, followed by the Photoelectric products sector (17.5%) and the Integrated circuits sector (14.1%). The firms in our sample range in size from 497 million to 461 billion New Taiwan dollars in revenues.

We selected this dataset for our research because the IT industry in Taiwan plays an important role in the global IT manufacturing value chain. Apart from the world’s biggest producers of computer components, Taiwan’s global market share for communication equipment, such as wireless modems, D.S.L. modems, and personal digital assistants, is above 70%\(^8\). A key factor behind Taiwan’s cutting edge in high tech industries is the availability of highly skilled talents, including high education level of citizens and the large number of overseas-educated Taiwanese who have returned to the island to work\(^9,10\). As more and more local industries are being urged to shift from labor intensive operations to high tech manufacturing and services due to the changing global trends, the demand for skilled employees particularly in Taiwan’s high tech sector is vastly increasing (Han et al. 2006). The distribution of industry sectors is shown in Table 2.

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**Insert Table 2 here**

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5. Results and discussions

In this section, we discuss and explain the results of our research models. Table 3 presents the results of our main model. We calculate the Variance Inflation Factors (VIF) to check for collinearity. All the VIF values are less than 5, which rules out any collinearity problem.

Since our sample is panel data, we use Fama-Macbeth method to run the regressions and employ Newey-West to adjust standard errors for autocorrelation (Cochrane 2001; Gujarati 2003). As in common in prior literature (Ang et al. 2002), we mean-centered the GRADUATES, UNDERGRADS, and RND_INT variables to control for multicollinearity in models with interaction terms. The second column denotes the results of our main model in equation (1). The coefficient of both GRADUATES and UNDERGRADS is positive and significant, which suggests that workforce capital has a positive impact on firm performance. This provides support for hypothesis H1a. We compare the coefficients of GRADUATES and UNDERGRADS and use a t-test to compare whether coefficient of GRADUATES is significantly higher than UNDERGRADS. We find that although the coefficient of GRADUATES is greater than that of UNDERGRADS, the difference is not statistically significant. Thus hypothesis H1b is not supported. Also, the coefficient of RND_INT is positive and significant in column 2, suggesting that investments in R&D are associated with a higher performance in IT industries. This provides support for hypothesis H2.

In column 3 of Table 3, we report the results of the regression where we add two interaction terms to the model in equation 1. We interact both our workforce capital variables with RND_INT variable – GRADUATES*RND_INT and UNDERGRADS*RND_INT. We find that both the interaction terms are positive and significant, suggesting that higher levels of workforce compensation are associated with even higher firm performance. This provides support for hypothesis H3a. Further, we find that the coefficient for the interaction term is significantly higher for employees with masters or higher education, suggesting that higher levels of education are in a better position to leverage the R&D investments of a firm, leading to a better firm performance. This finding supports for hypothesis H3b.
In addition, the coefficient of $STOCKHELD$ variable is positive and significant, suggesting that higher executive ownership is positively related to compensation. The coefficient of $BOARDSIZE$ is negative and significant suggesting that larger corporate boards are associated with a lower firm performance. Boards with more independent directors show a higher performance, as is evident from the positive coefficient of the $INDEPDIRECTOR$ variable. Volatility ($VOLATILITY$) has a positive and significant coefficient, which suggests that volatile stock returns are positively associated with firm performance. Executive ownership ($STOCKHELD$) is positively associated with higher returns, as expected (Morck et al. 1988). Advertising intensity and labor intensity are also associated with higher returns for a firm.

**Marginal Impact**

In a regression with interaction terms, the impact of the independent variables is more evident through the marginal effects. From equation 3, we can calculate the marginal impact of $UNDERGRADS$, $GRADUATES$, and $RND\_INT$ on firm performance. The marginal impact is as given below.

\[
\frac{\partial ROA}{\partial RND\_INT} = -0.4915 + 1.8203*GRADUATES + 0.4975*UNDERGRADS
\]  
\[
\frac{\partial ROA}{\partial UNDERGRADS} = 0.0248 + 0.4975*RND\_INT
\]  
\[
\frac{\partial ROA}{\partial GRADUATES} = 0.067 + 1.8203*RND\_INT
\]
It is interesting to note that the intercept in equation 2a is negative, whereas the intercepts in equations 2b and 2c are positive. This implies that the marginal impact of R&D is likely to be negative if the firm does not make complementary investments in an educated workforce. On the other hand, the intercept of the marginal impact of both education variables is positive, which suggests that a firm can benefit from an educated workforce even if it does not invest in R&D.

**Robustness Check**

From Table 3, we observe that the coefficient of $AVG\_LABOR\_COST$ is not significant, whereas the coefficient of $EXEC\_COMP$ is positive and significant; implying that compensation of top executives plays a significant role in firm performance whereas compensation of the rest of the employees does not. Could it be that the highly significant coefficient of $EXEC\_COMP$ is due to simultaneity in our model, where firm performance and executive compensation both depend on each other, as has been shown in previous research (Anderson et al. 2000)? To answer this question, we estimate a simultaneous equations model with both $ROA$ and $EXEC\_COMP$ as dependent variables using three stage least squares. The results are shown in Table 4. We can show that $EXEC\_COMP$ is no longer significant in this specification, whereas $AVG\_LABOR\_COST$ is barely significant. Our main results on the relationship between education, R&D and firm performance remain qualitatively the same. It is interesting to note, though, that the coefficient of workforce capital on executive compensation is negative and significant. This suggests that firms which have higher levels of workforce capital pay lower compensation to their executives. A likely reason is that higher workforce capital creates reduced information-processing demands for the higher executives which in turn drives down executive compensation (Henderson and Fredrickson 1996).
5. Discussion and Conclusion

This is the first study, to the best of our knowledge, which explores the complementary relationship between different levels of education and R&D investments in IT industries. This is an interesting area because while the role of education and R&D has been studied in prior literature, there is little work on how education moderates the relationship between R&D and firm performance. Moreover, while prior research associates human capital with innovativeness, absorptive capacity and other positive outcomes, there are very few studies which look at how human capital impacts the overall profitability of a firm. We also examine the impact of different levels of education separately, which has not been studied in prior literature.

This is especially relevant for IT industries because prior research in IT establishes that higher levels of education and experience are associated with higher compensation for IT professionals. We show that education leads to higher returns for a firm, suggesting that the benefits of having employees with higher skills outweighs the costs associated with these highly skilled employees for firms in our sample. We also compare the incremental benefit of different levels of education. While we did not find a significant difference between bachelors and higher degrees in general, we find that the moderating impact on the relationship between R&D and firm performance is higher for of masters and higher education levels than for Bachelors. This suggests that higher education levels mainly add value in the innovative activities of a firm in IT industries.

Consistent with previous research, we find that R&D intensity has positive impact on firm performance. Firms operating in highly competitive business environment usually focus on investing R&D to increase their innovation ability. In particular, we can see that IT firms face the challenge of rapid technology advancement, and these firms usually tend to emphasize their R&D investment in order to improve and sustain competitive advantage by creating innovative products or services. In addition, our examination of the interactive relationship between R&D and education shows that the impact of R&D on
firm performance is moderated by education. The moderating impact of higher education levels on the relationship between R&D and firm performance is also showed in our result. Because R&D is one of the main factors influencing the success of innovation, firms need high quality workforce to focus on R&D process. As more educated workforce is, on average, viewed as having higher comprehensive ability of learning fast and being more creative, more educated workforce will contribute more to increase the value of R&D outcomes. Therefore, firms are in a better position to leverage their R&D investments for higher profits if a higher percent of their employees are skilled.

The main limitation of our study is that the data is limited to IT firms based in Taiwan and one has to be careful in generalizing these results to other countries. As mentioned in the introduction, IT firms in different countries use education levels of potential employees for different purpose. For example, US IT firms are more R&D intensive than Taiwanese firms and students pick more job related skills in school; it is likely that the results of our study will hold for a sample of US based IT firms. On the other hand, countries such as India where firms primarily rely of education as a signal of an employee’s intelligence, our results on the moderating role of education on R&D might not hold. Our paper therefore provides some critical questions which can be addressed by future researchers. Moreover, the IT industry in Taiwan is largely dominated by IT producing firms. It would be interesting to test our results in an environment such as India where a bulk of the It industry is software development.

Our analysis also suggests that executive compensation is negatively related to workforce capital, suggesting that firms with higher level of skilled employees pay a lower compensation to their top executives. Since executive compensation is not a main area of study in this paper, we leave it to future research to explore this interesting finding in more detail. Our study contributes to human capital literature by examining firm level of human capital in the context of IT firms. In addition, our study also contributes to IT firm valuation research by examining two of the most important capital assets of IT firms, human capital and R&D capital. Previous literature in human capital and R&D are seldom combined together. Our study connects the linkage between these two important capital assets of firms.
Furthermore, our study provides reference value for IT firms about the valuation of different contribution of workforce and its impact on R&D, which is the important investment activity in IT firms. Future research can also look at how investments in information technology impact the relationship between human capital, R&D and firm performance.

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Figure 1 Research model

![Research Model Diagram]

- EDUCATION
- R&D INTENSITY
- COMPLEMENTARITY
  - EDUCATION*RDI
- CONTROL VARIABLES
  - Structural, Managerial, Governance

Figure 2a: Number of Bachelors and Masters Degree Holders in Taiwan from 1995-2006

![Number of Bachelors and Masters Degree Holders Chart]
Figure 2b: Number of PhD Degree Holders in Taiwan from 1995-2006

![Graph showing the number of PhD degree holders in Taiwan from 1995 to 2006.](image)

Table 1 Descriptive Statistics of Variables (N = 713)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Units</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>Min.</th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GRADUATES</td>
<td>Ratio</td>
<td>0.120</td>
<td>0.145</td>
<td>0.000</td>
<td>0.897</td>
</tr>
<tr>
<td>UNDERGRADS</td>
<td>Ratio</td>
<td>0.554</td>
<td>0.176</td>
<td>0.100</td>
<td>0.944</td>
</tr>
<tr>
<td>RND_INT</td>
<td>Ratio</td>
<td>0.036</td>
<td>0.037</td>
<td>0.000</td>
<td>0.233</td>
</tr>
<tr>
<td>ADV_INT</td>
<td>Ratio</td>
<td>0.002</td>
<td>0.005</td>
<td>0.000</td>
<td>0.049</td>
</tr>
<tr>
<td>LAB_INT</td>
<td>Ratio</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.001</td>
</tr>
<tr>
<td>CAP_INT</td>
<td>Ratio</td>
<td>0.329</td>
<td>0.385</td>
<td>0.015</td>
<td>2.166</td>
</tr>
<tr>
<td>VOLATILITY</td>
<td>Ratio</td>
<td>0.221</td>
<td>0.477</td>
<td>-0.534</td>
<td>5.712</td>
</tr>
<tr>
<td>AVG_LABOR_COST</td>
<td>T$</td>
<td>258.22</td>
<td>215.652</td>
<td>7.897</td>
<td>1,187.80</td>
</tr>
<tr>
<td>EXEC_COMP</td>
<td>T$</td>
<td>6.671</td>
<td>1.386</td>
<td>2.717</td>
<td>10.975</td>
</tr>
<tr>
<td>STOCKHELD</td>
<td>Ratio</td>
<td>0.099</td>
<td>0.071</td>
<td>0.019</td>
<td>0.885</td>
</tr>
<tr>
<td>INDEPDIRECTOR</td>
<td>Ratio</td>
<td>0.134</td>
<td>0.161</td>
<td>0.000</td>
<td>0.571</td>
</tr>
<tr>
<td>BOARDSIZE</td>
<td>Number</td>
<td>2.205</td>
<td>0.205</td>
<td>1.609</td>
<td>2.944</td>
</tr>
<tr>
<td>ROA</td>
<td>Ratio</td>
<td>0.074</td>
<td>0.055</td>
<td>-0.034</td>
<td>0.378</td>
</tr>
</tbody>
</table>
### Table 2 Industry Sectors

<table>
<thead>
<tr>
<th>Industry Sector</th>
<th>Frequency</th>
<th>% of Sample</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic Components</td>
<td>156</td>
<td>21.8</td>
</tr>
<tr>
<td>Photoelectric Products</td>
<td>125</td>
<td>17.5</td>
</tr>
<tr>
<td>Motherboard Scheme</td>
<td>93</td>
<td>13.0</td>
</tr>
<tr>
<td>Integrated Circuits</td>
<td>101</td>
<td>14.1</td>
</tr>
<tr>
<td>Electronic Channel</td>
<td>57</td>
<td>7.9</td>
</tr>
<tr>
<td>Software Applications</td>
<td>11</td>
<td>1.5</td>
</tr>
<tr>
<td>Network Modem</td>
<td>31</td>
<td>4.3</td>
</tr>
<tr>
<td>General Electronics</td>
<td>34</td>
<td>4.7</td>
</tr>
<tr>
<td>Consumer Electronics</td>
<td>34</td>
<td>4.7</td>
</tr>
<tr>
<td>Communication Technologies</td>
<td>30</td>
<td>4.2</td>
</tr>
<tr>
<td>Systematic Product and Others</td>
<td>41</td>
<td>6.3</td>
</tr>
<tr>
<td>Total</td>
<td>713</td>
<td>100.0</td>
</tr>
</tbody>
</table>

### Table 3: Results of Fama-McBeth Regression

<table>
<thead>
<tr>
<th></th>
<th>$ROA_{it}$</th>
<th>$ROA_{it}$</th>
<th>$VIF$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.0202*(0.0247)</td>
<td>0.0421**(0.0151)</td>
<td></td>
</tr>
<tr>
<td>$GRADUATES_{it}$</td>
<td>0.0962**(0.0477)</td>
<td>0.067*(0.0362)</td>
<td>3.9</td>
</tr>
<tr>
<td>$UNDERGRADS_{it}$</td>
<td>0.0401**(0.0206)</td>
<td>0.0248(0.0226)</td>
<td>2.5</td>
</tr>
<tr>
<td>$RND_INT_{it}$</td>
<td>0.0426**(0.0233)</td>
<td>-0.4915**(0.1769)</td>
<td>3.1</td>
</tr>
<tr>
<td>$GRADUATES_{it}$*$RND_INT_{it}$</td>
<td>1.8203**(0.7045)</td>
<td></td>
<td>4.98</td>
</tr>
<tr>
<td>$UNDERGRADS_{it}$*$RND_INT_{it}$</td>
<td>0.4975*(0.3222)</td>
<td></td>
<td>2.97</td>
</tr>
<tr>
<td>$ADV_INT_{it}$</td>
<td>0.4826*(0.5083)</td>
<td>0.6232*(0.5446)</td>
<td>1.1</td>
</tr>
<tr>
<td>$LAB_INT_{it}$</td>
<td>53.6365*** (9.8649)</td>
<td>49.5719** (12.3004)</td>
<td>2.53</td>
</tr>
<tr>
<td>$CAP_INT_{it}$</td>
<td>-0.0151(0.0081)</td>
<td>-0.0137(0.0081)</td>
<td>1.6</td>
</tr>
<tr>
<td>$VOLATILITY_{it}$</td>
<td>0.0126**(0.0051)</td>
<td>0.0135*** (0.0049)</td>
<td>1.1</td>
</tr>
<tr>
<td>$AVG_LABOR_COST_{it}$</td>
<td>-0.00002(0.00006)</td>
<td>-0.00001(0.00007)</td>
<td>2.2</td>
</tr>
<tr>
<td>$EXEC_COMP_{it}$</td>
<td>0.0071*** (0.0009)</td>
<td>0.0069*** (0.0007)</td>
<td>1.36</td>
</tr>
</tbody>
</table>
Table 4 Estimations of simultaneous equations model

<table>
<thead>
<tr>
<th></th>
<th>ROA_{it}</th>
<th>EXEC_COMP_{it}</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>0.13422***(.0001)</td>
<td>-3.35379***(.0001)</td>
</tr>
<tr>
<td>GRADUATES_{it}</td>
<td>0.08204***(.0104)</td>
<td>-0.49771(.2823)</td>
</tr>
<tr>
<td>UNDERGRADS_{it}</td>
<td>0.01051(.5919)</td>
<td>-1.16262***(.0001)</td>
</tr>
<tr>
<td>RND_INT_{it}</td>
<td>-0.45700(.1594)</td>
<td></td>
</tr>
<tr>
<td>GRADUATES_{it}*RND_INT_{it}</td>
<td>0.59157*.0948</td>
<td></td>
</tr>
<tr>
<td>UNDERGRADS_{it}*RND_INT_{it}</td>
<td>0.58705(.1827)</td>
<td></td>
</tr>
<tr>
<td>ADV_INT_{it}</td>
<td>0.95606**(.0249)</td>
<td></td>
</tr>
<tr>
<td>LAB_INT_{it}</td>
<td>-4.47940(.8669)</td>
<td></td>
</tr>
<tr>
<td>CAP_INT_{it}</td>
<td>0.00304(.1478)</td>
<td></td>
</tr>
<tr>
<td>VOLATILITY_{it}</td>
<td>0.01832***(.0001)</td>
<td></td>
</tr>
<tr>
<td>AVG_LABOR_COST_{it}</td>
<td>-0.00003*.0539</td>
<td></td>
</tr>
<tr>
<td>EXEC_COMP_{it}</td>
<td>-0.00741(.2370)</td>
<td></td>
</tr>
<tr>
<td>STOCKHELD_{it}</td>
<td>0.20614***(.0001)</td>
<td>0.32812(.7247)</td>
</tr>
<tr>
<td>INDEPDIRECTOR_{it}</td>
<td>0.05183***(.0001)</td>
<td>-0.31955(.2637)</td>
</tr>
<tr>
<td>BOARDSIZE_{it}</td>
<td>-0.02078***(.0524)</td>
<td>0.34464(.1062)</td>
</tr>
<tr>
<td>ROA_{it}</td>
<td>9.51703***(.0080)</td>
<td></td>
</tr>
<tr>
<td>TURNOVER^{12}_{it}</td>
<td>-0.10660(.2508)</td>
<td></td>
</tr>
<tr>
<td>FIRMSIZE^{12}_{it}</td>
<td>0.59227***(.0001)</td>
<td></td>
</tr>
<tr>
<td>Adjusted R^2</td>
<td>19.7</td>
<td>43.8</td>
</tr>
</tbody>
</table>

*: Significant at 0.10.  **: Significant at 0.05.  ***: Significant at 0.01.

11 TURNOVER is the average turnover rate of executives (Chairman, CEO, and CFO)

12 FIRMSIZE is measured as the log of revenues of the firm.