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Overcoming Financial Constraints on Firm Innovation: The Role of R&D Human Capital

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Abstract: This paper examines how R&D human capital can mitigate the negative effects of financing constraints on firm innovation, using survey data from 4000 South Korean manufacturing firms. The results confirm that financing constraints are generally associated with lower levels of product innovation. However, firms with stronger R&D human capital—measured by higher education levels and a larger proportion of R&D employees—are better able to overcome these financial barriers. Moreover, the positive moderating effect of R&D human capital is significantly enhanced in firms with an entrepreneurial culture, which supports risk-taking and innovation. These findings underscore the importance of investing in intangible assets, such as human capital and fostering a culture of entrepreneurship to sustain innovation during periods of financial distress. Policymakers should consider expanding financial support for R&D activities, particularly for small and medium-sized enterprises (SMEs) that face higher costs of capital. This study contributes to the literature by using direct measures of financial constraints and highlighting the role of human capital in innovation, especially in financially constrained environments.

Keywords: product innovation; R&D investment; financing constraints; human capital; entrepreneurial culture

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1. Introduction

The importance of technological innovation in sustaining economic growth and improving quality of life has long been recognized and continues to be a key driver of modern economic development (Organisation for Economic Co-operation and Development 2015). An innovation-driven economy enables a transition toward sustainable growth by continuously increasing economic efficiency with the development of technology. Innovation involves strategically enhancing the productivity of input factors, such as labor and capital, and finding better ways to combine these factors (Caves et al. 1982). Innovative firms are equipped with resources that cannot be easily transferred to others, such as knowledge-based structures embedded in organizational members, processes, and systems (Anand et al. 2007).

R&D investment is a prerequisite for the development, acquisition, and diffusion of technology. However, firms often suffer from financing constraints in funding R&D investment. Due to information asymmetry with external investors, firms struggle to raise external funds to finance their investments (Jensen and Meckling 1976; Stewart and Nicholas 1984). External financing is even more costly for innovative projects due to high uncertainty and technical novelty, which can increase information asymmetry with external investors (Hall 2002). In this regard, firms encountering financial constraints are expected to reduce their innovative activities (Savignac 2008; Hall 2002). However, the effect of financial constraints on innovation in the empirical literature has been inconclusive (Savignac 2008). While some studies find a significantly positive effect of financial slack (Himmelberg and Petersen 1994; Savignac 2008), the positive relationship does not always hold (Bond et al. 1999; Harhoff 1998).

This study suggests that mixed findings in the extant literature may result from firms' human capital variations. While financial constraints reduce innovative activities in general, human capital can attenuate the negative impact of financing barriers on firm innovation. In organizations, the knowledge and experience gained by each member are accumulated within the organization through processes, routines, and culture (Sackmann 1992). R&D human capital is the workers who play a key role in knowledge management (Chen and Huang 2009). R&D workers store knowledge in a firm's knowledge management system and apply and generate this knowledge for product development. The intellectual capital created by R&D workers enables firms to earn supranormal returns on the cost of obtaining that knowledge (Zucker et al. 1994). Even during financially constrained periods, firms with strong R&D human capital can discover creative methods for engaging in commercially valuable research.

To examine whether a firm's human capital attenuates the negative impact of financial constraints on innovation, we use the Corporate Innovation Survey, which explores a sample of 4000 Korean manufacturing firms. The survey is developed based on the Oslo Manual (OECD/Eurostat 2005) and covers firms' responses regarding innovation activities and performance, as well as the financing of innovation (from different types of investors and lenders). This survey enables us to measure existing financial constraints directly, increasing our empirical measures' construct validity (Savignac 2008).

The results indicate that financial constraints are, on average, negatively associated with a firm's propensity to innovate its products or services (Himmelberg and Petersen 1994; Savignac 2008). More importantly, we find that R&D human capital positively moderates the relationship between financial constraints and firm innovation. We measure R&D human capital by education level and the proportion of the workforce designated as R&D among total employees. The results indicate that a higher education level and a greater proportion of R&D staff mitigate the negative impact of financing constraints on product/service innovation.

Untabulated tests indicate that R&D human capital does not significantly mitigate the relationship between financial constraints and R&D intensity, indicating that human capital does not improve innovation performance through greater capital investment in innovative projects (measured by R&D intensity). Collectively, our findings suggest that intellectual capital created by strong R&D workforces enables firms to develop innovative products/services, although they may lack financial resources. It also implies that firms must invest in both tangible assets and human capital to sustain innovation.

Additionally, we explore circumstances where R&D human capital contributes to innovative outcomes to a greater extent through an entrepreneurial corporate culture. Managers often underscore the importance of fostering an entrepreneurial culture that tolerates failure and supports the willingness to take risks (Pisano 2019; Clark 2020). The results suggest that R&D human capital helps firms overcome financing constraints for innovative activities only when the organization encourages entrepreneurial employee behavior. This highlights the importance of corporate culture in stimulating and exploiting R&D human capital to overcome financial difficulties and reap innovative outcomes.

This study contributes to the literature on financing constraints and innovative performance. The results of the regression analysis indicate that, in general, there is a negative association between economic limitations and a firm's innovative outcomes. This study is differentiated from previous studies on cash flows and innovative performance in that it exploits a unique survey that directly measures the financing constraints perceived by firms' managers instead of relying on cash flows to indirectly measure a firm's financing ability (Himmelberg and Petersen 1994; Bond et al. 1999; Harhoff 1998). The result is especially relevant for industries that include small and medium enterprises (SMEs), whose cost of capital is much higher than larger companies with more credit. Fiscal authorities and central banks may expand financial assistance through government grants or low-interest loans for R&D investment to small businesses that pursue innovative projects.

This study generates an important managerial implication as it suggests a potential reason for the literature to produce inconclusive evidence (Savignac 2008). R&D human capital is measured by the proportion of educated employees committed to research and development activities, and it positively moderates the relationship between financing constraints and product/service innovation. This research highlights the importance of human resources in cultivating an innovative culture and meeting commercial requirements during financially constrained periods. To reap supranormal returns from capital investment in creative projects, investment in R&D talent should be implemented at both firm and societal levels.

Furthermore, this study underscores intangible assets in accomplishing innovative performance. While R&D human capital helps firms overcome financial constraints in innovation, the R&D workforce's role can be significantly limited in an inflexible culture. Additional analyses indicate that the positive moderating effect of R&D human capital appears only when firms have a highly entrepreneurial culture. Managers who want their team to innovate must create a culture of intellectual bravery in which organizational members are willing to challenge the status quo even when it requires the risk of marginalization or punishment.

This paper is organized as follows: Section 2 reviews prior studies on financial constraints, firm innovation, and human capital to develop the hypotheses. Section 3 proposes empirical models to examine the relationships among financial constraints, firm innovation, and human capital. The baseline model suggests a negative relationship between financial constraints and product/service innovation. R&D human capital is then added to the model as a moderating factor to examine its attenuation effect on financial constraints. Based on the results, practical recommendations are provided in the final section for firms pursuing innovation under financial distress.

2. Literature Review and Hypotheses Development

2.1. Financial Constraints and Firm Innovation

Since corporate innovation drives sustainable economic growth, it is necessary to identify the determinants of corporate innovation and promote innovation activities (Solow 1957; Griliches 1980). The literature explaining corporate innovation activities suggests several major factors contributing to these activities, such as firm size (Cohen and Klepper 1996), market power (Aghion et al. 2005; Arrow 1962; Schumpeter 1942), and the environment in which firms are located.

Previous studies have used corporate size as a proxy for financial constraints. Large firms are more active in innovation activities, as investments in innovative projects incur high sunk costs, and large firms can amortize these initial investments by increasing sales. In addition, it is relatively easy for large firms to leverage external networks to finance innovation investments from investors and lenders. Crépon et al. (1998) found that the larger the firm, the higher the likelihood of conducting R&D.

Financing constraints refer to any factor that restricts the amount or quality of investment options. They can be internal or external, as firms rely on their internal cash flow as well as external funds from capital markets. Financing constraints will discourage firms from investing in innovative projects because the unique characteristics of these projects—high complexity, high firm specificity, and high levels of uncertainty—increase information asymmetry with external investors (Bakker 2013). Complexity and firm specificity create significant information asymmetry between innovators and capital providers regarding the value of innovation (Bakker 2013; Santarelli 1991). In addition, innovative projects cause more uncertainty about future cash flow than traditional tangible investments—high volatility results in external investors demanding a risk premium, raising the cost of external capital.

In addition, due to the risk of appropriation, companies are reluctant to disclose details of innovative projects. This presents challenges for external investors in accessing the detailed information of a creative project, which is an obstacle to judging the financial value of an investment (Hall and Lerner 2010). However, reducing this information asymmetry by signaling external investors to inform them of the value of an innovative project also

entails a cost (Bhattacharya and Ritter 1983). Furthermore, creative projects accumulate intangible assets, such as technology and knowledge, instead of tangible assets. These soft assets are rarely used as collateral to borrow money from lenders, which, in turn, raises the cost of capital.

In short, firms undertaking innovative projects face a high cost of capital due to high asset specificity, high uncertainty, and appropriation problems. If creative activities can be fully funded with internal cash flow, the cost of raising capital would significantly decrease. However, it is difficult for many companies to finance all innovative projects with internal funds. Therefore, firm innovation is likely to be strongly affected by financial constraints. Based on our discussion so far, we postulate our baseline hypothesis:

H1. *Financial constraints are negatively associated with firm innovation.*

2.2. Human Capital and Firm Innovation

Although we predict a negative relationship between financial constraints and corporate innovation, empirical evidence supporting this is, at best, inconclusive. Using a firm's cash flow to measure financial limitations, some studies have determined that cash flow significantly affects investment (Himmelberg and Petersen 1994), while others have found no significant association (Bond et al. 1999; Harhoff 1998). Several studies have provided theoretical explanations for the inconsistent empirical results (Keupp and Gassmann 2009; Moreau and Dahl 2005) and suggest measurement error problems (Savignac 2008).

Such inconclusive findings indicate that moderating factors may exist. Specifically, we argue that the level of R&D human capital is an important moderator in the relationship between financing constraints and firm innovation. R&D human capital is how industry managers identify and gain access to relevant knowledge (Lin 2014) and is defined as the cumulative knowledge, skills, and experience of a firm's employees regarding innovative projects. In organizations, the knowledge and experience accumulated within organizational elements (e.g., processes, routines, and culture) provide valuable sources for knowledge creation and product development (Sackmann 1992). R&D workers play a key role in knowledge management by contributing to the firm's knowledge management system and generating knowledge for product development.

Intellectual capital enables firms to effectively exploit and transform organizational resources (Schultz 1961). For example, TSMC's technological advancement is correlated with the company's employment of professional human capital (TSMC 2011; Lin 2014). Corporate innovation requires unique knowledge, skills, and experience (Teece et al. 1997). Highly educated and skilled workers increase a firm's ability to address complex problems. These workers adapt quickly and efficiently to new tasks and possess the knowledge and skills necessary to identify problems and develop creative solutions (De Spiegelaere et al. 2018).

More importantly, innovative human capital—workers with high education, training, and research orientation—may be more valuable for product and process innovation in financially constrained firms (McGuirk et al. 2015). Financing constraints may lead firms to focus on routine tasks while reducing their emphasis on innovation. Strong R&D human capital enables firms to overcome financial resource constraints, thereby creating the necessary motivation for sharing knowledge, information, and ideas among employees.

When Steve Jobs returned to Apple in 1996, the company was in a bad state. Following his return, the company's performance grew from USD 10 billion in losses to USD 4 billion in profits in a year. The company dominated the market with the launch of the iPod in 2001 and the iPhone in 2007. In a YouTube video viewed six million times, Jobs emphasizes that Apple's core value is people with passion who want to change the world.[1] He hired the right people and trusted them to perform. As such, strong R&D human capital enhances cooperation, communication, and teamwork to effectively transform scarce resources into commercial outcomes. In other words, firms with strong intellectual capital earn supranormal returns through the minimal cost of obtaining knowledge and skills (Zucker et al. 1994). Based on this discussion, we develop our second hypothesis:

H2. *The negative association between financial constraints and firm innovation is positively moderated by R&D human capital.*

3. Data and Methodology

3.1. Data

To examine the research hypotheses, this paper used the Corporate Innovation Survey from 2020. The Science and Technology Policy Institute of Korea (STEPI), a government-funded research institute, administers the survey and provides the data results to the public. The survey was answered by 4000 manufacturing firms selected from 50,785 Korean firms with more than ten employees, using a stratified random sampling method, which divided the population into strata based on industry classification and workforce size. The response rate was 32.3%, resulting in the final 4000 firm respondents comprising the initial sample. Thank you for your question. The 32.3% response rate reflects the proportion of firms that completed the survey out of the total sample contacted. The survey used a stratified random sampling method, ensuring that respondents are representative of the broader population of South Korean manufacturing firms in terms of industry classification and firm size. After excluding firms that did not respond to survey items used in the analyses, the final sample consists of 3998 firms. Table 1 shows the top ten industries in our final sample.

Table 1. Top ten most frequent manufacturing industries of the sample firms.

Industry	Frequency	Percentage
Chemicals and chemical products	631	15.78
Other machinery and equipment	412	10.31
Motor vehicles, trailers, and semitrailers	394	9.85
Electronic components, computers; visual, sounding, and communication equipment	333	8.33
Basic metals	328	8.20
Electrical equipment	320	8.00
Fabricated metal products	304	7.60
Food products	296	7.40
Rubber and plastics products	184	4.60
Other non-metallic mineral products	140	3.50

The survey provides a powerful setting to examine the relationship between human capital, firm innovation, and financial constraints. It covers a comprehensive set of questions on the responding firms' innovation outcomes (e.g., product/service innovation during the past three years), enabling us to directly measure a firm's innovative performance. In addition, the survey provides information on human capital, such as the proportion of highly educated employees (e.g., those with master's or doctoral degrees) and the proportion of R&D employees compared to the total workforce (e.g., workers who research technology and develop products). Another advantage of the survey is that it presents questions about firms' financing constraints. In particular, it questions respondents on the difficulty of raising funds from various capital providers (e.g., internal cash reserves, related parties, banks, stockholders, governments, etc.). Using the survey items, we can directly measure the financing constraints instead of relying on cash flow to proxy these constraints (Savignac 2008). The composite reliability of the survey items is 0.76, supporting the construct validity of the instrument (Abernethy et al. 2004). Details of the survey items are in Appendix A.

3.2. Model Specification and Variable Measurement

To test Hypothesis 1, we estimated the following logit regression with fixed effects using 3998 firm observations:

$$Prob(Innovation_i = 1) = \alpha_0 + \alpha_1 Constraints_i + Controls + \varepsilon_i \quad (1)$$

where i denotes firms.

The dependent variable, *Innovation*, indicates product (service) innovation during the past three years. *Innovation* takes on 1 if a firm has produced (delivered) new or improved products (services) in the past three years or 0 otherwise.[2] Our variable of interest, *Constraints*, is the principal component of the survey items on the financing constraints of the seven types of capital providers. The seven survey items measure the financing difficulties from internal cash reserves, related parties, banks, stock issuance, bond issuance, investment institutions, and the government. Firms facing economic limitations from a greater (less) number of capital providers have higher (lower) values of *Constraints*. Details of the survey instruments are in Appendix A. Based on H1, the coefficient for *Constraints* is expected to be significantly negative ($\alpha_1 < 0$).

To test Hypothesis 2, we estimated the following logit regression with fixed effects using 3998 firm observations:

$$Prob(Innovation_i = 1) = \alpha_0 + \alpha_1 Constraints_i + \alpha_2\ Constraints_i \times Human\ Capital_i + \alpha_3\ Human\ Capital_i + Controls + \varepsilon_i \quad (2)$$

where i denotes firms.

As in Equation (1), the dependent variable is *Innovation*. To examine the moderating effect of R&D human capital, we interact *Constraints* with *Human Capital* and measure R&D human capital with two variables. Because highly educated employees have a better ability to identify problems and obtain knowledge to create solutions, our first measure of R&D human capital is *High Education*, which is the proportion of workers with master's degrees or higher. The second measure of R&D human capital is the proportion of researchers among total employees (*Researcher*). We use this measure because workers' experience in research and development, as well as their network with other research-oriented workers and institutions, formulates intellectual capital within organizations. Based on H2, the coefficient for *Constraints* × *Human Capital* is expected to be significantly positive ($\alpha_2 > 0$).

In Equations (1) and (2), we control for the variables that may influence a firm's innovation outcomes. Control variables include the natural logarithm of sales (*LogSales*) and employees (*LogEmployee*), which proxy for firm size. Sizable firms have more complementary assets, which can be used for commercializing innovative ideas (Teece 1986). We also control for firms' listings on stock exchanges (*Listed*) because stock investors may demand riskier investments than other types of capital providers, such as lenders. *Complex* indicates whether a firm is located in an industrial complex. *Network Diversity* is the log number of information sources firms rely on to obtain innovative knowledge and technology. *Complex* and *Network Diversity* proxy the external networks that may benefit firms in acquiring external knowledge and market information. We further control for corporate size fixed effects because different sizes of firms receive varying government support and subsidies for innovative activities. Lastly, we control for industry-fixed effects because innovative activities vary across industries.

While endogeneity concerns such as reverse causality are often present in studies examining the relationship between innovation and firm resources, the specific labor market context in Korea reduces the likelihood of this issue. In many countries, firms might increase or decrease their R&D human capital in response to innovation outcomes or financial changes. However, in Korea, labor laws and the rigidity of the labor market make it difficult for firms to flexibly adjust their workforce. The Korean labor market is characterized by strong protections for employees, making it challenging to hire and fire R&D workers in response to short-term innovation performance or financing conditions. As a result, the path from innovation to R&D capital or financing is less likely compared to the reverse. Firms in Korea are more likely to maintain a stable base of R&D human capital, which suggests that the relationship from R&D human capital to innovation and financing constraints is more credible in this setting.

3.3. Descriptive Statistics

Panel A of Table 2 reports the descriptive statistics of the sample firms. Among our sample firms, 23.8% have experienced product/service innovation (*Innovation*). *Constraints* has a mean of zero and a standard deviation of one (because it is the principal component), while its distribution is left-skewed (as revealed by the median that is greater than the mean). Among the employees in the sample, 3.5% have a master's degree or higher (*High Education*), and 7.1% are dedicated to research and development activities (*Researcher*). Average sales (*Sales*) are about 125 billion Korean won (equivalent to 87 million USD). In the empirical analysis, we use the natural logarithm of sales (*LogSales*) instead of the raw value of sales. On average, a firm has 182 workers (*Employee*). Among our sample firms, 24% are located in an industrial complex (*Complex*), and 15% are listed on a stock exchange (*Listed*). *Network Diversity* has a mean value of 1.680. Additionally, we examine the relationship between financial constraints and R&D intensity. *R&D Intensity*, measured by R&D expenditure scaled by sales, has a mean value of 3.7%.

Panel B shows the Pearson correlation coefficients among variables. *Innovation* is negatively correlated with *Constraints* ($\rho = -0.349$, $p < 0.01$). While this univariate analysis result is consistent with H1 in that financing constraints may hinder firm innovation, we discuss the hypothesis testing based on multivariate analysis (that controls for other factors that may influence firm innovation) in the following section. *Innovation* is positively correlated with *High_Education* ($\rho = 0.232$, $p < 0.01$) and *Researcher* ($\rho = 0.279$, $p < 0.01$), suggesting that firm innovation increases with stronger R&D human capital. *Innovation* is also positively correlated with the proxies for firm size (*LogEmployee*, *LogSales*) and listings on the stock exchange (*Listed*). However, *Innovation* negatively correlates with external networks (*Network_Diversity*).

Table 2. Panel A: Descriptive statistics. Panel B: Descriptive statistics.

Panel A

Variables	N	Mean	Median	Min	Max	STD
Innovation	3998	0.238	0.000	0.000	1.000	0.426
Constraints	3998	0.000	0.224	−6.674	0.564	1.000
High_Education	3998	0.035	0.000	0.000	0.900	0.065
Researcher	3998	0.071	0.050	0.000	0.980	0.096
Sales *	3998	124,973	17,789	634	2,668,852	353,630
Employee	3998	182	57	10	2500	363
Complex	3998	0.237	0.000	0.000	1.000	0.425
Listed	3998	0.150	0.000	0.000	1.000	0.357
Network_Diversity	3998	1.680	1.609	0.693	2.303	0.598
R&D Intensity	2352	0.037	0.017	0.000	3.000	0.098

Panel B

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) *Innovation*	1.000								
(2) *Constraints*	**−0.349** <0.0001	1.000							
(3) *High_Education*	**0.232** <0.0001	**−0.263** <0.0001	1.000						
(4) *Researcher*	**0.279** <0.0001	**−0.210** <0.0001	**0.439** <0.0001	1.000					
(5) *LogEmployee*	**0.321** <0.0001	**−0.442** <0.0001	**0.222** <0.0001	**0.115** <0.0001	1.000				
(6) *LogSales*	**0.293** <0.0001	**−0.414** <0.0001	**0.218** <0.0001	**0.138** <0.0001	**0.885** <0.0001	1.000			
(7) *Listed*	**0.240** <0.0001	**−0.422** <0.0001	**0.228** <0.0001	**0.167** <0.0001	**0.526** <0.0001	**0.506** <0.0001	1.000		

Table 2. *Cont.*

	Panel B								
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
(8) *Complex*	0.023 0.138	**−0.099** <0.0001	0.018 0.262	**0.037** 0.019	**0.100** <0.0001	**0.103** <0.0001	**0.052** 0.001	1.000	
(9) *Network_Diversity*	**−0.337** <0.0001	**0.103** <0.0001	**−0.249** <0.0001	**−0.461** <0.0001	**−0.313** <0.0001	**−0.311** <0.0001	**−0.187** <0.0001	−0.018 0.255	1.000

Panel A: * Per million Korean won. One million Korean won approximates 700 USD as of 23 October 2022. Variable definitions are in Appendix B. Panel B reports the Pearson correlation coefficients among variables. Bolded are significant at the 5% level. Variable definitions are in Appendix B.

4. Empirical Results

4.1. Human Capital, Financial Constraints, and Firm Innovation

Table 3 reports the logit estimation results of Equations (1) and (2). The values of variance inflation factors (VIFs) associated with each predictor do not exceed ten for all three columns. The mean VIFs are 2.10, 2.16, and 2.17 in columns (1), (2), and (3), respectively, suggesting that the effects of multicollinearity are within acceptable limits across columns.

In all columns, the dependent variable is a firm's innovation outcomes regarding products or services (*Innovation*). Column (1) shows the estimation result of Equation (1). The coefficient for financing constraints (*Constraints*) is significantly negative ($\alpha_1 = -0.712$, $p < 0.01$), suggesting that firms facing greater financing constraints exhibit less innovative performance, supporting Hypothesis 1. Other variables are also worth noting: Proxies for R&D human capital (*Researcher*, *High_Education*) have significantly positive loadings on *Innovation*, suggesting that a firm's innovative outcomes increase with a strong workforce. Between the two proxies of firm size, *LogEmployee* is positively associated with *Innovation*, while *LogSales* is negatively associated with it. This implies a firm's human resources better explain its innovative outcomes than its revenue-generating capacity. Interestingly, *Network_Diversity* is strongly and negatively associated with *Innovation*, suggesting that a firm's network position offers both opportunities and constraints (Aldrich et al. 1986). When a firm is over-embedded in its networks, the network has constraining effects on the focal firm's behaviors.

Columns (2) and (3) show the estimation results of Equation (2). In column (2), we measure a firm's R&D human capital with the proportion of the workforce designated as R&D out of total employees (*Researcher*). In column (3), we measure the employees' education level (*High_Education*). In column (2), the coefficient for *Constraints* is significantly negative, as in column (1) ($\alpha_1 = -0.825$, $p < 0.01$). The coefficient for the interaction term *Constraints* × *Researcher* is strongly positive ($\alpha_2 = 1.213$, $p < 0.01$). The sum of the coefficient test (H_0: $\alpha_1 + \alpha_2 = 0$) cannot reject the null ($p = 0.35$), indicating that financing constraints' negative effect on firm innovation disappears when the firm has a greater proportion of R&D workforce. In column (3), the coefficient for the interaction term *Constraints* × *High_Education* is strongly positive ($\alpha_2 = 1.300$, $p < 0.05$). The sum of the coefficient test (H_0: $\alpha_1 + \alpha_2 = 0$) cannot reject the null ($p = 0.39$). Collectively, the results in columns (2) and (3) suggest that strong R&D human capital mitigates the negative effects of financing constraints on product/service innovation, supporting Hypothesis 2. In Table 3, the pseudo R-squared values for our logit models range from 0.269 to 0.271. Given the context of logistic regression, where pseudo R-squared values around 0.2 to 0.3 are considered strong, we believe this metric provides a sufficient evaluation of the model's accuracy and predictive performance (Hosmer and Lemeshow 2000).

Untabulated tests indicate that R&D human capital does not significantly impact R&D intensity. This finding can be explained by considering the nature of R&D human capital in relation to R&D expenditure. Highly educated and skilled R&D employees may enhance innovation outcomes by using existing financial resources more efficiently, fostering creativity, and maximizing the returns on limited investments. As such, firms

with strong R&D human capital may be able to innovate without increasing their R&D intensity, i.e., the proportion of R&D expenditure relative to total sales.

Table 3. The results of the logit regression with fixed effects.

	(1)	(2)	(3)
VARIABLES		**Dep var: *Innovation***	
Constraints	−0.712 ***	−0.825 ***	−0.798 ***
	(−13.150)	(−11.572)	(−11.416)
Constraints × *Researcher*		1.213 ***	
		(2.654)	
Constraints × *High_Education*			1.300 **
			(2.089)
Researcher	2.470 ***	2.711 ***	2.471 ***
	(4.886)	(5.274)	(4.889)
High_Education	1.510 **	1.656 **	1.854 ***
	(2.148)	(2.369)	(2.603)
LogEmployee	0.368 ***	0.364 ***	0.358 ***
	(4.525)	(4.467)	(4.384)
LogSales	−0.132 *	−0.131 *	−0.133 *
	(−1.790)	(−1.783)	(−1.804)
Listed	0.017	0.025	0.033
	(0.128)	(0.189)	(0.255)
Complex	−0.108	−0.118	−0.119
	(−1.025)	(−1.122)	(−1.130)
Network_Diversity	−1.489 ***	−1.462 ***	−1.480 ***
	(−14.628)	(−14.249)	(−14.486)
Constant	0.781	0.723	0.827
	(0.916)	(0.846)	(0.967)
Industry FE	Yes	Yes	Yes
Corporation Size FE	Yes	Yes	Yes
Observations	3981	3981	3981
Pseudo R-squared	0.269	0.271	0.270

*, **, and *** denote significance at 10%, 5%, and 1%, respectively, and the z-statistics are in parentheses. Columns (1)–(2) show the estimation results of the logit regressions. Variable definitions are in Appendix B.

4.2. Additional Analysis: Entrepreneurial Culture and R&D Human Capital

So far, we have examined how human capital mitigates the negative effect of financial constraints on innovative outcomes. Additionally, we explore circumstances where R&D human capital contributes to creative outcomes to a greater extent via entrepreneurial corporate culture. Managers often underscore the importance of fostering an entrepreneurial culture that tolerates failure and encourages risk-taking. Two of the most innovative companies, Amazon and Google, have flat organizational hierarchies in which decision-making involves everyone, and employees at all levels enjoy a high level of autonomy to pursue entrepreneurial endeavors (Pisano 2019; Clark 2020). Strong R&D human capital is likely accompanied by an entrepreneurial culture, which enables the R&D workforce to fully realize their creative ideas to compete with market rivals. Although the R&D workforce possesses rich ideas and capacity, organizations emphasizing stable financial performance may discourage innovative activities. In contrast, entrepreneurial firms encourage employees to exploit their knowledge and expertise to compete proactively with competitors.

Table 4 shows whether the effectiveness of R&D human capital hinges on a firm's entrepreneurial culture. We measure entrepreneurial orientation based on three survey items on a firm's aggressive competition to expand market share, because competitive aggressiveness is an important element of entrepreneurial orientation (Dess and Lumpkin 2005). We divide our sample into *Highly Entrepreneurial Culture* (above-or-equal-to-median principal components of the three survey items) and *Less Entrepreneurial Culture* (below-median principal components of the three survey items) subsamples.[3] Columns (1) and

(2) use the *Highly Entrepreneurial Culture* subsample to re-estimate Equation (2). In both columns, we find a significantly positive moderating effect of R&D human capital on the relationship between financing constraints and firm innovation, as shown by the positive coefficients for *Constraints* × *Researcher* and *Constraints* × *High Education* (α_2 = 1.303, $p < 0.05$ in column (1), α_2 = 2.302, $p < 0.01$ in column (2)). This is consistent with our main findings supporting H2.

In contrast, in columns (3) and (4), which use the *Less Entrepreneurial Culture* subsample, we do not find a significant moderating effect of R&D human capital. Collectively, the results in columns (1)–(4) suggest that R&D human capital helps firms overcome financing constraints for innovative activities *only when* the organization encourages the entrepreneurial behaviors of their employees. This highlights the importance of corporate culture in stimulating and exploiting R&D human capital to overcome financial difficulties and reap innovative outcomes.

Table 4. The results of the logit regression with fixed effects.

	(1)	(2)	(3)	(4)
	Dep var: *Innovation*			
VARIABLES	**Highly Entrepreneurial Culture**		**Less Entrepreneurial Culture**	
Constraints	−0.913 ***	−0.956 ***	−0.533 ***	−0.399 ***
	(−9.48)	(−9.99)	(−4.38)	(−3.09)
Constraints × *Researcher*	1.303 **		0.450	
	(2.07)		(0.60)	
Constraints × *High Education*		2.302 ***		−1.479
		(2.88)		(−1.16)
LogEmployee	0.447 ***	0.428 ***	0.234 *	0.239 *
	(3.94)	(3.77)	(1.81)	(1.85)
Researcher	1.989 ***	1.674 **	2.676 ***	2.537 ***
	(2.80)	(2.41)	(3.36)	(3.25)
High Education	1.458	1.971 **	2.292 **	1.897 *
	(1.57)	(2.12)	(2.06)	(1.65)
LogSales	−0.119	−0.119	−0.185	−0.184
	(−1.17)	(−1.16)	(−1.60)	(−1.59)
Listed	−0.154	−0.132	0.262	0.238
	(−0.92)	(−0.79)	(1.19)	(1.07)
Complex	−0.202	−0.214	0.034	0.046
	(−1.41)	(−1.49)	(0.20)	(0.28)
Network_Diversity	−1.255 ***	−1.276 ***	−2.256 ***	−2.303 ***
	(−9.23)	(−9.40)	(−11.46)	(−11.67)
Constant	0.044	0.192	2.837 **	2.866 **
	(0.04)	(0.16)	(2.07)	(2.09)
Industry FE	Yes	Yes	Yes	Yes
Corporation Size FE	Yes	Yes	Yes	Yes
Observations	1991	1991	1941	1941
Pseudo R-squared	0.259	0.261	0.340	0.341

*, **, and *** denote significance at 10%, 5%, and 1%, respectively, and the z-statistics are in parentheses. Columns (1)–(2) show the estimation results of the logit regressions. Variable definitions are in Appendix B.

5. Conclusions and Policy Implications

To better understand how firms can overcome financing constraints for innovative investment, this study examines the relationships among financing constraints, innovative outcomes, and R&D human capital and how these relationships differ across corporate cultures. A survey of 3998 manufacturing firms in Korea is used to test the hypotheses. The primary objective of this study is to incorporate a resource-based view of firm innovation, suggesting that a firm's human resources may substitute for its capital resources to realize innovative outcomes. Three main conclusions are summarized as follows:

First, the results of the regression analysis indicate that, in general, there is a negative association between financing constraints and a firm's innovative outcomes. This suggests

that financing constraints are an obstacle to a firm's innovative activities, especially because innovative projects are characterized by a high asset specificity and uncertain outcomes that require risk premiums for capital. This study is differentiated from previous studies on cash flow and innovative performance in that it exploits a unique survey that directly measures the financing constraints perceived by firms' managers instead of relying on cash flow to indirectly measure a firm's financing ability. This study has been less concerned with the measurement errors of financing constraints, showing that economic barriers significantly hinder innovative achievement. The result is especially relevant for industries that include small and medium enterprises (SMEs), as SMEs have a higher cost of capital than larger companies with more credit. Fiscal authorities and central banks may expand financial assistance to small businesses that pursue innovative projects through government grants or low-interest loans for R&D investment. While SMEs face greater restrictions to providing collateral for borrowing from banks, capital providers may introduce R&D valuation to adequately qualify small firms with a high expected value for loans.

Second, this study generates an important managerial implication. Although our results show a negative association between financing constraints and innovation performance, the literature has documented inconclusive evidence, calling for further investigation. This study fills the void in the literature by suggesting moderating factors that may alter this relationship. R&D human capital, measured by the proportion of highly educated employees committed to research and development activities, positively moderates the relationship between financing constraints and product/service innovation. The results indicate that a firm with strong human resources can overcome the negative effect of financial difficulties on innovative outcomes. This supports the importance of human resources in cultivating an innovative culture to achieve commercial outcomes in financially constrained periods. R&D human capital accumulates knowledge and creative processes within an organization, enabling firms to utilize constrained financial resources more efficiently to produce innovative outcomes. To reap supra-normal returns from capital investment on innovative projects, firms should invest in R&D talent. Managers should attract and retain tech talent to accumulate organizational intellectual capital at the individual firm level. Engagement at a societal level is also required in the form of training and educational programs for technical workers.

Third, this study underscores the intangible assets in accomplishing innovative performance. While R&D human capital helps firms overcome financial constraints on innovation, the R&D workforce's role can significantly be limited in an inflexible culture. Additional analyses indicate that the positive moderating effect of R&D human capital appears only when firms have a robust entrepreneurial culture. Managers who want their team to innovate must create a culture of intellectual bravery in which organizational members are willing to challenge the status quo, even if it involves being marginalized and punished. As leaders, managers should encourage employees to think beyond short-term stability and pursue fundamental changes to overcome financial distress.

This paper is subject to the following caveats. First, since it exploits a survey of Korean manufacturing firms in 2020, the results may not be generalizable to settings with different labor and product market conditions. While Korean firms have low turnover rates, enabling them to retain staff even during financial distress, firms in countries with flexible labor markets may not be able to exploit human capital to produce returns from limited financial resources. Secondly, the proxies of R&D human capital may reflect confounding factors that simultaneously increase financing constraints and firm innovation. However, such concerns make our results more conservative because any factors that intensify financing constraints (e.g., the dilution of a firm's collateral for loans) would reduce (rather than enhance) innovation performance. In this regard, our empirical models are less likely to suffer endogeneity problems. Nevertheless, our results must be interpreted with an understanding of the specific research setting.

While this study focuses on firms operating under financial constraints, we acknowledge that the dynamics between innovation, financial resources, and human capital could

differ in firms with abundant financial resources. In such contexts, the reliance on high-quality human capital may diminish as sufficient financial resources enable innovation more directly. Furthermore, personnel policies, including corporate social responsibility (CSR) initiatives, may become more prominent when financial constraints are less binding. These considerations offer valuable avenues for future research, which could explore how financial flexibility alters the balance between resource allocation, innovation strategies, and workforce development.

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Institutional Review Board Statement: This study did not require Institutional Review Board (IRB) approval as it utilized secondary survey data that had already been anonymized by a third party prior to our access. Therefore, there was no potential risk to the privacy or rights of individuals participating in the original survey.

Informed Consent Statement: Informed consent was not applicable to this study, as it relied exclusively on secondary survey data that had been anonymized by a third party before we accessed it. No direct interaction with participants occurred, and all personally identifiable information was removed, ensuring participant confidentiality and compliance with ethical research standards.

Data Availability Statement: The raw data supporting the conclusions of this article will be made available by the authors on request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Survey Questionnaire and Measurement Instruments

Table A1. Sample of survey questionnaire.

Innovation Performance	
Have you made/delivered any improved or new products/services (compared to the previous ones) in the past three years (i.e., 2017–2019)? Please respond yes or no.	
Financing Constraints	
Please rate the extent to which you rely on the financing from each source for your innovation activities. The answer ranges from 0 ("We can finance part of our investment in innovative projects from the source", or "We can successfully finance from the source") to 1 ("We do not have any financing from the source", or "We failed to receive financing from the source").	
Financing Source	Reliance on Each Financing Source
1. Internal Cash Reserves 2. Related Parties 3. Borrowings from Banks 4. Stock Issuance 5. Corporate Bond Issuance 6. Borrowings from Investment Institutions 7. Central Government 8. Local Government	*"We can finance part of our investment in innovative projects from the source", or "We can successfully finance from the source."*—0 *"We do not have any financing from the source", or "We failed to receive financing from the source."*—1
R&D Human Capital	
1. What proportion of your total employees have a master's degree or higher? *2. What proportion of your total employees oversee research and development?*	

Table A1. *Cont.*

Entrepreneurial Culture		
The following three survey items use 7-point Likert-type scales ranging from 1 to 7.		
1.		
We cautiously take a position after checking our competitors' moves.	1 2 3 4 5 6 7	*We strive to be a first mover to combat our competitors.*
2.		
We avoid overly aggressive actions and try to maintain our market share.	1 2 3 4 5 6 7	*We take an aggressive posture to gain market share.*
3.		
We defend ourselves from our competitors in a defensive, calm manner.	1 2 3 4 5 6 7	*We take preemptive actions and a forceful approach toward rivals.*

Table A2. Measurement instruments.

	Mean	Median	Min	Max	STD	Factor Loadings	Composite Reliability
Firm Innovation (N = 3998)							
Innovation = 1	Indicates "yes": the firm has made improved or new products/services in the past three years.						
Innovation = 0	Indicates "no": the firm has not made improved or new products/services in the past three years.						
Innovation							
Financing Constraints (N = 3998)							
Difficulties in financing internal cash reserves	0.000	0.224	−6.674	0.564	1.000	0.42	
Difficulties in financing related parties' funds	0.487	0.000	0.000	1.000	0.500	0.61	
Difficulties in borrowing from banks	0.936	1.000	0.000	1.000	0.244	0.43	
Difficulties in issuing stocks	0.808	1.000	0.000	1.000	0.394	0.80	
Difficulties in issuing bonds	0.961	1.000	0.000	1.000	0.193	0.81	0.76
Difficulties in financing from investment institutions	0.960	1.000	0.000	1.000	0.195	0.33	
Difficulties in receiving subsidies from central governments	0.981	1.000	0.000	1.000	0.137	0.54	
Difficulties in receiving subsidies from local governments	0.986	1.000	0.000	1.000	0.118	0.23	
***Constraints** **	0.000	0.224	−6.674	0.564	1.000		
R&D Human Capital (N = 3998)							
High_Education	0.035	0.000	0.000	0.900	0.065		
Researcher	0.071	0.050	0.000	0.980	0.096		
Entrepreneurial Culture (N = 3998)							
First mover	3.693	4.000	1.000	7.000	1.471	0.85	
Aggressively expand market share	4.006	4.000	1.000	7.000	1.378	0.86	0.80
Preemptive actions	3.458	4.000	1.000	7.000	1.359	0.53	
***Entrepreneurial Culture** ***	0.000	0.177	−2.513	2.952	1.000		

* For the principal component analysis, we entered seven survey items (difficulties in financing from each financing source) into the analysis. We used the first principal component with an eigenvalue greater than 1. ** For the principal component analysis, we entered survey items into the analysis after standardizing them (Abernethy et al. 2004). We used the first principal component with an eigenvalue greater than 1.

Appendix B

Variable Definitions

Variables	Definitions
Innovation *	Indicator that takes on 1 if a firm has produced (delivered) new or improved products (services) in the past three years or 0 otherwise.
Constraints *	Principal component of the survey items on the financing constraints of the seven types of capital providers. The seven survey items measure the financing difficulties from internal cash reserves, related parties, banks, stock issuance, bond issuance, investment institutions, and the government.
High Education *	Proportion of workers with master's degrees or higher.
Researcher *	Proportion of researchers among total employees.
LogSales	Natural logarithm of sales.
LogEmployee	Natural logarithm of the number of employees.
Listed	Indicator of a firm's listings on stock exchanges.
Complex	Indicates whether a firm is located in an industrial complex.
Network Diversity	Log number of information sources firms rely on firms to obtain innovative knowledge and technology.
Entrepreneurial Culture *	Principal component of three survey items on a firm's aggressive competition to expand market share, because competitive aggressiveness is an important element of entrepreneurial orientation.

* Details of survey instruments are in Appendix A.

Notes

1 The link for the video: https://youtube/keCwRdbwNQY (accessed on 10 October 2023).

2 We used a single measure of innovation instead of separately measuring products and services, as we aimed to determine the output of firm innovation in general.

3 The composite reliability of the survey items is 0.80, supporting the construct validity of the instrument (Abernethy et al. 2004).

References

Abernethy, Margaret A., Jan Bouwens, and Laurence Van Lent. 2004. Determinants of control system design in divisionalized firms. *The Accounting Review* 79: 545–70. [CrossRef]

Aghion, Philippe, Nick Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt. 2005. Competition and innovation: An inverted-U relationship. *The Quarterly Journal of Economics* 120: 701–28.

Aldrich, Howard, Catherine Zimmer, and Trevor Jones. 1986. Small business still speaks with the same voice: A replication of 'the voice of small business and the politics of survival'. *The Sociological Review* 34: 335–56. [CrossRef]

Anand, Narasimhan, Heidi K. Gardner, and Tim Morris. 2007. Knowledge-based innovation: Emergence and embedding of new practice areas in management consulting firms. *Academy of Management Journal* 50: 406–28. [CrossRef]

Arrow, Kenneth Joseph. 1962. Economic welfare and the allocation of resources for invention. In *The Rate and Direction of Inventive Activity: Economic and Social Factors*. Princeton: Princeton University Press, pp. 609–26.

Bakker, Gerben. 2013. Money for nothing: How firms have financed R&D-projects since the Industrial Revolution. *Research Policy* 42: 1793–814.

Bhattacharya, Sudipto, and Jay R. Ritter. 1983. Innovation and communication: Signalling with partial disclosure. *The Review of Economic Studies* 50: 331–46. [CrossRef]

Bond, Stephen, Dietmar Harhoff, and John Van Reenen. 1999. *Investment, R&D, and Financial Constraints in Britain and in Germany*. IFS Working Paper 99/5. London: Institute for Fiscal Studies.

Caves, Douglas W., Laurits R. Christensen, and W. Erwin Diewert. 1982. The economic theory of index numbers and the measurement of input, output, and productivity. *Econometrica: Journal of the Econometric Society* 50: 1393–414. [CrossRef]

Chen, Chung-Jen, and Jing-Wen Huang. 2009. Strategic human resource practices and innovation performance—The mediating role of knowledge management capacity. *Journal of Business Research* 62: 104–14. [CrossRef]

Clark, Timothy R. 2020. To Foster Innovation, Cultivate a Culture of Intellectual Bravery. Harvard Business Review. Available online: https://hbr.org/2020/10/to-foster-innovation-cultivate-a-culture-of-intellectual-bravery (accessed on 10 October 2023).

Cohen, Wesley M., and Steven Klepper. 1996. A reprise of size and R&D. *The Economic Journal* 106: 925–51.

Crépon, Bruno, Emmanuel Duguet, and Jacques Mairessec. 1998. Research, Innovation and Productivity: An econometric analysis at the firm level. *Economics of Innovation and New Technology* 7: 115–58. [CrossRef]

De Spiegelaere, Stan, Guy Van Gyes, and Geert Van Hootegem. 2018. Innovative work behaviour and performance-related pay: Rewarding the individual or the collective? *The International Journal of Human Resource Management* 29: 1900–19. [CrossRef]

Dess, Gregory, and G. T. Lumpkin. 2005. Entrepreneurial orientation as a source of innovative strategy. *Innovating Strategy Process* 1: 3–9.

Griliches, Zvi. 1980. *R&D and the Productivity Slowdown*. No. w0434. Cambridge, MA: National Bureau of Economic Research.
Hall, Bronwyn H. 2002. The financing of research and development. *Oxford Review of Economic Policy* 18: 35–51. [CrossRef]
Hall, Bronwyn H., and Josh Lerner. 2010. The financing of R&D and innovation. In *The Handbook of the Economics of Innovation*. Amsterdam: North-Holland, vol. 1, pp. 609–39.
Harhoff, Dietmar. 1998. Are there financing constraints for R&D and investment in German manufacturing firms. *Annales d'Economie et de Statistique* 49: 421–56.
Himmelberg, Charles P., and Bruce C. Petersen. 1994. R&D and internal finance: A panel study of small firms in high-tech industries. *The Review of Economics and Statistics* 76: 38–51.
Hosmer, David W., Jr., and Stanley Lemeshow. 2000. *Applied Logistic Regression*, 2nd ed. New York: Wiley.
Jensen, Michael C., and William H. Meckling. 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics* 3: 305–60. [CrossRef]
Keupp, Marcus Matthias, and Oliver Gassmann. 2009. The past and the future of international entrepreneurship: A review and suggestions for developing the field. *Journal of Management* 35: 600–33. [CrossRef]
Lin, Jun-You. 2014. Effects on diversity of R&D sources and human capital on industrial performance. *Technological Forecasting and Social Change* 85: 168–84.
McGuirk, Helen, Helena Lenihan, and Mark Hart. 2015. Measuring the impact of innovative human capital on small firms' propensity to innovate. *Research Policy* 44: 965–76. [CrossRef]
Moreau, C. Page, and Darren W. Dahl. 2005. Designing the solution: The impact of constraints on consumers' creativity. *Journal of Consumer Research* 32: 13–22. [CrossRef]
Organisation for Economic Co-operation and Development (OECD). 2015. *The Innovation Imperative: Contributing to Productivity, Growth and Well-Being*. Paris: OECD Publishing. [CrossRef]
OECD/Eurostat. 2005. *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd ed. The Measurement of Scientific and Technological Activities. Paris: OECD Publishing. [CrossRef]
Pisano, Gary P. 2019. The hard truth about innovative. *Harvard Business Review* 97: 62–71. Available online: https://hbr.org/2019/01/the-hard-truth-about-innovative-cultures (accessed on 10 October 2023).
Sackmann, Sonja A. 1992. Culture and subcultures: An analysis of organizational knowledge. *Administrative Science Quarterly* 37: 140–61. [CrossRef]
Santarelli, Enrico. 1991. Asset specificity, R&D financing, and the signalling properties of the firm's financial structure. *Economics of Innovation and New Technology* 1: 279–94.
Savignac, Frédérique. 2008. Impact of financial constraints on innovation: What can be learned from a direct measure? *Economic Innovation and New Technology* 17: 553–69. [CrossRef]
Schultz, Theodore W. 1961. Investment in human capital. *The American Economic Review* 51: 1–17.
Schumpeter, Joseph. 1942. Creative destruction. *Capitalism, Socialism and Democracy* 825: 82–85.
Solow, Robert M. 1957. Technical change and the aggregate production function. *The Review of Economics and Statistics* 39: 312–20. [CrossRef]
Stewart, Myers, and Majluf Nicholas. 1984. Corporate financing and investment decisions when firms have information that investors do not have. *Journal of Financial Economics* 13: 187–221.
Teece, David J. 1986. Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy* 15: 285–305. [CrossRef]
Teece, David J., Gary Pisano, and Amy Shuen. 1997. Dynamic capabilities and strategic management. *Strategic Management Journal* 18: 509–33. [CrossRef]
TSMC. 2011. TSMC 2011 Business Overview. Available online: http://www.tsmc.com/english/investorRelations/annual_reports.htm (accessed on 10 October 2023).
Zucker, Lynne G., Michael R. Darby, and Marilynn B. Brewer. 1994. *Intellectual Capital and the Birth of US Biotechnology Enterprises*. Cambridge, MA: National Bureau of Economic Research.