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How are the Firms' Innovative Activities and Credit Rating Signals Received in the Market?☆

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Abstract

Firm innovativeness and financing capacity are critical signals to stakeholders as they are key drivers of firm performance and competitiveness and indicate the firm's ability to fund its operations and growth initiatives. Based on signaling theory, this study investigates the signaling effect of a firm's innovativeness and creditworthiness and examines its signaling effectiveness. Using Korean innovation data and Korea Investors Service financial data for nine years, the findings indicate that a firm's technological innovation has a negative impact on its credit ratings, while non-technological innovation has a positive impact. Furthermore, a firm's credit ratings positively impact its performance. The current study contributes to the literature on signaling theory by exploring the signaling effect of a firm's innovativeness and creditworthiness. The findings provide insights for managers on how to send and monitor signals to stakeholders.

Keywords: Technological innovation, Non-technological innovation, Creditworthiness, Signaling theory

1. Introduction

In increasingly severe market competition, a firm's technological/non-technological innovation and financing capacity are among the most important factors in sustaining its ongoing business since they are key drivers of firm performance and competitiveness, and indicate the firm's ability to fund its operations and growth initiatives (Rubera and Kirca 2012). Efficient and stable financing and operations allow firms to maintain market competitiveness. If a firm reaches technical insolvency due to worsening liquidity, it can be difficult to secure market prospects or additional funds, which consequently leads to business closure. Moreover, even if there is a good investment plan, it is difficult to raise new funds, limiting investments to maximize corporate value (Choi, Yang, and Kim 2020).

To have a sustained competitive advantage in generating internal resources, many firms try to invest in R&D, which leads to innovation. However, since innovation performance has a lagged effect and technology development is usually unobservable, innovation activities are considered inherently uncertain and can evaluate the exact value only after realizing the future (Heeley, Matusik, and Jain 2007). Moreover, to secure a budget for innovation activities, firms commonly rely on internal resources or external funds such as bank loans and investments. Therefore, in the corporate finance market, there is a risk of information asymmetry and default between borrowers and financial institutions (Choi, Yang, and Kim 2020). Thus, a firm's creditworthiness is the most important determinant (i.e., signals) of its financing (Choi, Yang, and Kim 2020). Based on their creditworthiness, banks and investors determine the maximum loan provision and interest (Choi, Yang, and Kim 2020). Previous research posits that, while implementing innovation, information asymmetry exists among parties: firm managers (i.e., agents), internal customers (i.e., employees), and external customers (i.e., stakeholders) (Connelly et al. 2011; Eisenhardt 1989; Stiglitz 2002). In order to mitigate uncertainty, firms provide signals to stakeholders concerning their implementation of technological and non-technological innovation, as well as their capability to fulfill financial obligations punctually, through creditworthiness indicators like credit ratings (Bergh et al. 2014; Connelly et al. 2011;

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Czarnitzki and Kraft 2004). In particular, from an organizational and marketing perspective, it is important to check whether their signals are effectively sent to receivers and to monitor responses to the signals (Gupta, Govindarajan, and Malhotra 1999).

Even though firms' innovativeness and creditworthiness are critical signals of financing that allow firms to survive, previous research shows unclear results. Moreover, previous research has mainly focused on technological innovations within the relationship toward credit ratings (Czarnitzki and Kraft 2004). Credit rating agencies in Korea reflect financial and non-financial information disclosed by firms to independently evaluate firms' default risk. However, these agencies have not yet reflected firm innovativeness in the estimated model (Choi, Yang, and Kim 2020). Previous research suggests that firms' innovativeness enhances market uncertainty, which could lead to a decrease in their credit ratings (Ho, Xu, and Yap 2004; Liu, Whited, and Zhang 2009). However, recent research shows that a firm's innovative efficiency negatively affects credit ratings in the short term and positively in the long term (Griffin, Hong, and Ryou 2018). This is because, as innovation performance is difficult to observe in the short term, both information asymmetry between the firm and stakeholders and uncertainty increase (Heeley, Matusik, and Jain 2007). Therefore, this study explores the signaling effect of a firm's innovativeness and credit ratings and investigates its effectiveness. Based on signaling theory, this study empirically investigates aggregated data using the Korean Innovation Survey (KIS) data and Korea Investors Service Value (KIS-Value) data (provided by the NICE) for the period 2011 to 2019. These results contribute to the literature on signaling theory by exploring the signaling effect of a firm's innovativeness and credit rating. Moreover, by considering both technological and non-technological innovations, this study provides a holistic understanding of the relationship between firm innovation and credit ratings. The remainder of this paper is organized as follows. First, it presents the theoretical background and hypotheses development. The methods and results are described in the next section. Third, this study presents the findings and implications. The final section presents limitations and directions for future research.

2. Conceptual background

2.1. Signaling of innovation

Signaling theory mainly focuses on decision-making in cases of information asymmetry and reducing asymmetry in information between the two parties (Connelly et al. 2011; Spence 2002). A signal is known as providing observable information about the underlying, unobservable, or ambiguous ability to meet the demands of receivers (Spence 1978). In general, signaling theory helps parties fill the informational gap between the information they have and the information they want (Bergh et al. 2014). Innovations such as technological development and the implementation of new organizational or marketing methods are hardly observed by outsiders, indicating that information asymmetry exists between insiders and outsiders (Connelly et al. 2011; Spence 2002). Previous studies have identified two types of signals that can be analyzed using signaling theory: firm-controlled signals and non-controlled signals (Micheli and Gemser 2016). Firm-controlled signals refer to information that a firm intentionally communicates to external parties, such as investors or customers, in order to influence their perceptions of the firm. These signals are directly under the control of the firm and can include marketing activities, financial reports, and press releases. On the other hand, non-controlled signals such as customer or expert reviews, media coverage, or rumors, can also impact external stakeholders' perceptions of the firm (Micheli and Gemser 2016). Despite not being directly controlled by the firm, non-controlled signals can still play a significant role in shaping external perceptions of the company. Stakeholders evaluating firms take into account both firm-controlled and non-controlled signals. Given the emphasis on transparency in modern markets, firms now disclose information from both sources. As an example, companies may include various ratings provided by expert agencies in their financial reports (Micheli and Gemser 2016). This approach reflects a growing recognition that both types of signals play a critical role in shaping stakeholder perceptions of a firm's performance (Boot, Milbourn, and Schmeits 2006). In this way, firms have become active signalers, using a range of mechanisms to communicate information to stakeholders and shape their perceptions of the company's activities and prospects (Taj 2016).

Innovation is generally defined as 'a significant or new improvement compared to the previous methods' (OECD 2018). With technological innovation, firms can significantly change or develop the existing market structure, products, or processes, whereas non-technological innovation mainly focuses on significant changes in internal organization and marketing (Lee, Lee, and Garrett 2019; Siriram 2022). Innovation activities are inherently uncertain and can only evaluate exact values after realizing the future (Heeley, Matusik, and Jain 2007). To reduce the uncertainty caused by asymmetric information among

parties, firms send signals to stakeholders to affect their choices (Micheli and Gemser 2016).

Firms provide signals to their stakeholders regarding their creditworthiness, which is crucial for investors and creditors to assess the firm's financial health and future prospects (Boot, Milbourn, and Schmeits 2006). In this context, the firm can be considered a signaler, as it conveys information that can influence external parties' perceptions. Credit ratings assigned by independent rating agencies are a common way for firms to communicate their creditworthiness to stakeholders, and these ratings are not directly controlled by the firm. Thus, credit ratings can also be classified as non-controlled signals since the firm's influence over them is limited (Micheli and Gemser 2016). However, firms can still take steps to maintain a favorable credit rating by ensuring sound financial management and meeting debt obligations promptly, which can signal their creditworthiness to stakeholders.

2.2. *The effect of innovation on creditworthiness*

Credit ratings are an evaluation of credit risk (i.e., default risk) regarding a firm's ability to meet financial obligations within the due date (Czarnitzki and Kraft 2004). Since it is related to the firm's financial obligations, it is highly associated with business and financial risks, including 3Cs (i.e., companies, customers, and competitors), productivity, profitability, policy, and liquidity (Czarnitzki and Kraft 2004). Therefore, the firm's credit ratings show current and future observable firm characteristics.

Innovation is a critical driver of firm competitiveness and growth by enhancing productivity and profitability (Damanpour 1991). However, since innovations are considered uncertain and risky, the relationship between innovation and credit ratings shows mixed results (Czarnitzki and Kraft 2004; Lee, Lee, and Garrett 2019). Prior research shows that uncertainty and risk negatively affect a firm's creditworthiness (Czarnitzki and Kraft 2004; Liu, Whited, and Zhang 2009). Technological innovations, such as a firm's R&D activity, product innovation, and process innovation are likely to have a high failure probability (OECD 2018), which could enhance risk and uncertainty and negatively affect creditworthiness. Therefore, this group of researchers has suggested a negative relationship. However, of late researchers have argued the opposite perspective (Griffin, Hong, and Ryou 2018). As innovation can lead to economic success, implementing innovation might achieve a positive creditworthiness (Czarnitzki and Kraft 2004). Non-technological innovation, such as innovation in management practices, organizational structure, and marketing strategies, can positively impact a firm's creditworthiness. Firms that engage in non-technological innovation are perceived as having a more diversified business model and a stronger capacity to adapt to changing market conditions, thereby reducing the uncertainty and risk of failure of the firm which are important factors in creditworthiness assessment (Schmidt and Rammer 2007). For example, a firm that adopts innovative management practices may have more efficient operations and better financial performance, leading to higher creditworthiness (Volberda, Van Den Bosch, and Heij 2013). Similarly, a firm that implements innovative marketing strategies may have a better reputation and brand image, which can positively impact its creditworthiness (Mukonza and Swarts 2020). Research on the effect of non-technological innovation on firm credit rating is still in its early stages. For instance, some studies have found a positive relationship between non-technological innovation and creditworthiness (Aboal and Tacsir 2018). A high possibility of innovation success may allow firms to achieve good creditworthiness. Hence, this study hypothesizes the following.

H1. *A firm's technological innovation will negatively affect the firm's creditworthiness.*

H2. *A firm's non-technological innovation will positively affect the firm's creditworthiness.*

2.3. *The effect of creditworthiness on firm performance*

Creditworthiness is generally considered a firm's financial constraint (Aktas et al. 2021). A low credit rating indicates high default risk and difficulties in raising external capital (Kim and Shin 2017). Meanwhile, high credit ratings present a firm's creditworthiness and high possibility of external financing (Furfine and Rosen 2011). Therefore, with the disclosure of information about a firm's financial risk and creditworthiness, uncertainty and perceived risk can be reduced.

Prior research indicates that effective signals enhance stakeholders' understanding (Akdeniz and Berk Talay 2013; Micheli and Gemser 2016). Signaling effectiveness is solely dependent on the receiver's characteristics such as attention and interpretation (Connelly et al. 2011). Several studies have shed light on the importance of feedback to signalers regarding signal effectiveness (Gupta, Govindarajan, and Malhotra 1999). To conduct more efficient signaling, firms also desire information from receivers (i.e., stakeholders) in the form of countersignals (Gulati and Higgins 2003). Since credit ratings provide overall information

on firms' creditworthiness and reduce information asymmetry between firms and stakeholders, such signals might reduce uncertainty and have more credibility for the firm which may improve its financial performance (Bergh et al. 2014; Connelly et al. 2011). For example, firms can interpret the effectiveness of signals from financial performance, such as return on assets (ROA) and return on equity (ROE). Thus,

H3. *A firm's creditworthiness will positively affect firm performance.*

3. Research methodology

3.1. Data

We collected data from the Korean Innovation Survey (KIS), which provides firms' innovation activity data, from 2011 to 2018. The KIS data offers comprehensive innovation data, including a firm's financial information and the number of full-time employees. To construct the samples, the data were filtered and complete data for all eight years were obtained. We merge KIS data with firms' financial information gathered from Kis-Value through the NICE Information Service. The financial database was collected from 2011 to 2019 because innovation activities might have lagged effects, and the outcome might reflect performance in the following year. Finally, 86 firms are selected to examine this relationship.

3.2. Variables

3.2.1. Dependent variables

This study uses return on equity (ROE) as a dependent variable to measure a firm's financial performance. ROE is measured as the ratio of net income to total equity and has been widely accepted as a financial performance indicator (Kang, Germann, and Grewal 2016; Wiseman 2009).

3.2.2. Signaling of firm innovation

We use the implementation of technological innovation and non-technological innovation as independent variables, provided by the KIS database. Following the OECD (2018) Oslo Manual, the KIS dataset posits that technological innovation comprises product and process innovation. Data were set on a binary scale. The measurement items included firms' radical and incremental product and process innovation. For instance, items ask whether the product is new, first to the market, or significantly improved. For process innovation, the scale includes whether the firm has introduced new processes or significantly improved its business practices. A firm is considered to implement technological innovation if it includes any product or process innovation (OECD 2018).

Regarding non-technological innovation, which is composed of organizational and marketing innovation (OECD 2018), measurement items include whether the firm significantly changed the organization's structure or marketing 4Ps: product design, placement, promotion, and pricing. A firm is considered to implement non-technological innovation if it includes significant organizational and marketing changes (OECD 2018).

3.2.3. Creditworthiness

The current study uses credit ratings as another independent variable that provides KIS-Value (i.e., KIS rating). Credit ratings offer a firm's overall creditworthiness (Aktan et al. 2019). The ratings are categorized into 10 subcategories from AAA to D, which show different levels of the possibility of default risks (Table 1). AAA represents the best rating (10 points) and D represents the worst rating (1 point). AAA through BBB ratings are considered investment grades, and BB through C ratings are considered speculative grades.

3.2.4. Control variable

Previous research indicates that firms' innovation capabilities and creditworthiness improve depending on their size (Czarnitzki and Kraft 2004; Stoneman 1995). Moreover, previous research has established that larger firms tend to have more extensive innovation capabilities due to their access to abundant resources, including in-house research and development (R&D), in accordance with the resource-based view (Stoneman 1995). However, there is also evidence to suggest that smaller firms may have an advantage in implementing innovative practices due to their flexibility and adaptability in responding to market changes and resource constraints (Ettlie and Rosenthal 2011). To account for the potential influence of firm size on innovation, this study has employed the natural logarithm of total assets as a control variable (Czarnitzki and Kraft 2004).

In the context of innovation research, the proportion of research and development (R&D) personnel within a firm is often used as a variable to examine the relationship between R&D investment and innovation outcomes (Damanpour and Aravind 2012; Hagedoorn and Cloodt 2003). This variable is commonly used to control for the influence of human capital on innovation, as the proportion of R&D personnel can serve as an indicator of the level of expertise and knowledge within a firm's innovation team (Damanpour and Aravind 2012).

Table 1. Definitions of KIS rating's credit rating.

Classification	Rating	Definition
Investment grade	AAA	The highest capacity to meet its financial obligations.
	AA(+/non/−)	Very high capacity to meet its financial obligations.
	A(+/non/−)	High capacity to meet its financial obligations.
	BBB(+/non/−)	Adequate capacity to meet its financial obligations.
Speculative grade	BB(+/non/−)	Some uncertainty over the possibility of complying with financial obligations and speculative elements.
	B(+/non/−)	Substantial uncertainty over the possibility of complying with financial obligations and speculative elements.
	CCC	High risk of default on financial obligations and doubtful to comply with financial obligations.
	CC	Very high risk of default on financial obligations and an extremely low possibility of complying with financial obligations.
	C	Extremely high risk of default on financial obligations and lack of possibility of complying with financial obligations.
	D	Default.

Source: Korea Investors Service Ratings.

3.3. Data analysis

The current study employs panel regression with a firm fixed-effect estimation to examine the effect of innovation on a firm's creditworthiness (H1–H2) and to explore the effect of the firm's creditworthiness on firm performance (H3). The causal inference of the correlation between a firm's creditworthiness and its performance remains questionable due to potential endogeneity. To mitigate this issue, this study employs lagged independent variables and a panel fixed-effect model to consider the effects of the variables on the dependent variable in the previous time periods (Baltagi 2005; Wooldridge 2010). The Hausman test showed no correlation between the independent variables and the error term. The equation for the model is specified as

$$\begin{aligned} Credit_{it+1} = \alpha + \ & \beta_1 * Technological\ Innovation_{it} \\ & + \beta_2 * Non\ technological\ Innovation_{it} \\ & + \beta_3 * Firm\ size_{it} + \beta_4 * Proportion\ of\ R\&D \\ & personnel_{it} + \varepsilon_{it} \end{aligned} \quad (1)$$

$$\begin{aligned} Performance_{it+1} = \alpha + \ & \beta_1 * Credit_{it} \\ & + \beta_2 * Technological\ Innovation_{it} \\ & + \beta_3 * Non\ technological\ Innovation_{it} \\ & + \beta_4 * Firm\ size_{it} + \beta_5 * Proportion\ of\ R\&D \\ & personnel_{it} + \varepsilon_{it} \end{aligned} \quad (2)$$

Subscripts i and t denote an individual firm and time period respectively. The dependent variable was measured at $t+1$ to reflect the time-lagged impact of innovation. In Eq. (1), the dependent variable represents a firm's present and future financial stability, specifically its creditworthiness. The independent variables in Eq. (1) firm's high level of technological and non-technological innovations, are considered signals of lower default risk. In Eq. (2), the dependent variable represents a firm's financial performance, while the independent variables represent a firm's high level of creditworthiness, which are considered signals of lower uncertainty in financing.

4. Results

Table 2 presents the correlations and descriptive statistics of the variables. The correlations between the variables were acceptably low. Variance inflation factor (VIFs) tests were conducted to check the multicollinearity of the variables. All VIF values were below the recommended cut-off of 10. The mean VIF value was 1.23, indicating no concern regarding multicollinearity in the data (Neter et al. 1996).

The results show that technological innovation negatively affects a firm's credit ratings ($\beta = -0.619$, $p < 0.01$), consistent with the traditional view (Czarnitzki and Kraft 2004; Liu, Whited, and Zhang 2009). However, non-technological innovation positively affects firms' credit ratings ($\beta = 0.369$, $p < 0.05$) (see Table 3). Therefore, consistent with Griffin, Hong, and Ryou (2018), the findings indicate that innovation could be either positive or negative, depending on the risk and uncertainty of the innovation's success. Thus, H1 and H2 are supported.

Creditworthiness significantly and positively affects firm performance ($\beta = 0.0346$, $p < 0.05$), thus

Table 2. Correlations and descriptive statistics ($n = 86$ firms).

	Variables	1	2	3	4
1	Performance	1			
2	Technological Innovation	−0.070*	1		
3	Non-technological Innovation	0.099	0.299*	1	
4	Creditworthiness	0.076*	0.040	0.069*	1
	Mean	4.566	0.504	0.430	5.473
	SD	12.298	0.501	0.496	1.882

*$p < 0.05$.

Table 3. Relationship between innovation and creditworthiness.

Variables	Model 1	Model 2
	Dependent variable: Creditworthiness	
Technological Innovation	−0.2529**	−0.6185***
	(0.107)	(0.234)
Non-technological Innovation	.	0.3687**
	.	(0.163)
Firm size	0.3072	0.2089
	(0.348)	(0.347)
Proportion of R&D personnel	0.0043	0.0035
	(0.006)	(0.006)
Constant	2.2085	0.1753
	(8.773)	(8.730)
Observations	769	769
Number of firms	86	86

Standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

supporting H3 (see Table 4). We also examine the effect of innovation on firm performance. However, Model 3 shows that both technological innovation and non-technological innovation do not significantly and directly affect firm performance ($\beta = -0.025$, $p = n.s.$; $\beta = 0.001$, $p = n.s.$, respectively). These results show that creditworthiness can act as a signal of sound financing, which leads to enhancement in firm performance. Moreover, since technological innovation and non-technological innovation do not directly or significantly affect a firm's financial performance, the findings indicate that both technological and non-technological innovations have an indirect effect on firm performance via creditworthiness.

4.1. Robustness check

Robustness tests were conducted to verify these findings. Additional analyses were conducted using an alternative measure of firm performance such as return on assets (ROA) and net worth growth rate. Using this alternative measurement, this study replicated Model 3. These results are consistent with the main finding that creditworthiness positively and significantly affects a firm's financial performance ($p < 0.05$) (see Table 4). Furthermore, technological innovation and non-technological innovation again do not significantly affect ROA ($\beta = 0.0005$, $p = n.s.$; $\beta = 0.0006$, $p = n.s.$, respectively) and the net worth growth rate ($\beta = 6.2718$, $p = n.s.$; $\beta = 2.3054$, $p = n.s.$, respectively).

5. Discussion and implications

Through multiple regression analyses, this study suggests that technological innovation may act as a negative signal to a firm's creditworthiness, while non-technological innovation may act as a positive signal. Moreover, the findings show that a firm's creditworthiness positively affects its performance. In addition, this study successfully ruled out alternative explanations regarding the relationship between credit ratings and firm performance.

5.1. Theoretical and managerial implications

The current study contributes to the growing literature on signaling theory by revealing the signaling effect of a firm's innovativeness and credit rating on firm performance. Although the signaling effect of firm innovation and creditworthiness has been discussed in marketing, management, and finance literature, it mainly focuses on the firm's technological innovation and shows unclear results (Czarnitzki and Kraft 2004; Griffin, Hong, and Ryou 2018; Liu, Whited, and Zhang 2009). Considering that

Table 4. Relationship between credit ratings and firm performance.

Variables	Model 3 DV: ROE	Model 4 DV: ROA	Model 5 DV: Net worth growth rate
Creditworthiness	0.0751***	0.0283***	7.8905**
	(0.010)	(0.003)	(3.290)
Technological Innovation	−0.0252	0.0005	6.2718
	(0.023)	(0.007)	(7.182)
Non-technological Innovation	0.0006	0.0009	2.3054
	(0.0221)	(0.007)	(6.974)
Firm size	−0.0371	0.0206	−0.1530
	(0.001)	(0.015)	(14.612)
Proportion of R&D personnel	−0.0000	0.0003	0.0077
	(0.001)	(0.000)	(0.2487)
Constant	1.4024	0.3417	60.3645
	(1.165)	(0.3712	(368.080)
Observations	683	683	683
Number of firms	86	86	86

Standard errors in parentheses.
***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

many firms implement both technological and non-technological innovation simultaneously, examining both types of innovation is necessary. Moreover, since firms' creditworthiness is becoming more important, particularly for innovative firms, the current study extends the discussion on how a firm's innovation and credit ratings act as signals toward firm performance.

Second, the findings argue that creditworthiness could be a significant mediator between a firm's technological/non-technological innovation and firm performance, explaining how they reduce stakeholders' perceived uncertainty and risks. Previous research shows that innovation is uncertain and risky in nature (Lee, Lee, and Garrett 2019; Liu, Whited, and Zhang 2009). Therefore, signals regarding innovation do not always positively impact firm performance. For instance, the current study reveals that technological and non-technological innovation does not directly impact firm performance but has an indirect effect via credit ratings.

Third, the findings provide insights for managers on how to send and monitor signals to stakeholders. Because it is difficult for external stakeholders to identify internal firm innovations and creditworthiness, information asymmetry occurs (Connelly et al. 2011). With the development of digital technology, firms send signals about their innovations to the market more easily and stakeholders also send feedback as a response signal. To provide an effective signal, it is necessary to properly identify and monitor feedback and to focus on two-way communication. If a firm sends the wrong signals, it could negatively affect the firm's image and performance, even though the firm spends a lot of money.

5.2. *Limitations and future research*

Although the current study provides an idea of a firm's innovativeness and creditworthiness signaling effect, several issues should be addressed in future studies. First, this study relied on secondary data. In other words, even though the study empirically examined signaling and signaling effectiveness, it would be the signaler's view. Therefore, future research should capture the receiver's view through online reviews on corporate evaluation platforms such as Blind or conduct surveys with stakeholders.

Second, aligning with the first issue, this study relies on the credit rating agency's score to evaluate a firm's creditworthiness. Previous research also mainly uses the rating to evaluate the firm's creditworthiness (Aktas et al. 2021; Czarnitzki and Kraft 2004; Furfine and Rosen 2011). However, if it is possible to identify stakeholders' perceived credibility of the firm, future studies may identify signaling effectiveness and examine the effect of counter-signaling throughout the market.

Finally, as the findings show statistically significant differences in firm size, it is necessary to identify the possible differences among firms based on firm size. Therefore, the effect of signaling and effectiveness should be examined depending on firm size. For example, future studies may examine the difference between small and medium enterprises (SMEs) versus big firms or high-tech versus low-tech industries. Thus, conducting a study using a different framework in future research may be interesting.

Conflict of interest

The author declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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