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Negative performance feedback and firm cooperation: How multiple upward social comparisons affect firm cooperative R&D

David Diwei Lv [a], Hang Zhu [a], Weihong Chen [b,c,*], Hailin Lan [b,c]

[a] Business School, Sun Yat-sen University, Guangdong 510275, China
[b] School of Business Administration, South China University of Technology, Guangdong 510640, China
[c] Research Center of Chinese Corporate Strategic Management, South China University of Technology, Guangdong 510640, China

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ABSTRACT

This paper studies the impact of inconsistencies in upward social comparisons on a firm's cooperative R&D. We find that firms with inconsistent industrial and regional upward social comparison results show higher levels of cooperative R&D intensity than those with consistent results. Furthermore, in facing inconsistency, firms with a "high industrial upward social comparison gap-low regional upward social comparison gap" combination show higher levels of cooperative R&D intensity than those with a "low industrial upward social comparison gap-high regional upward social comparison gap" combination. These results indicate that inconsistent social comparison results can promote the openness of a firm's R&D. In cases of inconsistency, better regional comparison results can help a firm narrow its industrial upward social comparison gap in an open and innovative way. The above findings provide insights for policymakers committed to guiding and promoting openness in corporate innovation.

1. Introduction

The rapid development of new technologies such as big data and digital technologies has profoundly changed trends of management research and practice (Donthu, Kumar, & Pattnaik, 2020; Donthu, Kumar, Pattnaik, & Campagna, 2020; Ribeiro-Soriano, McDowell, & Kraus, 2019). While innovation creates value for the firms that develop it, it also leads to the emergence of new markets (Gustafsson, Snyder, & Witell, 2020; Ostrom, Parasuraman, Bowen, Patrício, & Voss, 2015). The inclusion of new technologies such as digital technologies into a business context poses major challenges and opportunities for firms, sometimes going as far as resulting in the Schumpeterian destruction of whole industries (Kraus, Roig-Tierno, & Bouncken, 2019). In this case, firms need not only compete with rivals within their industries but must also seek growth opportunities more broadly (Hannah & Eisenhardt, 2018). Decision makers must identify industrial growth opportunities and solve problems to achieve their industrial vision and lend coherence to decisions (Ribeiro-Soriano & Kraus, 2018). Meanwhile, firms must be on high alert for growth opportunities emerging in their region. As research suggests (Berbegal-Mirabent, Mas-Machuca, & Guix, 2019), firms must prevent shocks from various competitors in the market, including those occurring outside their industries.

In this case, upward social comparison and performance feedback are important mechanisms that can help firms cope with this new environment. When there is a gap between a firm's performance and its target of social comparison (i.e., aspirations or referent points), it must take corresponding actions such as acquiring new technologies or improving innovation efficiency as soon as possible to narrow the gap (René Belderbos, Carree, & Lokshin, 2004). However, under the constraints of relatively limited resources and time (Etemad, Wright, & Dana, 2001), many firms may lack some of the skills required to develop such new products and technologies internally (Anzola-Román, Bayona-Sáez, & García-Marco, 2018; Berbegal-Mirabent, Gil-Doménech, & Ribeiro-Soriano, 2020). In this case, cooperative R&D and the use of external technology sourcing become alternative means for firms to shorten their product life cycles and accelerate product renewal, thus alleviating the above challenges (Berchicci, 2013). For example, to encourage innovation, European countries have implemented strengthened innovation policies, encouraging firms to establish formal operational links to centers of knowledge creation and promoting cooperative R&D to facilitate the transfer of knowledge (Berbegal-Mirabent, Alegre, & Guerrero, 2020). Increasing numbers of firms carry out

* Corresponding author.
E-mail addresses: davidatscut@gmail.com, lvdiwei@mail.sysu.edu.cn (D. Diwei Lv), mnszh@mail.sysu.edu.cn (H. Zhu), whchan@protonmail.com (W. Chen), bmhllan@scut.edu.cn (H. Lan).

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R&D through modes of technical cooperation such as copatenting (Rene Belderbos, Cassiman, Faems, Leten, & Van Looy, 2014). To cooperate successfully, firms must address the transaction risks associated with R&D investments, which produce firm-specific assets, uncertainty, and weak appropriability (James & McGuire, 2016). Before pursuing cooperative R&D, firms compare themselves to other firms to determine the value of and need for cooperation.

In summary, firms can achieve a balance between the pursuit of industry growth and the pursuit of growth opportunities in other fields through multiple social comparisons and cooperative R&D. However, this raises an important but still unanswered question. How do the inconsistencies between multiple social comparisons affect corporate cooperative R&D? The previous literature suggests that the same firm may have inconsistent status based on social comparisons to different fields, and such differences in status in different fields will motivate firms to change their weak status (Han & Pollock, 2020; Wang & Jensen, 2019). We believe that these views also apply to the context of corporate behavior: the leading firm that has achieved close to the best performance in the industry will also seek to achieve the optimum performance in the region in which it is located. Understanding how multiple upward social comparisons affect a firm's cooperative R&D is crucial to understanding the cognitive-behavioral foundation of a firm's cooperative behavior and business strategies (Kacperczyk, Beckman, & Moliterno, 2015).

To this end, using the variable of upward social comparison gap inconsistency derived from multiple upward social comparisons via response surface analysis, we examine how a firm's cooperative R&D is affected by multiple upward social comparisons. We make two main contributions. First, in studies of performance feedback, upward social comparisons are usually based on comparisons made between firms in the same industry. However, we believe that in reality, firms' decisions are still affected by upward social comparisons to firms operating in different industries but located in the same region (Feldman, Gartenberg, & Wulf, 2018). With this paper, we contribute to the literature on performance feedback (Obloj & Zenger, 2017; Shi, Zhang, & Hoskisson, 2017) by proving that a cross-industry upward social comparison gap within a region will also have a great impact on firm innovation input and especially on the intensity of cooperative R&D. Second, for firms in the same region, their understanding of relative performance within this region increases the likelihood of upward social comparisons being drawn between firms (Blanes i Vidal & Nossol, 2011; Charness, Masclet, & Villeval, 2014). However, existing performance feedback studies do not determine how different combinations of region-based social comparison results and classic industry-based social comparison results affect firms' cooperative R&D. We extend the classic performance feedback model by using response surface analysis techniques to divide upward social comparisons into industry and regional dimensions. The expanded model allows us to consider the combined impact of industrial and regional upward social comparisons on corporate cooperative R&D.

The rest of this paper is structured as follows. In the first section, we extend the traditional single performance feedback model to take multiple upward social comparison gaps into account and propose corresponding theoretical hypotheses. In the second section, we discuss the study design and sample data and provide our response surface analysis results based on polynomial regression. In the third section, we discuss these results. The fourth section concludes.

2. Theory and hypotheses

2.1. Social referent points and multiple upward social comparisons

In a structure with multiple social referent points or comparison groups, firms have varied statuses and expect their status to be verified multiple times through different comparisons (Jones, Ratten, Klapper, & Fayolle, 2019). For example, a firm achieving close to the best performance in its industry is considered a "leading firm." Once achieving this status in its industry, the firm will continue to draw comparisons to firms outside of its industry to confirm that it also occupies such a position in other realms such as amongst its external (nonpeer) audience or in its local community (Fini, Jourdan, & Perkmann, 2018). For both external observers and internal decision makers, the ability to maintain a high degree of consistency between different upward social comparisons serves as a reliable assessment of a firm's status. Conversely, when a recognized status is not reconfirmed in another area of upward social comparison, firms may be inclined to seek problems and solutions (Deutsch, 1973).

In addition to the gap between current performance and the performance of other firms in the same industry, firms care about the performance of other firms outside of their industries, especially for those firms that are geographically close to them (Obloj & Zenger, 2017). Firms draw external upward social comparisons and care about the performance of firms in other industries operating in the same region for two main reasons. First, geographic proximity is conducive to the formation of a network among firms, facilitating the flow of information and making performance comparisons easier to make (Festinger, 1954; Festinger, Schachter, & Back, 1950). Second, firms in the same region face more similar microenvironment and external resource conditions (McPherson, Smith-Lovin, & Cook, 2001; Milton & Westphal, 2005; Nickerson & Zenger, 2008). Therefore, especially considering the possibility of competition for local resources and opportunities among firms in the same region, the performance of other firms in the same region often becomes a reference point for a firm.

Specifically, after confirming its position in its industry through upward comparisons, a firm will often compare its performance to that of other firms in the same region (Hasan & Koning, 2019). The feedback consistency of upward social comparisons based on industrial and regional referent groups implies that the results of comparison to different groups can be mutually confirmed, which means that a firm's current perceived status is trustworthy and not easily changed (Tarakci, Ateş, Floyd, Ahn, & Wooldridge, 2018). Under such circumstances, managers' initiative is greatly restricted, and firms are less likely to make great efforts to deny these confirmed statuses. By contrast, when the results of comparisons drawn between the two groups are inconsistent, the higher status of one group will become the reference point of the status of the other group. Inconsistency between the comparison results provides more leeway for managers to subjectively interpret such results in a self-enhancing way, motivating firms to improve their lower status in specific groups through efforts (Tarakci et al., 2018).

2.2. The relationship between the multiple upward social comparison gap and cooperative R&D

According to the behavioral theory of the firm, the gap between a firm's actual performance and its social referent points affects its tendency to take risks (Hu, He, Blettner, & Bettis, 2017; Kacperczyk et al., 2015). When performance falls short of social aspirations, a firm defines this situation as a performance problem and launches a problemistic search (Posen, Keil, Kim, & Meissner, 2018). At this point, the firm will try to find a new means to improve its performance to above its aspiration level by increasing its inputs into innovation (Cyert & March, 1963). In terms of firms' search strategies, the existing research divides firms' searches into local and nonlocal searches. Local searches are characterized as internal, narrow and focused while distant searches are external, broad and explorative (Afuah & Tucci, 2012; Kim, Arthurs, Sahaym, & Cullen, 2013).

As a firm's search follows the principle of proximity (Baum & Dahlin, 2007; Cyert & March, 1963), nonlocal searches are conducted only when all internally available alternatives are identified as failing to close the current performance gap. Cooperative R&D is a typical type of nonlocal search (Alexy & Reitzig, 2013; Laursen & Salter, 2006) because only when a firm lacks the resources or knowledge needed for innovation will it try to open its organizational boundaries and seek external

cooperation (Helfat & Quinn, 2006). As a type of nonlocal search, through cooperative R&D, a firm benefits less from its accumulated experience and more from the experience of other firms (Alexy, Bascavusoglu-Moreau, & Salter, 2016). This characteristic renders firms' social comparison results key to influencing and even determining a firm's tendency to engage in cooperative R&D: firms only actively engage in cooperative R&D when they believe that they can gain more benefits through cooperative R&D with other firms.

Furthermore, studies have shown that although cooperative R&D can provide underperforming firms access to new resources, which can enhance their capabilities to create and commercialize innovative ideas (Helfat & Quinn, 2006), the shift from traditional internal R&D to cooperative R&D still requires firms to adopt a new mindset and to exhibit a strong motivation to change (Ahn, Minshall, & Mortara, 2017). Consistent and mutually validated social comparison results can limit incentives for firms to cooperate with R&D. In the face of these mutually validated results, firms are more likely to enhance their internal R&D efforts and exploit local resources to close the gap (Chen & Miller, 2007; Greve, 2003). In contrast, results that are inconsistent or not mutually validated often expose firms to more uncertainty and create more leeway for the subjective interpretation of performance (Joseph & Gaba, 2015; Lucas, Knoben, & Meeus, 2018). In the face of inconsistency, in addition to internal R&D, firms have more leeway to consider other more cost-efficient alternatives such as cooperative R&D (Cassiman & Valentini, 2016; Vanhaverbeke, Van de Vrande, & Chesbrough, 2008). In this respect, inconsistency between social comparison results is conducive to cooperative R&D.

As mentioned above, the intensity of cooperative R&D is affected not only by the results of upward social comparisons made within an industry but also by the upward social comparisons drawn within a region. Firms care about comparisons made within their regions and have an incentive to avoid disadvantages (Blanton & Christie, 2003; Burt, 1982). Below, we use an extended multiple performance feedback model to effectively analyze this problem.

Specifically, firms use upward social comparisons to determine their status within their group. Through upward social comparison, the gap between a firm's performance and the best performance will reduce the firm's self-evaluation (Yu, Duffy, & Tepper, 2018). According to this logic, when a firm's performance falls far behind the best performing firm in its region and industry (that is, consistent industrial-regional social comparison results), the firm is likely to be in a disadvantaged position in terms of social comparison. With such consistent feedback, firms will find it difficult to change the status quo (Ref & Shapira, 2017). Research shows that when self-evaluation among firms is low, firms focus on survival rather than on development and will rely more on familiar, proximal and low-cost knowledge rather than on unfamiliar, distant and high-cost open innovation (Choi, Lee, & Bae, 2019). In contrast, when industrial and regional upward social comparison results are inconsistent, firms have more leeway to interpret performance in a self-enhancing manner, which creates an impetus for a firm to conduct distant searches to narrow the gap (Tarakci et al., 2018). Such initiatives are conducive to promoting cooperative R&D. Therefore, we believe that consistently negative social comparison results will lead to a lower self-evaluation, resulting in a lack of motivation to change and thus reducing the intensity of cooperative R&D. In contrast, inconsistency in multiple upward social comparison results reduces the possibility of low self-evaluation, improving the intensity of cooperative R&D. We thus formulate the following hypothesis:

Hypothesis 1. Firms with inconsistent industrial and regional upward social comparison results have higher levels of cooperative R&D intensity than those with consistent results.

2.3. Industrial and regional upward social comparison

Furthermore, we discuss which type of inconsistency has a greater impact on the cooperative R&D activities of firms. Previous studies shown that different types of inconsistencies may have different effects on a firm (Baum, Rowley, Shipilov, & Chuang, 2005). Different combinations of industrial-regional upward social comparison result combinations provide different prospects for decision makers, which must be discussed separately (Daspit, Chrisman, Sharma, Pearson, & Mahto, 2018).

From one perspective, a firm's regional-industrial upward social comparisons can result in the high regional upward social comparison gap-low industrial upward social comparison gap combination. Such a combination suggests that firms are missing the development opportunities emerging in the region. This regional upward social comparison gap can have a profound influence on firm development. Studies have shown that in a region, excellent talent always prefers to flow to well-treated and profitable firms (Netessine & Yakubovich, 2012). When a firm's performance is far from the best in its region but nearly the best in terms of its industry, a small industrial upward social comparison gap indicates that the firm has absorbed most of the high-quality resources provided by the industry. There is then a threat of the leakage of key quality resources and assets, which limits firms' motivations to seek external R&D partners (Radicic & Balavac, 2019). Additionally, performance that lags far behind the best regional performance indicates a large gap between a firm and firms operating in other industries within the same region. In this case, the best talent and resources in the region are likely to flow out of the firm and into firms in other industries with stronger performance in the same region. The pressure to retain good talent and resources will also force firms to take more risks (e.g., unrelated diversification) to secure higher returns outside of their industries (Lubatkin & Rogers, 1989; Williamson, 1975). Studies have shown that a regional upward social comparison gap will trigger more risky speculation (Kacperczyk et al., 2015). Based on these two effects, when a firm's performance is far from the best regional performance but close to the best industrial performance, the firm will invest more resources in deviant risk-taking behaviors (e.g., invest in risky portfolios for higher returns) and participate less in cooperative R&D (Xu, Zhou, & Du, 2019).

By contrast, a firm's regional-industrial upward social comparison can also result in the high industrial upward social comparison gap-low regional upward social comparison gap combination. A firm performing far behind others in its industry indicates a large gap between the firm and the rest of its industry and demonstrates that the industry has a large number of opportunities that have not yet been seized by the firm (Lucas et al., 2018). This gap will encourage firms to more aggressively seek ways to capitalize on these growth opportunities. Additionally, when a firm's performance is far from the best industrial performance, but near the best regional performance, the small regional upward social comparison gap indicates that the firm has absorbed most of the high-quality resources provided by the region. In this case, it is difficult to narrow the gap between firms and other firms in the industry relying on internal R&D alone. Firms must then cross organizational boundaries and absorb more high-quality talent, knowledge and resources needed for further innovation from areas outside their regions (Helfat & Quinn, 2006). Such ambition and desire create a strong incentive for firms to collaborate on R&D. To seize the development opportunities of these industries, firms showing a high-low industrial-regional upward social comparison gap prefer to take innovative measures such as cooperative R&D rather than risk-taking.

Studies show that a large regional upward social comparison gap triggers risk-taking behaviors, but a large industrial upward social comparison gap does not (Kacperczyk et al., 2015). A large industrial upward social comparison gap can trigger a problemistic search because poor performance relative to firms in other industries does not necessarily denote problems in operation but may be a symptom of the industry itself (Barker & Schmitt, 2017; Kacperczyk et al., 2015). However, poor performance relative to firms of the same industry is more likely to be perceived as a result of firms' operation problems.

Meanwhile, individuals are fundamentally concerned about their prospects within a firm (Barnett, Baron, & Stuart, 2000; Baron & Bielby, 1980). Studies have shown that an upward social comparison gap in an industry can be attributed to the failure of an organization due to the failure of its managers to set or implement appropriate development strategies. Such strategic mistakes in a firm's operations affect the careers of firm managers, constituting a considerably negative impact. In such cases, managers will receive less compensation, support, and resources from their firm (Kempf & Ruenzi, 2008). Therefore, an industrial upward social comparison gap will not only have negative effects on a firm but also cause individual managers to be considered to demonstrate "strategic incompetence," which will lead to individual managers' termination or salary reduction and other major personal losses (Hambrick & Cannella, 1993; Hu, Kale, Pagani, & Subramanian, 2011). In this case, managers prefer to recalibrate their organizations' strategies (such as engaging in more cooperative R&D) to eliminate this reputation for strategic incompetence. Managers engage in cooperative R&D for the following main reasons. First, when there is an industrial upward social comparison gap, the opportunity cost of external technologies used by firms is lower than it is at other times, and an internal leakage of advanced technologies is less likely (Eggers & Kaul, 2018; Makarevich, 2018). Second, compared to internal R&D, cooperative R&D has a shorter cycle and is more likely to spur progress over the short term, which is very attractive to managers urgently needing to change their reputations for strategic incompetence (Berchicci, 2013). Based on the effects of these two aspects, when firm performance lags far behind the best firm performance in the same industry but is nearly the best in the region, the firm will dedicate resources to cooperative R&D activities. We thus propose the following hypothesis:

Hypothesis 2. When the result of regional upward social comparison is inconsistent with that of industrial upward social comparison, firms with the "high industrial upward social comparison gap-low regional upward social comparison gap" combination have higher levels of cooperative R&D intensity than those with the "low industrial upward social comparison gap-high regional upward social comparison gap" combination.

3. Research design

3.1. Data and sample

We used a sample of firms listed in China from 2007 to 2018. Variations in cooperative R&D intensity among these firms are relatively high compared to those of firms in a single industry sector and are coupled with public information, making these firms a good sample for research on the relationship between performance and firms' cooperative R&D (Qian, Wang, Geng, & Yu, 2017).

Three main data sources were used: the China Stock Market and Accounting Research (CSMAR) database, the China Center for Economic Research (CCER) database, and the Chinese Research Data Services (CNRDS) database. The CSMAR database is one of the largest databases available on Chinese publicly listed firms and serves as a primary source of information on Chinese stock markets and the financial statements of China's listed firms. The CCER database provides information about the institutional development of different regions of China. The CNRDS database is the primary source for information on firms' R&D investments because, since 2007, China's Accounting Standard for Business Firms (No. 6–Intangible assets) has required firms to disclose R&D spending and patenting in annual reports following international standards. The study covers the period of 2007 through 2018. For correctness, we consulted annual reports, firm websites and press releases to cross-check the data. To reduce potential impacts of endogeneity, all explanatory variables were processed with a lag of one year. Therefore, the explanatory and control variables cover the period of 2007–2017 while the explained variables cover the period of 2008–2018. Because firms operating in certain industries are affected by high entry barriers and strong government interventions, their decision-making patterns are quite different from those of other firms. Consistent with previous studies (Chen & Miller, 2007), we exclude firms from the following industries: (1) the financial industry (CSRC code: J); the scientific research and technical service industry (CSRC code: M); water conservancy, environment, and public facilities management (CSRC code: N) and health and social work (CSRC code: Q). (2) We also eliminate firm samples with serious data gaps. Through the above screening steps, we finally obtained 9449 unbalanced panel data for 1865 listed firms for the sample period.

3.2. Measures

3.2.1. Dependent variables

3.2.1.1. Cooperative R&D intensity (CPI). There are different ways to collaborate on R&D such as commissioning external agencies for R&D or forming alliances with other firms for joint R&D. To maximize cooperation and expand common interests, final results of cooperative R&D are often obtained through modes of coownership such as copatenting (Rene Belderbos et al., 2014). Copatent arrangements reinforce the mutual commitment of both collaboration partners and thus have become an appropriate proxy of cooperative R&D widely used in the previous literature (Rene Belderbos et al., 2014; Lv, Zeng, & Lan, 2018). Therefore, following previous studies, we measured cooperative R&D intensity by copatenting intensity. Specifically, we measure *copatent intensity* from data on firms' patent application data (copatenting as a percentage of total patenting) from the CNRDS listed firm patent database. We use information on the ownership structures of patents to differentiate between solitary owned and collaborative patents (Rene Belderbos et al., 2014). A patent was considered collaborative when jointly owned with an economic actor that is not part of the consolidated focal firm (e.g., another firm, a university, or a public research institute). Patents jointly owned by individual persons were excluded since it was not known whether these individuals were employed by the focal firm. The measure was calculated to a percentage ranging from a minimum of 0 to a maximum of 1.

3.2.2. Explanatory variables

3.2.2.1. Performance measure and aspirations. Returns on assets (ROA) is our focal performance variable. In publicly listed firms, ROA is undoubtedly the performance measure tracked most closely by firms, making it ideal for the present study (Shi, Hoskisson, & Zhang, 2017). We constructed two performance-aspiration discrepancy measures to serve as independent variables. Following earlier studies (Kacperczyk et al., 2015), we used a measure of industrial and regional social aspiration levels. Both performance feedback measures were based on ROA.

We calculated two different aspiration levels based on ROA. First, we determined the industrial social aspiration level (*IA*) from the maximum ROA of firms in the industry. Therefore, the industrial social upward social comparison gap is the level of industrial social aspiration minus the actual performance of focal firm *IA-P*. Then, the industrial social upward social comparison gap (*I*) was normalized as a linear function to ensure its comparability to the regional social upward social comparison gap (*R*) (Mindruta, Moeen, & Agarwal, 2016). Similarly, we determined the regional social aspiration level (*RA*) from the maximum ROA of firms in the same region. Therefore, the regional social upward social comparison gap is the level of regional social aspiration minus the actual performance of focal firm *RA-P*. Finally, the external social upward social comparison gap (*R*) was also normalized as a linear function to ensure its comparability to the internal social upward social comparison gap (*I*) (Mindruta et al., 2016).

3.2.3. Control variables

To account for alternative explanations, we apply a comprehensive set of control variables. First, we use control variables that account for the effect of firm heterogeneity. Previous research shows that the heterogeneity of firms will affect firm attitudes towards cooperative R&D. Compared to mature large firms with abundant resources, young and small firms with limited resources can enhance their competitiveness by establishing cooperative relations with large firms (Dana, 2001). Therefore, to control the influence of enterprise heterogeneity, we control for variables such as firm size, firm age, the asset-liability ratio and ownership (Dana, Etemad, & Wright, 2013; Wright & Dana, 2003). *Firm Size (SIZE)* is measured as the logged total assets of the firm while *Firm Age (AGE)* is measured as the log of the number of years since its establishment. *Firm Ownership (STA)* is a dummy variable coded as 1 if the target firm is state owned and 0 otherwise (Ozer & Zhang, 2015; Park & Luo, 2001). The *Debt Ratio (LEV)* is measured as the ratio of total debt to total assets.

Second, previous research shows that decision makers can interpret performance feedback in a self-enhancing way (Tarakci et al., 2018). In this case, CEOs who have more power or are less monitored by the board of directors may be more likely to use inconsistency in performance feedback as an excuse to interpret adverse performance in a self-enhancing way, thus affecting the impact of inconsistency on the firm's cooperative R&D. To this end, we control for the potential effects of CEO duality, board size and board independence. Following previous studies (Gentry, Dibrell, & Kim, 2016; Kang & Zaheer, 2018; Rowley, Shipilov, & Greve, 2017; Shipilov, Greve, & Rowley, 2019), we use *CEO Duality (DUA)*, *Board Size (BSIZE)*, and *Board Independence (BIND)* (measured as a percentage of the independent directors) to control for the effect of top management team heterogeneity.

Third, we include control variables that account for the effect of industry and regional heterogeneity. Research shows that one of the main motivations behind cooperative R&D is to overcome the liability of foreignness and successfully introduce new products to the international market (Bertrand, 2009). In this case, the product structure and international trade of a firm may be important factors to consider when making decisions and may affect a firm's attitude towards cooperative R&D (Lien & Klein, 2013). To this end, we control for the effects of product diversification and export intensity. Specifically, following previous research (Lu, Liu, Filatotchev, & Wright, 2014), the entropy index (Mayer, Stadler, & Hautz, 2015) is included to control for firm-level product diversification (*PDIV*). Export intensity (*EI*) is measured as the ratio of overseas sales revenue to total sales revenue. In addition, as a firm's R&D strength is also an important factor in attracting cooperative R&D partners (Chen & Miller, 2007; Greve, 2003; Lim, 2015; O'Brien & Sasson, 2017), following similar studies, we measured R&D intensity (*RD*) as R&D investments divided by a firm's annual sales. Patent stock (*PS*) is measured as the number of valid patents that a firm has in period *t*-1 (Boeing, Mueller, & Sandner, 2016; Tyler & Caner, 2016).

3.3. Statistical analysis

3.3.1. Panel-level polynomial regression estimation

To test the inconsistency effects described in Hypothesis 1, we used panel-level polynomial regressions and response surface modeling (Edwards & Parry, 1993; Herhausen, 2016). First, from our research problems and existing literature, we explain the reasons to adopt panel-level polynomial regression estimation. As a measurement method of effective measure consistency/inconsistency, the value of polynomial regression estimation has been recognized by leading journals in the field of management, including Organization Science (Durand & Georgallis, 2018; Yang & Schwarz, 2016), Academy of Management Journal (AMJ) (Richard, Triana, & Li, 2020), and Strategic Management Journal (SMJ) (Starr & Goldfarb, 2020).

In statistics, this method explores the relationship between several explanatory variables and one or more response variables. The main goal is to examine a series of combinations with varying degrees of consistency/inconsistency to obtain the optimal response. In examining the problem studied here, which is the relationship between inconsistency in multiple social comparison feedback results and corporate cooperative R&D, this method offers the following advantages. (1) It alleviates concerns regarding the limited reliability and confounding effects of other tools such as difference scores (Yang & Schwarz, 2016). (2) It allows us to use polynomial regression to generate a three-dimensional response surface to test the effect of inconsistency on the resulting variables (Edwards & Cable, 2009; Edwards & Van Harrison, 1993). This visual approach allows us to interpret results carefully and visually while avoiding only using abstract terms such as "statistical significance" (Maula & Stam, 2020). (3) It allows us to compare differences between the results of different inconsistencies (e.g., high regional gap-low industry gap vs. low regional gap-high industry gap), and these results are theoretically considered to be equivalent (with the same degree of inconsistency) (Scott, Awasty, Johnson, Matta, & Hollenbeck, 2020). Based on the above advantages of this method and our research problems, we use this method to test the impact of inconsistencies.

Specifically, the dependent variable (i.e., cooperative R&D intensity, *CPI*) was regressed on the control variables (*X*) as well as five polynomial terms, namely, the regional upward social comparison gap (*R*), the industrial upward social comparison gap (*I*), the square term of the regional upward social comparison gap (R^2), the interaction term of the regional upward social comparison gap and industrial upward social comparison gap ($R \times I$), and the square term of the industrial upward social comparison gap (I^2). To reduce multicollinearity and facilitate the interpretation of results, we centered *R* and *I* around the pooled grand mean before calculating the second-order terms (Zhang, Wang, & Shi, 2012). The regression model is as follows:

$$CPI = b_0 + b_1R + b_2I + b_3R^2 + b_4R \times I + b_5I^2 + b_6X + \varepsilon \quad (1)$$

In this paper, response surface analysis (RSM) is used to explain the influence of regional and industrial upward social comparison gaps on copatenting intensity. That is, the combined coefficients of $b_1 \sim b_5$ in the results of the polynomial regression analysis were used for a response surface analysis, and 3D surface graphs were drawn to help explain the findings. Specifically, we are interested in the impact of the combination of social performance feedback signals from different sources on the strength of corporate copatenting in cases of consistency and inconsistency. This kind of effect is mainly studied by analyzing the slope and curvature of the incongruence line of the response surface. The so-called incongruence line denotes that in the *R* - *I* plane, the sum of the two measurement values is zero ($R + I = 0$). We substitute $I = -R$ into Equation (1) to obtain the following equation for the incongruence line:

$$CPI = b_0 + (b_1 - b_2)R + (b_3 - b_4 + b_5)R^2 + \varepsilon \quad (2)$$

Along the incongruence line, the curvature is denoted by the squared term coefficient b_3-b_4 + b_5 on the right side of the equation, and the slope is denoted by the first-order term coefficient b_1-b_2 on the right side of the equation. Curvature (b_3-b_4 + b_5) is used to test Hypothesis 1 on the cross-section where the incongruence line is located. The curvature is positive and significant, indicating that the incongruence line forms a U-shaped curve. The two ends of the curve are inconsistent, and the middle is consistent. Closer to the two ends (more inconsistency), the intensity of copatenting is higher. In contrast, the curvature is negative and significant, indicating that the incongruence line forms an inverted U-shaped curve. The two ends of the curve are inconsistent, and the middle is consistent. Closer to the two ends (the more inconsistent), the intensity of copatenting is lower. The slope (b_1-b_2) is used to test Hypothesis 2. If the slope is negative and significant, the right side of the line is lower than the left side. In contrast, if the slope is negative and significant, the left side of the incongruence line is higher than the right side. According to our hypotheses, the expected curvature (b_3-b_4 + b_5) is

positive, and the expected slope (b_1-b_2) is negative.

4. Results

Table 1 lists the descriptive statistics and correlation coefficients of the variables. According to the descriptive statistical results shown in Table 1, the mean value and standard deviation of copatent intensity (CPI, in percentage) are 9.63 and 21.99, respectively, indicating significant differences in copatent intensity among firms. The mean value of the regional social upward social comparison gap (R) is −0.05, the mean value of the industrial social upward social comparison gap (I) is 0.19, and there are great differences between firms. As shown by the correlation coefficients listed in Table 1, the regional social upward social comparison gap (R) is not directly related to copatent intensity (CPI). The industry social upward social comparison gap (I) is significantly negatively correlated with copatent intensity (CPI); however, the regional social upward social comparison gap (R) and industry social upward social comparison gap (I) are significantly positively correlated. A further statistical analysis of the relationships between these variables is provided below.

Before performing the empirical analysis, four measures were taken to ensure the effectiveness and consistency of the model estimation. (1) We centered the explanatory variables before constructing the interaction terms. (2) Variance inflation factor (VIF) diagnosis was conducted for all input variables of the regression models. The results show that the VIF of each model ranged from 1.01 to 3.54, falling far below 10, indicating that multicollinearity was controlled and that the accuracy of the regression results would not be affected (Aiken, West, & Reno, 1991). (3) As the explained variable used in this work is a proportional value of 0 to 100 and as panel data are used in this paper, we ran panel Tobit models corresponding to each of our regressions (Chen & Miller, 2007). (4) To control for the influence of heteroscedasticity, the robust standard error adjusted by heteroscedasticity is reported.

Table 2 presents the results of our polynomial and hierarchical regression analyses regarding the effect of multiple upward social comparison gap inconsistencies on cooperative R&D intensity. Hypothesis 1 suggests an inconsistency effect of multiple upward social comparison gaps on cooperative R&D intensity. The estimated coefficients as well as the slopes and curvatures along congruence and incongruence lines are presented for the panel-level polynomial regressions in predicting R&D intensity. Model 1 is the baseline model, and only control variables are added; Model 2 adds the regional social upward social comparison gap (R) and industrial social upward social comparison gap (I) based on Model 1. Based on Models 1 and 2, Model 3 adds five polynomials (R, I, R^2, $R \times I$, and I^2) and obtains the corresponding regression coefficient, covariance, and standard error. Based on this, the coefficients and significance of the slope and curvature in cross-sections corresponding to the congruence and incongruence lines are calculated. For the cross-section corresponding to the incongruence line, the curvature (b_3-b_4 + b_5) is used to test Hypothesis 1; the slope (b_1-b_2) is used to test Hypothesis 2. At the same time, based on the polynomial regression results of Model 3, a three-dimensional surface graph that directly reflects the response surface analysis results and a two-dimensional curve graph of the section corresponding to the incongruence line are drawn in Fig. 1 (a) and (b), respectively. As shown in Fig. 1 (a), the congruence line runs from the front (low *R*-low *I*) to the back (high *R*-high *I*) while the incongruence line runs from the left (low *R*-high *I*) to the right (high *R*-low *I*).

According to the response surface analysis data of Model 3 shown in Table 2, the curvature of the response surface along the incongruence line (b_3-b_4 + b_5) is significant and positive (curvature = 5.52, $p < 0.05$). As shown in Fig. 1 (b), the incongruence line projected onto the response surface forms a U-shaped curve with inconsistencies shown at both ends and in the middle. This indicates that copatenting intensity is higher in firms with inconsistent upward social comparison gaps than in firms with consistent upward social comparison gaps. Therefore, we assume that Hypothesis 1 is supported.

The analysis results of the response surface of Model 3 shown in Table 2 also demonstrate that the slope of the response surface along the incongruence line (b_1-b_2) is significant and negative (slope = −3.21, $p < 0.01$). As shown in Fig. 1 (b), the copatenting intensity on the left side (low *R*-high *I*) of the incongruence line is higher than that on the right side (high *R*-low *I*), which suggests that when the regional upward social comparison gap and industrial upward social comparison gap are inconsistent, a high-low industrial-regional upward social comparison gap combination will be more closely associated with higher levels of cooperative R&D intensity than a low–high industrial-regional upward social comparison gap combination. Therefore, Hypothesis 2 is supported.

Since panel data are used in this study, pooling repeated observations on the same organizations violates the assumption of observation independence, resulting in autocorrelation in the residuals. To overcome this limitation and correct for the autocorrelation of error terms, we use random-effects (GLS) panel data models with robust standard errors (Greene, 2003). Specifically, following previous studies (Hoechle, 2007; Kavusan & Frankort, 2019), we use the random effects (GLS) panel data model with the Driscoll-Kraay robust standard error to correct the autocorrelation of the error term and address the heteroscedasticity and cross-sectional correlation. Table 3 shows the robustness test results, which are consistent with the previous results.

Table 1
Correlations, means, and standard deviations.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. *CPI*	1.00													
2. *R*	0.02	1.00												
3. *I*	−0.05	0.24	1.00											
4. *SIZE*	0.12	0.00	−0.15	1.00										
5. *AGE*	−0.01	0.03	0.01	0.14	1.00									
6. *LEV*	0.04	0.07	0.04	0.55	0.10	1.00								
7. *STA*	0.06	0.04	0.02	0.36	0.07	0.38	1.00							
8. *DUA*	0.00	0.03	0.01	−0.18	−0.06	−0.17	−0.28	1.00						
9. *BSIZE*	0.05	−0.08	−0.06	0.25	0.01	0.19	0.27	−0.18	1.00					
10. *BIND*	0.00	0.08	0.01	0.05	−0.05	−0.01	−0.02	0.10	−0.48	1.00				
11. *PDIV*	0.03	0.06	0.01	0.16	0.15	0.14	0.10	−0.05	0.04	0.00	1.00			
12. *EI*	0.02	0.04	0.03	−0.12	−0.03	−0.09	−0.13	0.09	−0.05	0.00	−0.08	1.00		
13. *RD*	−0.04	0.14	0.13	−0.21	0.02	−0.36	−0.25	0.15	−0.15	0.05	−0.11	0.03	1.00	
14. *PS*	0.03	0.09	0.02	0.45	0.18	0.18	0.05	−0.01	0.02	0.07	0.01	−0.03	0.18	1.00
Mean	9.63	−0.05	0.19	21.96	2.80	0.41	0.32	0.30	2.26	0.37	0.33	0.22	0.03	4.19
Std	21.99	0.55	0.39	1.21	0.32	0.20	0.46	0.46	0.17	0.05	0.42	0.23	0.03	1.44
Min	0.00	−1.00	−1.00	18.45	0.65	0.06	0.00	0.00	1.61	0.00	0.00	0.00	0.00	0.69
Max	100.00	1.00	1.00	25.60	3.51	0.89	1.00	1.00	2.77	0.57	1.63	0.93	0.13	7.66

Notes: N = 9,449. Correlations with an absolute value of greater than 0.03 are significant at $p < 0.01$.

Table 2
Panel-level polynomial regressions of CPI on performance feedback consistency/inconsistency.[a]

	Model 1		Model 2		Model 3	
	Beta	*S.E.*	*Beta*	*S.E.*	*Beta*	*S.E.*
Control variables:						
SIZE	2.42***	(0.54)	2.36***	(0.54)	2.43***	(0.54)
AGE	3.35	(2.83)	3.85	(2.82)	3.48	(2.84)
LEV	−3.71	(2.03)	−3.27	(2.05)	−3.56	(2.06)
STA	−0.53	(2.00)	−0.60	(2.00)	−0.57	(2.00)
DUA	−0.46	(0.59)	−0.46	(0.59)	−0.45	(0.58)
BSIZE	−2.26	(2.31)	−2.15	(2.31)	−1.99	(2.31)
BIND	−8.58	(6.06)	−8.46	(6.07)	−8.49	(6.07)
PDIV	−0.42	(0.76)	−0.44	(0.76)	−0.48	(0.76)
EI	−2.05	(1.84)	−1.82	(1.85)	−1.99	(1.85)
RD	−0.39	(10.22)	1.05	(10.18)	−0.49	(10.22)
PS	−0.65	(0.38)	−0.63	(0.38)	−0.64	(0.38)
Constant	10.14***	(0.12)	9.92***	(0.18)	9.11***	(0.37)
Explanatory variables:						
R (b_1)			−1.74**	(0.61)	−1.90**	(0.62)
I (b_2)			0.68	(0.72)	1.31	(0.77)
R^2 (b_3)					1.11	(0.90)
R × I (b_4)					−1.55	(1.22)
I^2 (b_5)					2.87*	(1.37)
F	3.00***		3.13***		3.03***	
N	9449		9449		9449	
Response surface analysis:						
Congruence line: Slope ($b_1 + b_2$)					−0.58	(0.79)
Congruence line: Curvature ($b_3 + b_4 + b_5$)					2.43	(1.42)
Incongruence line: Slope (b_1-b_2)					−3.21**	(1.16)
Incongruence line: Curvature (b_3-$b_4 + b_5$)					5.52*	(2.44)

[a] $N = 9449$. Robust standard errors are shown in parentheses. The year effect is controlled.
* $p < .05$ ** $p < .01$ *** $p < .001$ two-tailed tests.

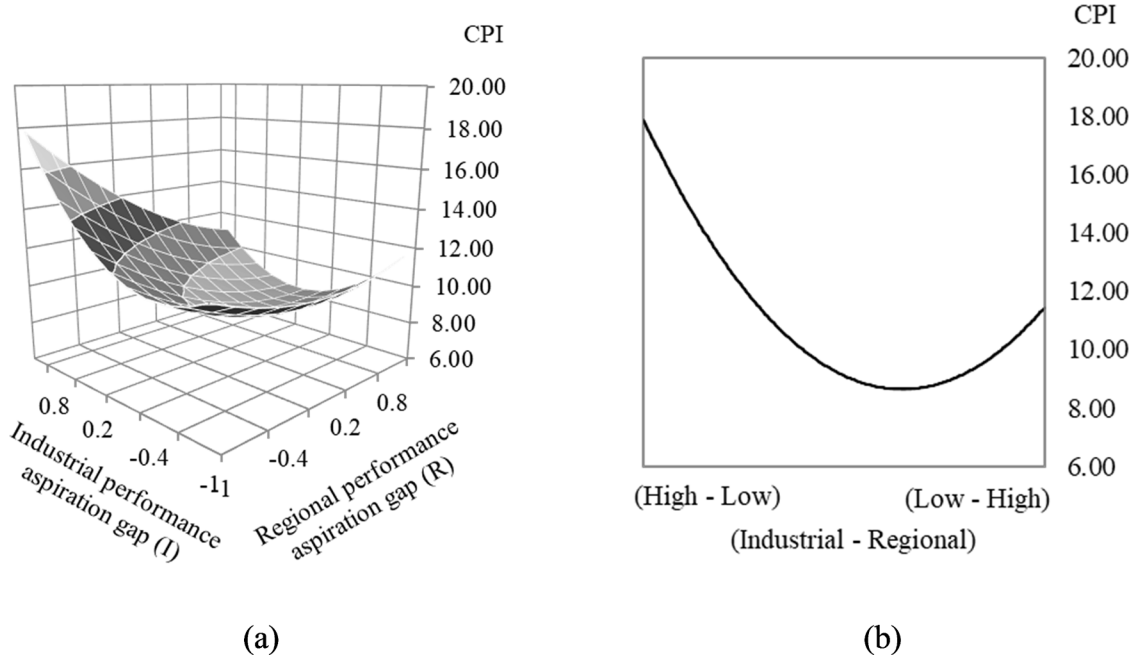

Fig. 1. Response surface depicting the hypothesized relationship between multiple upward social comparison gaps and CPI.

5. Discussion

In this paper, we examine the effect of the inconsistency in industrial-regional upward social comparison results on corporate cooperative R&D decision making (Huarng, Mas-Tur, & Moreno, 2018). Although the influence of the upward social comparison gap on firm cooperative R&D intensity is manifold (Alexy et al., 2016), researchers have not yet studied how upward social comparison gap consistency/inconsistency affect firm cooperative R&D intensity. In this study, we extended the behavioral theory of the firm and found that upward social comparison gap inconsistency based on multiple upward social comparisons has a significant impact on the intensity of a firm's cooperative R&D. We find that cooperative R&D intensity is a response to inconsistencies in the results of upward social comparisons. In cases of inconsistent results, cooperative R&D behavior is more driven by the industrial upward social comparison gap than by the regional upward social comparison gap.

Regarding the impact of firm heterogeneity, despite differences found across settings, our estimates are consistent with previous studies

Table 3
Random-effects (GLS) panel data models with Driscoll-Kraay standard errors.[a]

	Model 1		Model 2		Model 3	
Control variables:	*Beta*	*S.E.*	*Beta*	*S.E.*	*Beta*	*S.E.*
SIZE	2.59**	(0.80)	2.56**	(0.79)	2.55**	(0.79)
AGE	1.61*	(0.63)	1.68*	(0.66)	1.66*	(0.65)
LEV	−3.83***	(0.76)	−3.53***	(0.64)	−3.81***	(0.70)
STA	0.92	(0.46)	0.94	(0.44)	0.82	(0.39)
DUA	0.11	(0.80)	0.12	(0.81)	0.14	(0.81)
BSIZE	−0.23	(3.64)	−0.27	(3.65)	−0.16	(3.70)
BIND	−3.08	(7.21)	−2.92	(7.05)	−2.99	(6.91)
PDIV	−0.12	(0.41)	−0.09	(0.42)	−0.13	(0.43)
EI	1.02	(1.01)	1.09	(0.95)	1.01	(0.93)
RD	12.42	(8.48)	14.32	(8.36)	14.72	(8.60)
PS	−0.11	(0.52)	−0.09	(0.50)	−0.06	(0.52)
Constant	9.75***	(0.07)	9.74***	(0.06)	9.09***	(0.28)
Explanatory variables:						
R (b_1)			−0.65	(0.66)	−0.73	(0.58)
I (b_2)			−0.11	(0.53)	0.53	(0.49)
R^2 (b_3)					0.75	(0.56)
R × I (b_4)					−1.77	(1.24)
I^2 (b_5)					2.62*	(1.18)
Chi2	2345.13***		7968.75***		1323.54***	
N	9449		9449		9449	
Response surface analysis:						
Congruence line: Slope ($b_1 + b_2$)					−0.20	(0.95)
Congruence line: Curvature ($b_3 + b_4 + b_5$)					1.60	(1.49)
Incongruence line: Slope (b_1-b_2)					−1.25*	(0.51)
Incongruence line: Curvature (b_3-$b_4 + b_5$)					5.14*	(2.01)

* $p < .05$ ** $p < .01$ *** $p < .001$ two-tailed tests.
[a] $N = 9449$. Driscoll-Kraay standard errors are shown in parentheses. The year effect is controlled.

based on cross-sectional data from questionnaires. For example, research shows that for small and medium-sized enterprises (SMEs), not only the business environment but also a lack of capabilities and available resources play an important role when it comes to new technologies (Kraus, Gast, Schleich, Jones, & Ritter, 2019). Previous studies have made use of questionnaire data on SMEs in the UK's technology and service industries and found that when a firm's performance lags far below the aspiration level but the firm has sufficient resource endowments (human capital and R&D investment), the firm will engage in more open innovation activities such as cooperative R&D (Alexy et al., 2016). Relevant research also finds that the capacity for firms to acquire, assimilate, transform and exploit new knowledge plays an important role in the innovation of firms in different respects such as products, processes, and management (Ali, Ali, Al-Maimani, & Park, 2018; Ali, Kan, & Sarstedt, 2016). In contrast, firms lacking sufficient resource endowments will not engage in more cooperative R&D. Their research also finds that performance feedback does not directly affect open innovation in firms (the direct effect is not significant). Our results show that the cooperative R&D intensity of firms with an inconsistent upward social comparison gap signal is higher than that of firms with a consistent upward social comparison gap. These findings imply that when determining whether to engage in external cooperative R&D, firms will consider not only the gap between their current performance and that of other firms but also their perceptions of their abilities to engage in external cooperative R&D. Having sufficient resource endowments or inconsistent upward social comparison results will reduce the negative impact of negative self-evaluation on cooperative R&D and promote cooperative R&D.

Regarding inconsistent upward social comparison gaps, our findings are most easily compared to those of Jordan and Audia (2012) who propose that in the face of an inconsistent upward social comparison gap, it is difficult for managers to downplay a strong upward social comparison gap regardless of whether another gap signal is serious or not, as at least in terms of this signal, firm performance is "very poor" (Jordan & Audia, 2012). This mindset leaves little room for self-enhancement, and firms will then actively seek ways to close the gap. Our results for Hypothesis 2 support their views. When firm performance lags far behind the regional best performance, even if firm performance is close to the industry's best performance levels, the firm will still pay attention to the signal that is far from the aspiration level. In this case, firms will be tempted by the high profits of other industries in the region to engage in more risky behaviors and continue to cooperate in R&D and innovation. In contrast, when firm performance lags far behind the industry's best performance, even if a firm's performance is nearly the best in its region, the firm will focus on its industry performance gap and on the fact that lags far behind the aspiration level.

It is also useful to compare our results with those of Kacperczyk et al. (2015), whose results include measures of risk-taking and strategic change. These authors found that the upward social comparison gap relative to external upward social comparison does not trigger problemistic searches or strategic changes because poor performance relative to other firms in other industries does not necessarily mean that a firm is experiencing operation problems and might be a symptom of the industry involved (Kacperczyk et al., 2015). In contrast, such an upward social comparison gap based on external social comparison will trigger risky speculation, which will have a negative impact on firm innovation. The impact illustrated in Kacperczyk et al. (2015) involves a certain type of social comparison rather than consistency between two different social comparisons. We cannot quantify the sensitivity of firms to different types of upward comparisons without determining the degree of "inconsistency" associated with such comparison. However, under the plausible assumption that Kacperczyk et al. (2015) results emerge from a consistent upward social comparison gap, our estimated results are similar to theirs. Our research show that firms with consistent results of industrial and regional upward social comparison have lower levels of cooperative R&D intensity than those with inconsistent results.

Other patterns shown by our results bear qualitative similarities to those presented in the recent literature on social comparison. It is worth noting that the similarities between our findings and those of Vissa, Greve, and Chen (2010) extend beyond the significant response to the social upward social comparison gap; similar to us, these authors found that internal social comparisons produce good results such as facilitating problemistic searches; external social comparisons can produce negative results and hinder problemistic searches (Vissa et al., 2010).

Specifically, our findings regarding asymmetry in the upward social comparison response add to a growing body of literature by providing evidence showing that some types of social comparison adversely affect a firm's strategic behavior such as its innovation (Baumann, Eggers, & Stieglitz, 2019; Nickerson & Zenger, 2008; Sengul & Obloj, 2017). If the part of the larger performance gap away from the best performance originates from internal upward social comparison, the response from firms will not be strong. In this case, firms can still look at problems rationally and actively carry out problemistic searches or even pursuing external cooperative R&D. By contrast, if the part of the larger performance gap away from best performance originates from external upward social comparison, the firm will react strongly, even the performance of those firms lack comparability with the performance of the firm. In this case, the firm will envy the excellent performance of its neighbor and will not rationally understand the problem, will reduce its efforts in cooperative R&D in its industry, and may even engage in more risk-taking behavior.

6. Managerial implications

In addition to describing the value of our results, we now briefly discuss the relevance of our findings to decision makers. Specifically, the most relevant enlightenment of our research results to policy-makers is about the benchmarking practice that is popular among firms. Benchmarking helps firms identify business problems by comparing their own performance to that of the best performing firm in the industry or region to promote firm improvements. However, previous studies have pointed out that under benchmarking pressures, firms may also show reduced ambition and professionalism. Neely provides a vivid example of this phenomenon (Neely, 2013). Their research shows that organizations try to selectively invest in order to maximize their output: schools selectively admit students with high test scores; hospitals admit patients who are more likely to survive. Based on the results of our study, we believe that increasing the diversity of evaluation indicators can help reduce the likelihood of this negative impact of benchmarking. Firms are more likely to generate inconsistent and different results under diverse assessment indicators. This inconsistency creates some dependency of performance evaluation on the personal professional judgments of decision makers, which can afford decision makers some discretion to interpret performance results and encourage them to consider more proactive responses such as using cooperative R&D to reverse adverse situations. To some extent, such discretion reduces the likelihood of adverse effects of benchmarking on firms and provides firms with a foundation for cooperative R&D and even open innovation.

Moreover, previous studies have shown that (Dana et al., 2013) in transition economies, cooperative behavior and symbiotic entrepreneurship among firms is noticeable. For economies such as China, which is transitioning from a centrally planned economy to a market economy, cooperative R&D has effectively increased the overall efficiency of resource allocation. These results further our understanding of the basis of cooperative R&D behavior. In particular, our findings on the role of multiple upward social comparisons of firms in regions and industries in promoting firms' cooperative R&D provide inspiration for the formulation of policies that promote cooperative R&D among firms. Specifically, although most corporate strategy makers will consider a social comparison to their peers during performance evaluations to find gaps and problems, most corporate strategy makers usually pay less attention to social comparisons to other firms in the same region. In transition economies such as China, new regional growth opportunities will emerge as the local institutional environment changes. Our research shows that combining the results of industrial upward social comparison with those of regional upward social comparison can provide more comprehensive feedback where the inconsistency of multiple feedback is conducive to providing more information to decision makers and to promoting cooperative R&D among firms. This means that strategy makers who value open innovation need to enrich the social comparison criteria for performance assessment to include regional upward social comparisons. As for policy-makers concerned with regional innovation, if they wish to promote the open innovation activities of local firms, they need to create conditions to make firms take leading firms of the same region as their performance comparison benchmarks, such as helping to strengthen the network connection among the executives of local firms (Hasan & Koning, 2019).

7. Limitations and future research

Although our findings are consistent with previous research, it is necessary to further study the generalizability of these findings. For example, the sensitivity of corporate R&D to inconsistent performance feedback may be modulated by contextual factors. It will be meaningful to investigate the role of relevant situational factors. In particular, given the interconnectedness of industries, it is probably not unreasonable to think that the best performance in another industry is selected as a reference point. Recent research on platform competition has found that firms can benefit from platforms or open ecosystems (Jacobides, Cennamo, & Gawer, 2018). In this case, the boundaries between different industries may become blurred, and even two industries that are considered incomparable may interact or even merge in the near future. It would be promising and meaningful to consider the potential moderating effect of an industry's entry barriers on the relationship between inconsistent upward social comparison gaps and a firm's cooperative R&D. Furthermore, we find that when the performance gap between a firm and the firm with the best performance in the same region is larger than that between the firm and the firm with the best performance in the same industry, the firm's cooperative R&D intensity is lower. This raises concerns about inequality in regional growth opportunities. Recent research shows that transformational entrepreneurship utilizes novel business practices to reduce inequalities in markets and to transform societies through innovative solutions that bring about changes (Jones & Maas, 2019). Based on our findings, future research can investigate the impact of multiple performance pressures based on internal and external upward social comparisons on firms' transformation entrepreneurship. Finally, it would be meaningful to further explore the situational factors identified in this paper. For example, recent research on diversity indicates that group heterogeneity can reach a moderate level, and psychological attitudes related to social identity theory and self-categorization processes are more likely to occur (Kraus, Schleich, Tröster, & Roig-Tierno, 2019). In cross-industry upward social comparisons made within the same region, are firms more likely to choose firms that are less different (ethnically/culturally/linguistically) from themselves as a reference point? Future research can study the influence of group heterogeneity based on different demographic characteristics on firms' selection of social comparison reference objects and its moderating effect on the relationship between inconsistent multiple performance feedback and corporate cooperative R&D.

Second, we assume the presence of similarities between cooperative R&D across industries, particularly through an emphasis on patent importance. However, patent coownership is not equally important across all industries. Due to limitations of data acquisition, future research can use qualitative content data such as R&D cooperation contracts and R&D alliance contracts to test the generalizability of our findings. Third, we caution against the linear extrapolation of our estimates to infer how firms respond to other types of social comparisons (e.g., setting the reference point to the mean or median performance), as these response functions are likely to be different or even nonlinear. For example, previous research has found a nonlinear relationship between the gap between firm performance and average industry performance and firm innovation (measured by entering new markets) (Kuusela, Keil, & Maula, 2017). Such nonlinearity partly results from the fact that a severe drop will cause a firm to become concerned about its own survival, resulting in rigidity (Staw, 1981). Given these warnings, it would

be useful to consider how downward social comparisons might affect firm behavior and the practice of comparing their results to those of upward social comparisons. When firms are performing poorly, existential threats may prompt them to reduce, not increase, the cooperative R&D efforts. However, inconsistencies in performance feedback identified here will likely reduce a firm's awareness of this threat, which may lead to an attempt to redefine its firm strategy (Lungeanu, Stern, & Zajac, 2016; Shinkle, Kriauciunas, & Hundley, 2013). For example, firms previously accustomed to internal R&D may turn to external R&D, firms previously accustomed to external R&D may turn to internal R&D, or both (Cassiman & Valentini, 2016). Therefore, examination of changes in R&D intensity (Lucas et al., 2018) and of how long it takes for local and nonlocal searches used as a combined search strategy to become advantageous (Winter, Cattani, & Dorsch, 2007) is another important area for future research.

Finally, considering our research problems and data characteristics, we use panel-level polynomial regression estimation to test the impact of inconsistencies. Alternative tools such as correlation coefficients (Joseph & Gaba, 2015), multiple-category variables (Eggers & Suh, 2019), and survey data can also be used to test the impact of inconsistency. We encourage future studies that use appropriate methods in testing the generalizability of our findings in the context of their specific data and research questions.

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Dr. David Lv is a research fellow in the Business School, Sun Yat-sen University. His research examines the implications of organizational learning and decision-making for strategy and innovation management. So far, part of this line of research were published in the international journal such as Technovation, Journal of Business Research and The Journal of Engineering and Technology Management. He is also a peer reviewer for several international and national journals such as International Journal of Innovation Management, Journal of Accounting & Organizational Change, Nankai Business Review.

Prof. Hang Zhu is a Professor in the Business School, Sun Yat-sen University, Guangzhou, Guangdong (China).He has published in several strategic and innovation management journals including Strategic Management Journal and Management and Organization Review.

Mr. Chen is a PhD candidate in Business Management at the School of Business Administration, South China University of Technology and a visiting PhD student at the Department of Strategy and Policy, National University of Singapore. His research interests relate to strategic management and entrepreneurship.

Prof. Hailin Lan is a Professor in the School of Business Administration, South China University of Technology, Guangzhou, Guangdong (China) and the Director of Research Center of Chinese Corporate Strategic Management, as well as the Director of Research Base of New-industrialization Development and Innovation issued by Ministry of Education of China. His research works have published in some journals such as Asia Pacific Journal of Management, The Academy of Management Executive, etc.