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Cheng, Colin C. J.; Shiu, Eric

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Corresponding Author:	Eric C.C. Shiu, PhD University of Birmingham Birmingham, West Midlands UNITED KINGDOM
First Author:	Colin C Cheng, PhD
Order of Authors:	Colin C Cheng, PhD
	Eric C.C. Shiu, PhD
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Abstract:	Fueled by continuing advances in information and social media, the ever-improving social media networks provide firms with a unique opportunity to conveniently communicate with their supply chain partners in a dynamic manner. However, it is a critical unknown as to whether buying firms aiming at enhancing new product performance can benefit from their suppliers' participation in social media networks. Building on social network theory, and using a longitudinal design and secondary proxy dataset of 256 buying firms and their suppliers, the authors find that social media-based supplier network involvement can generate superior new product performance of buying firms. Additionally, social media-based supplier network involvement is more effective for new product performance when this network of suppliers shows strong network strength and network heterogeneity. In contrast, network density is found counter-productive. The results provide guidelines for managers interested in enhancing their innovation outcomes through social media networks.

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Colin C.J. Cheng
Department of Business Administration
National Taipei University
cjcheng@gm.ntpu.edu.tw

Eric C. Shiu*
Birmingham Business School
University of Birmingham
e.c.shiu@bham.ac.uk
+44 (0) 121 414 6529
University of Birmingham, Edgbaston, Birmingham, B15 2TT

*Corresponding author

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ABSTRACT

Fueled by continuing advances in information and social media, the ever-improving social media networks provide firms with unique opportunities to communicate conveniently with their supply chain partners in a dynamic manner. However, a critical unknown is whether buying firms, aiming at enhancing new product performance, can benefit from their suppliers' participation in social media networks. Building on social network theory, and using a longitudinal design and secondary proxy dataset of 256 buying firms and their suppliers, the authors find that social media-based supplier network involvement can generate superior new product performance of buying firms. Additionally, social media-based supplier network involvement is more effective for new product performance when this network of suppliers shows strong network strength and network heterogeneity. In contrast, network density is found to be counter-productive. The results provide guidelines for managers interested in improving their innovation outcomes through social media networks.

Keywords: Social media networks, Supplier involvement, Social media network structure, New product performance

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1. Introduction

Various aspects of supplier involvement in new product development (NPD) have been investigated, such as knowledge protection (Jean, Sinkovics, & Hiebaum, 2014), timing of involvement (Laursen & Andersen, 2016), informal social interaction (Liu, Huang, Dou, & Zhao, 2017), and the role of firm capabilities (Cheng & Krumwiede, 2018). Supplier involvement in NPD refers to the resources (capabilities, investments, information, knowledge, ideas) that suppliers provide, the tasks they carry out, and the responsibilities they assume regarding the development of a new product for the benefit of a buying firm (Jean et al., 2014). For example, Toyota's success is attributed primarily to the heavy involvement of its suppliers in the NPD process, in which suppliers are obligated to reciprocate in knowledge exchange to the extent that suppliers frequently share novel knowledge (Aoki & Lennerfors, 2013). Recently, the use of social media has been proposed as a valid alternative to other, more conventional, means of supplier involvement (e.g., Bhimani, Mention, & Barlatier, 2019; Cheng & Krumwiede, 2018; Bashir, Papamichail, & Malik, 2017).

Social media is defined as applications encompassing easily accessible mobile and web instruments that allow individuals to create, share, and seek content, as well as to communicate and collaborate with one another (Du, Yalcinkaya, & Bstieler, 2016; Trainor, Andzulis, Rapp, & Agnihotri, 2014). Social media has made much use of instant communication applications, such as Twitter, WhatsApp, Facebook Messenger, and Line, as noted in Hanna, Rohm, & Crittenden (2011) and updated by Muninger, Hammedi, & Mahr (2019) and Pivec and Maček (2019). One form of instant communication applications is "*closed-loop social media*

networks", which are used for private communication within pre-designated groups (Kane, Alavi, Labianca, & Borgatti, 2014).

Closed-loop social media networks involve not only those networks for individuals/units within firms, but also those within a defined group of firms in close collaboration with each other (Keinänen & Kuivalainen, 2015). Social media networks used in business settings tend to be closed-loop in nature, due to the sensitivity and secrecy of the information shared among manufacturers, suppliers, business partners or business customers (Keinanen & Kuivalainen, 2015). As a result, the use of closed-loop social media networks leads to more professional use, less network transparency, and more information security and control (Wang, Pauleen, & Zhang, 2016). Although existing research indicates some features of closed-loop social media networks (e.g., Wang et al., 2016; Keinänen & Kuivalainen, 2015), theoretical and empirical research on how firms use closed-loop social media networks to enhance their new product performance remains scarce (Bhimani et al., 2019). To address this research gap, we focus specifically on how buying firms use closed-loop social media networks to provide venues for communication and collaboration with their supply chain partners, to effectively and efficiently develop their new products. For simplicity, we refer to the use of closed-loop social media networks as "social media" in the remainder of this manuscript.

The supply chain management literature (e.g., Cheng & Krumwiede, 2018; Bashir et al., 2017) has acknowledged the benefit of involving suppliers in the NPD process via using social media, that is, *social media-based supplier involvement*. This refers to those suppliers directly involved in the NPD process of the buying firms to which they supply parts and materials, who rely on social media to exchange knowledge regarding product design, product testing, and product commercialization (Cheng & Krumwiede, 2018). An added benefit rarely cited in previous literature is that social media-based supplier involvement enables many-to-many (as opposed to one-to-one) simultaneous communications among the focal buying firm and its

suppliers (Bashir et al., 2017). Apparently, social media provides a more effective alternative for buying firms to communicate directly and immediately with suppliers incorporating their knowledge into the ideation stage, development stage, or launch stage of their NPD process (Roberts, Piller, & Lüttgens, 2016). However, despite a growing scholarly interest in social media-based supplier involvement, these previous studies (e.g., Cheng & Krumwiede, 2018; Bashir et al., 2017) highlight only separate one-on-one social media-based supplier involvement, with much less attention given to whether the research results and resulting theories are largely the same if the research focus is on the effects of many-to-many social media-based supplier network involvement. To investigate the issue of social media-based supplier involvement within closed-loop networks, we rely on network content of social network theory, which refers to resources that flow within and across social networks, while network structure refers to the pattern of collaborative relationships of a network graph (Dobrow, Chandler, Murphy, & Kram, 2012).

Network content to support collaboration network beyond organizational boundaries seems to be recognized in the literature as a critical feature for accelerating NPD (e.g., Lin & Lin, 2016; Phelps, Heidl, & Wadhwa, 2012). In this regard, social media-based supplier network content, such as social media-based supplier involvement, is expected to provide buying firms with much quicker and richer access to new knowledge that can be important for NPD. It is important to note that one key implied difference in communication modes between this study and previous studies (e.g., Cheng & Krumwiede, 2018; Bashir et al., 2017) is that the former allows for many-to-many communications, virtually and simultaneously, resulting in a group of the focal buying firm and its pre-designated suppliers connected via social media, which can rightly be called a defined supplier network. In addition, there are a number of previous studies using the term “supplier network” as part of a variable in their studies (e.g., Bellamy, Ghosh, & Hora, 2014; Terpend & Ashenbaum, 2012; Mahmood, Zhu, & Zajac,

2011). Further, the term "supplier network involvement" represents a group-based variable, which is a collection of involvements among suppliers in the same network (Lynch, O'Toole, & Biemans, 2016). Taken together, we deem it appropriate to use the term "social media-based supplier network involvement" in the remainder of this manuscript. As for supplier network structure, research based on social network theory suggests that supplier network structure is essential in supply chain networks because the supplier network structure can be an effective governance mechanism that creates co-operative bonding between suppliers and the buying firms to whom they supply parts and materials (Carnovale & Yeniyurt, 2015; Bellamy et al., 2014). Therefore, *social media-based supplier network structure* represents a contingency factor that influences the impact of social media-based supplier network involvement on new product performance.

Overall, this study investigates the following two research questions: (1) Whether buying firms can benefit from their social media-based supplier network involvement in their pursuit of improved new product performance; and (2) To what extent does the effect of social media-based supplier network involvement on buying firms' new product performance vary with social media-based supplier network structure? By addressing the above research questions, the current study contributes to the literature in two ways.

First, our study contributes to the collaborative innovation literature by offering a new position on the relationship between supplier involvement and buyers' new product performance. While most existing research focuses on supplier involvement in buyers' NPD (Suurmond, Wynstra, & Dul, 2020), we develop novel insights into the use of social media networks across suppliers and buyers involved in NPD, which enables us to uncover interplays across supplier–buyer and within supplier social media networks in the NPD process.

Second, despite the importance of suppler involvement to buyers' NPD, few studies have investigated how social media-based supplier network structure differentially shapes buyers'

NPD success. The results of this study not only indicate that social media-based supplier network strength and network heterogeneity enhance buyers' new product performance, but also that network density is found to be counter-productive. As such, we extend the social network literature by detailing various forms of social media-based supplier network structures and how they influence buyers' NPD success, aspects that have not been addressed in previous research. These findings are not only theoretically important, but can also contribute to reducing the scarcity of empirical research on social media network structure (Muller & Peres, 2019). As Bhimani et al. (2019) reveal, buying firms today rely heavily on the collaboration of their social media-based supplier networks when developing new products. These firms can learn from the findings for improving their new product performance.

2. Theory and hypotheses development

2.1 Social media-based supplier network involvement

Social network theory, referring to a social structure of relationships and links, which can be established in the form of exchanges among individuals, businesses, and organizations (Burt, 1997), suggests that firms are interconnected with one another and embedded in various external social networks, which enable the firms to gain efficient access to rich and diverse knowledge (Burt, 1997). The rationale for this process that builds on social network theory is that network configurations and positions in social networks facilitate dissemination of knowledge and, thus, innovation (Wang, Chen, & Fang, 2018; Phelps et al., 2012). The investigation of the relevant studies indicates that firms can use their social networks to enhance new product performance (e.g., Muller & Peres, 2019; Soto-Acosta, Popa, & Palacios-Marqués, 2017). In addition, since a buying firm's own knowledge base alone may not be sufficient to obtain diversified knowledge, the buying firm must capture, interpret, and deploy knowledge resources from supply chain networks (Phelps et al., 2012).

The collaborative innovation literature indicates that supplier involvement in NPD can enhance the outcomes of inter-firm innovation projects (e.g., Cheng & Krumwiede, 2018; Laursen & Andersen, 2016). In practice, Apple engineers often involve their suppliers in developing new products to fine-tune the industrial processes that translate into mass-produced devices (Satariano & Burrows, 2011). Giant, Taiwan's leading cycling firm, works closely with its core suppliers to generate novel knowledge on how to improve manufacturing process performance while, at the same time, minimizing cost, both of which are keys to the superiority of their new products (Brookfield, Liu, & MacDuffie, 2008). From a knowledge-based view, it is not knowledge itself, but rather its being shared with the firm that drives sustainable competitive advantage (Grant, 1996). For this reason, knowledge-sharing activities of suppliers through the use of social media networks can help a buying firm efficiently solve causally ambiguous technical problems within its NPD (Bhimani et al., 2019). In addition, supplier involvement using social media networks can boost interconnections between suppliers and buying firms and then facilitate knowledge-sharing which, in turn, helps buying firms develop superior new products (Grant & Preston, 2019). Therefore, building on previous research, this study contends that social media-based supplier network involvement likely enhances buying firms' new product performance.

2.2 Social media-based supplier network structure

Social network theory assumes that a comprehensive understanding of supplier networks requires a more complete consideration of network content and network structure (Burt, 1997; Phelps, 2010). In this study, social media-based supplier network involvement reflects valuable network content. However, the effect of social media-based supplier network involvement depends on social media-based supplier network structure because, according to the knowledge management and social media literature, social media-based supplier network structure affects

the motivation and efficiency of knowledge transfer between the buying firm and its suppliers (Carnovale & Yeniyurt, 2015). As indicated by Kwahk and Park (2016), partners' interactions within their network structure allow them to exchange knowledge with each other frequently in enterprise social media environments. In addition, social media-based supplier network structure reflects how a buying firm is embedded relationally in the social media-based supplier network (Terpend & Ashenbaum, 2012). Therefore, we consider the social media-based supplier network structure a contingency condition between social media-based supplier network involvement and buying firms' new product performance.

There are several elements of supplier network structure, such as network strength, network heterogeneity, network density, network centralization, and network complexity (Muller & Peres, 2019; Phelps, 2010), each of which could exert different degrees of impact on buying firms' new product performance (Bashir et al., 2017). Based on the social network literature (e.g., Terpend & Ashenbaum, 2012; Swaminathan & Moorman, 2009; Rowley, Behrens, & Krackhardt, 2000), we examine three main forms of social media-based supplier network structure: network strength, network heterogeneity, and network density.

Social media-based supplier network strength refers to the social closeness between the buying firm and its social media-based suppliers (Eisingerich, Bell, & Tracey, 2010; Swaminathan & Moorman, 2009). By cultivating strong trust, social media-based supplier network strength affects the extent to which a buying firm can integrate knowledge from external supplier networks. Social media-based supplier network heterogeneity refers to the diversity of social media-based suppliers involved in the NPD process and their level of cross-boundary exchange (Corsaro, Cantù, & Tunisini, 2012). Network heterogeneity is considered a specific form of diversity, within which links among different types of nodes are the essential constituents. Social media-based supplier network density is defined as the number of total ties in a social media-based supplier network relative to the number of potential ties (Borgatti &

Li, 2009). It captures the extent of social media-based suppliers' social interconnection, and fosters shared mind-sets among suppliers and buying firms (Mahmood et al., 2011).

Overall, social media-based supplier network strength, network heterogeneity, and network density reflect the configuration of the social media-based supplier network structure and likely affect the efficacy of social media-based supplier network involvement in buying firms' new product performance.

2.3 Social media-based supplier network involvement and new product performance

We propose that social media-based supplier network involvement can potentially benefit a buying firm's new product performance because developing new products requires the buying firm to assimilate and recombine knowledge perspectives from various sources (Phelps et al., 2012). Social media-based supplier network involvement provides access to dissimilar knowledge for the buying firm, which increases the number and variety of potential combinations and novel solutions (Wang et al., 2016). Since the use of social media supports idea exchange, network interaction, and collaboration among suppliers with diverse knowledge (Du et al., 2016), social media-based suppliers stimulate the buying firms to whom they supply parts and materials to access diverse knowledge and perspectives and, thus, to blend different knowledge elements, which reflects a key cognitive process for generating novel insights (Zhou et al., 2014). By using social media, social media-based supplier network involvement can also provide the buying firm with brokerage advantages through rich connections (Burt, 2005). In such connections, the buying firm can access diverse expertise, perspectives, and knowledge in various fields which, in turn, lead to novel knowledge experimentation to achieve innovative outputs (Du et al., 2016). As suggested by Wang et al. (2018), strong inter-organizational interactions in social networks with high levels of knowledge heterogeneity are good sources of successful new product performance.

In addition, by using social media, employees of buying firms tend to maintain connections with external co-workers (such as suppliers) with whom they do not regularly interact offline (Garcia-Morales, Martín-Rojas, & Lardón-López, 2018), which can stimulate the buying firm to develop flexible, outside-the-box thinking (Busse, Meinlschmidt, & Foerstl, 2017). Given the access it provides to suppliers' communications, the use of social media enables employees' learning through passive exposure to communications among suppliers (Leonardi, 2014). Thus, social media-based supplier network involvement is useful in facilitating development of more accurate knowledge through engagement in social media's communications than they would develop through direct experiential involvement in communication with those employees.

In summary, social media-based supplier network involvement enables buying firms to enhance new product performance by acquiring and transforming external knowledge. In addition, since buying firms' employees can learn from multiple knowledge sources through social media-based suppliers, social media-based supplier network involvement can exert a positive effect on new product performance. Accordingly, we expect that buying firms with a high level of social media-based supplier network involvement are more likely to achieve better new product performance. Therefore, we hypothesize that:

Hypothesis 1. Social media-based supplier network involvement has a positive effect on buying firms' new product performance.

2.4 Social media-based supplier network strength

Social media-based supplier network strength captures the social closeness between partners in social media-based supplier networks (Eisingerich et al., 2010). For this study, we focus on the closeness between the buying firm and its social media-based suppliers. Research on social networks suggests that supplier network strength provides three primary advantages.

First, supplier network strength cultivates strong trust, such that buying firms rely on the intentions and behaviors of suppliers in a specific relationship (Vuori & Okkonen, 2012). Second, supplier network strength facilitates tacit knowledge transfer, because tacit knowledge is difficult to articulate and its transfer requires frequent, deep interactions between partners (Kwahk & Park, 2016). Third, according to Rapp, Beitelspacher, Grewal, & Hughes (2013), because the use of social media is a collective action, the use of social media with high network strength enables social media participants to share in the collective benefit of an interactive communication device. Therefore, extending previous research, we propose that high social media-based supplier network strength between a buying firm and its social media-based suppliers should help the buying firm enhance the value of social media-based supplier network involvement for its new product performance for the following reasons.

First, with strong trust in the social media context, high social media-based supplier network strength can help the buying firm overcome difficulties associated with diverse knowledge recombination, mainly because sharing exclusive and novel knowledge with buying firms is inherently risky (Forti, Franzoni, & Sobrero, 2013). Most importantly, social media-based suppliers could lose their core proprietary assets if the buying firm behaves opportunistically (Grandinetti, 2017). In contrast, social media-based supplier network strength with strong trust can enhance social media-based suppliers' confidence that the buying firm will not exploit its vulnerabilities, even if given an opportunity to do so (Vuori & Okkonen, 2012). Therefore, social media-based suppliers with high social media-based network strength should be more willing to become involved in NPD of buying firms.

Second, by facilitating tacit knowledge acquisition, social media-based supplier network strength augments the value of social media-based supplier network involvement. Although a diverse social media-based supplier network provides novel knowledge, the knowledge is usually complex, and difficult to assimilate and utilize (Kwahk & Park, 2016). Especially in

the social media context, knowledge is distributed across a network of connections and, therefore, learning consists of the ability to construct and traverse those networks (Soto-Acosta et al., 2017). As high social media-based supplier network strength enables buying firms to develop mutual knowledge from social media-based suppliers (Tzabbar & Vestal., 2015), it improves buying firms' capacity to absorb knowledge from social media-based suppliers. As Yang and Wang (2011) suggest, a high level of network strength has a greater capacity to transfer knowledge than a low level of network strength does.

Third, because social media-based supplier network involvement enables buying firms to connect with their suppliers in a multi-modal manner (e.g., verbal, written, pictorial, and video) and on a real-time basis, it speeds up buying firm-supplier connections and improves knowledge exchange and access (Cheng & Krumwiede, 2018). When the focal buying firm is working very closely with its supplier on a mutual trust basis (high supplier network strength), it is hypothesized logically that the connections would be even faster and the quality of knowledge being exchanged or accessed would be even higher. This is because the buying firm and its suppliers in the social media-based network, as a group, would share more knowledge at a faster speed, since they are close to each other and trust each other (Rapp et al., 2013) and, thus, have no hesitation in sharing knowledge. Therefore, we posit that high social media-based supplier network strength would facilitate new knowledge creation which, in turn, would enhance new product performance of buying firms, leading to the following hypothesis:

Hypothesis 2. The level of social media-based supplier network strength moderates the relationship between social media-based supplier network involvement and buying firms' new product performance, such that the relationship is stronger when the level of social media-based supplier network strength is high.

2.5 Social media-based supplier network heterogeneity

The diversity in the nature of social media-based suppliers (e.g., raw material, simple component, and technology suppliers) represents social media-based supplier network heterogeneity (Corsaro et al., 2012). The supply chain management literature has suggested that network heterogeneity facilitates the NPD process by enabling firms to create new linkages (Lau, Tang, & Yam, 2010). Prior studies have also demonstrated that network heterogeneity helps firms facilitate their innovation development (Muller & Peres, 2019; Corsaro et al., 2012; Gronum, Verreynne, & Kastelle, 2012). For example, network heterogeneity provides efficient access to diverse sources of knowledge that can be combined to develop new, more innovative products than those created through single partner collaborations (Corsaro et al., 2012). In addition, firms that possess a heterogeneous network of different suppliers have new and improved products (Gronum et al., 2012). Further, in the social media context, high network heterogeneity enables buying firms to generate better ideas, to interact with social media-based suppliers from different sectors, and to acquire novel knowledge (Boulianne, 2015).

Similarly, in social media-based supplier networks, network heterogeneity raises the likelihood of achieving superior new product performance, due to the amount and variety of knowledge. A recent work supports the idea that using a wide range of social media networks should help a firm achieve successful new product performance (Scuotto, Del Giudice, & Carayannis, 2017) because social media network heterogeneity provides access to diverse sources of knowledge that can be combined to develop more innovative products than those created through a single source. In addition, social media-based supplier network heterogeneity could facilitate the flow of network knowledge because, according to Kilduff and Brass (2010), heterogeneous networks facilitate the flow of knowledge that is highly related to science (pp. 329-331). This is because the flow of more diverse knowledge in fields of science, which is allowed by a more heterogeneous network, provides a greater chance for creating the "eureka"

moment in scientific breakthrough. This eureka moment could be the defining moment in NPD. Thus, considering the social media-based supplier network as an important channel through which suppliers share their knowledge with buying firms, the more heterogeneous buying firms' social media-based supplier networks are, the more diverse knowledge and efficient flow of scientific knowledge buying firms could receive from social media-based supplier network involvement in their NPD which, in turn, could lead to superior new product performance.

Finally, for buying firms operating in rapidly changing environments, being competitive requires not only developing effective in-house innovation, but also access to diverse knowledge sources to keep abreast of innovations (Muller & Peres, 2019). Thus, faced with an increasingly competitive environment, buying firms need both the width and depth of knowledge for successful innovation. Social media-based supplier network involvement within heterogeneous networks is able to provide buying firms with a greater variety of information, resources, and knowledge (Bhimani et al., 2019) which, in turn, would increase the new product performance of the buying firms. Therefore, we hypothesize that:

Hypothesis 3. The level of social media-based supplier network heterogeneity moderates the relationship between social media-based supplier network involvement and buying firms' new product performance, such that the relationship is stronger when the level of social media-based supplier network heterogeneity is high.

2.6 Social media-based supplier network density

Social media-based supplier network density reflects the extent to which social media-based suppliers of a focal buying firm are socially interconnected (Borgatti & Li, 2009). Given that high network density indicates a closer connection among nodes, social media-based

supplier network density enables buying firms and social media-based suppliers to capture directly the incidence of production shifts in the network (Shin & Lee, 2019). In addition, in a dense social media-based supplier network, suppliers have close ties with one another, which can generate deterrence-based trust, including an ability to detect and punish deviant behaviors in an efficient manner (Mahmood et al., 2011). While high social media-based supplier network density brings potential benefits, social media-based supplier-dense networks do not necessarily help buying firms realize the value of social media-based supplier network involvement for their new product performance. They might even reduce this value.

First, Cappella (2017) suggests that social media studies of network influence have produced some conclusions indicating that dense networks can yield less social influence than sparse ones. In addition, from the perspective of social network theory, collective social capital in a dense network can limit its members' openness to knowledge from outside the network (Zhou et al., 2014). Thus, high social media-based supplier network density could decrease the effect of social media-based supplier network involvement in the NPD of buying firms because, in environments with high network density the network content becomes increasingly redundant (Kogut & Walker, 2001), making buying firms less motivated to acquire novel knowledge via this network. In contrast, low social media-based network density offers a more suitable context to facilitate social media-based supplier network involvement in the NPD of buying firms, which enables buying firms to access novel knowledge and, thus, facilitates innovation development. Therefore, within high social media-based supplier network density, the potential value of social media-based supplier network involvement for buying firms' new product performance is likely to decline.

Second, if a social media-based supplier network is dense, it reduces the ability of social media-based suppliers to obtain novel insights from the social media network. The main reason for this is that a dense social media-based supplier network with fewer structural holes,

referring to the absence of ties between two parts of a social network (Burt, 1997), provides the social media-based suppliers with less access to novel knowledge, which leads them to generate fewer novel ideas (Kwahk & Park, 2016). According to Laursen and Andersen (2016), suppliers are a novel knowledge resource outside of the firm that can be utilized for new product success by involving them in the NPD process. To achieve the benefits of NPD, suppliers involved in NPD need to possess novel knowledge required to support NPD (Liu et al., 2017). As such, in a dense social media-based supplier network, social media-based suppliers seem to be unable to provide highly novel knowledge when involved in NPD of buying firms, leading to inferior new product performance. Therefore, we hypothesize that:

Hypothesis 4. The level of social media-based supplier network density moderates the relationship between social media-based supplier network involvement and buying firms' new product performance, such that the relationship is weaker when the level of social media-based supplier network density is high.

3. Research method

3.1 Sample

The target population was defined as high-tech firms and their suppliers based in Taiwan that had used social media in their NPD projects. These firms were selected for two reasons. First, this study chose high-tech industry in Taiwan as its research setting because, compared with other industries, the high-tech industry has been under the most pressure to innovate and introduce new products (Cheng, Yang, & Sheu, 2014). Second, to maintain their competitive advantage in the China market, high-tech firms in Taiwan usually involve suppliers in the NPD process by using social media to efficiently develop new products (Cheng & Krumwiede, 2018).

To collect data effectively, we used the initial set of respondents from China Credit Information Service (2014), a leading business database in Taiwan, which included contact information for the Top 1000 Taiwan-based high-tech firms. We chose sample firms that met the following two criteria. First, we contacted each high-tech firm's NPD manager by telephone to determine whether the firm had used social media-based supplier network involvement in its NPD process. Next, following the approach of Andersson, Forsgren, & Holm (2002), we identified buying firms with at least five social media-based suppliers, which gave us a sufficient number of social media-based suppliers to measure social media-based supplier network involvement. The result shows that the number of social media-based suppliers ranges from 32 to 78. Then, following previous studies of Moran (2005), Andersson et al. (2002), and Rindfleisch and Moorman (2001), we asked buying firms to select their five most important social media-based suppliers, since a buying firm usually has a limited number of suppliers who are more important than its all other suppliers (Zhou et al., 2014; Kim, Choi, Yan, & Dooley, 2011). In addition, by limiting the scope to the five most important social media-based suppliers, we can obtain more sophisticated information from respondents regarding supplier network characteristics (Yang, Zhang, & Xie, 2017; Moran, 2005).

Second, consistent with the selection criterion in previous research (e.g., Dai, Goodale, Byun, & Ding, 2018; Autio & Rannikko, 2016; McDougall, Oviatt, & Shrader, 2003), we chose high-tech firms that have been in existence for at least six years, as most new venture researchers employ a six-year time span for new ventures to be realized. In addition, following the definition of the high-tech industry given by the Ministry of Economic Affairs, Taiwan (2016), we chose high-tech firms that generated at least 60 percent of their annual revenue from their high-tech product business. Moreover, we screened through high-tech firms as potential respondents and included in our study only those firms that confirmed they have cooperated with their respective suppliers and set up a social media-based supplier network through which

they have been collectively involved in at least one ongoing NPD project (Cheng et al., 2014). Thus, as the unit of analysis refers to the project level, we asked each high-tech firm's NPD manager to identify one on-going NPD project (in which social media-based suppliers were involved), and to respond to the items as they related to that particular NPD project. This resulted in a target population of 283 high-tech firms asked to participate in this study.

3.2 Data collection

Following previous studies that conducted surveys in Asian economies (e.g., Zhou et al., 2014), we collected the data on-site, so we could clarify respondents' questions and ensure the questionnaires collected were complete and usable. We recruited trained interviewers, who then presented the questionnaires to the respondents on-site, with each interview lasting about ninety minutes.

To reduce the potential for common method bias associated with single sourcing (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003, p. 898), we measured the different variables by obtaining different data from multiple respondents in each high-tech firm. In addition, this study was designed to collect data longitudinally over four waves of data collection, mid-2015, early-2016, mid-2016, and early-2019. The main purpose was to allow time for the performance effects of social media-based supplier network involvement, social media-based supplier network structure (network strength, network heterogeneity, and network density), and new product performance to materialize (Rindfleisch, Malter, Ganesan, & Moorman, 2008). Most importantly, the effects of these variables can evolve over time (Ployhart & Vandenberg, 2010).

In mid-2015, following the study of Jean et al. (2014), we contacted senior purchasing managers of 283 high-tech firms and asked them to rate their social media-based supplier network involvement. We then asked senior purchasing managers (or others responsible for

managing social media-based suppliers) to provide contact information for the five most important social media-based suppliers who participated in the same NPD project identified by the NPD managers. In early-2016, we randomly selected one of the five most important social media-based suppliers from each of the 283 high-tech firms and sent the paired questionnaire regarding social media-based supplier network involvement to these social media-based suppliers. Subsequently, this study received useful responses from 269 paired firms (538 questionnaires). To verify the response data, we contacted each social media-based supplier by phone to confirm they had completed the questionnaire. In mid-2016, we attempted to contact senior NPD managers of the same 269 high-tech firms and asked those we reached to rate control variables. Four of the original firms could not be reached, leading to 265 responses. In early-2019, we obtained secondary proxy data of social media-based supplier network structure (network strength, network heterogeneity, and network density), and new product performance from external sources, which will be described in detail in the Measures section.

The instrument included post-hoc checks on the respondents' knowledge and involvement in the firms' NPD process. On a seven-point scale, the mean of their knowledge was 6.18, and the mean of their involvement was 6.05. Two responses that showed inadequate levels of informant knowledge or involvement (less than 4 on a seven-point scale) were eliminated. In addition, after we dropped incomplete secondary proxy data, the final sample was comprised of 256 high-tech firms. Table 1 presents the details of data collection.

Insert Table 1 about here

Among the 256 high-tech firms, average annual sales revenue was US $7.6 million. The average number of employees was 1279. These respondents had a mean industry experience of 10.9 years, a mean firm experience of 8.7 years, and a mean for the use of social media in NPD projects of 6.9 years. The firms in the sample were distributed by sector, as follows: 54 firms were pharmaceuticals (21.1%); 51 firms came from information technology (19.9%); 45

firms were electronics (17.6%); 39 firms were advanced materials (15.2%); 36 firms represented telecommunication (14.1%); 28 firms were semiconductor (10.9%); and 3 firms were in other sectors (1.1%). We compared participating and nonparticipating firms based on firm size and R&D intensity. No significant ($p < 0.05$) differences were found in either case.

3.3 Questionnaire development

We measured the perceptual items with a seven-point scale. For items adapted from the literature and written in English, a double-translation method was used to translate them into Chinese. This process included: (1) our initially translating the items into Chinese; (2) two other academics then translating the Chinese version back into English; and (3) this translation being checked by a third academic to ensure conceptual equivalence (Douglas and Craig, 2007).

Once the initial items were developed, two pilot tests were performed to ensure the measurement was reliable and valid. First, four academics and 31 experienced practitioners were interviewed to detect ambiguous questions, check the face and content validity of the measurement scales, and agree on the wording of the items. Second, refined scales were tested with a sample of 98 senior managers with work experience in social media-based supplier network involvement, network structure, and the NPD process. Some minor adjustments were made regarding wording and formatting.

3.4 Measurement

The measurement scales for the constructs appear in Table 2. To measure social media-based supplier network involvement, we developed the 10-item scale based on Fang and Zhou (2010) and Fang, Palmatier, & Evans (2008). It assesses whether social media-based suppliers participate in ten activities of the NPD process related to the particular NPD project, using

aggregated responses from both senior purchasing managers and social media-based suppliers of buying firms. Specifically, we asked if the social media-based suppliers were participating (0 = not involved and 1 = involved) in this activity, and the total number of activities the social media-based suppliers checked was used to represent the breadth of social media-based supplier network involvement. If social media-based suppliers were involved in the activity, we used a seven-point Likert scale to measure the depth of their involvement. We determined the overall depth of involvement across the activities they were involved in by calculating the mean of the completed items. Thus, the level of social media-based supplier network involvement is treated as a latent variable with two items: social media-based supplier network involvement depth and social media-based supplier network involvement breadth. Since breadth is determined as an additive measure (0 to 10), it was converted into a seven-point Likert scale to correspond to the depth measure (Fang et al., 2008).

Following Swaminathan and Moorman (2009), we measured social media-based supplier network strength based on the average quality of a social media-based supplier in a supplier network. We constructed the measure by using a buying firm's social media-based supplier in the Top 100 list provided by China Credit Information Service, assuming a value of 1 for an appearance and 0 otherwise. The final value of social media-based supplier network strength is the average score across social media-based suppliers in a firm's social media-based supplier network.

Following Baum, Calabrese, & Silverman (2000), we measured social media-based network heterogeneity with a Herfindahl index of heterogeneity in types of social media-based suppliers, such as pharmaceuticals, information technology, electronics, advanced materials, telecommunication, and semiconductor. To assess the robustness of this measure, we created an alternative measure of network heterogeneity based on structural hole rationale (Tortoriello, 2015). We obtained the buying firm's network constraint values by using UCINET 6 (Borgatti,

Everett, & Freeman, 2002) and timed the constraint value with -1 to simplify interpretation (Zaheer and Bell, 2005). Though the two measures differ in values, they produce qualitatively similar results. We report the results of the Herfindahl index measure.

Following Rowley et al. (2000), we measured social media-based supplier network density as the number of connections among all social media-based suppliers in a buying firm's social media-based supplier network divided by the total number of possible connections among these suppliers. We mean-centered this value before entering it into the model.

Following Kostopoulos, Papalexandris, Papachroni, & Ioannou (2011), we measured new product performance as the percent change in the ratio of the annual sales from t_0 to t_1 that originated from the particular NPD project, such that we obtained the data (2013) in 2014 and the data (2016) in 2017. For example, we measured new product performance as (annual $sale_{t1}$ – annual $sale_{t0}$)/annual $sale_{t0} \times 100$.

Finally, we included five control variables based on their relevance to firm characteristics and industrial factors. First, using an official Taiwanese government classification, we controlled for firm size with a dichotomous scale, on which 1 = small (fewer than 200 employees) and 2 = large (200 or more employees). Second, following Marano and Kostova (2016), we controlled for R&D intensity using the ratio of R&D expenditures to sales. Third, we controlled for prior innovation performance because if a firm has had good innovation performance in past years, the firm is more likely to achieve higher new product performance (Soto-Acosta et al., 2017). A two-item scale adapted from Yanadori and Cui (2013) measures prior innovation performance. Fourth, we included social media-based supplier stability as a control because the stability of suppliers affects suppliers' motivation and capacity to share knowledge with the buying firm (Grant & Preston, 2019). Respondents evaluated the extent to which their firms changed social media-based suppliers over the last three years, ranging from 1 (a very low proportion) to 7 (a very high proportion). Finally, we measured environmental

turbulence with seven items adapted from Lau (2014) because scholars of NPD have called for the incorporation of environmental turbulence as an external contingent variable in social media-based supplier involvement in NPD studies (Cheng & Krumwiede, 2018). In particular, when social media environments are turbulent, buying firms need to take immediate action for NPD decision-making to leverage the changing preferences of consumers (Hartono & Sheng, 2016).

Insert Table 2 about here

3.5 Reliability and validity

To assess the reliability and validity of the constructs measured by multiple-item scales, we ran a confirmatory factor analysis (CFA) allowing the latent constructs of social media-based supplier network involvement and control variables (prior innovation performance and environmental turbulence) to correlate freely, with randomly formed item-parcels used as indicators of each construct. The results indicate a good fit (x^2/d.f. = 1.87, $p < 0.001$; comparative fit index = 0.95, incremental fit index = 0.96, root mean square error of approximation = 0.03). The standardized factor loadings were all significant, at $p < 0.001$, and in the range of 0.73 to 0.86.

We assessed the discriminant validity of the measures in two ways. First, we ran a series of nested CFA model comparisons in which we constrained the correlation between each pair of constructs to equal 1 (Gerbing & Anderson, 1988). We then compared the chi-square value of the model with that of the unconstrained model. The results all supported the unconstrained model. Second, we calculated the shared variances between all possible pairs of constructs to determine if they were lower than the average variance extracted (AVE) values of the individual constructs. The results indicated that the AVEs were much higher than the highest shared variance with other constructs. The results, thus, suggest an acceptable level of discriminant validity (Fornell & Larcker, 1981).

In summary, Cronbach's alphas, composite reliability, and AVE for all the measures are above the cut-off values recommended by Bagozzi and Yi (2012), providing evidence of strong measurement quality. Table 3 shows descriptive statistics, correlations, and the square root of AVEs of constructs.

Insert Table 3 about here

4. Analyses and results

Hypotheses 2, 3, and 4 posit the interaction effects between social media-based supplier network involvement and social media-based supplier network strength, network heterogeneity, and network density, respectively. We employed hierarchical moderated regressions to test our hypotheses because this approach allows for a comparison between alternative models with and without interaction terms (Aiken & West, 1991). In addition, this approach offers some better benefits than other methods (e.g., structural equation modeling), such as more easily assessing differences between models and calibrating the relative effects (Hair, Black, Babin, & Anderson, 2013).

We first mean-centered each scale to construct the moderating effects and then tested seven models sequentially (Aiken & West, 1991). Model 1 included control variables only. In Model 2, we included the control and the independent variables to test the direct relationship between social media-based supplier network involvement and new product performance. In Model 3, we added the independent variable, social media-based supplier network involvement, as well as the moderators. For Models 4-6, we added the interaction items one by one. Finally, Model 7 provides the full model with all controls, independent variables, and interaction items. The results remained consistent across models. The adjusted R-square values ranged from 0.408 to 0.448. According to the collinearity diagnostic, the variance inflation factors (1.10-1.39) were all well below 10, so multicollinearity was not a serious problem for our inferences (Hair et al., 2013). We provide these results in Table 4.

The results reported in Model 2 indicate a positive relationship between social media-based supplier network involvement and new product performance ($b = 0.018$; $p < 0.05$), which supports Hypothesis 1. In Model 4, we note a positive regression coefficient for social media-based supplier network involvement and social media-based supplier network strength ($b = 0.028$; $p < 0.05$), in support of Hypothesis 2. In Model 5, the results show that social media-based supplier network heterogeneity positively moderates the effect of social media-based supplier network involvement on new product performance ($b = 0.021$; $p < 0.05$), in support of Hypothesis 3. In Model 6, the result shows that social media-based supplier network density negatively moderates the link between social media-based supplier network involvement and new product performance ($b = -0.015$; $p < 0.05$), supporting Hypothesis 4. Finally, model 7 shows that all main and moderating effects have similar values, which indicates the robustness of our results. For control variables, R&D intensity and prior innovation performance positively relate to new product performance, while environmental turbulence negatively affects new product performance.

To further investigate the moderating effects, we decomposed all three significant interaction terms and compared the impact of social media-based supplier network involvement on new product performance at low and high levels of the moderating variables (Aiken & West, 1991), that is, at one standard deviation below and above the mean scores, respectively. Fig. 1 depicts the effect of social media-based supplier network involvement on new product performance for high and low levels of the moderating variables. Fig. 1a suggests the positive effect of social media-based supplier network involvement is stronger when social media-based supplier network strength is high rather than low. Fig. 1b suggests the positive effect of social media-based supplier network involvement is stronger when social media-based supplier network heterogeneity is high rather than low. In contrast, Fig. 1c shows the positive effect is stronger when social media-based supplier network density is low rather than high.

The three figures, thus, offer further support for our predictions about the moderating effects of social media-based supplier network strength, network heterogeneity, and network density.

Insert Table 4 and Fig. 1 about here

4.1 Robustness analysis

To ensure robustness, we conducted partial least squares structural equation modeling (PLS-SEM) to test the hypotheses. The explanatory power of a PLS-SEM model is determined by the amount of variance explained (R^2) by the endogenous latent variables. The model estimation is based on 5,000 bootstrap samples. The R^2 value for new product performance is 0.447. The results suggest a satisfactory predictive power for our proposed model. To further check the predictive capability of the model, Stone-Geisser's Q^2 is used (Henseler, Ringle, & Sinkovics, 2009), applying the blindfolding method (Tenenhaus, Vinzi, Chatelin, & Lauro, 2005). The Q^2 value for new product performance is 0.276. The value is larger than zero, indicating the predictive relevance of the construct. The Variance Inflation Factor values range from 1.039 to 2.235, suggesting the lack of a collinearity issue.

For the moderation analyses, our results show that the relationship between social media-based supplier network involvement and new product performance is positively moderated by social media-based supplier network strength ($b = 0.152$, $p < 0.05$) and network heterogeneity ($b = 0.137$, $p < 0.05$), but negatively moderated by network density ($b = -0.124$, $p < 0.05$). For the control variables, the results show that R&D intensity, prior innovation performance, and environmental turbulence are significant, while firm size and social media-based supplier stability are not significant. Overall, the results shown in the PLS-SEM model are very much in line with the results shown in the hierarchical moderated regression models.

5. Discussion

This study is motivated by a need to improve our understanding of why some firms benefit more from their social-media based supplier network in their NPD activities than their counterparts. Building on social network theory, this study examines whether and how social media-based supplier network involvement and social media-based supplier network structure might enhance buying firms' new product performance. The results of integrating a longitudinal design with secondary proxy dataset of 256 buying firms and their suppliers, highlight the differential interaction impacts of social media-based supplier network involvement and certain supplier network structures and suggest some theoretical and managerial implications.

5.1 Theoretical implications

This study contributes to the collaborative innovation and social network literature in the following ways. First, this study contributes to the collaborative innovation literature by extending the growing research on supplier involvement to the context of social media networks. The predominant view in prior research is that supplier involvement plays an important role in determining buying firms' new product performance (e.g., Laursen & Andersen, 2016; Jean et al., 2014). These prior research efforts were mostly investigating supplier involvement in its more traditional fashion, such as face-to-face or by email. There were very limited, if any, efforts examining whether suppliers and buying firms can use social media to enhance new product performance (Rapp et al., 2013). More recently, a few studies (e.g., Cheng & Krumwiede, 2018; Bashir et al., 2017) began to look into supplier involvement via social media, but they still treated supplier involvement as a one-to-one means of communication even though social media make possible many-to-many communications. We address this important research gap by developing a research model that looks into social media-based supplier network involvement based on the social network theory (Burt, 1997) in

which the many-to-many interactions among social media-based suppliers are taken into account. Therefore, this study augments existing collaborative innovation literature to demonstrate that research results and corresponding theories in previous papers focusing on one-to-one can also apply to situations in which the suppliers are studied from a social network perspective of multiple interactions (e.g., Bellamy et al., 2014; Phelps, 2010).

Second, this study contributes to the social network literature by considering social media-based supplier network structures as moderating factors (Wang et al., 2018; Phelps et al., 2012; Burt, 1997). Although social network structures have been extensively examined as boundary conditions (e.g., Corsaro et al., 2012; Eisingerich et al., 2010; Borgatti & Li, 2009), existing studies have reached conflicting conclusions (e.g., Eisingerich et al., 2010 vs. Chung, 2011) and more knowledge is needed to understand how firms deal with different forms of supplier network structure (Muller & Peres, 2019; Yang & Wang, 2011). Our study extends social network theory (Burt, 1997) to social media networks by addressing three forms of social media-based supplier network structure (network strength, network heterogeneity, and network density) on the social media-based supplier network involvement–new product performance relationship. Our findings reveal that both high social media-based supplier network strength and network heterogeneity enhance the effectiveness of social media-based supplier network involvement. Therefore, this study provides strong evidence that, while social media-based supplier network involvement may cause difficulties in knowledge cooperation due to suppliers' diverse knowledge (Garcia-Morales et al., 2018), high social media-based supplier network strength helps overcome the difficulty in tacit knowledge transfer and facilitate the utilization of such knowledge in NPD. In addition, high social media-based supplier network heterogeneity increases a buying firm's access to diverse knowledge from different areas of expertise. This result extends previous studies (Muller & Peres, 2019; Corsaro et al., 2012; Gronum et al., 2012) indicating that a heterogeneous social media-based supplier network

structure plays a critical role in the collaborative innovation network. However, social media-based supplier network density decreases the value of social media-based supplier network involvement. This finding provides new evidence to social network theory by asserting that, when social media-based suppliers are closely connected to each other, the chances of recognizing new social media knowledge, identifying new opportunities, and actually tapping into them can be reduced. Overall, our study provides a more sophisticated understanding of how three forms of social media-based supplier network structure influence the effectiveness of social media-based supplier network involvement. This study thus augments extant social network literature through confirming that the functions of these three forms of social media-based supplier network structure differ essentially (Muller & Peres, 2019; Bellamy et al., 2014; Phelps, 2010).

To sum up, this study provides strong evidence that social media-based supplier network involvement and supplier network structure represent key factors for buying firms in achieving superior new product performance. This study thus enriches the emerging collaborative innovation and social network literature by incorporating the unique features of the supplier network structure and investigating the conditions under which supplier involvement enhances new product performance in the social media context.

5.2 Managerial implications

Our findings provide important implications for managers to leverage their social media-based supplier networks to improve new product performance. First, managers of buying firms should encourage social media-based suppliers to be involved in their NPD process. By involving social media-based suppliers, buying firms can easily acquire diversified knowledge and, thus, greatly improve their new product performance. For example, given the use of its closed-loop social media networks, TSMC easily incorporates its global suppliers with

diversified expertise into the NPD process, leading to better design of semiconductor chips (Chesbrough, 2012). Therefore, social media-based supplier network involvement can serve as a source of innovation for managers who want to boost their innovation outcomes.

Second, managers of buying firms should understand how to match social media-based supplier network involvement with different forms of social media-based supplier network structure. Our results indicate that social media-based supplier network involvement is more effective for new product performance when this network of suppliers shows strong network strength and network heterogeneity. In contrast, network density is found to be counter-productive. Thus, managers need to recognize clearly the impact of social media-based supplier network strength, network heterogeneity, and network density, respectively. For example, if managers want to get more depth knowledge from their social media-based suppliers in assisting in their NPD, they should attempt to enhance the network strength through increasing levels of frequency, intensity, and stability of interactions, as well as doing what is needed to facilitate the mutual trust of each other in the network. In addition, managers should develop heterogeneous social media-based supplier networks in order to capture more breadth knowledge. However, managers should be aware of the potentially adverse consequences of suppliers with a highly dense social media-based supplier network.

5.3 Limitations and further research

The results of this study must be viewed in light of its limitations. First, the measure of social media-based supplier network involvement was based on managers' perceptions, which could contain perceptual bias. While we employed multiple informants, doing so did not completely eliminate the bias. Future research could use secondary proxy data or other sources of information to overcome this limitation. Second, this study took a supply-side view to focus on new product performance generated by buying firms. Future studies could take a demand-

side view of social media-based customer network involvement and link it to demand-side performance, such as customer value. Third, respondents for this study are all Taiwanese of Chinese origin. Triandis, McCusker, & Hui (1990) note the Chinese are more likely than Americans to recognize themselves by group membership. This cultural trait could positively contribute to the social media-based suppliers of this study being more willing to share information and knowledge on the same social media network, which limits the generalizability of our findings across cultures. As noted in Begley and Tan (2001), there are clear disparities in socio-cultural environments that lead to differences in business practices between Eastern and Western countries. Future research could replicate this study in Western countries in order to determine if the significant relationships found in this study also happen in these countries. Another exciting research direction is to involve respondents of different cultures working in the same global countries to see if similar findings occur in cross-cultural business contexts.

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Figure

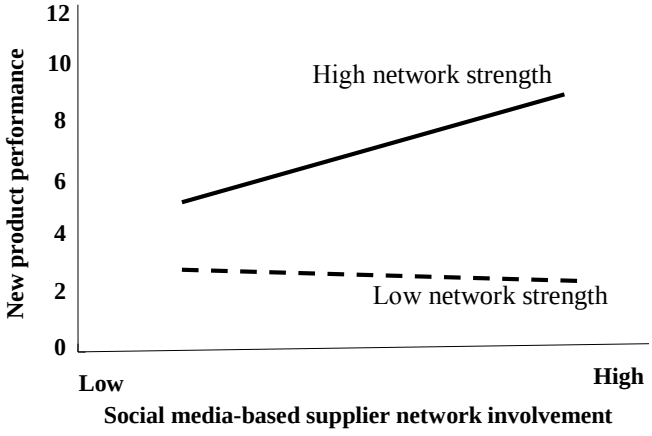

Fig. 1a. Social media-based supplier network strength

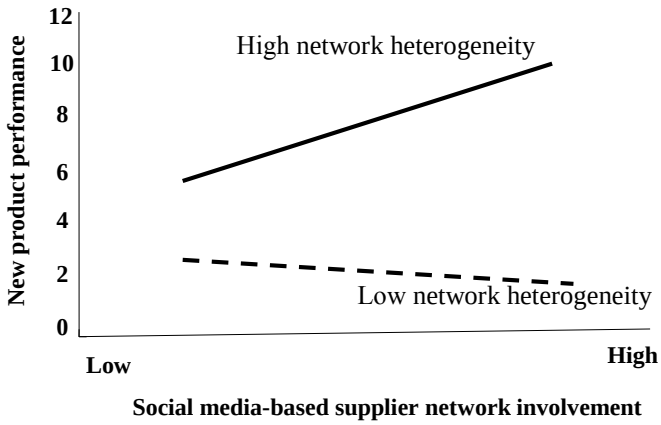

Fig. 1b. Social media-based supplier network heterogeneity

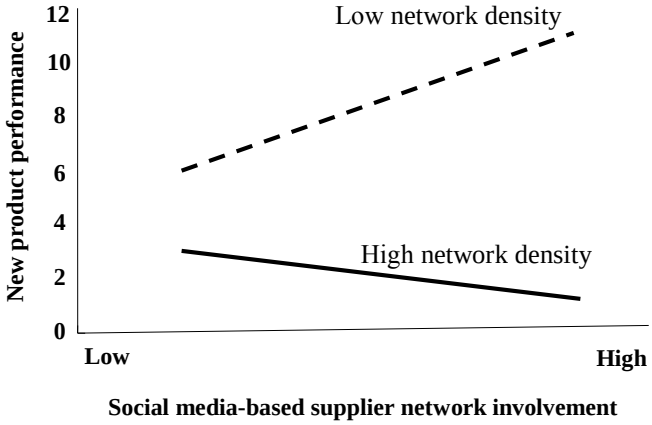

Fig. 1c. Social media-based supplier network density

Fig. 1 Moderating effects

Tables

Table 1
The details of data collection

Mode of collection	Time of collection	Positions of respondents	Numbers of respondents	Measures	Note
On-site interview	Mid-2015	Senior purchasing managers	283	Social media-based supplier network involvement	
Mail	Early-2016	Suppliers	269	Social media-based supplier network involvement	283 questionnaires were sent and 269 were useful questionnaires
Phone	Early-2016	Suppliers	269	Social media-based supplier network involvement	To verify the response data
On-site interview	Mid-2016	Senior new product development managers	265	Prior innovation performance, social media-based supplier stability, and environmental turbulence	Four of the original firms could not be reached
Post-hoc check	Mid-2017	All respondents	263	Respondents' knowledge and involvement	Two responses showed inadequate levels of knowledge or involvement
Secondary proxy data	Early-2019	N.A.	256	Social media-based supplier network strength, network heterogeneity, network density, and new product performance	Seven of the original firms' secondary proxy data could not be fully obtained

Table 2
Construct measurement and validity assessment

Social media-based supplier network involvement (New scale; α = 0.92, CR = 0.94, AVE = 0.62)	Factor loading
For each of the following activities, we would like you to identify whether you are involved in this activity through the use of social media (0 = No, 1 = Yes). If you are involved, how deeply are you involved? (1 = very superficial and 7 = very deeply)	
Idea generation	0.79
Concept screening	0.83
Product specification	0.75
Business evaluation	0.82
Product design	0.78
Product engineering	0.80
Prototyping	0.76
Product testing	0.81
Formation of cross-functional new product development team	0.77
Controlling and monitoring of the development process	0.79
Prior innovation performance (Gao et al. 2015; α = 0.79; CR = 0.77, AVE = 0.63)	
Relative to competitors, turnover of new products has a higher portion of contribution in our total sales.	0.81
Relative to competitors, our firm introduces technologically new or technologically improved products to the market at a more rapid pace.	0.78
Social media-based supplier stability (New scale; α = N.A., CR = N.A., AVE = N.A.)	
The extent to which our firm changed social media-based suppliers over the last three years	0.86
Environmental turbulence (Lau 2014; α = 0.91; CR = 0.92, AVE = 0.61)	
In the social media context,	
Product market is familiar to our firm.	0.82
Product market demand is easily-predictable.	0.75
Customer's needs are well-defined.	0.73
Customer's needs are readily translated into product specifications.	0.79
Technological phenomena are well-known to our firm.	0.81
Technological information is available for guidance.	0.77
Product is developed without complex trial and error methods.	0.78

Notes: α: Cronbach's alpha; CR: composite reliability; AVE: average variance extracted;
N.A.: not applicable (Because of single-item, α, CR, and AVE are not meaningful)

Table 3
Basic descriptive statistics of the constructs

Constructs	M	SD	1	3	4	5	6	7	8	9	10	11
1 Social media-based supplier network involvement	5.24	1.68	**0.79**									
2 Social media-based supplier network strength	0.891	0.303	0.21**	-								
3 Social media-based supplier network heterogeneity	0.095	0.063	0.19*	0.19*	-							
4 Social media-based supplier network density	0.402	0.349	0.18*	0.18*	0.19*	-						
5 New product performance	0.24	0.27	0.23**	0.20**	0.24**	0.21**	-					
6 Firm size	1.63	0.19	0.12	0.04	0.05	0.03	-0.13	-				
7 R&D intensity	0.08	0.09	0.06	0.10	0.12	0.10	0.20*	-0.12	-			
8 Prior innovation performance	4.73	1.28	-0.04	0.15*	0.19*	0.18*	0.34**	-0.05	0.10	**0.79**		
9 Social media-based supplier stability	5.36	0.89	0.02	0.28**	0.26**	0.24**	0.06	-0.01	-0.07	0.19*	-	
10 Environmental turbulence	5.09	1.37	0.01	0.02	0.01	0.05	-0.21*	0.01	-0.07	0.15*	-0.10	**0.78**

Notes: M: Mean; SD: Standard Deviation; Bold figures on the diagonal are the square root of the AVE; * $p < 0.05$; ** $p < 0.01$; N = 256

Table 4
Results of hieratical moderated regression

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Results
Control variables							
Firm size	-0.195 (0.110)	-0.246* (0.112)	-0.241* (0.112)	-0.239* (0.112)	-0.242* (0.113)	-0.201 (0.111)	
R&D intensity	0.031** (0.011)	0.027* (0.011)	0.024* (0.011)	0.025* (0.011)	0.021* (0.010)	0.028* (0.011)	
Prior innovation performance	0.556*** (0.071)	0.489*** (0.076)	0.486*** (0.076)	0.479*** (0.075)	0.475*** (0.075)	0.496*** (0.076)	
Social media-based supplier stability	-0.106 (0.092)	-0.093 (0.095)	-0.126 (0.097)	-0.124 (0.097)	-0.082 (0.091)	-0.142 (0.098)	
Environmental turbulence	-0.204*** (0.048)	-0.203*** (0.048)	-0.194*** (0.047)	-0.193*** (0.047)	-0.196*** (0.047)	-0.214*** (0.048)	
Main effects							
Social media-based supplier network involvement (SMBSNI)		0.018* (0.009)	0.019* (0.009)	0.020* (0.009)	0.020* (0.009)	0.022* (0.010)	Hypothesis 1 Supported
Social media-based supplier network strength (SMBSNS)		0.129 (0.114)	0.195 (0.115)	0.112 (0.114)	0.117 (0.114)	0.283* (0.135)	
Social media-based supplier network heterogeneity (SMBSNH)		0.124 (0.116)	0.193 (0.117)	0.110 (0.116)	0.114 (0.116)	0.279* (0.132)	
Social media-based supplier network density (SMBSND)		0.081 (0.058)	0.092 (0.059)	0.086 (0.058)	0.092 (0.059)	0.087 (0.058)	
Moderating effects							
SMBSNI × SMBSNS			0.028* (0.014)			0.031* (0.015)	Hypothesis 2 Supported
SMBSNI × SMBSNH				0.021* (0.007)		0.027* (0.012)	Hypothesis 3 Supported
SMBSNI × SMBSND					-0.015* (0.006)	-0.018* (0.007)	Hypothesis 4 Supported
Constant	2.061** (0.732)	2.692*** (0.784)	2.879*** (0.851)	2.848*** (0.829)	2.604*** (0.753)	3.013*** (0.886)	
F value	9.187***	6.539***	6.182***	5.929***	5.824***	5.620***	
R^2	0.460	0.492	0.499	0.500	0.504	0.544	
Adjusted R^2	0.408	0.416	0.419	0.420	0.424	0.448	

Notes: N = 256; Standard errors in parentheses; * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (two-tailed tests reported)

What makes social media-based supplier network involvement more effective for new product performance? The role of network structure

Highlights

- Social media-based supplier network involvement enhances buying firm's new product performance.
- This performance enhancement effect is even stronger when network strength is greater.
- The same effect is even stronger when network heterogeneity is greater.
- However this effect is lessened when network density is greater.

Author biography

Colin C.J. Cheng is an academic researcher in innovation. He has published widely in journals including Journal of Product Innovation Management, Technovation, International Journal of Production Economics, Supply Chain Management, and many others. He is affiliated with National Taipei University.

Eric Shiu is an academic researcher in innovation. He has published widely in journals including Transportation Research Policy and Practice, Psychology and Marketing, Technovation, International Journal of Innovation Management, and many others. He is affiliated with the University of Birmingham in the UK.