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When customer involvement hinders/promotes product innovation performance: The concurrent effect of relationship quality and role ambiguity

Saeed Najafi-Tavani [a], Ghasem Zaefarian [b,*], Matthew J. Robson [c], Peter Naudé [a], Faramarz Abbasi [d]

[a] Manchester Metropolitan University Business School, All Saints Campus, Oxford Road, Manchester, UK
[b] Leeds University Business School, University of Leeds, Maurice Keyworth Building, Leeds, UK
[c] Cardiff Business School, Cardiff University, Aberconway Building, Cardiff, UK
[d] Management Division, Institute for Management and Planning Studies, Number 6, Mokhtar Asgari Street, Niavaran, Tehran, Iran

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ABSTRACT

Despite recent attempts to explain the nature of customer involvement, the question of how to curb its negative effect on product innovation has yet to be explored. This study focuses on the association between customer involvement and developers' product innovation performance, and relies on relationship management theory and the role hazard perspective to explore what levels of relationship quality and role ambiguity, which coexist in partnerships, can turn ineffective customer involvement into a successful strategy. Using a survey of 273 manufacturing firms, we found an inverted U-shaped relationship between customer involvement and product innovation performance, and verified that the interplay of relationship quality and role ambiguity significantly moderate this association. We unpack the role of our moderators by developing a 2 × 2 matrix of high versus low levels of role ambiguity and relationship quality, and exploring the nature of the association between customer involvement and product innovation performance in each quadrant.

1. Introduction

In recent years, customer involvement (CI), the extent to which a customer firm participates in the product innovation process of the developer, has received substantial attention from practitioners (Anning-Dorson, 2018). Many successful companies such as Boeing, Microsoft, and IBM are increasingly turning to their business customers for assistance in the design and development of new products. CI has likewise received increased attention from scholars, who have shown it to be an important antecedent of successful product innovation (i.e. Cheng, Chen & Tsou, 2012; Cui & Wu, 2016; Morgan, Obal & Anokhin, 2018). The prevailing view among scholars and practitioners alike, is that customers are valuable sources of knowledge. Hence, customers' collaboration in the innovation process could be helpful in transforming their needs into new products and services, thereby increasing market acceptance (Najafi-Tavani, Mousavi, Zaefarian & Naudé, 2020).

An examination of the literature, however, suggests that our understanding of the contribution of CI to product innovation and ultimately to company performance is incomplete in at least two important ways. First, many scholars focus solely on the bright side of CI, as a successful strategy for firms. They argue that the involvement of customers in the new product development (NPD) process can benefit the developer in various ways, such as helping them to generate more creative ideas, enhancing the innovativeness of their new products (Cui & Wu, 2017; Morgan et al., 2018), and improving their new product performance (Cui & Wu, 2016; Najafi-Tavani et al., 2020; Tseng & Chiang, 2016). Recent works have begun to explore the dark side of CI, contending that such involvement may come at too high a cost. Close collaboration with business customers can escalate the complexity of managing NPD processes when the two sides differ widely in their strategic orientations, capabilities, goals, and values (Blut, Heirati & Schoefer, 2020; Chan, Yim & Lam, 2010; Najafi-Tavani et al., 2020).

In response to these contradictory views, a few studies (e.g. Homburg & Kuehnl, 2014; Millson, 2015; Storey & Larbig, 2018; Tang &

* Corresponding author at: Leeds University Business School, University of Leeds, Maurice Keyworth Building, Leeds LS2 9JT, UK.
E-mail addresses: S.Najafi.Tavani@mmu.ac.uk (S. Najafi-Tavani), G.zaefarian@leeds.ac.uk (G. Zaefarian), RobsonM@cardiff.ac.uk (M.J. Robson), P.Naude@mmu.ac.uk (P. Naudé), F.Abbasi@imps.ac.ir (F. Abbasi).

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Marinova, 2020) have proposed the existence of a curvilinear relationship between CI and firms' product innovation outcomes. This emerging work characterises CI as a '*double-edged sword*' (Chan et al., 2010) that, depending on the level of involvement, may improve or harm developers' innovation performance. Yet, findings on the non-linear association between CI and product innovation performance are inconclusive as some studies claim the existence of a U-shaped relationship (e.g. Homburg & Kuehnl, 2014; Millson, 2015), while others suggest an inverted U-shaped link (e.g. Tang & Marinova, 2020; Zhao, Feng & Wang, 2015).

Second, while the debate on whether and how CI can hinder product development and innovation performance is ongoing, few attempts have been made to explore contingent factors that can curb the negative effects of CI on product innovation performance. One example is Wang, Jin, Zhou, Li, and Yin (2020), who empirically explored how role confusion stemming from CI can lead to role conflict, a relational phenomenon that adversely affects NPD performance. They further investigated how product characteristics such as market and technology newness play contrasting roles in mitigating or exacerbating the severity of these effects. Although this study paid focal attention to the detrimental effect of role conflict and the uncertainties that may arise due to product newness to explain how they adversely affect NPD, the source of uncertainty in their study is primarily limited to the newness of the product. Indeed, uncertainty can stem from (role) ambiguities inherent in business partnerships (Gong, Shenkar, Luo & Nyaw, 2001). Role ambiguity (RA), a key aspect of the role hazard perspective, is an often-recurring theme and a major source of uncertainty that can potentially arise when a business customer is closely involved in the developer's NPD processes (Nygaard & Dahlstrom, 2002). From the role hazard perspective, RA, or a "*lack of clarity and predictability of the outcomes of one's behaviour*" (House & Rizzo, 1972, p. 475), emerges when the developer and/or the business customer are uncertain about their obligations and boundaries in their collaborative relationship (Dong, Ju & Fang, 2016). An example of the occurrence of ambiguity in developer–customer relationships is the case of Samsung Display, the sister company of Samsung Mobile, and its collaborative relationship with Apple for co-developing OLED displays. Although Samsung Display has made considerable efforts to meet Apple's robust quality standards, the co-development process has never turned into a trouble-free collaboration as each party's different view on the co-developed product has led to the emergence of RA (Wang et al., 2020).

Given that CI involves continuous interactions between the developer and its customer, the relational coordination problem of RA seems inevitable and, in fact, is more salient in the collaborative relationship context than in a conventional transactional-based relationship. The presence of RA would force the developer to allocate more resources to understand the nature of the uncertainties and also to better manage and address such uncertainties by paying particular attention to the quality of the relationship.

Here, relationship quality (RQ) refers to the extent to which the developer and the involved customer trust each other and are committed to the long-term maintenance of their collaboration (Athanasopoulou, 2009). RQ can be considered a key means of providing certainty in a partnership, in its own right, as well as of reducing uncertainties that may arise in close partnerships due to RA (Hewett, Money & Sharma, 2002; Lai, Pai, Yang & Lin, 2009). From relationship management theory, RQ represents relationship momentum (Jiang, Shiu, Henneberg & Naudé, 2016) that could regulate the behaviour of both parties (Izquierdo & Cillan, 2004; Jiang, Henneberg & Naudé, 2012; Shahzad, Ali, Takala, Helo & Zaefarian, 2018). Low-quality relationships stemming from poor communication, misunderstandings, and misperceptions, can lead to infidelity in the developer–customer relationship, dampening the effectiveness of CI in product innovation processes (Leonidou, Aykol, Spyropoulou & Christodoulides, 2019; Najafi-Tavani, Sharifi, Naudé & Parvizi-Omran, 2022). The critical role of RQ in maintaining long-term, high-quality partnerships is well evidenced in the case of many leading collaborative partnerships. For example, Toyota's competence in harnessing the leading edge of technology, and Chrysler's survival are both achieved by establishing and maintaining quality relationships with their networks of business partners (Chang, Cheng & Wu, 2012).

Although both of these relational phenomena (i.e. RA and RQ) and their role in developing and maintaining business relationships are well explored in previous studies (see Jiang et al., 2016; Nygaard & Dahlstrom, 2002; Srivastava, 2015), the literature has not examined the potentially varying and decisive, unilateral or concurrent impact of RA and RQ in shaping CI's contribution to developers' innovation processes.

Against this backdrop, we designed our study to revisit the relationship between CI and product innovation performance with two specific aims in mind: first, we intend to add to emerging work on the curvilinear effect of CI on innovation performance by providing evidence that the relationship linking CI to innovation performance has an inverted U shape. Second, we examine when CI could damage the developer's product innovation performance and how and under what conditions a developer can turn ineffective CI into a successful strategy. Specifically, our point of departure is that we examine the concurrent effects of two specific relational factors, that is, RA and RQ, to explain how these relational traits can aggravate or offset the adverse effects of CI on product innovation performance. Drawing on the role hazard perspective and relationship management theory, we theorise that since developers and customers involved in collaborative activities can experience different levels of RQ and at the same time encounter varying intensities of RA, it is vital to consider the joint effect of RA and RQ on the link between CI and product innovation performance.

Accordingly, we develop a RA–RQ matrix and discuss in depth the nature of the relationship between CI and innovation performance under low versus high levels of RA and RQ. Using a matrix structure, we suggest that the relationship between CI and product innovation performance can be categorised into four distinct quadrants of '*Dark box*', '*Dark-Grey box*', '*Bright-Grey box*', and '*Bright box*'. Our results reveal that while the Dark box (high levels of RA and low levels of RQ) is the most destructive condition for CI, the Bright box (low levels of RA and high levels of RQ) reflects the desired condition in which CI presents its most effective form for the developer's product innovation. The quadrants, Bright-Grey box (high levels of both RA and RQ) and Dark-Grey box (low levels of both RA and RQ), suggest CI acts as a double-edged sword. In both Bright-Grey and Dark-Grey conditions, our results confirm an inverted U-shaped relationship between CI and product innovation performance. Comparison of the Bright-Grey box and Dark-Grey box unveils that high levels of RA and RQ steepen the curve, while the existence of low levels of the two relational factors flattens the curve.

2. Theoretical background

2.1. CI in product development and innovation

The key driving force to innovation (be it product, service, process, or technological) is that business growth depends fundamentally on successful innovation. Across the different forms of innovation, the industrial customer's involvement in exchanging information and solution-related knowledge with the developer is considered as an effective strategy in a B2B context (Wang et al., 2020). Different terms such as CI, '*customer participation*', and '*customer integration*' have been used in the literature to reflect the role of business customers in the developer's innovation process. These terms are often used interchangeably but all echo the same principle, that is, firms increasingly rely on their customers' insights and expertise in the process of NPD.

While the importance of involving business customers in innovation and product development has been highlighted in the literature, the findings of previous studies are inconclusive, with some studies stating a positive link (e.g. Chatterji & Fabrizio, 2014; Morgan et al., 2018) and others reporting no link (e.g. Fang, 2008; Lau, Tang & Yam, 2010) or even a negative one (e.g. Anning-Dorson, 2018; Knudsen, 2007), between CI and innovation-related outcomes. A few studies endeavoured to explain such inconsistency by empirically revealing a curvilinear association between CI and performance (see Table 1). However, the inconsistency persists. For example, Homburg and Kuehnl (2014) found a U-shaped relationship between customer integration and new product success. They claim that the developer may experience a non-beneficial effect of low to medium levels of CI on innovation performance. This is because monitoring/managing customer behaviour takes a disproportionate amount of time and resources. However adopting high levels of customer integration can provide a long-lasting benefit for their new product process (Homburg & Kuehnl, 2014, p. 1365). Similarly, with the focus on a market aspect of new product performance, Millson (2015) suggested a U-shaped relationship between customer engagement in the developer's product development process and performance.

In contrast, Zhao et al. (2015) reported an inverted U-shaped relationship between customer integration and products' financial performance. Likewise, and using a knowledge-based perspective, Tang and Marinova (2020) found an inverted U-shaped association between customer knowledge sharing behaviours and NPD performance. These authors suggest that while low to medium levels of CI can improve the developer product innovation performance, excessive CI should become detrimental as a result of overloading the developer's information processing capacities (Tang & Marinova, 2020; Zhao et al., 2015). We concur with this viewpoint and propose (and observe empirically) that developers enjoying low to medium involvement of their industrial customers benefit from their product-market knowledge input. Yet uncertainty, excessive information processing, overreliance on customers, and collective blindness, are all potential reasons that can make high levels of CI counterproductive.

2.2. The importance of RA and RQ in shaping CI consequences

As discussed earlier, several studies on CI have reported that co-development efforts are not necessarily always successful. Such collaborations may not achieve their planned goals. In light of this, recent studies have begun to explore the dark side of CI with the intention of identifying detrimental factors that could hinder or impede successful CI. Existing contributions have explored and explained how factors such as increasing complexity, misalignment of partners' strategic orientation, lack of mutual understanding, cultural differences, and power asymmetry can lead to undesirable outcomes of CI (Blut et al., 2020; Chan et al., 2010; Najafi-Tavani et al., 2020). The common ground for these impeding factors is the emergence of some level of uncertainty in the collaborative partnership (Najafi-Tavani et al., 2020; Villena, Revilla & Choi, 2011; Wang et al., 2020). Uncertainty as a key relational impediment occurs due to insufficient information processing capabilities, inability to envisage or understand partner actions, or when a firm is not clear on what is expected of them. Such uncertainties provoke undesirable outcomes such as adversely affecting co-development efforts and reducing the success rate of co-developed products, or worse still, they may sabotage the entire partnership (Kreye, 2017). Given the detrimental effects of uncertainty, it is vitally important for the developer to detect and, where possible, eliminate the cause of such a relational hazard.

Existing literature has documented RA as one of the major sources creating uncertainty for developer–customer relationships (Dong et al., 2016; Yan & Dooley, 2013). These studies have largely treated RA as a detrimental factor that arises due to a lack of necessary information and that it is positively associated with uncertainty about the task assigned by a business partner (Cicero, Pierro & van Knippenberg, 2010). Therefore, in our study, we consider RA as an indicator of uncertainty stemming from ambiguous conditions in a partnership.

Against this backdrop, we argue that RQ is a factor that can bring certainty back to the partnership and help reduce or eliminate uncertainties associated with RA. RQ is a key relational attribute that allows partners to create and develop dyadic, normative bonds that can mitigate uncertainties in a close partnership and their unfavourable effects (Gounaris, 2005; Jiang et al., 2012).

2.2.1. The role of RA

The developer–business customer relationship is a complex entity that, despite the best intentions of both parties, is subject to a variety of complications and disputes. Indeed, close relationships may fail to achieve their pre-agreed mutual objectives, because of relational problems that stem from a lack of clarity regarding role expectations owing to insufficient information on assigned tasks (Dong et al., 2016; Yan & Dooley, 2013). Previous studies have used the role hazard perspective to shed light on relational coordination problems and mechanisms underlying their occurrence (Dong et al., 2016; Nygaard & Dahlstrom, 2002). Role hazard refers to "*a social condition in which partners' role obligations*

Table 1
Selected literature on the curvilinear customer involvement–outcome association.

Source	Empirical approach	Consequences	Moderators	Summary of key findings
Homburg and Kuehnl (2014)	A survey of 285 managers from service and manufacturing firms	-Product innovation -Service innovation	–	-Customer integration ∪ Product innovation -Customer integration ∩ Service innovation
Millson (2015)	A survey of 131 managers responsible for NPD from the US-based manufacturing firms	-New product market success	–	-Customer integration + new product market success -Customer integration ∪ new product market success
Storey and Larbig (2018)	Online survey of 126 senior managers from the service firms operating in Europe	-Customer knowledge assimilation -Concept transformation	–	-CI + Customer knowledge assimilation -CI ∪ Customer knowledge assimilation -CI + Concept transformation -CI ∩ Concept transformation
Tang and Marinova (2020)	Online survey of 182 managers and employees involved in NPD processes from two US-based biotech firms	-NPD Performance	-Perceived diagnostic value of customer knowledge	-Customer knowledge sharing behaviours ∩ NPD performance -Customer knowledge sharing behaviours + Shared common customer knowledge -Shared common customer knowledge ∩ NPD performance -Perceived diagnostic value of customer knowledge ↓ Shared common customer knowledge-NPD performance
Zhao et al. (2015)	Mail survey of 195 senior managers from manufacturing firms operating in China	-Financial performance	-Top management support	-Customer integration ∩ Financial performance -Top management support +↓ Customer integration-Financial performance

Notes: CI: Customer involvement; ∪: U-shaped relationship; ∩: Inverted U-shaped relationship; +: Positive relationship; +↓: Positively moderates.

and responsibilities are vague, discrepant, and difficult to meet" (Dong et al., 2016, p. 5). In line with this perspective, we propose that given the interactive nature of the developer–business customer relationship, RA is inevitable, and consequently the developer is likely to encounter uncertainties. Relational complications and disputes are likely to occur in collaborative developer–customer relationships due to the high frequency and levels of joint and shared activities that form the essence of such relationships.

RA and role conflict are two facets of the role hazard perspective (Nygaard & Dahlstrom, 2002). While the literature is unanimous regarding the detrimental consequences of RA in exchange partnerships, it is far from conclusive with respect to role conflict. While some scholars suggest that these two facets of role hazard are interrelated, and argue that role conflict is one of the main negative consequences of RA (Shenkar & Zeira, 1992; Wuyts, 2007), others have more favourable views on role conflict, suggesting that it is positively associated with job performance, job efforts, and venture performance (Gong et al., 2001; Schmitz & Ganesan, 2014). Given the lack of consensus regarding the potential consequences of role conflict, in this study we focus on RA alone as the main facet of role hazard shaping the relationship between CI and product innovation performance.

RA occurs when staff are uncertain and have doubts regarding their duties and authority (Coelho, Augusto & Lages, 2011), and when roles and obligations have not been appropriately formalised and communicated by either party involved, in an exchange relationship (Wuyts, 2007). The literature has sought to establish the undesirable outcome of RA at a firm level. For example, Nygaard and Dahlstrom (2002) found a nonlinear influence of RA on firms' sales and customer satisfaction. More recently, Dong et al. (2016) extended the subject into a supply chain partnership context and found a negative relationship between RA and supply chain performance. In this study, we argue that high levels of RA can give rise to uncertainty among employees, making them feel uncertain as to how to do their tasks and activities appropriately (De Clercq & Belausteguigoitia, 2017). This is due to the relational coordination problem, which is derived from the misalignment of activities by the developer and customer firms (Yan & Dooley, 2013). We therefore envisage that the uncertainty from high levels of RA can have a harmful influence on the consequences of involving the key customer in the developer's product innovation process.

2.2.2. The role of RQ

Relationship management theory pays focal attention to the understanding and management of collaborative business relationships between developers and customers, through which partners can gain competitive advantage and improve their performance (Brown, Mohan & Boyd, 2017). Theorists have identified RQ as a pivotal trait of the developer–customer relationship that can influence relational outcomes (Najafi-Tavani et al., 2022). RQ is also recognised as the key developer–customer relationship attribute that can affect other relational traits such as dependency, norms, and mutual goals (Izquierdo & Cillan, 2004; Jiang et al., 2012). Given that CI constitutes a relationship and interaction between two parties, we propose that RQ can influence the efficiency and efficacy of CI-related outcomes and it is critical to consider its contingent effect in studying the association between CI and product innovation performance.

RQ is usually discussed in the literature as a multidimensional construct (Jiang et al., 2016; Palmatier, 2008), comprising different but interrelated dimensions that strengthen each other (Zaefarian, Najafi-Tavani, Henneberg & Naudé, 2016). Among the different dimensions introduced in the pertinent literature, trust and commitment are consistently highlighted as key factors reflecting RQ (Athanasopoulou, 2009; Hewett et al., 2002; Lai et al., 2009). Trust and commitment, as equal dimensions constructing RQ (Hewett et al., 2002), help to maintain and strengthen the relationship between partners, increasingly making it more efficient (Lai et al., 2009). These two dimensions are also seen to be the key antecedents of other dimensions of RQ such as satisfaction and having a long-term relationship (Zaefarian et al., 2016). Therefore, in line with the suggestion of several studies in the pertinent literature (e.g. Lai et al., 2009; Palvia, King, Xia & Palvia, 2010; Zaefarian et al., 2016), we employ trust and commitment as two main facets of RQ.

Trust and commitment encourage partners to develop a fruitful and rewarding bond, which in turn can significantly reduce uncertainty, create greater value, and improve resource utilisation in the developer–customer relationship (Gounaris, 2005). In close developer–customer partnerships, such as where the customer is directly involved in the innovation process, the existence of trust and commitment can considerably improve the working relationship's atmosphere (Dawson, Young, Murray & Wilkinson, 2017) and increase confidence of the developer in customer contributions (Hemmert, Kim, Kim & Cho, 2016).

3. Hypothesis development

3.1. Curvilinear relationship between CI and product innovation performance

We argue that low to moderate levels of CI can enhance the developer's product innovation performance. The logic behind this effective involvement is that the level of uncertainty linked with the customer offering is manageable due to the low to intermediate levels of CI. Such a key customer can offer the developer fruitful knowledge and effective skills and resources that help in developing innovative products. From a knowledge-based perspective, the developer's key customer is a valuable market-based resource (Anning-Dorson, 2018) that can provide diversified demand-driven knowledge, enabling the developer to identify market trends and latent market needs; which ultimately reduces the chances of innovation failure (Flynn, Huo & Zhao, 2010; Song, Ming & Xu, 2013). The benefits of CI might also go beyond providing market intelligence. In fact, the key customer can play the vital role of *co-developer* in product innovation processes (Blazevic & Lievens, 2008; Cui & Wu, 2017). From this operational perspective, the key customer works with the developer's NPD team as a partner and engages in joint value creation activities such as problem solving and making decisions regarding the new product (Cui & Wu, 2017; Heidenreich, Wittkowski, Handrich & Falk, 2015). The interaction with the key customer enables the developer to directly assimilate the customer's tacit knowledge and expertise into the innovation process (Lin & Huang, 2013). In particular, involving the key customer in product design activities helps the developer to jointly—together with the customer—embed new ideas in the design process, which facilitates customer-oriented designs that enhance the developer's innovative outputs (Menguc, Auh & Yannopoulos, 2014). Therefore, utilising the key customer's ideas and information facilitates the developer in creating greater value via innovation. It could also be helpful in reducing the time to product launch (Mahr, Lievens & Blazevic, 2014; Zhao et al., 2015).

However, in line with recent studies (Tang & Marinova, 2020; Zhao et al., 2015), we argue that high levels of CI become counterproductive. In other words, we expect that higher levels of CI may not be beneficial for the developer's product innovation performance. While the key customer can still offer valuable knowledge, their intense and frequent involvement makes it difficult for both parties to develop a mutual understanding of the needs and ideas of the other due to increasing uncertainties. From the knowledge-based perspective, this uncertainty could be seen as the result of receiving too much information from the key customer that makes it more difficult for the developer to assimilate and absorb useful information. At the very least, the overload can push the developer into a resource consuming process (be it cognitive or financial) to digest and embed useful information and knowledge into the product development project (Carayannopoulos & Auster, 2010; Villena et al., 2011). The developer may need to allocate more resources to the process (e.g. extra NPD team members generally, or more experts and specialists). It could also need to spend a lot more time absorbing the high volume of information to not only understand what the key customer's input means, but also digest and make good use of their offerings. Allocating more resources and time to learn from key customers can limit the developer's focus on other essential activities in the innovation process. In addition, the uncertainty associated with high levels of CI can take the shape of confusion in recognising beneficial versus non-beneficial information (e.g. an idea not compatible with the developer's in-house capability) offered by the key customer (Zhao et al., 2015), which again could be costly for the developer in terms of its time and resources.

Further, from the operational perspective, parties involved in a dyadic interaction "*may have different frames of reference, standards, language and codes*" (Lin & Huang, 2013, p. 5). At high levels of CI, those differences can play a serious and harmful role that can damage the efficacy of CI in the product innovation process. It is expected that at high levels of CI the developer is likely to progressively invest in relational norms to facilitate collaborative activities. However, this developer effort will come at a cost. The developer needs to allocate considerable resources to achieve an acceptable level of coordination—which serves to increase the total cost of the innovation process and may delay the introduction of new products to the market.

Therefore, we argue that while low to moderate CI can increase the product innovation performance, the increase of CI from moderate to high levels can result in diminishing product innovation performance. This leads to our first hypothesis:.

H_1: CI exhibits an inverted U-shaped relationship with product innovation performance, with product innovation performance increasing with low to moderate levels of CI and decreasing with moderate to high levels of CI.

3.2. The moderating roles of RA and RQ in the CI–product innovation performance link

Employing relationship management theory, we argue that the outcome and performance of the developer's relationship with its key customer significantly relies on the characteristics of their partnership. Hence, in the following section we focus on relational features such as RA and RQ[1] in examining the CI–product innovation performance relationship.

The presence of high levels of RA between the developer and customer can be detrimental as it has been shown to increase the level of uncertainty and cause relational issues in joint innovation-related activities (De Clercq & Belausteguigoitia, 2017; Wuyts, 2007). Here, uncertainty is the result of relational coordination problems, which are mainly derived from the misalignment of activities of the developer and customer firms (Yan & Dooley, 2013).

By contrast, the existence of high levels of RQ can reduce the occurrence of uncertainty between the parties and thus improve the outcomes of developer–customer collaboration. The logic behind this claim is that the existence of trust and commitment leads to the development of a stronger relational bond between the sides, which can enhance their joint activities (Gounaris, 2005). High levels of trust and commitment can also improve the working relationship's atmosphere (Dawson et al., 2017). In such a climate, partners can develop a better understanding of each other's needs and ideas, and consequently deal more effectively with uncertainties that may arise due to the occurrence of some operational obstacles such as the different frames of standards, language and codes (Lin & Huang, 2013).

As any developer–customer relationship can be shaped by the simultaneous existence, or otherwise, of RA and RQ, we propose the concurrent moderating effect of such relational features on the relationship between CI and product innovation performance. We expect that under different levels of RA and RQ, CI impacts product innovation performance differently, resulting in the four hypothetical scenarios below.

Scenario 1: the existence of high levels of both RA and RQ. In this scenario, we argue that high levels of RA and RQ steepen the inverted U-shaped relationship between CI and product innovation performance. For low to moderate levels of CI, we expect a sharper upward slope for the left-half of the CI–product innovation performance relationship. Increasing CI up to moderate levels can offer fruitful knowledge for the developer's product innovation while the level of uncertainty associated with the customer input is manageable due to the low to intermediate levels of CI. In this situation, uncertainty connected with high levels of RA can also be managed with a less detrimental effect due to high levels of RQ, which potentially results in an efficient relationship between the firm and its key customer. With RQ and RA both be at their peak, the relational atmosphere is not ideal, nevertheless, lower levels of involvement create the condition that the benefits of high RQ can kick in, enabling the developer's NPD team to communicate more effectively with the customer's employees. (Dawson et al., 2017). Through a constructive relational atmosphere, parties are able to co-manage their efforts to better define and achieve mutual relational objectives despite existing ambiguities by better digesting and embedding the customer's input into the product innovation process, resulting in more promising product innovation performance enhancement (Jiang et al., 2016). When the developer's employees are committed to the relationship with the customer and feel that the customer's employees are trustworthy, they can initiate and progress more productive information exchanges to manage uncertainty stemming from high levels of RA by clarifying unclear roles and responsibilities (De Clercq & Belausteguigoitia, 2017).

However, increasing CI from moderate to high levels can result in less robust product innovation performance. In other words, we expect a sharper downward slope for the right-half of the CI–product innovation performance relationship. In this situation, the uncertainty that comes with high levels of CI will be compounded by the uncertainty from high levels of RA. Under these circumstances, even having high levels of RQ works to product innovation performance's disadvantage. High levels of RQ oblige the partners to look for inefficient resource-based solutions that otherwise would not have been considered viable. The goodwill intention to make the relationship work despite disagreements and dubieties would only exacerbate the problem of extreme uncertainties. To cope with this situation, in a best case-scenario, the developer would allocate more resources (e.g. in terms of people and time) with the aim of dampening and managing the varied uncertainties. But this can increase the overall costs and interrupt the smooth flow of the innovation process.

Scenario 2: the existence of low levels of RA and high levels of RQ. In this scenario, we expect a positive relationship between CI and product innovation performance. We thus argue that under these unique conditions, while for low to moderate levels of CI, the upward and positive slope for the left-half of the CI–product innovation performance relationship (in hypothesis 1) remains in place, the downward slope for the right-half of the relationship will also become upward and positive. Due to the low levels of RA, CI is the only major source of uncertainty. Given the established RQ between the two partners, the developer can more effectively manage uncertainty caused by heightened involvement of the customer, achieving superior product innovation performance. The logic behind this is twofold. First, with high levels of trust and commitment, the developer can develop an efficient mode of information exchange with the key customer (De Clercq & Belausteguigoitia,

[1] We acknowledge that in addition to their moderating effect, relational attributes such as RA and RQ may have a direct impact on the level of CI. Specifically, RQ can increase the likelihood that parties involved forge a stronger relationship that in turn may increase the extent to which the developer involves its key customer in innovation processes. This phenomenon does not affect the moderating role that RQ plays on the association between CI and product innovation performance. However, such a source of bias should be considered in the analysis and testing of hypotheses. We explain how we have addressed this bias in Section 5.2 that examines the issue of endogeneity.

2017), resulting in better acquisition and assimilation of the customer's knowledge into the innovation process. The efficiency of the knowledge exchange even helps when CI grows beyond moderate levels.

Second, high levels of RQ also have positive psychological implications, which can secure a constructive atmosphere of collaboration among employees involved in the innovation process (Leonidou, Samiee, Aykol & Talias, 2014; Najafi-Tavani et al., 2022). A developer that is committed to the relationship with a trustworthy customer would be able to believe in its customer and be more confident about their inputs (Hemmert et al., 2016). The positive relational atmosphere stops the developer from obsessing over the usefulness of the ideas put forward by the customer, even when these ideas become numerous. A mutual collaborative atmosphere also motivates the key customer to behave cautiously in the relationship with the developer and, as a result, continuously endeavour to have valuable participation in the innovation process. Thus, the constructive mechanisms and positive psychological implications of RQ not only result in more efficient management of involvement uncertainties but can even reduce perceived uncertainty occurrences in the relationship, resulting in more productive involvement of the customer in NPD.

Scenario 3: the existence of high levels of RA and low levels of RQ. In this scenario, we anticipate a negative relationship between CI and product innovation performance. As such, for low to moderate levels of CI, the upward slope for the left-half of the CI–product innovation performance relationship (in hypothesis 1) will become negative and downward, while the downward slope for the right-half of the relationship will continue to exist. By increasing CI from low to moderate levels, the developer experiences a gradual increase in uncertainty caused by the involvement of the customer. Yet, the concurrent presence of high RA can only exacerbate the overall uncertainties and the associated hindrances, which then harm involvement outcomes (Dong et al., 2016). This, in turn, may result in disorder and confusion in the co-innovation process. Here, the level of RQ is not sufficient to manage the uncertainty stemming from RA. Due to the lack of trust and commitment, it will be difficult to communicate effectively (Naudé & Buttle, 2000; Yumurtacı Hüseyinoğlu, Kotzab & Teller, 2020) to solve problems arising from the occurrence of RA in terms of unclear roles and responsibilities between the partners. Against this backdrop, low to moderate levels of CI can layer on damaging uncertainty.

The situation is even worse when the level of CI is between moderate and high as this can increase uncertainty to some unmanageable degree. Under this circumstance, the developer is likely to struggle to cope with the uncertainty stemming from high levels of both CI and RA. The absence of RQ could cause serious relational problems and, as such, the developer must deal with a potential difficulty in understanding and assimilating the customer's knowledge offering. Further, confidence of the developer in its key customer's inputs is also low due to the lack of adequate trust and commitment between partners, resulting in it having doubts about the value of the customer's input into the innovation process. The presence of relational complications and disputes (at high levels of RA) as well as the existence operational obstacles such as different standards and codes (Lin & Huang, 2013) can make it even harder for the developer to manage effective information exchanges. The occurrence of miscommunication and poor coordination (as a result of low levels of RQ) can therefore significantly sabotage the performance of joint efforts on behalf of the developer's innovation project.

Scenario 4: the existence of low levels of both RA and RQ. In this scenario, we expect that low levels of RA and RQ flatten the inverted U-shaped relationship between CI and product innovation performance. In other words, under this condition, the upward trend for the inverted U-shaped relationship between CI and product innovation performance experiences a slower growth and the downward trend slows down. Increasing CI from low to moderate levels can result in an increase in product innovation performance, as the developer confronts the low levels of uncertainty stemming from both CI and RA. This condition enables the developer to benefit from involving the customer in the innovation process to some extent. However, due to the lack of high levels of RQ, the involvement of the partner may not be as beneficial as it should be due to the absence of trust in the customer and lack of belief in what the customer puts forward (Leonidou et al., 2014; Naudé & Buttle, 2000). This will result in less than the predicted success of joint collaborative efforts and product innovation performance.

Further, increasing CI from moderate to high levels will result in increased levels of uncertainty. Due to the absence of established RQ, the developer would struggle to manage the uncertainty effectively which can in turn negatively affect product innovation performance. Still, the absence of high levels of RA can slow the downward trend as in this situation the developer will only have to deal with uncertainty that comes with high levels of CI. However, due to the existence of poor RQ we still predict a negative relationship.

Therefore, we suggest the following hypothesis:.

H_2: The interaction of RA and RQ will moderate an inverted U-shaped relationship between CI and product innovation performance, in which there is a difference between the effect of CI on product innovation performance under different levels of RA and RQ.

4. Method

4.1. Sample selection and data collection

We conducted an on-site questionnaire-based survey to collect data from Iranian manufacturing firms. Iran's economy is highly concentrated on manufacturing sectors with relatively limited international trade opportunities, due to political and economic sanctions. Therefore, Iranian manufacturing firms are highly reliant on local interfirm partnerships to survive in a challenging business environment. The collaboration and close interaction with other domestic supply chain players and, in particular, customers, has been identified as one of the main drivers of innovation in Iranian manufacturing in recent years (Najafi-Tavani, Najafi-Tavani, Naudé, Oghazi & Zeynaloo, 2018). As such, manufacturing settings in Iran offer an appropriate research context for studying the role of CI in innovation processes; particularly as cross-country and -cultural factors in CI are not our focus (Najafi-Tavani et al., 2020). Iran's culture in general can be described as a hierarchical society—it scores 58 on Hofstede's power distance dimension. At the same time, the Iranian culture scores 41 for individualism, suggesting it is a collectivist society. Most importantly, as Iran scores 59 on the uncertainty avoidance dimension, many firms operating there have a clear preference for avoiding uncertainty. Thus, from a cultural perspective, our sample should consist of firms that tend to dislike role ambiguity and the associated uncertainty. The organisational culture in our sample is similar to countries such as Germany (uncertainty avoidance score of 65), but contrasts with commonly used samples of UK and US firms that have low uncertainty avoidance scores (35 for the UK and 46 for the US).

To design our survey instrument, we first developed an English version of our questionnaire using existing measures that two professional translators independently translated into Farsi before back-translating them. We observed conceptual equivalence with the original questionnaire. To ensure the content and face validity of our measures, we carried out 12 in-depth interviews with senior supply chain managers in Iran, who were asked to verify the relevance of terminologies used in our questionnaire and completeness of the measures.

For our survey, we randomly selected a set of 1000 Iranian manufacturing companies listed in the Ministry of Industry, Mine and Trade database (https://www.behinyab.ir). We carefully checked each firm in our sampling frame to ensure they were still in business and met the following two criteria: first, they must have been operating in B2B markets for the last 5 years; and second, they should have at least 10 employees. We removed 325 firms that did not meet our criteria, leaving us with 675 eligible firms. We then made initial contact by phone with CEOs, vice presidents, managing directors, and/or NPD managers, as key informants for the eligible firms, to encourage their participation, guarantee confidentiality and anonymity (reducing social desirability bias), and request a 30 min appointment to conduct the survey on-site.

To limit potential method bias we split our survey into two parts and collected data from *two informants* in each firm, carefully chosen for their knowledge of the study constructs. Data for variables such as CI, RA, RQ, and customer-specific controls such as joint planning and joint problem solving were collected from the NPD manager. Data for our dependent variable, product innovation performance, and firm-specific controls such as the firm's number of employees, firm's age, and the firm's number of products designed in the last five years were collected from the CEO, vice president, or managing director. We asked both respondents to focus on their interaction with their key business customer that had been most significantly involved in new product innovation processes over the previous five years.

We secured appointments with two managers of 380 firms (i.e. 760 appointments). We visited the informants in their offices, provided them with the survey, clarified any ambiguity, and then collected the questionnaire after completion. This proven method of obtaining quality data resulted in the collection of 273 valid and usable pairs of responses from two informants per firm. Several managers missed their appointment and we removed any response from firms for which we were not able to collect data from the two informants.

After collecting the data, we checked for the possibility of non-response bias by comparing the main characteristics (i.e. firm's age and number of employees) of respondent and non-respondent firms (from the sampling frame). The results suggest no significant differences, indicating that non-response bias is not problematic. The firms participating in the study spanned diverse industries (i.e. automotive 18%, electrical and electronics 14%, plastic 13%, textile 13%, chemical 12%, engineering and machinery equipment 11%, food 9%, metal 7%, and other industries 3%). The responding firms are aged between 5 and 58 years while their number of employees are ranged from 10 to 750.

4.2. Common method bias

We examined for common method bias using the latent single-method-factor approach. We added a latent common method (LCM) construct to our baseline model. We loaded all items both to their pre-identified theoretical constructs and to the LCM construct. Comparing the fit indices of the baseline model ($\chi^2_{df=309} = 493.592$; CFI = 0.945; and RMSEA = 0.047) against the new model with the added LCM construct ($\chi^2_{df=308} = 488.752$; CFI = 0.946; and RMSEA = 0.046) suggests no significant difference ($\Delta\chi^2_{df=1} = 4.840$; $p > 0.05$), indicating that CMB is not problematic in our study. We also employed a marker variable technique to further examine the presence of CMB. We first selected the correlation between joint planning and RA as an estimate for the marker variable in our model (the second smallest positive correlation among all the variables). Using the selected marker variable, the CMB-adjusted correlations were then computed for all constructs in the model. The adjustment resulted in no difference to the statistical significance of the original correlations, further increasing our confidence that CMB is not a concern in our study.

4.3. Measures

Table 2 presents a full description of the questionnaire items. We drew our reflective, multi-item scales from previous well-established studies and any minor modifications were based on our pre-test interviews with the managers. To measure *product innovation performance,* we used a five-item scale from the study of Prajogo and Ahmed (2006), which assesses the level of "*generating ideas or the creation of something entirely new that is reflected in changes in the end product or service offered by the organisation*" (Prajogo & Ahmed, 2006, p. 505). *CI* was measured using a six-item scale adopted from Feng, Sun, and Zhang (2010) to assess the level of involvement of the key customer in the developer's NPD and innovation. For the measures of *RA*, we adapted a six-item scale from Nygaard and Dahlstrom (2002), which assesses the level of clarity concerning the developer employees' authority and responsibilities in the relationship with the key customer's employees involved in the innovation processes. The four-item scale of *RQ* with the key customer was adapted from Palmatier (2008). These items capture the calibre of developer–customer relational ties and reflect the developer's level of trust and commitment in the customer.

Controls. We considered a number of control variables to limit the possibility of our model's misspecification. Based on relationship management theory, we used five- and three-item scales (Table 2), respectively, to tap *joint planning* and *joint problem solving* between the developer and key customer (Zhou, Zhang, Zhuang & Zhou, 2015). Next, we also measured the developer firm's general characteristics such as the *firm's number of employees*, *firm's age*, and *firm's number of products designed in the previous five years*. Finally, as industry differences may affect our results, we also included an *industry dummy* to capture whether a developer operates in a low or high technology industry.

Table 2
Measurements.

Scales	Loadings
Product Innovation Performance (AVE = 0.600; CR = 0.857)	
How well your firm performs relative to the major competitors in terms of:	
The level of newness (novelty) of our firm's new products	0.748
The speed of our new product development	0.807
The number of our new products that are first-to-market (early market entrants)	0.765
The number of new products our firm has introduced to the market	0.777
Customer Involvement (AVE = 0.535; CR = 0.851)	
This customer often put forward improvement suggestions for our products*	–
We often hear this customer's opinions on product prototypes when developing new products	0.659
We involve this customer in our products' design and development	0.793
This customer has a major influence on the design of new products	0.823
There is a strong consensus in our firm that the involvement of this customer is needed in our products' design/development	0.694
We have continuous improvement programs that include our key customer	0.674
Relationship Quality (AVE = 0.531; CR = 0.818)	
We are willing 'to go the extra mile' to work with this customer	0.659
We view the relationship with this customer as a long-term partnership	0.754
We have trust in this customer	0.809
This customer is trustworthy	0.684
Role Ambiguity (AVE = 0.564; CR = 0.885)	
Our employees feel certain about how much authority they have ®	0.744
Our employees know what their responsibilities are ®	0.782
Our employees know that we have allocated their time properly ®	0.671
Our employees know exactly what is expected of them ®	0.771
The customer's explanation of what has to be done is clear ®	0.807
Our employees perform work that suits our values ®	0.772
Joint Planning (AVE = 0.584; CR = 0.875)	
Our firm plans volume demands for the upcoming years together with this customer	0.685
Our firm jointly plans the new product demands for the upcoming years with this customer	0.725
Our firm plans the variety demands for the upcoming years together with this customer	0.799
This customer provides us with sales forecasts for the products our firm sells	0.820
Our firm shares our long-term plans for our products with this customer	0.783
Joint Problem Solving (AVE = 0.547; CR = 0.783)	
This customer and our firm jointly deal with problems that arise in the relationship	0.684
This customer and our firm often help each other	0.789
This customer and our firm jointly take responsibility for getting things done	0.743

Notes: All items were measured using seven-point scales anchored by 1 = 'strongly disagree' and 7 = 'strongly agree' except for product innovation performance which anchored by 1 = 'very poor' and 7 = 'very good'; *: Deleted based on loadings; ®: reverse-scored items; AVE: average variance extracted; CR: composite reliability.

5. Analysis

5.1. Reliability, validity, and descriptive statistics

We performed confirmatory factor analysis (CFA) using AMOS 25 to validate our measures. After eliminating one item that performed poorly in our CFA analysis, the fit indices show that our measurement model fits the data reasonably well, with $\chi^2_{df=309} = 493.592$; CFI = 0.945; TLI = 0.933; IFI = 0.946; and RMSEA = 0.047. To check the convergent validity, we considered item loadings, average variance extracted (AVE) and composite reliability for all constructs in our model. As presented in Table 2, all items loaded highly (ranging from 0.659 to 0.823) and significantly (at $p = 0.01$) on their pre-identified constructs. Composite reliabilities are higher than the benchmark level of 0.7, suggesting good internal reliability. All computed AVE scores are above the cut-off point of 0.5, ranging from 0.531 to 0.600. We also assessed discriminant validity by verifying that the inter-construct correlations are smaller than the square root of all constructs' AVEs (see Table 3).

5.2. Endogeneity

An endogeneity problem occurs when a predictor is correlated with the error term of the dependent variable (Zaefarian, Kadile, Henneberg & Leischnig, 2017). We carried out two different statistical tests to address this potential bias in our study.

First, in our model, relational attributes such as RQ, joint planning (JP), and joint problem solving (JPS) may increase the likelihood that parties (developer and customer) forge a stronger and more intimate relationships. As such, these factors may increase the extent to which a developer involves its key customer in innovation processes. At the same time, the presence of RA could discourage a developer from involving its customer in innovation processes. Thus, from theoretical perspective, it is likely that relational attributes such as JP, JPS, RQ and even RA directly impact our independent variable CI—suggesting that CI could potentially not be a perfectly exogenous independent variable. To correct for this type of endogeneity bias, we used a residual-based three-stage least squares (3SLS) analysis (Zaefarian et al., 2017). Because a portion of our independent variable is likely to be explained by our moderators and controls, we need to purify our independent variable, making it free of effects from our moderators and controls, which can be done by taking the residuals from regressing our independent variables to our moderators and controls.

In the first stage, as specified in Equation (1), we regressed CI against RQ, RA, JP, and JPS to achieve a predicted value for our independent variable, CI. The results suggest that RQ, RA, JP, and JPS are significantly associated with CI, enhancing our confidence in the use of the 3SLS technique to eliminate such endogeneity bias.

$$CI = \beta_0 + \beta_1(RQ) + \beta_2(RA) + \beta_3(JP) + \beta 4(JPS) + \zeta \tag{1}$$

In the second stage, we computed residuals for CI that are free from the effect of RQ, RA, JP, and JPS, using the following equation:.

$$CI_{residual} = CI - - CI_{predicted} \tag{2}$$

We then replaced our independent variable (CI) with the computed residual one ($CI_{residual}$) in any subsequent analysis. In stage three, we regressed product innovation performance against $CI_{residual}$ and our control variables (Model 1 in Table 4). To deal with the skewness problem, the natural logarithm values for control variables, firm's number of employees, age, and number of products designed in the last five years are included in this model. We then added the quadratic term of our independent variable, CI (H_1) and two moderators, RQ and RA into the equation model (Model 2). In the next step, we included the interaction terms of $CI_{residual} \times RQ$, $CI_{residual} \times RA$, RQ × RA, and $CI_{residual} \times RQ \times RA$ to our product innovation performance equation (Model 3). In the last stage, we included the two-way quadratic interactions of ${CI_{residual}}^2 \times RQ$ and ${CI_{residual}}^2 \times RA$ as well as the three-way quadratic interaction term of ${CI_{residual}}^2 \times RQ \times RA$ (H_2) to the equation (Model 4). Equation (3) shows our full regression model. It should be noted that, before computing the interaction terms, all relevant variables were mean centred to deal with the multi-collinearity issue.

$$\begin{aligned} Product\ innovation\ performance = {} & \beta_0 + \beta_1(CI_{residual}) + \beta_2(CI_{residual})^2 + \beta_3(RQ) + \beta_4(RA) + \beta_5(CI_{residual} \times RQ) + \beta_6(CI_{residual} \times RA) + \beta_7(RQ \\ & \times RA) + \beta_8(CI_{residual} \times RQ \times RA) + \beta_9\left(CI^2_{residual} \times RQ\right) + \beta_{10}\left(CI^2_{residual} \times RA\right) + \beta_{11}\left(CI^2_{residual} \times RQ \\ & \times RA\right) + \beta_{Controls}(Controls) + \zeta \end{aligned} \tag{3}$$

Second, as a robustness check for addressing endogeneity, we used the Gaussian copula approach (Park & Gupta, 2012) to model the

Table 3
Inter-construct correlation estimates and square root of the AVEs.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) PIP	**0.775**									
(2) CI	0.157**	**0.731**								
(3) RQ	0.337**	0.250**	**0.729**							
(4) RA	−0.153*	−0.151*	−0.038	**0.751**						
(5) JP	0.149*	0.374**	0.192**	0.015	**0.764**					
(6) JPS	0.072	0.355**	0.106	−0.121*	0.521**	**0.740**				
(7) NOE	0.055	−0.135*	0.122*	0.047	−0.066	−0.126*	n/a			
(8) Age	0.001	0.088	0.156*	−0.007	0.176**	0.086	0.255**	n/a		
(9) NPDL5	0.086	0.068	0.068	0.034	0.030	0.056	0.139*	0.190**	n/a	
(10) $Industry_{dummy}$	0.034	0.021	−0.009	0.066	0.187**	0.115	0.095	0.087	−0.095	n/a
Mean	5.328	4.289	5.707	3.554	3.828	3.966	290.238	17.202	14.653	0.549
SD[a]	1.229	0.760	0.713	1.865	0.845	0.839	179.305	9.267	9.602	0.498
Min value	1.000	1.800	2.250	1.000	1.200	1.330	10.000	5.000	1.000	0.000
Max value	7.000	6.200	7.000	7.000	6.600	7.000	750.000	58.000	25.000	1.000

Notes: The bold, underlined figures on the diagonal are the square root of AVEs; ** $p < 0.01$; * $p < 0.05$; a: Standard deviation; PIP: Product innovation performance; JP: Joint planning; JPS: Joint problem solving; NOE: Number of employees; NPDL5: Number of products designed in the last five years.

correlation between our potentially endogenous variables (i.e. CI, RA, and RQ) and the error term of our dependent variable (i.e. product innovation performance) using a copula. We first conducted a Kolmogorov-Smirnov test to verify that our endogenous variables are nonnormally distributed ($p < 0.05$ in all three cases). In the next step, we used the REndo package in R (Gui, 2019) to compute Gaussian copula terms for each of our endogenous constructs separately. The Gaussian copula terms for CI, RA, and RQ are CI_star, RA_star, and RQ_star, respectively. These copula terms control for the correlation between our endogenous independent variables and the error term of product innovation performance. We added these copula terms as additional independent variables to our full regression model (Equation (3)) to form Equation (4).

$$\begin{aligned} Product\ innovation\ performance &= \beta_0 + \beta_1(CI_{residual}) + \beta_2(CI_{residual})^2 + \beta_3(RQ) + \beta_4(RA) + \beta_5(CI_{residual} \times RQ) + \beta_6(CI_{residual} \times RA) + \beta_7(RQ \times RA) \\ &+ \beta_8(CI_{residual} \times RQ \times RA) + \beta_9(CI^2_{residual} \times RQ) + \beta_{10}(CI^2_{residual} \times RA) + \beta_{11}(CI^2_{residual} \times RQ \times RA) + \gamma_1(CI\_star) \\ &+ \gamma_2(RA\_star) + \gamma_3(RQ\_star) + \beta_{Controls}(Controls) + \zeta \end{aligned} \quad (4)$$

The unstandardised coefficients for the copula terms and their significance levels were obtained with 10,000 bootstraps. The nonsignificant results for the copula terms (γ_1 = -0.13, p = 0.86; γ_2 = -0.24, p = 0.23; γ_3 = -0.28, p = 0.24) indicate that endogeneity is not problematic in our research.

6. Results

Table 4 presents the result of our regression analysis. In Model 2, the β coefficient for the squared term, $CI_{residual}^2$ is found to be negative (β = -0.253, $p < 0.001$), providing provisional support for H_1 which suggests an inverted U-shaped relationship between $CI_{residual}$ and product innovation performance. According to Haans, Pieters, and He (2016), two additional conditions must be met to fully confirm the existence of an inverted U-shaped relationship. First, the slope of the curvilinear relationship should be sufficiently steep at both ends of the data range, and second the turning point must be also positioned within the data range. In our dataset, the lowest and highest values for $CI_{residual}$ is −1.815 and 1.705 respectively. The slope at $(CI_{residual})_{Low}$, ($\beta_1 + 2\beta_2(CI_{residual})_{Low}$ = 0.994), is positive and significant, and the slope at $(CI_{residual})_{High}$, ($\beta_1 + 2\beta_2(CI_{residual})_{High}$ = -0.794), is also negative and significant, meeting the first condition. For the second condition, the turning point of 0.142 was calculated based on the $-\beta_1/2\beta_2$ formula. Based on the estimation of the 95 percent confidence interval for the turning point, we found that it is positioned well within the data range, suggesting support for the second condition. Overall, these findings lend support to our first hypothesis, confirming that while we can expect the increase for product innovation performance from low to moderate levels of $CI_{residual}$, product innovation performance decreases in turn from moderate to high levels of $CI_{residual}$.

Our second hypothesis predicted that the interaction of the RQ × RA bundle and CI is associated with product innovation performance, in which there is a difference between the effect of CI on product innovation performance under the conditions of high versus low levels of RQ and RA. As predicted, the β coefficient for the three-way interaction term $CI_{residual}^2 \times RQ \times RA$ is found to be negative (β = -0.380, p < 0.001), thus, supporting H_2. The negative β coefficient is an indication that the inverted U-shaped relationship between $CI_{residual}$ and product innovation performance steepens under high as opposed to low levels of RQ and RA. To shed further light on the moderating effect of the bundle of RQ × RA, we plotted Fig. 1 using the unstandardised β coefficient values

Table 4
Regression results (DV: product innovation performance).

	Model 1		Model 2		Model3		Model4		Hypothesis
	β	Sig.	β	Sig.	β	Sig.	β	Sig.	
Control variables									
Firm's NOE	0.137	0.057	0.055	0.408	0.057	0.393	0.028	0.650	
Firm's Age	−0.065	0.340	−0.095	0.127	−0.091	0.145	−0.129*	**0.028**	
NPDL5	0.101	0.126	0.099	0.101	0.089	0.142	0.102	0.074	
$Industry_{dummy}$	0.011	0.863	0.048	0.413	0.054	0.360	0.033	0.544	
JP	0.174*	**0.020**	0.181*	**0.011**	0.181*	**0.011**	0.138*	**0.039**	
JPS	−0.001	0.992	−0.039	0.570	−0.065	0.348	−0.064	0.339	
Predictors									
$CI_{residual}$	0.050	0.427	−0.001	0.989	0.034	0.591	0.072	0.238	
$CI_{residual}^2$			−0.253**	**0.000**	−0.253**	**0.000**	−0.254**	**0.000**	**H1: Supported**
RQ			0.279**	**0.000**	0.285**	**0.000**	0.381**	**0.000**	
RA			−0.094	0.113	−0.128*	**0.041**	−0.042	0.551	
Interactions									
$CI_{residual}$ × RQ					0.116	0.059	0.073	0.233	
$CI_{residual}$ × RA					−0.102	0.104	−0.119	0.054	
RQ × RA					0.079	0.200	0.264**	**0.000**	
$CI_{residual}$ × RQ × RA					−0.038	0.537	−0.066	0.276	
$CI_{residual}^2$ × RQ							−0.098	0.179	
$CI_{residual}^2$ × RA							−0.174*	**0.034**	
$CI_{residual}^2$ × RQ × RA							−0.380**	**0.000**	**H2: Supported**
R^2	0.055		0.220		0.243		0.351		
Adjusted R^2	0.028		0.188		0.199		0.305		
F-Value	2.055*		6.913**		5.537**		7.588**		

Notes: DV: Dependent variable; NOE: Number of employees; NPDL5: Number of products designed in the last five years; JP: Joint planning; JPS: Joint problem solving; ** p < 0.01; * p < 0.05; The bold and underlined figures represent p values below 0.05.

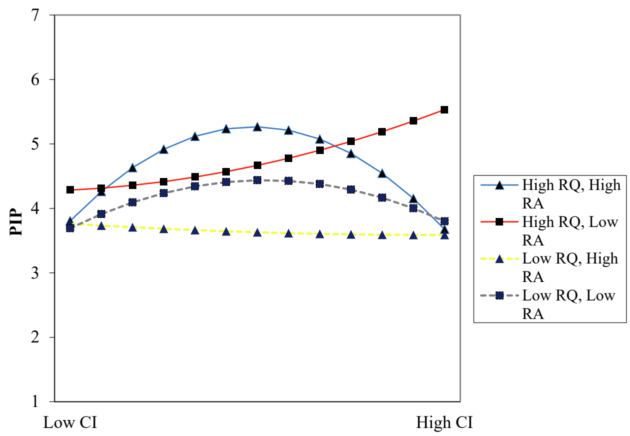

Fig. 1. Interaction of $CI_{residual}^2 \times RQ \times RA$ and product innovation performance.

Table 5
Unstandardised β coefficient.

Variable	Unstand. β
$CI_{residual}$	0.131
$CI_{residual}^2$	−0.479
RQ	0.656
RA	−0.028
$CI_{residual} \times RQ$	0.207
$CI_{residual} \times RA$	−0.111
RQ × RA	0.265
$CI_{residual} \times RQ \times RA$	−0.103
$CI_{residual}^2 \times RQ$	−0.223
$CI_{residual}^2 \times RA$	−0.137
$CI_{residual}^2 \times RQ \times RA$	−0.468

presented in Table 5. As this interaction plot suggests, CI's association with product innovation performance varies significantly depending on different levels of RQ and RA. We further elaborate on this finding and its managerial implications in the discussion section.

6.1. Additional analysis

In our hypothesis development, our main argument relies on the level of 'certainty' that comes from RQ and the level of 'uncertainty' that arises from the existence of RA. To capture the dynamics of the relationship between RA and RQ, we paid focal attention to the 'outcome' of the concurrent presence of RA and RQ. Here, we used *'conflict'* as the possible outcome of RA and RQ. We captured conflict in our study via five items adapted from Nygaard and Dahlstrom (2002). Indeed, conflict can be considered as a valid proxy for the outcome of the concurrent presence of RA and RQ in any developer–customer relationships. The argument is that any developer–customer relationships can be described by some (low or high) level of RQ, and at the same time, is prone to some degree of RA. Consequently, the amalgamation or the interaction between different levels of RA and RQ should lead to different levels of conflict being presented in such relationships. As such we expect that relationships that are characterised with low levels of RA and high levels of RQ should experience significantly lower levels of 'conflict' comparing to relationships that are described by high levels of RA and low levels of RQ. To test this proposition, we first conducted the K-mean cluster analysis to split our sample into four groups based on high versus low levels of RA and RQ (see Fig. 2). In the next step, we carried out a one-way ANOVA test to compare the mean value of conflict in those four different clusters. Our between group analyses indicate that the mean value of conflict is significantly different across the four clusters ($F = 19.410$, $p < 0.01$).

We then carried out an additional post-hoc comparison analysis

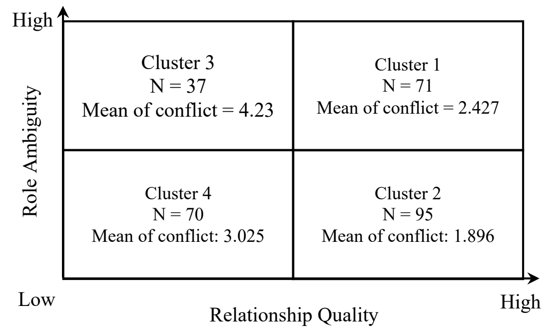

Fig. 2. A two-by-two matrix of high vs low RA and RQ.

Table 6
Post-hoc comparison analysis using Tukey method.

(I) Cluster	(J) Cluster	MD* (I-J)	SE	Sig.
	2	0.530	0.197	0.038
1	3	−1.804	0.393	0.000
	4	−0.599	0.211	0.025
	1	−0.530	0.197	0.038
2	3	−2.335	0.384	0.000
	4	−1.129	0.194	0.000
	1	1.804	0.393	0.000
3	2	2.335	0.384	0.000
	4	1.205	0.392	0.012
	1	0.599	0.211	0.025
4	2	1.129	0.194	0.000
	3	−1.205	0.392	0.012

Notes: MD: Mean difference; SE: Standard Error.

using Tukey as a method of assuming equal variances to find out where the significant difference lies in between the four identified clusters. The results suggest that each of the four clusters are significantly different from the other clusters (see Table 6).

Although not directly capturing certainty and uncertainty in our study, we believe that using conflict as a proxy for the outcome of such certainty and uncertainty clearly suggests that there is a relationship between the level of certainty that comes from RQ and the level of uncertainty that stems from RA.

7. Discussion and implications

The innovation literature has paid extensive attention to the advantages of involving customers in product innovation processes. However, the evident significant gains from pursuing CI strategies have served to limit scholars' and practitioners' attention to understanding the dark side of CI in a developer's product innovation practices. Grounded in relationship management theory and the role hazard perspective, we revisited the relationship between CI and product innovation performance with the intention of finding out under what levels of RA and RQ the benefits of CI diminish, when CI may harm the developer's product innovation performance, and how and when unproductive CI can be turned into a successful strategy.

7.1. Theoretical implications

The study extends academic innovation research in two main ways. First, our statistical analysis provides robust empirical evidence for the presence of an inverted U-shaped relationship between CI and product innovation performance. This finding is consistent with the findings of limited recent studies (e.g. Storey & Larbig, 2018; Tang & Marinova, 2020; Zhao et al., 2015), which also suggest that although the involvement of the key customer can offer valuable knowledge and resources to the developer in developing innovative products, excessive

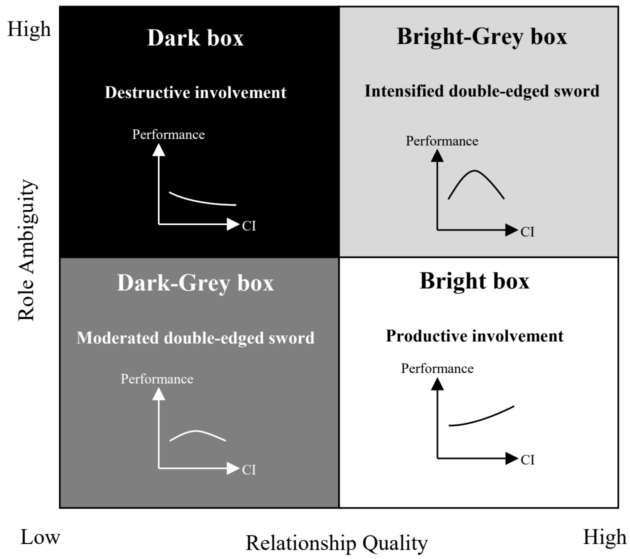

Fig. 3. The RA–RQ Matrix. **Notes: Dark box-** the bundle of high levels of RA and low levels of RQ - Under these circumstances, regardless of the level of involvement, CI persistently continues to distort product innovation success. **Dark-Grey box-** the bundle of low levels of RA and low levels of RQ- Under these circumstances, an inverted U-shaped relationship between CI and product innovation performance is flattened. **Bright-Grey box-** the bundle of high levels of RA and high levels of RQ- Under these circumstances, an inverted U-shaped relationship between CI and product innovation performance is steepened. **Bright box-** the bundle of low levels of RA and high levels of RQ - Under these circumstances increase in CI leads to higher product innovation performance**.**

and/or poorly managed CI can rapidly become counterproductive, adversely affecting the developer's product innovation performance. The harmfulness of excessive levels of CI could be due to increased levels of uncertainties in the process of developer–customer collaborations. Such uncertainties can transpire in the shape of confusion in discerning between beneficial versus non-beneficial information exchanges (Zhao et al., 2015) or be based on receiving too much information from the involved customer (Carayannopoulos & Auster, 2010; Villena et al., 2011). Moreover, relying too much on a key customer's input can also result in less efficient exploitation of internal competencies.

Second, our study demonstrates the efficacy of relationship theories in explaining CI's contribution to the developer's product innovation performance. Drawing on relationship management theory and the role hazard perspective, we found that the synchronised effect of RA and RQ can determine the extent of usefulness and/or harmfulness of CI in driving product innovation performance. The variability of RA and RQ and the differential impact of CI on product innovation performance are illustrated in the four quadrants of Fig. 3. The bundle of high levels of RA and low levels of RQ that we labelled the Dark box is found to be the most destructive form of CI. Under these circumstances, regardless of the level of involvement, CI persistently continues to distort product innovation success. In contrast, CI seems to be most effective when the developer can maintain high levels of RQ while keeping RA as low as possible, conditions that we labelled the Bright box. For as long as developers can keep RA under control and build good RQ, an increase in CI leads to higher performance.

The above two conditions present straightforward theoretical implications: RQ provides benefits while RA causes confusion in the collaborative developer–customer product innovation. In general, RQ as theoretically speculated, is a '*relational facilitator*' enabling the developer to harvest the benefits of involving the key customer in an innovation project. In contrast, RA can be considered as a '*relational trouble generator*' in developer–customer partnerships as it generally causes relational difficulties and coordination problems in collaborative product innovation (De Clercq & Belausteguigoitia, 2017; Yan & Dooley, 2013). Under the conditions of the Dark box, when the level of RQ is low, partners struggle to manage the uncertainties that stem from an increase in CI as well as the uncertainties associated with RA, resulting in poor relational outcomes in the innovation project. Under the collaborative climate of the Bright box, however, partners experience low levels of RA and therefore don't need to allocate too much cognitive resources to deal with the associated uncertainties. At the same time, the presence of high RQ helps to manage any uncertainties that stem from increasing involvement of the customer in the innovation process.

The conditions of high levels of RA and RQ, i.e., the Bright-Grey box, or low levels of RA and RQ, i.e., the Dark-Grey box, suggest that CI should be considered as a double-edged sword. In both of these conditions, we witnessed an inverted U-shaped relationship between CI and product innovation performance. Considering the bundle of high levels of RA and RQ, low to moderate levels of CI are indeed beneficial as established RQ can help the developer to mitigate the potential uncertainties associated with high levels of RA between partners. As CI increases to high levels, the existence of excessive levels of uncertainty can however have adverse consequences and affect the product innovation performance. This pattern is also the case under low levels of RA and RQ, even though the intensity of the effect is different. The comparison of the blue and grey lines in Fig. 1 suggests that the existence of high levels of RA and RQ steepens the curve while the existence of low levels of the two relational traits flattens the curve. A number of theoretical implications can be made from these findings.

First, the intensity of RA and RQ can (de)escalate the impact of CI on the product innovation performance. Good RQ is particularly effective in making moderate levels of CI a successful strategy even if a developer has to deal with high levels of RA. Second, the mere existence of RA may not always be a destructive phenomenon. Indeed, the existence of RA can create some opportunities for the parties to improve product innovation performance subject to the quality of relationship between them as well as the extent of CI. This interesting finding can be explained from the lens of a social cognitive perspective. While high levels of RA can give rise to uncertainty among employees, making them feel uncertain how to perform their jobs appropriately (De Clercq & Belausteguigoitia, 2017) they can also create "*the necessary space for cognitive flexibility*" (Wang, Zhang & Martocchio, 2011, p. 212). The occurrence of cognitive flexibility among the NPD project team members can promote their 'voice behaviour' enabling them to share new ideas and propose suggestions for improvement (Liu, Zhu, Liu & Fu, 2020). Under these circumstances, RQ acts as a controlling mechanism. The existence of a high RQ between the developer and customer facilitates the transformation of those ideas into some tangible benefits for product innovation; however, a lack of high RQ will convert those ideas and suggestions into some new forms of uncertainty among employees, which consequently results in less productive CI in innovation performance.

Third, when the level of CI increases from medium to high levels even a high level of RQ is not sufficient to control and manage the uncertainty, thus resulting in a sharper downward slope for the right-half of the CI–product innovation performance relationship. Overall, these findings emphasise the important role of RA and RQ in forming outcomes of developer–customer relationships. However, our findings also suggest that maintaining high levels of RQ is not always a winning strategy. While the potential benefits of RQ in improving the partners' collaboration cannot be denied, its relational facilitating role may become less effective when the key customer is excessively involved in the developer innovation projects (high CI) and at the same time there is a lack of clarity regarding the team members' roles and procedures (high RA). Thus, successful product innovation relies primarily on maintaining a fine balance between the level of CI, level of RA and the extent of RQ.

7.2. Managerial implications

This research derives a number of important implications for managers of manufacturing firms. First, while it is beneficial to involve key customers in product innovation, managers should pay close attention to the detrimental consequences of CI when it exceeds certain levels, as an intense involvement can make it difficult to develop a mutual understanding of the needs between the parties due to the rise of uncertainties. In particular, managers should be attentive to information overload and challenges in handling high levels of customer participation in the innovation process. To successfully deal with such challenges, firms need to develop and enhance the learning capability (see Najafi-Tavani et al., 2020) to seize, absorb, and utilise information offered by key customers. The appropriate knowledge absorbing mechanism can enable the developer not only to distinguish between beneficial and non-beneficial information, but can also facilitate them in discerning brilliant ideas from good ones for their product innovation. To manage the exploitation of ideas more effectively, managers could also allocate separate teams to work on different ideas. The screening and managing of ideas within different teams can prevent overloading one team with too many ideas, and also improve the speed of the innovation process. Managers should also set up mechanisms to manage the level of CI, ensuring that overenthusiastic customers do not participate too much or do not exceed their defined role, since over-participation can result in additional uncertainties. In controlling the level of CI, the adjustment of the scope of tasks can be considered as the first step. Managers should define and set a combination of closed tasks (i.e. activities that impose constraints) and open tasks (i.e. no restrictions on what can be done) for NPD project team members from the customer firm to adjust their level of participation (Blut et al., 2020). This can be also expanded to the organisational level by appropriately setting when, where, and how the customer's input is required in the product development process.

Second, to achieve the optimum level of CI and maximise the ability to innovate, managers should continuously consider the effects of two relational attributes, RA and RQ. Depending on the levels of RA and RQ, Fig. 3 categorises the potential outcomes of CI in terms of four quadrants: Dark, Bright, Bright-Grey and Dark-Grey boxes. While the Dark box indicates a complete waste of time and resources, the Bright box is the optimum condition that mangers should try to achieve in their collaboration with the key customer. These quadrants clearly indicate that while managers should endeavour to maintain a high level of RQ, they should try to manage levels of RA to maximise the benefits of CI in the innovation process. A good example for managers is the case of IBM and their emphasis on the importance of minimising ambiguity in business relationships as well as the improvement of trust and effective communications both internally and externally. This view on undertaking business partnerships is reflected in their collaboration with Intel. IBM and Intel made a partnership to conduct joint R&D activities with the aim of advancing research in next generation hardware and software products and technologies. In this partnership, the parties agreed that engineers from both sides should work together to co-create new products and technologies. The two firms decided to exchange researchers and engineers in a delicate process. Their gradual teamwork was planned not only to reduce concerns regarding the ownership of intellectual property, but also to avoid overwhelming levels of ambiguity, confusion, and misunderstanding between the members of the co-development team. The slow but steady growth in relationship quality also enabled them to improve the overall quality of the working atmosphere. This delicate process is indeed an appropriate strategy to enhance levels of trust and commitment as the two firms historically are competitive titans of the semiconductor industry in the US, and inevitably it took time for them to convert the competitive attitude to a collaborative attitude among their employees (see Forbes, 2021; IEEESpectrum, 2021).

Further, the comparison of Bright-Grey and Dark-Grey boxes suggests RA as the toxic factor that can disturb the involvement process when there is a poor relationship between the partners. The case of Boeing's 787 Dreamliner which was designed and developed based on a series of close collaborations between international developers such as Alenia (Italy), Kawasaki (Japan), and Rolls-Royce (England) and their key customer, Boeing, can be seen by managers as a good example of the detrimental effect of RA in terms of poor quality developer–customer relationships. While this project was anticipated to be a global symbol of success of collaboration in the aerospace industry, it faced serious and unexpected issues such as quality problems in terms of engine failures, fuel leaks, and the lithium battery fire (Hwang, Kim, Hur & Schoenherr, 2019). These design-related issues as well as some operational shortcomings (e.g. delays in and incomplete delivery of parts) resulted in a 40-month delay in introducing Boeing's 787 Dreamliner to the market. Among the different factors that have been identified as triggering the failure of this project, the co-existence of ambiguity and poor-quality relationships between partners has prominence. For example, co-designing activities between international developers and Boeing needed considerable and regular on-site interactions which did not take place due to the significant geographical distance between the parties. To deal with this issue, they employed a web-based interaction platform, Exostar, to share relevant data between each developer and Boeing. However, some of the developers were reluctant to upload accurate data on the system due to lack of trust in the relationship with Boeing (Forbes, 2013). This poor relationship quality and excessive levels of miscommunication caused high levels of uncertainty in the interactions between developers and Boeing, which ultimately resulted in a lack of competency to diagnose potential problems in a timely manner in the project's partnerships (see Hwang et al., 2019).

To avoid such a destructive situation, firms need to develop effective monitoring mechanisms that can raise the alarm when RA is in danger of reaching a level that can permanently damage the relationship and turning cognitive flexibility into cognitive exhaustion. We believe that managers should employ both *'output'* and *'behaviour'* monitoring mechanisms (Heide, Wathne & Rokkan, 2007) to keep track of the level of RA in their relationship with key customers. As for output monitoring, managers can detect visible consequences of the emergence of RA in the relationship such as delay in the implementation or the poor-quality outcomes of joint activities with the key customer. The success of output monitoring mechanisms relies significantly on information intensity, i.e., the quality and accuracy of information provided (Jean, Sinkovics & Cavusgil, 2010).

Although output monitoring mechanisms can generate appropriate indicators to detect and measure the level of RA, because such mechanisms focus primarily on the consequences of developer–customer joint activities, managers could struggle to use implications of these mechanisms in a timely manner. By the time that managers detect high levels of RA, it might be already too late to fix the problem. For this reason, managers should also consider behaviour/process monitoring mechanisms. An example of such mechanisms is regularly inspecting and auditing co-innovation procedures (Jean et al., 2010), which enables managers to detect key sources of uncertainties associated with RA. However, employing behaviour monitoring mechanisms may signal intervention in the customer's autonomy which in turn can negatively impact RQ between partners (Heide et al., 2007). Therefore, managers must be cautious about the extent to which such mechanisms should be adopted.

Further, managers would be well advised to develop and employ complementary actions in the form of *'bonding'* mechanisms to enhance the levels of trust and commitment between the two firms. This can be done through creating social ties and adopting socialisation practices, i.e., framing an informal relationship between the developer and key customer (Gounaris, 2005). The implementation of such mechanisms can also provide a valuable information basis for managers, enabling them to continuously monitor and gauge the level and extent of RQ between partners. While relational bonding mechanisms should be employed to improve the RQ between partners where and when possible, managers should also be aware that unimprovable RQ clearly indicates that the CI would not be beneficial under such circumstances, and tough decisions such as limiting the involvement or ending relationships might be a better decision despite its bitterness.

8. Limitations and directions for further research

As with all studies, there are some theoretical and methodological limitations associated with our research, which future research could seek to overcome. First, our study only investigated the moderating roles of two key relational facets, RA and RQ, in the relationship between CI and product innovation performance. It would be beneficial for future studies to examine the moderating roles of other business relationship attributes (e.g. relationship norms and types) on the association between CI and product innovation performance. Second, we only studied the role of the key customer in the developer's innovation. As developers deal with a portfolio of tiers of customers, future studies can utilise a wider context and examine the role of key customers' networks in the developer's innovation. Further, using an open innovation perspective, future studies can employ the proposed moderation factors in our study and re-examine the relationship between the involvement of other types of external partners (i.e. supplier, competitor, and university) and product innovation performance.

Third, in this study we did not directly capture the levels of certainty and uncertainty stemming from RQ and RA, respectively. Therefore, future studies ought to measure the degree of certainty and uncertainty in the developer–customer relationship to further elaborate on nuances of the link between CI and product innovation performance. Fourth, as we used a sample of Iranian manufacturing firms to test our research hypotheses, the generalisability of our findings may require further validation, which can be done through future studies collecting data from other regions. Finally, our study focused on the developer's perception regarding the level of RA and RQ. Since the perception of key customers on relational traits may vary from the developer's perception, future research can use our theoretical framework and focus on the dyadic relationship to examine contingent roles of RA and RQ in the CI–product innovation performance relationship.

CRediT authorship contribution statement

Saeed Najafi-Tavani: Writing – review & editing, Writing – original draft, Conceptualization, Formal analysis. **Ghasem Zaefarian:** Writing – review & editing, Writing – original draft, Conceptualization. **Matthew Robson:** Writing – review & editing, Writing – original draft, Conceptualization. **Peter Naudé:** Writing – review & editing, Writing – original draft, Conceptualization. **Faramarz Abbasi:** Data curation.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Saeed Najafi-Tavani holds a PhD in supply chain management from the University of Liverpool Management School. His main research interests focus on supply chain, product innovation, and buyer-supplier relationship. Saeed is a Senior Lecturer at Manchester Metropolitan University Business School.

Ghasem Zaefarian is an Associate Professor of Marketing at Leeds University Business School. He earned his PhD at Alliance Manchester Business School. His research foci span business and global marketing as well as organizational psychology. Dr Zaefarian currently serves as an Associate Editor of the Industrial Marketing Management journal.

Matthew Robson is a Professor of Marketing at Cardiff Business School. His research focuses on inter and intra organisational relationships, innovation, and knowledge related issues in MNCs.

Peter Naudé graduated with his PhD from Manchester University and works in the area of business-to-business marketing. Peter is a Professor at Manchester Metropolitan University Business School.

Faramarz Abbasi holds a MSc in Marketing from the Institute of Management and Planning Studies in Iran. His research interests include B2B marketing, supply chain management, and innovation.