Industrial Marketing Management 112 (2023) 113–127

Contents lists available at ScienceDirect

Industrial Marketing Management

journal homepage: www.elsevier.com/locate/indmarman

Opening up early or late? The effect of open innovation before and after product launch on new product market performance

Seongsoo Jang [a,*], Max von Zedtwitz [b,c]

[a] Cardiff Business School, Cardiff University, Aberconway Building, Colum Drive, Cardiff CF10 3EU, United Kingdom
[b] Dep't of Int'l Economics, Government and Business, Copenhagen Business School, Porcelaenshaven 24A, Frederiksberg, Denmark
[c] School of Economics and Business, Kaunas University of Technology, Gedimino 50, Kaunas, Lithuania

ARTICLE INFO

Keywords:
Open innovation
New product development
Product launch
Market performance

ABSTRACT

Despite a growing literature on open innovation in new product development (NPD), little is known about when openness is most beneficial during the innovation process. This study investigates the effectiveness of opening up NPD projects early or late, or before or after product launch, leading to four intertemporal NPD strategies: closed-closed, closed-open, open-closed, and open-open. Utilizing novel data of product innovation and market performance of 536 digital games, the authors study the effects of intertemporal NPD strategies on new product market performance under moderating effects of technological capability, marketing capability, and project complexity. The results indicate that the early open (open-closed) NPD strategy outperforms the late open (closed-open) strategy. Furthermore, the positive effect of open NPD strategies is stronger when technological capability is high, but weaker when marketing capability is high and when projects are complex. This study contributes to the literature by proposing a typology of NPD strategies that conceptualizes open innovation before and after product launch, and by demonstrating that NPD benefits from early openness, although firms decide to close the NPD project after launch. Managerially, this study offers empirical evidence that open NPD strategies with a consideration of project contingencies are important predictors of new product success.

1. Introduction

Innovative firms often adjust internal new product development (NPD) processes in response to changes in the external environment imposed by new technologies or new customer needs, and to changes in resource availability (Kock & Gemünden, 2016). NPD processes can be purely closed (proprietary and controlled by a firm), purely open (neither proprietary nor controlled by a firm), or partially open (both freedom and restriction) (e.g., Boudreau, 2010). Open innovation strategies in the NPD process can contribute to the differentiation and performance of new products in challenging market environments (Kim & Atuahene-Gima, 2010). From a temporal perspective of the NPD process, open innovation can take place at earlier stages (Thomke & Fujimoto, 2000), at later stages (Fixson & Marion, 2012), or across stages (Grönlund, Sjödin, & Frishammar, 2010). Although collaboration timing is important (Katila & Mang, 2003), research has focused mainly on how firms access external knowledge during the NPD stages before new products launch (e.g., Inauen & Schenker-Wicki, 2011).

Despite the importance of the pre-launch open NPD process, the innovation effort does not end once all pre-launch NPD activities are complete, and often products are improved, updated, revised, or upgraded after a product has been launched. Entrepreneurship researchers suggest that the timing of entrepreneurial learning activities consists of (1) pre-launch learning in the form of technology development prior to entering a market, and (2) post-launch learning in the form of pivots in response to market reactions and customer feedback after entering the market (Cope, 2005; Marvel, Wolfe, Kuratko, & Fisher, 2020). Entrepreneurial orientation, which refers to a firm's attempt to scan and monitor its environment to identify new market opportunities (Covin & Miles, 1999), tends to create a fertile setting for benefiting from open innovation (Cheng & Huizingh, 2014). However, prior NPD studies have examined open innovation approaches either before product launch (Grönlund et al., 2010; Pateli & Lioukas, 2019) or after product launch (Jang & Chung, 2015). Although some studies address the importance of opening up NPD processes during pre- and post-launch stages (Roberts, Palmer, & Hughes, 2022), the question of when to open up NPD processes, as a means to enhance new product performance, has not been answered.

* Corresponding author.
E-mail address: JangS@cardiff.ac.uk (S. Jang).

https://doi.org/10.1016/j.indmarman.2023.05.009
Received 5 July 2022; Received in revised form 21 April 2023; Accepted 13 May 2023
Available online 20 May 2023

To fill these gaps, we propose four types of NPD strategies characterized by open or closed innovation phases before and after product launch (thus, *closed-closed*, *closed-open*, *open-closed*, and *open-open*) and investigate their relationships with the market performance of NPD projects. Specifically, by applying the dynamics of open innovation (Appleyard & Chesbrough, 2017) to the NPD process, we define intertemporal open NPD strategies as the strategic switching from closed (open) to open (closed) or staying open before and after a new product is launched. In addition, as NPD success is driven by strategic and tactical factors (Cooper, 2019), this study examines contingency roles of firm- and project-level characteristics in terms of technological and marketing capabilities (Moorman & Slotegraaf, 1999) and project complexity (Heim, Mallick, & Peng, 2012), in the relationship between intertemporal NPD strategies and market performance. For the empirical research, we obtained actual data of product innovation and market performance of 536 digital games launched by 265 firms. Our results show that the early open (open-closed) NPD strategy outperforms the late open (closed-open) NPD strategy. Furthermore, the positive effect of open (vs. closed) NPD strategies is stronger when technological capability is high, but weaker when marketing capability is high or when projects are complex.

These findings contribute to the literature on open innovation and NPD by understanding how and when project teams benefit from intertemporal open NPD strategies under heterogeneous context of firm- and project-level characteristics. By examining the effectiveness of open innovation approaches both before and after product launch, this study empirically investigates when to open up NPD processes for improving product success, which extends our knowledge in the innovation management (Bahemia, Sillince, & Vanhaverbeke, 2018). Specifically, the present study shows that project teams can benefit more from early collaborations than late collaborations and manage product- or project-level open innovation under different firm and project contingencies. Our study is among the first not only to propose a typology of such intertemporal NPD strategies, but also to demonstrate empirically the effectiveness of intertemporal openness in NPD in the context of the digital service industry.

2. Theoretical background

2.1. Intertemporal NPD strategies

Extant research on intertemporal openness in innovation process has paid much attention to how firms seek external knowledge and technology from users (Chu, Li, & Lin, 2011), universities (Fabrizio, 2009), and licensors (West & Gallagher, 2006) during the pre-launch stage. Some firms open up the innovation process during the post-launch stage by conducting product upgrades with the help of user communities (Jang & Chung, 2015), while other firms utilize user communities to obtain new ideas during the pre-launch stage or to engage with upgrades of the existing products (Miric, Boudreau, & Jeppesen, 2019; Roberts et al., 2022). The pre- and post-launch innovation approach is often used in the entrepreneurship literature (Marvel et al., 2020), which highlights that entrepreneurs invest in exploratory learning before launching a new venture (Cope, 2005) and in learning from market reactions and customer feedback after the launch (Dencker, Gruber, & Shah, 2009). Intertemporal and entrepreneurial processes can create a fertile setting for integrating external knowledge in internal innovation process (Cheng & Huizingh, 2014). Like entrepreneurs, NPD managers invest in external knowledge related to the product under development before and after product launch. Table 1 presents recent research differentiating between open innovation before or after product launch.

Among numerous openness drivers, this study focuses on two types of external knowledge – technical knowledge and market knowledge – in NPD (Cui & Xiao, 2019; Grönlund et al., 2010; Jang & Chung, 2015) in

Table 1
Related literature on drivers and benefits of intertemporal openness in innovation process.

Source	Method	Study area	Pre-launch		Post-launch		Benefits
			Driver(s)	Contributor(s)	Driver(s)	Contributor(s)	
Bahemia et al. (2018)	Single case	Car manufacturing	Design and development	External partners			Profiting from innovation
Chu et al. (2011)	Survey	High-tech firms	Exploratory learning	Users and competitors			NPD performance
Fabrizio (2009)	Panel data	Biotechnology firms	Co-authored publications	University scientists			Search for new inventions
Grönlund et al. (2010)	Interviews	Vetco Gray (GE's oil & gas business)	External technology	External partners			Product innovation, cost reduction
Inauen and Schenker-Wicki (2011)	Survey	Stock-listed firms	Inbound openness	Customers, suppliers, universities			Innovation performance
Jang and Chung (2015)	Transaction data	Digital games			Product upgrades	User community	Market performance
Katila and Mang (2003)	Secondary data	Biopharmaceutical projects	Collaboration experience	External partners			Collaboration timing
Laursen and Salter (2006)	Survey	Manufacturing firms	Search breadth and depth	External partners			Innovation performance
Miric et al. (2019)	Survey	Mobile applications	External innovation ideas	Users	Versioning (rapid innovation)		Appropriability strategies
Pateli and Lioukas (2019)	Survey	Open innovation hubs	External knowledge transfer	Market players, research institutions, intermediaries			Innovation performance
Roberts et al. (2022)	Single case	A global confectionery brand	Idea cocreation for new product concepts and communication	Consumers	Feedback on commercialized products	Website/ forum	Innovating product and innovation process
West and Gallagher (2006)	Cases	Open source software	Technology licensing	Licensors			Innovation strategies
This study	Transaction data	Digital games	Technology licensing	Licensors	Product upgrades	User community	New product market performance

that the external knowledge should be integrated over time through conception, development, and commercialization (Day, 1994; Moorman & Slotegraaf, 1999). At the pre-launch stage, firms may acquire external technologies by forming licensing agreements with other firms or joining NPD projects (Yoo, Boland, Lyytinen, & Majchrzak, 2012). NPD teams attempt to create value by choosing which activities to outsource through license agreements and which to keep in-house (Teece, 2018). At the post-launch stage, interaction mechanisms between firm and market become critical as a source of product innovations (West & Bogers, 2014). For example, NPD teams sometimes modify software code of existing products after commercialization (Helfat & Raubitschek, 2018) because they use customers as a source to gain knowledge for continuous innovation (Cui & Wu, 2017; Zhang & Xiao, 2020). Consequently, NPD teams can strategically open up (close) their innovation process by seeking out external (internal) technical and/or market knowledge across different project stages (Appleyard & Chesbrough, 2017; Markovic, Bagherzadeh, Vanhaverbeke, & Bogers, 2021; Ritala & Stefan, 2021).

2.2. NPD and project contingencies

When NPD project teams engage in open innovation, some projects perform better than others due to contingency factors such as firm capabilities and project characteristics (Bagherzadeh, Markovic, & Bogers, 2021; Du, Leten, & Vanhaverbeke, 2014; Laursen & Salter, 2006). The resource-based view suggests that firm resources and capabilities become critical organizational contingencies for executing innovation (Barney, 1991). That is, complementary assets such as manufacturing, marketing, and sales channels are necessary to commercialize technological innovation (Teece, 1986). Furthermore, when a firm transitions from traditional (closed) to open NPD strategies, the firm needs to sense, seize, and reconfigure complementary resources and relational capabilities – dynamic capabilities – across open NPD strategies so as to capture value through open innovation (Randhawa, Wilden, & Hohberger, 2016). Research on open innovation has emphasized the importance of organizational context on the open innovation-performance relationship (Lichtenthaler, 2011). In addition, NPD projects tend to vary in their performance from open innovation within the same firm (Salge, Farchi, Barrett, Michael, & Dopson, 2013), which calls for incorporating the project-related contingencies when measuring the performance of open innovation.

From the firm-level perspective, successful commercialization of innovation and appropriation of its returns require manufacturing, marketing, and a variety of other complementary resources (Cohen, Nelson, & Walsh, 2000). While many firm capabilities (i.e., capacities to deploy resources, usually in combination, to effect a desired end, see Amit & Schoemaker, 1993) support innovation, technology and marketing are considered directly critical to its success (Danneels, 2002; Moorman & Slotegraaf, 1999). Technological capability refers to a firm's technological ability to develop new products and related processes, such as technical proficiency, R&D, and technical resources and skills as important to NPD (Teece, Pisano, & Shuen, 1997). In addition, marketing capability refers to a firm's ability to develop and maintain customer relationships through marketing activities, such as advertising or marketing research expenditures (Dutta, Narasimhan, & Rajiv, 1999). Hence, firm capabilities are often cospecialized to the innovation, which suggests that a bilateral dependence between the innovation and the firm capabilities (Teece, 1986).

From the perspective of project-level contingency, research emphasizes the importance of considering project attributes, particularly project complexity, when managing open innovation (Gurca, Bagherzadeh, Markovic, & Koporcic, 2021). Project complexity is regarded as the most important attribute for innovation projects (Almirall & Casadesus-Masanell, 2010; Bagherzadeh, Markovic and Bogers, 2021; Lee, Fong, Barney, & Hawk, 2019). Project complexity refers to the difficulties encountered during the NPD process caused by complexities of product, process, technology, and user interfaces (Novak & Eppinger, 2001). Researchers also suggest that project complexity influences the use of NPD practices and software tools (Heim et al., 2012). Open innovation projects are often confronted with high complexity (Felin & Zenger, 2014). When designing highly complex new products or services, project teams need to integrate a greater number of distinct knowledge sources (Laursen & Salter, 2006).

3. Research model

Conceptualizing closed and open innovation strategies in the pre- and post-launch phase of the NPD process, we propose a model of four intertemporal NPD strategies based on the type of innovation (closed vs. open) and the timing of product development (pre-launch vs. post-launch) (Fig. 1). Specifically, some NPD projects may develop new products by exploiting their accumulated internal knowledge over time (fully closed: *closed-closed*), whereas other project teams can open up the NPD process after launching internally developed products (late open: *closed-open*). For example, some mobile app developers modify internally-developed app software after product launch (Miric et al., 2019) by utilizing external information from users and competitors (Jang & Chung, 2015). In addition, projects may seek out external knowledge during the conception and development stage without further modifying their products to serve new customers' needs after product launch (early open: *open-closed*), or open up the NPD process by exploring new technology opportunities and market feedback before and after product launch (fully open: *open-open*). For instance, a project can utilize a user community because feedback from these users can be used in conjunction with the firm's internal expertise to modify or upgrade the existing product after the product is launched (Dahlander & Wallin, 2006). As such, firms can strategically close innovation processes before and after product launch (*closed-closed*) or open up innovation processes early (*open-closed*), late (*closed-open*), or fully (*open-open*). Our conceptualization focuses on how the intertemporal innovation process leads to closed (i.e., private) outcomes rather than how it leads to open (i.e., public) outcomes (Huizingh, 2011).

Furthermore, our research model incorporates the contingency roles of both firm- and project-level characteristics when investigating the effects of intertemporal NPD strategies on market performance. As discussed in Section 2.2, we argue that firm and project characteristics form an essential part of the organizational and project context in which NPD projects with intertemporal openness are performed, which may influence their moderation ability. As a result, this paper examines how three contingency factors – technological capability, marketing capability, and project complexity – moderate the relationship between intertemporal NPD strategies and market performance. The research model is shown in Fig. 2.

4. Hypotheses

4.1. Intertemporal NPD strategies and market performance

The nature of intertemporal NPD strategies is that firms can choose to pursue closed and open innovation approaches within the same project, even in radical innovation projects (Bahemia et al., 2018). For example, the early collaboration (open-closed) strategy allows firms to acquire advanced intellectual property (IP) and technology available in the open market (Fabrizio, 2009). Such an approach reduces innovation resources in internal R&D but focuses more on external technology and knowledge, which can compensate for weaknesses in internal R&D. Conversely, firms adopting late collaboration (closed-open) strategies tend to focus on launching internally developed products as quickly as possible, upgrading them later by bringing in customer feedback (Jang & Chung, 2015). When firms adopt open-open strategies, they collaborate with external partners for accessing technological knowledge before product launch and with customers and their feedback for upgrading

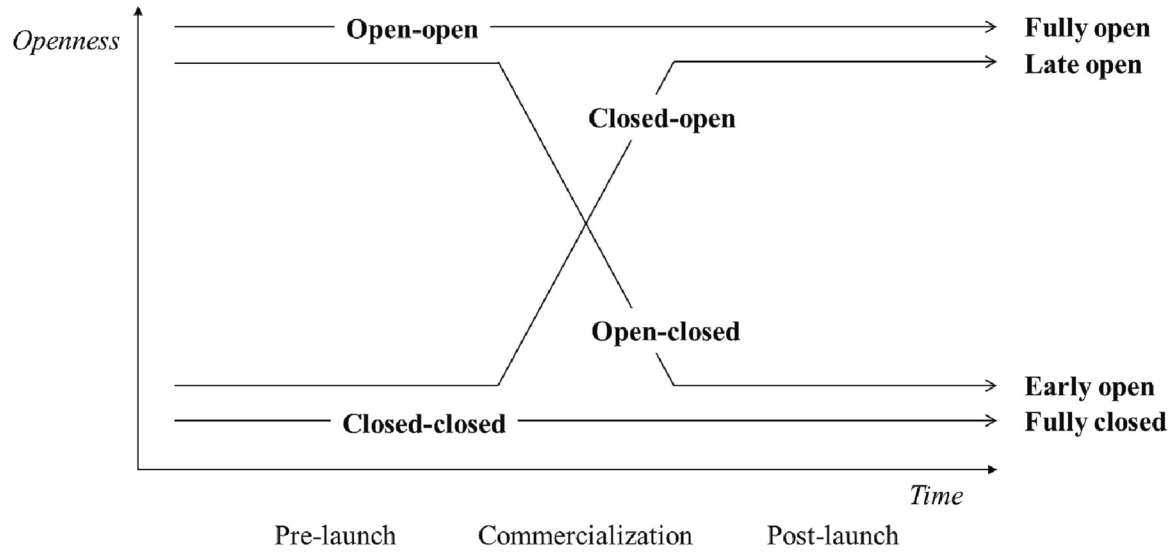

Fig. 1. Four types of intertemporal NPD strategy.

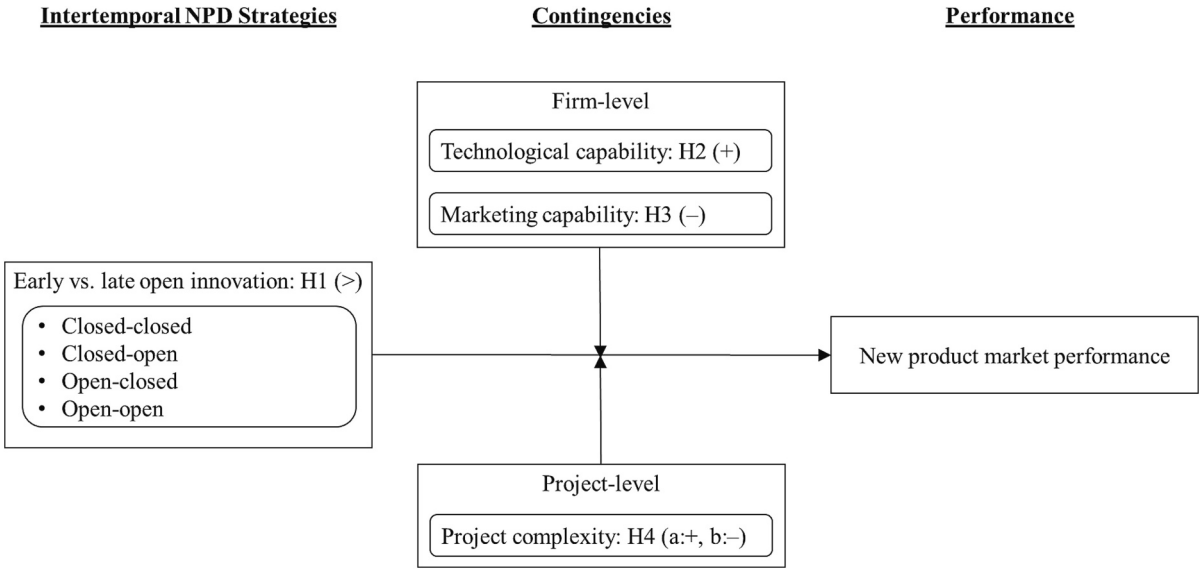

Fig. 2. The research model.

their existing products after launch (Helfat & Raubitschek, 2018; Miric et al., 2019).

The question is whether it is more fruitful to open the innovation process early and then close it, or only open it late in the post-launch stage. Although significant innovations are possible during post-launch stages (Roberts et al., 2022), the closed-open NPD strategy is characterized by postponing design decisions until late in the NPD process (Fixson & Marion, 2012). While this postponement offers the advantage of retaining planning flexibility when customer needs are still evolving, it also incurs significant development costs through rework and revision after product launch. An early (pre-launch) openness can help fuzzy front-end decision-makers to integrate changes in market requirements and technology capabilities and reconsider and refine previously made creative product concepts during the project (Schröder & Jetter, 2003; Seidel, 2007). For example, technology in-licensing can help firms to minimize their innovation costs, share uncertainty and risk in their NPD processes, and reach the market faster (Tether, 2002). Hence, firms that reduce uncertainties and involve suppliers in the early stages of NPD are more successful in product innovation (Verworn, Herstatt, & Nagahira, 2008), as well as development effectiveness and efficiency (Johnsen, 2009). In general, firms with faster product development cycle times are more successful than their competitors (Markham & Lee, 2013). Thus, externally sourced innovation such as in-licensing seems to lead to accelerated NPD cycle times which in turn is associated with increased profitability (Eling & Herstatt, 2017). Hence, we propose the following hypothesis:

H1. Early open (open-closed) NPD strategies exhibit higher market performance of new products than late open (closed-open) strategies.

4.2. The moderating role of project contingencies

4.2.1. Technological capability

Firms with greater technological orientation tend to use sophisticated technologies in NPD, integrate new technologies rapidly, and develop new technologies and create new product ideas proactively (Gatignon & Xuereb, 1997). Ongoing investments in product-related technological capabilities enable firms to value, assimilate, and exploit new NPD-related knowledge (Cohen & Levinthal, 1989). Technological

capability is especially pertinent to NPD projects because multiple new technologies or different versions of the same underlying technology are often prevalent in the dynamic market environments.

Firms with open NPD strategies are likely to apply external knowledge – whether technical knowledge or market knowledge (Cui & Xiao, 2019) – into the ongoing NPD processes if they have the technological capabilities. When firms open up the NPD process early (open-closed), firms with a higher level of technological capabilities can become more skilled at engaging in exploratory learning for identifying and acquiring external new knowledge (Renko, Carsrud, & Brännback, 2009) before the product is commercialized. Furthermore, when firms open up the NPD process late (closed-open), firms can leverage their strong technological capabilities when upgrading their existing products. When firms engage in the full open innovation before and after product launch (open-open), firms may be able to benefit from both their technological capabilities and continuous explorations of technology- and market-oriented knowledge throughout the development process. Consequently, we argue that if technological capability is high due to rich technical resources, the positive effect of open NPD strategies increases (Calantone & di Benedetto, 1998), leading to better product market performance. Hence, the following hypothesis is presented:

H2. Technological capability has a stronger positive effect on new product market performance with early and/or late open (closed-open, open-closed, or open-open) NPD strategies than the fully closed (closed-closed) NPD strategy.

4.2.2. Marketing capability

Besides technological capability, a firm's marketing capability (e.g., market information management) can moderate the effect of open innovation practice on new product innovativeness (Rubera, Chandrasekaran, & Ordanini, 2016). Marketing capability refers to a firm's ability to generate and disseminate information and respond effectively to current and potential customer needs (Vorhies, Morgan, & Autry, 2009). A firm's market orientation – such as the ability to use market intelligence about exogenous market factors that influence current and future customer needs – positively influences business performance (Jaworski & Kohli, 1993). Especially in high-technology markets, firm must absorb new external knowledge to complement, extend and replace internally existing knowledge (Eisenhardt & Martin, 2000). Hence, marketing capability is associated with achieving competitive advantage (Chu et al., 2011).

Although firms with superior marketing capabilities can improve their open innovation capability in NPD by acquiring external knowledge (Feng, Morgan, & Rego, 2017; Lee & Yoo, 2019), a high level of marketing capabilities may inhibit firms from identifying novel, external knowledge (Yang, Li, Jiang, & Zhao, 2020). NPD teams may leverage strong marketing capability by efficiently integrating external market knowledge into their existing knowledge bases for product innovation (Kyriakopoulos, Hughes, & Hughes, 2016). However, as marketing capabilities reflect a firm's ability to disseminate information and respond effectively to current and potential customer needs (Dutta et al., 1999; Vorhies et al., 2009), these capabilities enable firms to keep close relationships with external stakeholders such as customers, channels, and suppliers through pricing, advertising, personal sales, and communication (Narasimhan, Dutta, & Rajiv, 2006). Hence, firms with superior marketing capabilities tend to focus on existing routines and similar knowledge to refine managerial practices (Kyriakopoulos et al., 2016), and may find it more difficult to acquire novel and multifarious knowledge related with open innovation processes at early (pre-launch) and late (post-launch) stages. Based on these arguments, we present the following hypothesis:

H3. Marketing capability has a stronger negative effect on new product market performance when coupled with partially open (closed-open, open-closed) or fully open (open-open) NPD strategies than with a fully closed (closed-closed) NPD strategy.

4.2.3. Project complexity

The complexity of an NPD project – the extent to which a project consists of a complex set of activities and participants – affects the ability and willingness to innovate (Olson, Walker, Ruekert, & Bonner, 2001). Firms that engage in less complex projects can benefit from opening up the product innovation process to external partners (Almirall & Casadesus-Masanell, 2010). Through open NPD strategies, project teams discover new product features, technologies, and market opportunities that would be difficult to acquire through closed innovation (Almirall & Casadesus-Masanell, 2010). However, when project complexity is high (e.g., complex product design), closed innovation practices (e.g., internal development) are likely to be more attractive due to the reduction in transaction costs, e.g., costs to manage technical and managerial interfaces, or coordination cost to design and execute production (Almirall & Casadesus-Masanell, 2010; Novak & Eppinger, 2001). Knudsen and Mortensen (2011) showed that, on average, firms employing single-firm innovation strategies outperformed their more open counterparts with regard to innovation performance because higher openness leads to slower time to market, slower development, and higher development costs.

When firms manage complex innovation projects, opening up the innovation process not only enables firms to access relevant external resources, share risks, and improve time-to-market (Du et al., 2014) but also increases challenges with regard to knowledge sharing and system integration (Felin & Zenger, 2014). From a positive perspective, some firms engage purposefully in collaborative efforts with different business partners at various stages of their complex projects (Markovic & Bagherzadeh, 2018). Successful complex projects with open innovation processes include electric vehicles (Gurca & Ravishankar, 2016) and commercial aircraft (Tang, Zimmerman, & Nelson, 2009). Project complexity entails that more diverse competencies are needed to fulfil the project, which in turn increases the need of involving new business partners to fill the gap in one's R&D internal competencies. When firms open up complex projects early (open-closed), they can acquire external knowledge, share knowledge, and integrate systems within loosely coupled networks of business partners during the project (Pil & Cohen, 2006). When firms open up complex projects late (closed-open), they can incorporate sophisticated consumer needs into the existing products to offer more complex products with integrated architectures (Fujimoto, 2007). Hence, the following hypothesis is presented:

H4a. Project complexity has a stronger positive effect on new product market performance with open, intertemporally (closed-open, open-closed) or fully (open-open), NPD strategies than the fully closed (closed-closed) NPD strategy.

From a negative perspective, when complex NPD projects are sourced outside of organizational boundaries, project teams and project management experience complications associated with the transaction and agency costs from outsourcing and offshoring (e.g., finding a trustworthy vendor, negotiating and enforcing the contract, project alignment, etc.) (Thakur-Wernz, Bruyaka, & Contractor, 2020). Relying on open innovation processes for developing complex products may pose challenges for knowledge sharing and system integration, which can hinder the successful completion of the complex NPD projects. Rather, complex NPD projects often require a centralized decision-making authority that coordinates knowledge sharing and task completion among development contributors within the same project (Boudreau, 2010; Gassmann & von Zedtwitz, 2003) before and after product launch. To optimize for profits, firms can concentrate complex projects in-house or within firm boundaries over time (closed-closed), while outsourcing simpler projects through intertemporal openness (open-closed, closed-open, or open-open) (Thakur-Wernz et al., 2020). Hence, the following hypothesis is presented:

H4b. Project complexity has a stronger negative effect on new product market performance with the intertemporally open (closed-open, open-

closed, or open-open) NPD strategy than the fully closed (closed-closed) NPD strategy.

5. Method

5.1. Empirical setting

To examine our hypotheses, we use empirical data of digital game-related NPD projects listed on a leading mobile app store in South Korea, with 49 million users and $500 million gross merchandise volume. The category of digital games, as the largest revenue generator, was selected as the focus of this study due to the presence of closed and open innovation activities during pre- and post-launch stages. During the pre-launch stage, digital game firms develop new products internally by exploiting internal resources (i.e., closed innovation) or externally by in-licensing IP from other developers (i.e., open innovation). That is, digital game developers must decide whether to self-publish (e.g., creative freedom but limited resources) or use a publishing or licensee developer (e.g., rich resources but limited autonomy) to launch a competitive game product (Impey, 2019). Licensee developers provide additional support services to finish game development, and more direct and faster market access with better demand anticipation (Nucciarelli et al., 2017). In the digital game industry, licensee developers need to identify external innovations and combine the licensed IP with its internal resources to develop a competitive game; this practice belongs to pre-launch open innovation (Verworn et al., 2008; West & Gallagher, 2006).

After digital games are launched in mobile app markets (e.g., Apple App Store and Google Play Store), game users often provide feedback in online user communities, and some developers respond to user feedback (e.g., firm-generated postings and emails) and utilize the user-generated feedback for continuous product development (i.e., product upgrades) (Chu et al., 2011; Jang & Chung, 2015). User feedback from the digital game community can be used in conjunction with a firm's internal expertise to modify or upgrade the existing product after the product is launched (Dahlander & Wallin, 2006). Therefore, customer feedback-driven product upgrades during the post-launch stage constitute an open innovation practice because customer feedback enables knowledge sources more efficiently into the product innovation process (Roberts et al., 2022).

5.2. Data collection

To test our hypotheses, we collected secondary data related to product innovation, firm and project characteristics, and market performance of digital games that were launched in the mobile app store from June 2016 to April 2017 (11 months). Although a case study approach provides researchers with rich and detailed insights about the microfoundations underpinning intertemporal NPD strategies and market performance in a particular project, the case-based approach cannot unpack the effectiveness of four types of intertemporal NPD strategies under heterogenous contexts, such as different firm and project characteristics. Hence, we selected a quantitative study involving a large number of observations which enabled us to quantify the relative importance of intertemporal NPD strategies and estimate more complex models including three moderators and controls to formally test for contingency effects (Huizingh, 2011). The following three steps were taken for producing the final dataset.

First, the product-level transaction data generated by over 200,000 monthly active users from June 2016 to July 2017 (14 months) were extracted. Three additional months (May–July) were considered to observe minimum 3-month transactions of digital games that were launched in April 2017. The initial data included 1491 digital games that were produced by 1047 developers. Digital games in the store were launched by three types of developers: (1) 591 unregistered developers with 591 games – these developers were anonymous individuals who simply launched trial products, (2) 191 registered developers that launched 364 purely free games without in-app purchase or freemium functionality, and (3) 265 registered developers (individuals or firms) that launched 536 paid or freemium games and had financial settlement agreements with the store. Due to the absence of transaction records, NPD projects of the (1) unregistered and (2) free-only game developers were excluded from the final sample.

Second, to find out the type of pre-launch NPD strategy for digital games, seven account managers of the mobile app store coded each project into (1) internal development and (2) licensed IP-based development. Each manager checked the recorded information about the existence of NPD collaborations, which were obtained through multiple meetings before and after product launch. For those games with no records, each manager checked the existence of IP licensing in each digital game; when IP licensing existed during the NPD process, the first two screens reveal two logos of IP licensor (i.e., original developer) and licensee (i.e., publisher). To code the type of post-launch NPD strategy, the store database was reviewed for product upgrades after product launch, as developers upload the new version of a game with the brief description about upgrades to the store platform. Finally, by reviewing pre- and post-launch NPD activities for each project, we uniquely classified each project into one of four intertemporal NPD strategies.

Finally, detailed data of monthly transaction and product characteristics of digital games and available developer characteristics were extracted from the store database and developer portal. Specifically, each game's market performance includes free downloads (base game) and paid downloads (add-on products). Each game also had overall records of developer-generated postings, promotional expenditure, and product genre. In addition, we collected developer characteristics such as number of products launched in the market. For reasons of confidentiality, the actual names of a digital game and its developer were anonymized. The final sample consisted of intertemporal NPD strategies, firm- and project-level characteristics, and market performance of 536 digital games launched by 265 developers over a period of 14 months. The detailed operationalization of variables is explained in the next section.

5.3. Operationalization of variables

5.3.1. Dependent variables

Two indicators for market performance of each NPD project were used as the dependent variable (Table 2). Sales-driven market performance is a highly relevant measure of the focal NPD project's performance derived from pre- and post-launch product innovation activities (Jang & Chung, 2015; Mallick, Ritzman, & Sinha, 2013). Specifically, market performance was measured by (1) the average monthly downloads of a specific base game (volume) and (2) the average monthly dollar amount of actual billings for add-on product consumption (valence) during the observation period (Jang & Chung, 2015; Tang, Fisher, & Qualls, 2021).

5.3.2. Independent variables

H1 deals with the effects of intertemporal NPD strategies across pre- and post-launch stages on market performance. The type of NPD strategy used in each project before and after product launch was coded as a binary variable that takes the value of 1 if the project adopted one of four intertemporal NPD strategies, and 0 otherwise. Prior literature has used binary scales for technology licensing (Lee, Park, & Bae, 2017; Leone & Reichstein, 2012) and product upgrade (Jang & Chung, 2015; Kübler, Pauwels, Yildirim, & Fandrich, 2018). Hence, the four intertemporal NPD strategies consist of closed-closed (pre-launch internal development without post-launch user feedback-driven product upgrades), closed-open (internal development with product upgrades), open-closed (external licensed IP-based development without product upgrades), and open-open (licensed IP-based development with product upgrades). We validated that product upgrades of digital games in our sample

Table 2
Operationalization and sources of variables.

Variables	Operationalization	Sources
Volume	The average number of downloads of a digital game per month	Store database
Valence	The average dollar amount from the sale of add-on products per month	
Closed-closed	A binary variable; equals 1 if a game is developed internally without product upgrades, 0 otherwise	Product inspection
Closed-open	A binary variable; equals 1 if a game is developed internally with product upgrades, 0 otherwise	
Open-closed	A binary variable; equals 1 if a game is developed externally without product upgrades, 0 otherwise	
Open-open	A binary variable; equals 1 if a game is developed externally with product upgrades, 0 otherwise	
Technological capability	The number of game(s) introduced in the market during the observation period	Store database
Marketing capability	The number of firm-generated online postings during the observation period	
Project complexity	A binary variable; equals 1 if the game genre belongs to role playing, 0 otherwise	
Genre_Action	A binary variable; equals 1 if the game genre belongs to action, 0 otherwise	
Genre_Arcade	A binary variable; equals 1 if the game genre belongs to arcade, 0 otherwise	
Genre_Puzzle	A binary variable; equals 1 if the game genre belongs to puzzle, 0 otherwise	
Genre_Sports	A binary variable; equals 1 if the game genre belongs to sports, 0 otherwise	
Genre_Simulation	A binary variable; equals 1 if the game genre belongs to simulation, 0 otherwise	
Genre_Shooting	A binary variable; equals 1 if the game genre belongs to shooting, 0 otherwise	
Genre_Others	A binary variable; equals 1 if the game genre belongs to others, 0 otherwise	
Promotion expenditure	The dollar amount spent for monetary promotions per user during the observation period	
Age restriction	A binary variable; equals 1 if a game has age restrictions, 0 otherwise	

belong to post-launch open innovation because they were driven by cumulative level of online feedback from user community since they were launched in the focal store (Appendix A).

Measurements of technological capability, marketing capability, and project complexity were used as moderators in testing H2, H3, and H4. First, technological capability, defined as a firm's ability to develop new products and processes, was measured by recording the number of new products introduced in the market during the observation period. As mobile app firms rely heavily on early entry and rapid innovation as major appropriability strategies (Miric et al., 2019), our output-oriented technological capability indicator can overcome limitations of purely input-oriented measures such as R&D expenditure (Coombs & Bierly, 2006; Dutta et al., 1999).

Second, marketing capability, conceptualized as a firm's ability to manage customer relationship through firm-customer interactive communication, was measured as the cumulative number of firm-generated postings toward the focal product (Jang & Chung, 2015; Lee & O'Connor, 2003). The firm-customer interactions and communications offer rich insights into the trajectory of market trends and foster the firm's sense-making about customer requirements and market conditions (Day, 2011).

Finally, project complexity, conceptualized as difficulties and uncertainties encountered during the management of interfaces and product features during NPD, was measured by a binary variable: 1 if the focal digital game belongs to multiplayer role-playing game (RPG) and 0 otherwise. Compared to non-RPGs such as action and arcade games, multiplayer RPGs are advanced games that offer a persistent 3D virtual world to support hundreds or thousands of geographically distributed players for their simultaneous game play (Lo & Wen, 2010; Zhong, 2011). Prior research indicates that main elements of complexity in NPD are the number of product components in a new product, the extent of interactions to be managed between these components, the degree of product novelty, and the difficulty in interpreting users' requirements (Novak & Eppinger, 2001). To bring mass RPG players into a single game play, RPG developers need to deal with relatively complex product designs and game-play interactions (Rezaei & Ghodsi, 2014). Empirically, we assessed how the dummy variable of RPG (vs. non-RPG) can become a good moderator for the relationship between open NPD strategies and new product market performance (Appendix B).

5.3.3. Control variables

As product and marketing characteristics influence digital game performance (Park & Kim, 2013), we controlled for three factors related to product type, promotion expenditure, and age restriction. These factors represent specification and selection of the product (digital game), the awareness level, and the target market, which may secure the fit between product and target customer. First, product type was measured as the specific genre of a digital game that includes action, arcade, puzzle, sports, simulation, shooting, and others. We used simulation as the baseline and represented the other six genres by six dummy variables (Jang & Chung, 2021). Promotional expenditure, which can enhance the perceived value of a firms' new products in the minds of current and potential customers, was measured as the dollar amount spent for coupon and discount promotions per user of the focal game (Dutta et al., 1999). Finally, as age influences digital game adoption (Ha, Yoon, & Choi, 2007), age restriction was measured by a binary variable: 1 if the focal digital game has age restriction (age 12+, age 15+, adult only) and 0 otherwise (all ages).

6. Results

Table 3 shows correlations and descriptive statistics of all variables used in the analysis. We identified that the final sample of digital game development projects consists of the four proposed NPD strategies: closed-closed (43%), closed-open (36%), open-closed (9%), and open-open (12%). That is, more than half (57%) of the surveyed projects employed some form of openness in their NPD process; 21% engaged with pre-launch openness (technology licensing) and 48% engaged with post-launch openness (user feedback-driven product upgrades), which is in line with prior research showing 43% of app developers perform product upgrades of existing apps (Miric et al., 2019). On average, digital game firms developed 4.29 new games, generated 35.94 online postings per game, and spent 20.181 dollars per user for promotional expenditure during the observation period. 41% of digital games belonged to complex projects which developed and operated multiplayer RPGs. 51% of digital games in the sample had age restrictions. The four alternatives of intertemporal NPD strategies are exemplified in Appendix C.

We detected the potential presence of multicollinearity by calculating the variance inflation factor (VIF), which ranged from 1.031 to 1.535 (Models 1 and 2 measuring direct effects only) and from 1.045 to 6.375 (Models 3 and 4 measuring both direct and interaction effects). These results indicate that multicollinearity was not a serious problem in the final model. In addition, we found that Durbin Watson statistics were between 1.60 and 1.62, meaning that the values of residuals were independent. Hence, multiple regression analysis was performed using different sets of dependent and independent variables.

The regression analysis tested six models using two dependent variables with monthly average values in terms of sales volume and valence (Table 4). Models 1 and 2 measure direct effects of intertemporal NPD strategies, organizational and project characteristics, and the control variables on volume and valence performance. The results reveal that the early open NPD strategy exhibits higher market performance, i.e.,

Table 3
Correlations and descriptive statistics.

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) LnVolume	1																	
(2) LnValence	0.834*	1																
(3) Closed-closed	−0.415*	−0.348*	1															
(4) Closed-open	0.062	−0.034	−0.645*	1														
(5) Open-closed	0.257*	0.276*	−0.273*	−0.238*	1													
(6) Open-open	0.309*	0.332*	−0.322*	−0.281*	−0.119*	1												
(7) Technological capability	−0.470*	−0.409*	0.340*	−0.293*	−0.056	−0.035	1											
(8) Marketing capability	0.261*	0.230*	−0.063	−0.062	0.065	0.129*	−0.058	1										
(9) Project complexity	0.393*	0.451*	−0.248*	0.008	0.154*	0.227*	−0.235*	0.029	1									
(10) Genre_Action	−0.078	−0.115*	0.000	−0.013	0.016	0.004	0.114*	0.053	−0.261*	1								
(11) Genre_Arcade	−0.241*	−0.289*	0.120*	0.018	−0.101*	−0.119*	0.126*	−0.063	−0.267*	−0.098*	1							
(12) Genre_Puzzle	−0.193*	−0.234*	0.154*	−0.017	−0.078	−0.139*	0.117*	0.018	−0.312*	−0.115*	−0.118*	1						
(13) Genre_Sports	−0.113*	−0.091*	0.035	0.016	0.013	−0.088*	0.031	−0.036	−0.197*	−0.073	−0.074	−0.087*	1					
(14) Genre_Simulation	0.020	0.058	0.067	−0.027	−0.034	−0.032	−0.036	−0.006	−0.400*	−0.148*	−0.151*	−0.177*	−0.112*	1				
(15) Genre_Shooting	0.005	−0.080	−0.063	0.040	−0.044	0.074	−0.03	−0.021	−0.116*	−0.043	−0.044	−0.051	−0.032	−0.066	1			
(16) Genre_Others	−0.132*	−0.126*	0.071	0.005	−0.056	−0.066	0.118*	−0.023	−0.147*	−0.054	−0.056	−0.065	−0.041	−0.083	−0.024	1		
(17) Promotion expenditure	0.219*	0.279*	0.005	−0.080	0.052	0.065	−0.061	0.071	0.107*	−0.011	−0.046	−0.044	−0.012	−0.033	−0.020	−0.024	1	
(18) Age restriction	0.262*	0.336*	−0.144*	−0.026	0.117*	0.152*	−0.085*	0.065	0.227*	0.027	−0.310*	−0.047	−0.206*	0.111*	−0.058	−0.025	0.090*	1
Mean	7.548	14.952	0.430	0.360	0.090	0.120	4.290	35.940	0.410	0.090	0.090	0.120	0.050	0.180	0.020	0.030	20.181	0.510
Standard Deviation	2.974	3.568	0.495	0.480	0.288	0.329	4.027	155.70	0.493	0.283	0.288	0.327	0.223	0.388	0.135	0.170	135.767	0.500

* $p < 0.05$.

open-closed (Model 1: 2.453 with lower bound [1.761] and upper bound [3.145]; Model 2: 2.691 [1.894, 3.488]) and open-open (Model 1: 2.380 [1.747, 3.012]; Model 2: 2.667 [1.939, 3.396]), than the late open NPD strategy, i.e., closed-open (Model 1: 0.756 [0.313, 1.198]; Model 2: not significant). Because confidence intervals of coefficients between early open (open-closed and open-open) and late open (closed-open) NPD strategies do not overlap, the difference between two groups of coefficients is statistically significant. These results imply that NPD projects with early open innovation strategies (i.e., open-closed and open-open) outperform those with the late open (i.e., closed-open) strategy. These results support H1.

When moderating effects were incorporated in the model (Table 5), the results show a significant and positive moderating effect of technological capability on the relationship between open NPD strategies and market performance. Specifically, Model 3 reveals that technological capability has positive moderating effects on volume performance with open NPD strategies: open-closed (0.221), closed-open (0.300), or open-open (0.211). Interestingly, Model 4 reports that technological capability significantly accelerates the positive effect of late open (closed-open) strategy on valence performance (0.185), but not of the early (open-closed) or fully (open-open) open strategies. These results support H2.

Concerning the moderating role of marketing capability in the intertemporal NPD strategy-performance link, our results indicate that it has a negative moderating effect on the relationship between open NPD strategies and market performance: (1) fully open strategy and volume performance (Model 3: −0.002), (2) early open strategy and valence performance (Model 4: −0.005), and (3) fully open strategy and valence performance (Model 4: −0.003). These results support H3.

Finally, our results show that project complexity negatively moderates the relationship between open NPD strategies and market performance. Although project complexity has a direct, positive effect on market performance (Model 3: 1.147; Model 4: 1.650), it attenuates the positive effects of late open or fully open NPD strategy on volume performance (Model 3: −2.172 and − 1.560, respectively) and early open, late open, or fully open NPD strategies on valence performance (Model 4: −1.176, −3.060, and − 1.936, respectively). Hence, these results support H4b, not H4a.

The robustness of the analysis was checked by splitting the total sample into two sub-samples: sample 1 consisting of 268 observations of the earlier six months (June 1–November 10, 2016) and sample 2 consisting of 268 observations of the later six months (November 14, 2016-April 28, 2017). This analysis provides NPD project teams with information about whether the effectiveness of intertemporal NPD strategies vary across entry timing (early vs. later). Table 6 reports that early open or fully open NPD strategies have positive effects on volume performance (Model 5: 2.873 and 1.982, respectively) and valence performance (Model 5: 2.594 and 3.559, respectively). However, late open NPD strategy has no relationship with volume and valence performance. These results represent that the early open strategy outperforms the late open strategy across different periods, in support of H1.

Regarding the contingency effects, the analysis shows mixed results across different organizational and project characteristics. In the earlier period (sample 1), technological capability accelerates the positive effect of late open (0.496) or fully open (0.346) strategies on the volume performance (Model 5) and the positive effect of late open strategy (0.344) on the valence performance (Model 6), which are in support of H2. In addition, marketing capability has no moderation effects, not supporting H3, and project complexity only attenuates the positive effect of fully open strategy on the volume performance (−1.669), supporting H4b. In the later period (sample 2), technological capability attenuates the positive effect of early open strategy on the volume performance (Model 7: −1.945), and marketing capability had no moderation effects, which do not support H2 and H3. Interestingly, project complexity only accelerates the positive effect of fully open strategy on the volume performance (Model 7: 0.355), supporting H4a. The results

Table 4
The results of regression models measuring direct effects.

	Model 1 (DV: Volume)					Model 2 (DV: Valence)					VIF
	B	SE	Sig.	Lower bound	Upper bound	B	SE	Sig.	Lower bound	Upper bound	
Intercept	7.551	0.296	0.000	6.969	8.133	15.006	0.341	0.000	14.336	15.676	
Closed-open	0.756	0.225	0.001	0.313	1.198	0.296	0.259	0.255	−0.214	0.805	1.374
Open-closed	2.453	0.352	0.000	1.761	3.145	2.691	0.406	0.000	1.894	3.488	1.212
Open-open	2.380	0.322	0.000	1.747	3.012	2.667	0.371	0.000	1.939	3.396	1.316
Technological capability	−0.240	0.025	0.000	−0.291	−0.19	−0.234	0.029	0.000	−0.291	−0.176	1.237
Marketing capability	0.003	0.001	0.000	0.002	0.005	0.003	0.001	0.000	0.002	0.005	1.039
Project complexity	0.484	0.264	0.067	−0.034	1.003	0.615	0.304	0.044	0.017	1.212	1.989
Genre_Action	−0.685	0.382	0.074	−1.437	0.066	−1.556	0.441	0.000	−2.422	−0.690	1.376
Genre_Arcade	−1.172	0.396	0.003	−1.951	−0.393	−2.077	0.457	0.000	−2.974	−1.180	1.535
Genre_Puzzle	−0.891	0.347	0.010	−1.572	−0.21	−1.763	0.399	0.000	−2.547	−0.978	1.505
Genre_Sports	−0.947	0.472	0.045	−1.875	−0.02	−0.881	0.544	0.106	−1.950	0.187	1.299
Genre_Shooting	−0.336	0.717	0.639	−1.744	1.072	−2.588	0.825	0.002	−4.209	−0.967	1.105
Genre_Others	−1.091	0.583	0.062	−2.235	0.054	−1.551	0.671	0.021	−2.869	−0.233	1.156
Promotion expenditure	0.003	0.001	0.000	0.002	0.004	0.939	0.236	0.000	0.475	1.403	1.236
Age restriction	0.427	0.205	0.038	0.024	0.830	0.005	0.001	0.000	0.003	0.006	1.031
Number of observations	536					536					
Adjusted R^2	0.485					0.525					

Notes: Closed-closed and Genre_simulation variables are used as reference variables.

Table 5
The results of regression models including both direct and interaction effects.

	Model 3 (DV: Volume)					Model 4 (DV: Valence)					VIF
	B	SE	Sig.	Lower bound	Upper bound	B	SE	Sig.	Lower bound	Upper bound	
Intercept	7.541	0.325	0.000	6.903	8.178	14.699	0.374	0.000	13.964	15.433	
Closed-open	0.149	0.386	0.700	−0.610	0.908	0.025	0.445	0.955	−0.849	0.899	4.232
Open-closed	2.623	0.785	0.001	1.080	4.166	5.053	0.904	0.000	3.276	6.829	6.309
Open-open	2.518	0.692	0.000	1.157	3.878	3.497	0.797	0.000	1.931	5.064	6.375
Technological capability	−0.280	0.029	0.000	−0.337	−0.222	−0.243	0.034	0.000	−0.309	−0.177	1.690
Marketing capability	0.004	0.001	0.000	0.002	0.006	0.004	0.001	0.000	0.002	0.006	2.004
Project complexity	1.147	0.368	0.002	0.424	1.871	1.650	0.424	0.000	0.817	2.483	4.049
Closed-open × Technological capability	0.221	0.069	0.001	0.086	0.356	0.185	0.079	0.020	0.029	0.340	2.350
Open-closed × Technological capability	0.300	0.170	0.078	−0.034	0.635	−0.129	0.196	0.510	−0.515	0.256	4.881
Open-open × Technological capability	0.211	0.114	0.066	−0.014	0.435	0.073	0.132	0.580	−0.186	0.331	3.761
Closed-open × Marketing capability	0.003	0.002	0.167	−0.001	0.008	0.004	0.003	0.174	−0.002	0.009	1.261
Open-closed × Marketing capability	−0.003	0.002	0.231	−0.007	0.002	−0.005	0.002	0.046	−0.010	0.000	1.406
Open-open × Marketing capability	−0.002	0.001	0.064	−0.005	0.000	−0.003	0.002	0.087	−0.006	0.000	1.863
Closed-open × Project complexity	−0.674	0.456	0.140	−1.568	0.221	−1.176	0.525	0.025	−2.206	−0.145	3.278
Open-closed × Project complexity	−2.172	0.731	0.003	−3.608	−0.736	−3.060	0.842	0.000	−4.713	−1.406	3.692
Open-open × Project complexity	−1.560	0.684	0.023	−2.904	−0.215	−1.936	0.788	0.014	−3.484	−0.388	4.612
Genre_Action	−0.612	0.378	0.106	−1.354	0.130	−1.603	0.435	0.000	−2.458	−0.748	1.406
Genre_Arcade	−1.144	0.394	0.004	−1.918	−0.370	−1.992	0.454	0.000	−2.883	−1.100	1.588
Genre_Puzzle	−0.827	0.343	0.016	−1.501	−0.154	−1.671	0.395	0.000	−2.446	−0.895	1.541
Genre_Sports	−0.891	0.465	0.056	−1.805	0.023	−0.907	0.536	0.091	−1.960	0.145	1.319
Genre_Shooting	−0.589	0.709	0.406	−1.981	0.803	−2.804	0.816	0.001	−4.407	−1.201	1.132
Genre_Others	−0.778	0.574	0.176	−1.906	0.349	−1.280	0.661	0.053	−2.578	0.018	1.174
Promotion expenditure	0.003	0.001	0.000	0.001	0.004	0.004	0.001	0.000	0.003	0.006	1.266
Age restriction	0.461	0.203	0.023	0.063	0.860	1.022	0.234	0.000	0.563	1.480	1.045
Number of observations	536					536					
Adjusted R^2	0.508					0.547					

Notes: Closed-closed and Genre_simulation variables are used as reference variables.

of moderating effects are partially consistent with the main results using the total sample, possibly due to the smaller sample size and the different market environment. This finding may imply the strategic importance of a firm's new product launch timing in the digital product market (Klingebiel & Joseph, 2016). Nevertheless, the overall results from using two subsamples are consistent with the main findings using the total sample. Table 7 summarizes the results of hypothesis testing.

7. Discussion

The results of the empirical study enhance our knowledge about the extant literature on open innovation and NPD management. First, our study addresses the question of when to open up the innovation process (Katila & Mang, 2003; Laursen & Salter, 2006) before and after product launch for maximizing NPD performance. By focusing on the effectiveness of innovation process (closed vs. open) over time, this study strengthens the intertemporal aspect of open innovation strategy (Appleyard & Chesbrough, 2017; Bahemia et al., 2018). More attention has been given to how the open innovation and collaboration occur during the pre-launch stages (Pateli & Lioukas, 2019), but less is known about post-launch open innovation. Although some studies indicate the importance of open innovation in NPD during both pre- and post-launch stage, they rely on a single case (Bahemia et al., 2018; Roberts et al., 2022) or focus on a different subject altogether (appropriability strategies, Miric et al., 2019). Our research confirms the existence of dynamic openness in NPD strategies through exploring novel data of numerous

Table 6
Robustness checks using subsamples.

	Sample 1 (June 1, 2016 – November 10, 2016)							Sample 2 (Nov 14, 2016 – April 28, 2017)						
	Model 5 (DV: Volume)			Model 6 (DV: Valence)			VIF	Model 7 (DV: Volume)			Model 8 (DV: Valence)			VIF
	B	SE	Sig.	B	SE	Sig.		B	SE	Sig.	B	SE	Sig.	
Intercept	8.117	0.460	0.000	15.349	0.560	0.000		6.602	0.432	0.000	13.795	0.486	0.000	
Closed-open	−0.477	0.550	0.387	−0.386	0.669	0.564	4.710	0.451	0.525	0.391	0.135	0.590	0.819	4.471
Open-closed	2.873	1.123	0.011	5.960	1.366	0.000	5.848	2.594	1.184	0.029	4.025	1.331	0.003	9.579
Open-open	1.982	0.843	0.020	3.465	1.026	0.001	6.064	3.559	1.186	0.003	3.770	1.334	0.005	8.731
Technological capability	−0.337	0.039	0.000	−0.320	0.047	0.000	1.988	−0.202	0.043	0.000	−0.138	0.048	0.005	1.679
Marketing capability	0.004	0.001	0.000	0.004	0.001	0.000	1.837	0.016	0.004	0.000	0.013	0.004	0.001	6.508
Project complexity	1.435	0.548	0.009	1.276	0.667	0.057	4.895	0.906	0.458	0.049	1.691	0.515	0.001	3.611
Closed-open × Technological capability	0.496	0.100	0.000	0.344	0.122	0.005	2.349	−0.144	0.537	0.789	0.084	0.101	0.404	2.620
Open-closed × Technological capability	−0.086	0.338	0.800	−0.460	0.411	0.265	7.405	−1.945	0.540	0.000	0.002	0.214	0.994	4.524
Open-open × Technological capability	0.346	0.138	0.013	0.269	0.168	0.111	3.334	−0.222	0.440	0.614	−0.191	0.220	0.387	5.625
Closed-open × Marketing capability	0.001	0.002	0.609	0.002	0.003	0.397	1.229	−0.691	0.616	0.263	0.009	0.008	0.266	1.794
Open-closed × Marketing capability	0.009	0.012	0.452	−0.021	0.015	0.163	1.537	−0.670	0.971	0.491	−0.012	0.005	0.009	5.431
Open-open × Marketing capability	−0.002	0.001	0.136	−0.002	0.002	0.173	1.879	−0.583	0.713	0.414	−0.014	0.005	0.010	2.999
Closed-open × Project complexity	−0.725	0.659	0.272	−0.439	0.801	0.584	4.284	0.407	0.269	0.133	−1.585	0.662	0.017	2.654
Open-closed × Project complexity	−1.766	1.164	0.130	−1.157	1.416	0.414	2.953	0.043	0.089	0.633	−3.210	1.143	0.005	5.747
Open-open × Project complexity	−1.669	0.911	0.068	−1.754	1.108	0.115	5.377	0.355	0.191	0.064	−1.938	1.084	0.075	4.126
Genre_Action	−0.705	0.492	0.153	−1.668	0.598	0.006	1.520	0.040	0.195	0.839	−1.115	0.604	0.066	1.345
Genre_Arcade	−0.543	0.528	0.305	−1.876	0.642	0.004	1.694	0.010	0.007	0.167	−2.169	0.607	0.000	1.558
Genre_Puzzle	−1.200	0.506	0.018	−1.680	0.615	0.007	1.505	−0.014	0.004	0.000	−1.475	0.494	0.003	1.704
Genre_Sports	−0.761	0.635	0.232	−1.257	0.772	0.105	1.341	−0.016	0.005	0.001	−0.418	0.693	0.547	1.331
Genre_Shooting	−0.277	0.952	0.772	−3.255	1.158	0.005	1.115	−0.663	0.589	0.262	−1.835	1.091	0.094	1.222
Genre_Others	−0.447	0.855	0.601	−0.994	1.039	0.340	1.248	−1.641	1.017	0.108	−1.114	0.801	0.166	1.168
Promotion expenditure	0.002	0.001	0.002	0.004	0.001	0.000	1.446	0.009	0.003	0.001	0.020	0.003	0.000	1.138
Age restriction	0.423	0.294	0.152	0.701	0.358	0.052	1.080	−1.793	0.964	0.064	1.108	0.303	0.000	1.267
Number of observations	268			268				268			268			
Adjusted R^2	0.594			0.614				0.504			0.528			

Notes: Closed-closed and Genre_simulation variables are used as reference variables.

NPD projects and further identifies the strategic shift between closed and open innovation during the project across pre- and post-launch stages.

Second, the present study provides empirical evidence for the significant, positive effect of early-stage collaboration (i.e., pre-launch openness) on the market performance of NPD projects. Specifically, technology licensing-driven (open-closed) NPD strategies outperform product upgrade-driven (closed-open) strategies. Although customer feedback can help NPD teams improve products further at the post-launch stage (Helfat & Raubitschek, 2018; Miric et al., 2019), our findings emphasize the importance of bringing in external technological innovations through collaborations at earlier NPD phases (Eling & Herstatt, 2017; Verworn et al., 2008). That is, for firms intending to engage in late open innovation practices during NPD, the best outcomes are with inbound open innovation at the pre-launch stage and outbound open innovation at the post-launch stages (Lee, Park, Yoon, & Park, 2010). This research also confirms the importance of actively in-sourcing novel technologies during the pre-launch NPD stages, which supplements internal innovation efforts and in turn increases product innovation performance (Faems, De Visser, Andries, & Van Looy, 2010).

Finally, our study contributes to the project-level open innovation literature with context-specific empirical insights. Previous research has mainly focused on the contingency factors at the either firm (Bahemia et al., 2018) or project (Du et al., 2014) level, which moderate the relationship between open innovation strategies and project performance. However, while such research provides strategic knowledge about how to manage open vs. closed innovation, it fails to consider that the effectiveness of open NPD strategies varies across both firm- and project-level characteristics (Cooper, 2019). Concerning technological capability, we find that although firms with superior technological capability can increase sales performance through intertemporally open NPD strategies (early, late, or fully), they can also increase revenue performance only through the late open NPD strategy. Prior literature simply argues that technological capabilities enable firms to actively identify and acquire external new knowledge (Renko et al., 2009). Hence, this study extends our knowledge about when to open up innovation processes for revenue maximization for firms with a higher level of technological capabilities. The important role of technological capability in late open (closed-open) NPD projects can be explained by the synergistic effect of firms' technology-related internal knowledge (technological capability) with market-driven product upgrades (Foss, Lyngsie, & Zahra, 2013).

In addition, this study shows that firms with a greater marketing capability do not benefit from opening up innovation processes in NPD. Prior research argues that marketing capability in general enables firms to refine NPD practices (Dutta et al., 1999), achieve competitive advantage (Chu et al., 2011), and create value from open innovation (Feng et al., 2017). Although a firm's marketing capabilities efficiently integrate external market knowledge into its existing knowledge bases for product innovation (Kyriakopoulos et al., 2016), our finding confirms that a firm's greater marketing capability tends to undermine its ability to obtain innovative, disruptive knowledge from external sources during pre- and post-launch stages (Yang et al., 2020). However, as our empirical results show marginally significant effects of the interaction terms, the moderating role of marketing capability needs to be further investigated in different industry contexts and/or with different measurements of marketing capability.

Concerning the moderating role of project complexity, our findings confirm that complex NPD projects benefit more from fully closed innovation before and after product launch than open innovation approaches. Although multi-partner projects may benefit from open innovation, inter-firm knowledge sharing, and system integration (Felin & Zenger, 2014), our findings indicate negative consequences from the added complexity in such projects, possibly due to the transaction and agency costs from outsourcing (Boudreau, 2010; Thakur-Wernz et al., 2020) in the digital NPD context, and emphasize the importance of

Table 7
Overview of hypothesis testing results.

Hypothesis	Description	Supported (Yes / No)		Aggregated result
		DV: Volume	DV: Valence	
1	Open-closed NPD strategy > Closed-open NPD strategy → Market performance	Yes	Yes	Supported
2	Closed-open NPD strategy × Technological capability → Market performance	Yes	Yes	Supported
	Open-closed NPD strategy × Technological capability → Market performance	Yes	Yes	
	Open-open NPD strategy × Technological capability → Market performance	Yes	No	
3	Closed-open NPD strategy × Marketing capability → Market performance	No	No	Partially supported
	Open-closed NPD strategy × Marketing capability → Market performance	No	Yes	
	Open-open NPD strategy × Marketing capability → Market performance	Yes	Yes	
4a	Closed-open NPD strategy × Project complexity → Market performance	No	No	Not supported
	Open-closed NPD strategy × Project complexity → Market performance	No	No	
	Open-open NPD strategy × Project complexity → Market performance	No	No	
4b	Closed-open NPD strategy × Project complexity → Market performance	No	Yes	Supported
	Open-closed NPD strategy × Project complexity → Market performance	Yes	Yes	
	Open-open NPD strategy × Project complexity → Market performance	Yes	Yes	

exploiting internal resources when developing complex innovations (Almirall & Casadesus-Masanell, 2010). Thus, we contribute to the literatures on open innovation and NPD by emphasizing the importance of considering contingency roles of firm- and project-level characteristics when studying the NPD strategy-performance relationship, which provides a full understanding of open innovation project management (Antons, Kleer, & Salge, 2016).

8. Conclusions

Open innovation research thus far has provided few answers as to how NPD projects should understand the impact of project-level open innovation strategies on market performance (Du et al., 2014). Based on the dynamic characteristics of open innovation strategy (Appleyard & Chesbrough, 2017), this study proposed four 'archetypes' of intertemporal NPD strategies opening, resp., closing the innovation process before and after product launch. Specifically, NPD teams can open up the innovation process through acquiring external knowledge in the form of technology licensing at the pre-launch stage and/or customer feedback-based product upgrades at the post-launch stage, or exploit internal knowledge base at the pre- and post-launch stages. Next, this study empirically addressed which intertemporal NPD strategies enhance market performance of new products under heterogeneous firm- and project-level characteristics in the digital NPD context. We found that the early open – open-closed – strategy outperforms the late open – closed-open – strategy. From the contingency perspective, this study finds that intertemporal open NPD strategies – compared to the fully closed strategy – perform better when technological capability is high, but weaker when marketing capability is high, or NPD projects are complex.

This study holds important implications for NPD and innovating firms. Managers should make a clear, long-term strategic choice from conceptualization, development, and post-launch upgrades before starting NPD projects. As we propose four intertemporal NPD strategies based on the type of innovation (closed vs. open) and the timing of product development (pre-launch vs. post-launch), NPD teams may select one specific strategy among fully closed (closed-closed), early open (open-closed), late open (closed-open), and fully open (open-open) alternatives. Meanwhile, our empirical analysis suggests that innovating firms, in general, should prioritize early open innovation rather than late open innovation, and consider organizational (technological and marketing) capabilities and project complexity simultaneously with the choice of intertemporal NPD strategy. Different combinations of intertemporal NPD strategies and contingencies result in different market performance of new products. Thus, incorporating dynamic thinking into an open innovation framework will help managers make better use of open innovation processes in NPD and capture value from the NPD projects (Randhawa et al., 2016).

When a team decides to exploit internally-accumulated technical and market knowledge only and ignores other environmental factors during the NPD project (i.e., closed-closed strategy), managers may suffer from poor market performance of new products. Our research suggests that firms with superior marketing capabilities or engaging in complex NPD projects can benefit from engaging in fully closed innovation processes. This strategic fit may occur because the more complex a NPD project is, the more important are (1) the coordination and integration of different development activities within the project and (2) a firm's development and utilization of marketing capabilities for the project. In the context of digital games, development projects of multi-player RPGs need to allow thousands of geographically distributed users to interact and compete with each other in real time (Ang, Zaphiris, & Mahmood, 2007), thus increasing the complexity of product development and user management. When the development process of digital games appears to be more complex, the pursuit of openness dynamics in NPD strategy may be riskier, but the active interaction and communication with potential and existing customers can support project management and increase new product market performance.

If an open innovation approach is chosen (either before and/or after product launch), firms are well advised to limit unwanted complexity of its NPD projects. Improving the level of technological capability is desirable over increases in marketing capability; A project team with superior technological capabilities can expect an increase in sales volume through selecting an early open NPD strategy (e.g., outsourcing a new state-of-art technology (open-closed)), a late open strategy (e.g., transforming a closed project into an open project at the post-launch stage (closed-open)), or a fully open strategy (e.g., rely on externally developed breakthrough technologies before product launch and continue to upgrade the existing products after product launch (open-open)). However, if firms with superior technological capabilities aim at maximizing both sales volume and revenue from intertemporally open NPD projects, they should select a late open strategy as firms can benefit from both their technological capabilities and continuous explorations of market-oriented product upgrades throughout projects.

Although this study offers insightful implications, it suffers from several limitations that provide avenues for future research. First, the empirical setting is centered on a specific digital service industry. While there are many similarities to product innovation processes in other countries and markets and industries, our findings cannot be unconditionally generalized to NPD of purely physical products that necessitate quite different considerations, e.g., manufacturability, logistics, and distribution. In addition, open NPD strategies and activities may differ across low- and high-technology industries (Grimpe & Sofka, 2009).

Hence, future research should apply our empirical replication to other physical goods in high-technology industries (e.g., bio-pharmaceuticals and electric vehicles). Depending on different industries and markets, NPD projects may have to select different intertemporal strategies that maximize project performance.

Second, the selected measures for pre- and post-launch open innovation represent only two of many other open innovation tools. Although technology licensing and product upgrades are popular choices in NPD projects, the question remains how representative they are with respect to open innovation in general. Scholars have indicated various methods and approaches to open innovation for NPD projects such as R&D outsourcing and collaboration with external partners. In addition, the access to external knowledge may influence NPD performance positively (e.g., improved internal competencies) or negatively (e.g., costly projects) (Knudsen & Mortensen, 2011). Therefore, researchers may further explore how NPD projects benefit intertemporal NPD strategies under different types of open innovation source (e.g., suppliers, competitors, customers) and approach (e.g., networking and contracting).

Third, this study operationalizes the dummy variable of RPG (vs. non-RPG) as a measure of project complexity, which belongs to a representative project-level contingency. However, other project-level contingencies such as project manager skills, project uncertainty, and market dynamism might also affect the project performance. Depending on the different combinations of pre-launch and post-launch open innovation activities, the direct and interactive effects of open NPD strategies and firm- and project-level characteristics on market performance may vary. We suggest that further research specifically incorporate various firm- and project-level characteristics and examine what type of intertemporal NPD strategies should be selected under different contingencies.

Fourth, this study revolves around the timing of closed and open innovation during NPD projects. The pandemic has called for the need for accelerated product development through focused project teams coupled with effective portfolio management, new digital tools (e.g., virtual reality and artificial intelligence), lean development, and agile methods (Cooper, 2021). Externally sourced inventions in NPD of manufacturing firms can shorten the research time in the early stages of development and accelerate their innovation process (Arora, Cohen, & Walsh, 2016). Because accelerated development may have hidden costs, such as undertaking less innovative projects and cutting too many corners (Cooper, 2021), future research needs to incorporate the role of the development speed to examine what specific intertemporal NPD strategy lead to new product success under the accelerated innovation environment.

Finally, this study focuses on the intertemporal dimensions of open innovation process based on closed innovation outcome (i.e., private open innovation). However, prior research suggests that open innovation practices can also be grouped by distinguishing between process and outcome, implying that intertemporal openness, especially opening up after product launch, can contribute to the open outcomes such as public innovation and open source innovation (Huizingh, 2011). The open outcome perspective could trigger new research ideas about whether and how intertemporal innovation processes lead to the open outcomes that are available to the public (e.g., social innovation).

Data availability

The data that has been used is confidential.

Appendix A. Validation of post-launch open innovation practice in digital games

In order to validate the post-launch open innovation practice – whether projects open up innovation process by modifying the existing products based on crowd feedback, we collected additional dataset of online user postings and product upgrades on a monthly basis. Table A1 shows that while recent user feedback (one, two, or three months ago) had a weak effect on number of product upgrades, cumulative user feedback had a strong and positive effect. These findings imply that cumulative user feedback data, not instant data, play a key role in continuous product innovation after a new product is on the market.

Table A1
The effect of immediate and cumulative user feedback on product upgrades.

Variables	Model A1 (t-1 lagged effect)	Model A2 (t-2 lagged effect)	Model A3 (t-3 lagged effect)
Intercept	0.22650* (0.01846)	0.22630* (0.02168)	0.21810* (0.02529)
User feedback at t	−0.00033 (0.00024)	−0.00111† (0.00057)	−0.00116† (0.00067)
User feedback at t-1	−0.00013 (0.00018)		
User feedback at t-2		−0.00006 (0.00020)	
User feedback at t-3			−0.00006 (0.00022)
Cumulative user feedback	0.00009* (0.00003)	0.00012* (0.00004)	0.00012* (0.00004)
Number of observations	7701	6310	5094
R^2	0.00109	0.00147	0.00167
Adjusted R^2	0.00070	0.00099	0.00108

Notes: t denotes month. Standard errors are included in parentheses.

† $p < 0.10$, * $p < 0.05$.

Appendix B. Validation of RPG genre (project complexity) as a moderating variable

We split our sample into subsamples of non-RPG and RPG and ran a regression model using three independent variables (i.e., *closed-open*, *open-closed*, *open-open*). As shown in Table B1, open NPD strategies in non-RPG (less complex) projects have stronger positive effects on volume and valence performance than closed NPD strategy. Conversely, open-closed and open-open NPD strategies in RPG (more complex) projects have small, positive effects on volume and valence performance while the closed-open strategy has no effect. These results imply that the dummy variable of RPG (vs. non-RPG) can become a good moderator for the relationship between open NPD strategies and new product market performance.

Table B1
The effect of open NPD strategies on new product market performance (Non-RPG vs. RPG).

	Non-RPG sample		RPG sample	
	Model A4 (DV: Volume)	Model A5 (DV: Valence	Model A6 (DV: Volume)	Model A7 (DV: Valence)
Intercept	5.345 (0.201)	12.430 (0.237)	8.175 (0.276)	16.400 (0.321)
Closed-open	1.862** (0.317)	1.485** (0.373)	0.427 (0.366)	−0.401 (0.427)
Open-closed	4.909** (0.661)	5.984** (0.776)	1.616** (0.473)	1.465** (0.551)
Open-open	4.804** (0.628)	5.245** (0.738)	1.761** (0.420)	1.883** (0.490)
Number of observations	314	314	222	222
Adjusted R square	0.262	0.240	0.089	0.114

Notes: Closed-closed is used as a reference variable.
** $p < 0.01$.

Appendix C. Examples of four types of intertemporal NPD strategy in digital games

The four alternatives of NPD strategies are exemplified by sample products A, B, C, and D in Table B1. Product A (*closed-closed*) was newly launched and developed by a newly-entering corporate developer with a high technological capability (no game launched in the past but 11 digital games launched during the observation period). On the contrary, Product B (*closed-open*) and Product D (*open-open*) were relaunched from the existing products and developed by experienced individual and corporate developers, respectively, with low and medium technological capabilities (2 and 5 games launched in the past, but only one game launched during the observation period). Finally, Product C (*open-closed*) was newly launched and developed by a newly-entering corporate developer with a low technological capability (no game launched in the past, and only one game launched during the observation period).

Table C1
Description of exemplary products according to four intertemporal NPD strategies.

Description	Product A	Product B	Product C	Product D
Intertemporal NPD strategies	Closed-closed	Closed-open	Open-closed	Open-open
Launch date	April 20, 2017	April 28, 2017	July 5, 2016	January 19, 2017
Type of product	Newly launched	Relaunched	Newly launched	Relaunched
Observation period	3 months	3 months	1 month	6 months
Type of developer	Corporate	Individual	Corporate	Corporate
Organizational capabilities				
Past technological capability	0	2	0	5
Current technological capability	11	1	1	1
Past marketing capability	0	4	0	45
Current marketing capability	11	21	32	539
Project complexity (Product genre)	RPG	Non-RPG	Non-RPG	Non-RPG
Past market performance (one year)				
Volume (units)	0	400	0	249,116
Valence (revenue)	0	$27	0	$575,675
Average price of add-on product(s)	$2.93	$4.28	$3.99	$0.91
Observed market performance (monthly average)				
Volume (units)	538	92	279,376	18,610
Valence (revenue)	$39,920	$208	$472,150	$25,162

References

Almirall, E., & Casadesus-Masanell, R. (2010). Open versus closed innovation: A model of discovery and divergence. *Academy of Management Review, 35*(1), 27–47.
Amit, R., & Schoemaker, P. J. H. (1993). Strategic assets and organizational rent. *Strategic Management Journal, 14*, 33–46.
Ang, C. S., Zaphiris, P., & Mahmood, S. (2007). A model of cognitive loads in massively multiplayer online role playing games. *Interacting with Computers, 19*(2), 167–179.
Antons, D., Kleer, R., & Salge, T. O. (2016). Mapping the topic landscape of JPIM, 1984-2013: In search of hidden structures and development trajectories. *Journal of Product Innovation Management, 33*(6), 726–749.
Appleyard, M., & Chesbrough, H. (2017). The dynamics of open strategy. *Long Range Planning, 50*, 310–321.
Arora, A. W., Cohen, M., & Walsh, J. P. (2016). The acquisition and commercialization of invention in American manufacturing: Incidence and impact. *Research Policy, 45*(6), 1113–1128.
Bagherzadeh, M., Markovic, S., & Bogers, M. (2021). Managing open innovation: A project-level perspective. *IEEE Transactions on Engineering Management, 68*(1), 301–316.
Bahemia, H., Sillince, J., & Vanhaverbeke, W. (2018). The timing of openness in a radical innovation project, a temporal and loose coupling perspective. *Research Policy, 47*(10), 2066–2076.
Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management, 17*(1), 99–120.
Boudreau, K. (2010). Open platform strategies and innovation: Granting access vs. devolving control. *Management Science, 56*(10), 1849–1872.
Calantone, R. J., & di Benedetto, C. A. (1998). Strategies of product and process innovation: A loglinear analysis. *R&D Management, 18*(1), 13–21.
Cheng, C. C., & Huizingh, E. K. (2014). When is open innovation beneficial? The role of strategic orientation. *Journal of Product Innovation Management, 31*(6), 1235–1253.
Chu, C.-P., Li, C.-R., & Lin, C.-J. (2011). The joint effect of project-level exploratory and exploitative learning in new product development. *European Journal of Marketing, 45*(4), 531–550.
Cohen, W. M., & Levinthal, D. A. (1989). Innovation and learning: The two faces of R&D. *The Economic Journal, 99*, 569–596.
Cohen, W. M., Nelson, R. R., & Walsh, J. P. (2000). Protecting their intellectual assets: Appropriability conditions and why U.S. manufacturing firms patent or not. In *NBER Working Paper, 7552*.
Coombs, J. E., & Bierly, P. E. (2006). Measuring technological capability and performance. *R&D Management, 36*(4), 421–438.
Cooper, R. G. (2019). The drivers of success in new-product development. *Industrial Marketing Management, 76*, 36–47.
Cooper, R. G. (2021). Accelerating innovation: Some lessons from the pandemic. *Journal of Product Innovation Management, 38*(2), 221–232.
Cope, J. (2005). Toward a dynamic learning perspective of entrepreneurship. *Entrepreneurship Theory and Practice, 29*(4), 373–397.
Covin, J. G., & Miles, M. (1999). Corporate entrepreneurship and the pursuit of competitive advantage. *Entrepreneurship: Theory and Practice, 23*, 47–63.
Cui, A. S., & Wu, F. (2017). The impact of customer involvement on new product development: Contingent and substitutive effects. *Journal of Product Innovation Management, 34*(1), 60–80.

Cui, A. S., & Xiao, Y. (2019). The role of market and technical information generation in new product development. *Journal of Product Innovation Management, 36*(3), 305–330.
Dahlander, L., & Wallin, M. W. (2006). A man on the inside: Unlocking communities as complementary assets. *Research Policy, 35*, 1243–1259.
Danneels, E. (2002). The dynamics of product innovation and firm competences. *Strategic Management Journal, 23*(12), 1095–1121.
Day, G. S. (1994). The capabilities of market-driven organizations. *Journal of marketing, 58*(4), 37–52.
Day, G. S. (2011). Closing the marketing capabilities gap. *Journal of Marketing, 75*, 183–195. July.
Dencker, J. C., Gruber, M., & Shah, S. K. (2009). Pre-entry knowledge, learning, and the survival of new firms. *Organization Science, 20*(3), 516–537.
Du, J., Leten, B., & Vanhaverbeke, W. (2014). Managing open innovation projects with science-based and market-based partners. *Research Policy, 43*(5), 828–840.
Dutta, S., Narasimhan, O., & Rajiv, S. (1999). Success in high-technology markets: Is marketing capability critical? *Marketing Science, 18*(4), 547–568.
Eisenhardt, K. M., & Martin, J. A. (2000). Dynamic capabilities: What are they? *Strategic Management Journal, 21*(10/11), 1105–1121.
Eling, K., & Herstatt, C. (2017). Managing the front end of innovation—Less fuzzy, yet still not fully understood. *Journal of Product Innovation Management, 34*(6), 864–874.
Fabrizio, K. (2009). Absorptive capacity and the search for innovation. *Research Policy, 38*, 255–267.
Faems, D., De Visser, M., Andries, P., & Van Looy, B. (2010). Technology alliance portfolios and financial performance: Value-enhancing and cost-increasing effects of open innovation. *Journal of Product Innovation Management, 27*(6), 785–796.
Felin, T., & Zenger, T. R. (2014). Closed or open innovation? Problem solving and the governance choice. *Research Policy, 43*(5), 914–925.
Feng, H., Morgan, N. A., & Rego, L. L. (2017). Firm capabilities and growth: The moderating role of market conditions. *Journal of the Academy of Marketing Science, 45*(1), 76–92.
Fixson, S. K., & Marion, T. J. (2012). Back-loading: A potential side effect of employing digital design tools in new product development. *Journal of Product Innovation Management, 29*(S1), 140–156.
Foss, N. J., Lyngsie, J., & Zahra, S. A. (2013). The role of external knowledge sources and organizational design in the process of opportunity exploitation. *Strategic Management Journal, 34*(12), 1453–1471.
Fujimoto, T. (2007). Architecture-based comparative advantage—A design information view of manufacturing. *Evolutionary and Institutional Economics Review, 4*, 55–112.
Gassmann, O., & von Zedtwitz, M. (2003). Trends and determinants of managing virtual R&D teams. *R&D Management, 33*(3), 243–262.
Gatignon, H., & Xuereb, J.-M. (1997). Strategic orientation of the firm and new product performance. *Journal of Marketing Research, 34*(February), 77–90.
Grimpe, C., & Sofka, W. (2009). Search patterns and absorptive capacity: Low-and high-technology sectors in European countries. *Research Policy, 38*(3), 495–506.
Grönlund, J., Sjödin, D. R., & Frishammar, J. (2010). Open innovation and the stage-gate process: A revised model for new product development. *California Management Review, 52*(3), 106–131.
Gurca, A., Bagherzadeh, M., Markovic, S., & Koporcic, N. (2021). Managing the challenges of business-to-business open innovation in complex projects: A multi-stage process model. *Industrial Marketing Management, 94*, 202–215.
Gurca, A., & Ravishankar, M. N. (2016). A bricolage perspective on technological innovation in emerging markets. *IEEE Transactions on Engineering Management, 63*(1), 53–66.
Ha, I., Yoon, Y., & Choi, M. (2007). Determinants of adoption of mobile games under mobile broadband wireless access environment. *Information & Management, 44*(3), 276–286.
Heim, G. R., Mallick, D. N., & Peng, X. D. (2012). Antecedents and consequences of new product development practices and software tools: An exploratory study. *IEEE Transactions on Engineering Management, 59*(3), 428–442.
Helfat, C. E., & Raubitschek, R. S. (2018). Dynamic and integrative capabilities for profiting from innovation in digital platform-based ecosystems. *Research Policy, 47*, 1391–1399.
Huizingh, E. K. (2011). Open innovation: State of the art and future perspectives. *Technovation, 31*(1), 2–9.
Impey, S. (2019). Finding a publishing partner vs self publishing – Everything you need to know. Available online at https://gameanalytics.com/blog/publishing-partner-vs-self-publishing/>. checked on December 28, 2020.
Inauen, M., & Schenker-Wicki, A. (2011). The impact of outside-in open innovation on innovation performance. *European Journal of Innovation Management, 14*(4), 496–520.
Jang, S., & Chung, J. (2015). How do interaction activities among customers and between customers and firms influence market performance and continuous product innovation? An empirical investigation of the mobile application market. *Journal of Product Innovation Management, 32*(2), 183–191.
Jang, S., & Chung, J. (2021). What drives add-on sales in mobile games? The role of inter-price relationship and product popularity. *Journal of Business Research, 124*, 59–68.
Jaworski, B. J., & Kohli, A. K. (1993). Market orientation: Antecedents and consequences. *Journal of Marketing, 57*(July), 53–71.
Johnsen, T. E. (2009). Supplier involvement in new product development and innovation: Taking stock and looking to the future. *Journal of Purchasing and Supply Management, 15*(3), 187–197.
Katila, R., & Mang, P. Y. (2003). Exploiting technological opportunities: The timing of collaborations. *Research Policy, 32*(2), 317–332.
Kim, N., & Atuahene-Gima, K. (2010). Using exploratory and exploitative market learning for new product development. *Journal of Product Innovation Management, 27*, 520–537.
Klingebiel, R., & Joseph, J. (2016). Entry timing and innovation strategy in feature phones. *Strategic Management Journal, 37*(6), 1002–1020.
Knudsen, M. P., & Mortensen, T. B. (2011). Some immediate – But negative – Effects of openness on product development performance. *Technovation, 31*(1), 54–64.
Kock, A., & Gemünden, H. G. (2016). Antecedents to decision-making quality and agility in innovation portfolio management. *Journal of Product Innovation Management, 33*(6), 670–686.
Kübler, R., Pauwels, K., Yildirim, G., & Fandrich, T. (2018). App popularity: Where in the world are consumers most sensitive to price and user ratings? *Journal of Marketing, 82*, 20–44.
Kyriakopoulos, K., Hughes, M., & Hughes, P. (2016). The role of marketing resources in radical innovation activity: Antecedents and payoffs. *Journal of Product Innovation Management, 33*(4), 398–417.
Laursen, K., & Salter, A. (2006). Open for innovation: The role of openness in explaining innovation performance among UK manufacturing firms. *Strategic Management Journal, 27*, 131–150.
Lee, J.-S., Park, J.-H., & Bae, Z.-T. (2017). The effects of licensing-in on innovative performance in differenttechnological regimes. *Research Policy, 46*, 485–496.
Lee, K., & Yoo, J. (2019). How does open innovation lead competitive advantage? A dynamic capability view perspective. *PLoS One, 14*(11), Article e0223405.
Lee, S., Park, G., Yoon, B., & Park, J. (2010). Open innovation in SMEs—An intermediated network model. *Research Policy, 39*, 290–300.
Lee, Y., Fong, E., Barney, J. B., & Hawk, A. (2019). Why do experts solve complex problems using open innovation? Evidence from the US pharmaceutical industry. *California Management Review, 62*(1), 144–166.
Lee, Y., & O'Connor, G. C. (2003). The impact of communication strategy on launching new products: The moderating role of product innovativeness. *Journal of Product Innovation Management, 20*, 4–21.
Leone, M. I., & Reichstein, T. (2012). Licensing-in fosters rapid invention! The effect ofthe grant-back clause and technological unfamiliarity. *Strategic Management Journal, 33*, 965–985.
Lichtenthaler, U. (2011). Open innovation: Past research, current debates, and future directions. *Academy of Management Perspectives, 25*(1), 75–93.
Lo, Y.-F., & Wen, M.-H. (2010). A fuzzy-AHP-based technique for the decision of design feature selection in massively multiplayer online role-playing game development. *Expert Systems with Applications, 37*(12), 8685–8693.
Mallick, D. N., Ritzman, L. P., & Sinha, K. K. (2013). Evaluating product-centric continuous improvements: Impact on competitive capabilities and business performance. *Journal of Product Innovation Management, 30*, 188–202.
Markham, S. K., & Lee, H. (2013). Product development and management Association's 2012 comparative performance assessment study. *Journal of Product Innovation Management, 30*(3), 408–429.
Markovic, S., & Bagherzadeh, M. (2018). How does breadth of external stakeholder co-creation influence innovation performance? Analyzing the mediating roles of knowledge sharing and product innovation. *Journal of Business Research, 88*, 173–186.
Markovic, S., Bagherzadeh, M., Vanhaverbeke, W., & Bogers, M. (2021). Managing business-to-business open innovation: A project-level approach. *Industrial Marketing Management, 94*, 159–163.
Marvel, M. R., Wolfe, M. T., Kuratko, D. F., & Fisher, G. (2020). Examining entrepreneurial experience in relation to pre-launch and post-launch learning activities affecting venture performance. *Journal of Small Business Management*, 1–27.
Miric, M., Boudreau, M. J., & Jeppesen, L. B. (2019). Protecting their digital assets: The use of formal & informal appropriability strategies by app developers. *Research Policy, 48*(8), Article 103738.
Moorman, C., & Slotegraaf, R. J. (1999). The contingency value of complementary capabilities in product development. *Journal of Marketing Research, 36*(2), 239–257.
Narasimhan, O., Dutta, S., & Rajiv, S. (2006). Absorptive capacity of firms in high-technology markets: The competitive advantage of the haves. *Marketing Science, 25*(5), 510–524.
Novak, S., & Eppinger, S. D. (2001). Sourcing by design: Product complexity and the supply chain. *Management Science, 47*(1), 189–204.
Nucciarelli, A., Li, F., Fernandes, K. J., Gournagias, N., Cabras, I., Devlin, S., … Cowling, P. (2017). From value chains to technological platforms: The effects of crowdfunding in the digital game industry. *Journal of Business Research, 78*, 341–352.
Olson, E. M., Walker, O. C., Ruekert, R. W., & Bonner, J. M. (2001). Patterns of cooperation during new product development among marketing, operations and R&D: Implications for project performance. *Journal of Product Innovation Management, 18*(4), 258–271.
Park, H. J., & Kim, S. H. (2013). A Bayesian network approach to examining key success factors of mobile games. *Journal of Business Research, 66*(9), 1353–1359.
Pateli, A., & Lioukas, S. (2019). How functional involvement affects the transformation of external knowledge into innovation outcomes. *R&D Management, 49*(2), 224–238.
Pil, F. K., & Cohen, S. K. (2006). Modularity: Implications for imitation, innovation, and sustained advantage. *Academy of Management Review, 31*(4), 995–1011.
Randhawa, K., Wilden, R., & Hohberger, J. (2016). A bibliometric review of open innovation: Setting a research agenda. *Journal of Product Innovation Management, 33*(6), 750–772.
Renko, M., Carsrud, A., & Brännback, M. (2009). The effect of a market orientation, entrepreneurial orientation, and technological capability on innovativeness: A study of young biotechnology ventures in the United States and in Scandinavia. *Journal of Small Business Management, 47*(3), 331–369.

Rezaei, S., & Ghodsi, S. S. (2014). Does value matters in playing online game? An empirical study among massively multiplayer online role-playing games (MMORPGs). *Computers in Human Behavior, 35*, 252–266.
Ritala, P., & Stefan, I. (2021). A paradox within the paradox of openness: The knowledge leveraging conundrum in open innovation. *Industrial Marketing Management, 93*, 281–292.
Roberts, D. L., Palmer, R., & Hughes, M. (2022). Innovating the product innovation process to enable co-creation. *R&D Management, 52*(3), 484–497.
Rubera, G., Chandrasekaran, D., & Ordanini, A. (2016). Open innovation, product portfolio innovativeness and firm performance: The dual role of new product development capabilities. *Journal of the Academy of Marketing Science, 44*(2), 166–184.
Salge, T., Farchi, T., Barrett, M., Michael, I., & Dopson, S. (2013). When does search openness really matter? A contingency study of health-care innovation projects. *Journal of Product Innovation Management, 30*(4), 659–676.
Schröder, H.-H., & Jetter, A. J. M. (2003). Integrating market and technological knowledge in the fuzzy front end: An FCM-based action support system. *International Journal of Technology Management, 26*(5/6), 517–539.
Seidel, V. P. (2007). Concept shifting and the radical product development process. *Journal of Product Innovation Management, 24*(6), 522–533.
Tang, C. S., Zimmerman, J. D., & Nelson, J. I. (2009). Managing new product development and supply chain risks: The Boeing 787 case. *Supply Chain Forum: An International Journal, 10*(2), 74–86.
Tang, T. Y., Fisher, G. J., & Qualls, W. J. (2021). The effects of inbound open innovation, outbound open innovation, and team role diversity on open source software project performance. *Industrial Marketing Management, 94*, 216–228.
Teece, D. J. (1986). Profiting from technological innovation: Implications for integration, collaboration, licensing and public policy. *Research Policy, 15*, 285–305.
Teece, D. J. (2018). Profiting from innovation in the digital economy: Enabling technologies, standards, and licensing models in the wireless world. *Research Policy, 47*(8), 1367–1387.
Teece, D. J., Pisano, G., & Shuen, G. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal, 18*, 509–533.
Tether, B. S. (2002). Who co-operates for innovation, and why: An empirical analysis. *Research Policy, 31*(6), 947–967.
Thakur-Wernz, P., Bruyaka, O., & Contractor, F. (2020). Antecedents and relative performance of sourcing choices for new product development projects. *Technovation, 90-91*, Article 102097.
Thomke, S. H., & Fujimoto, T. (2000). The effect of "front-loading" problem-solving on product development performance. *Journal of Product Innovation Management, 17*, 128–142.
Verworn, B., Herstatt, C., & Nagahira, A. (2008). The fuzzy front end of Japanese new product development projects: Impact on success and differences between incremental and radical projects. *R&D Management, 38*, 1–19.
Vorhies, D. W., Morgan, R. E., & Autry, C. W. (2009). Product-market strategy and the marketing capabilities of the firm: Impact on market effectiveness and cash flow performance. *Strategic Management Journal, 30*(12), 1310–1334.
West, J., & Bogers, M. (2014). Leveraging external sources of innovation: a review of research on open innovation. *Journal of Product Innovation Management, 31*(4), 814–831.
West, J., & Gallagher, S. (2006). Challenges of open innovation: The paradox of firm investment in open-source software. *R&D Management, 36*(3), 319–331.
Yang, D., Li, L., Jiang, X., & Zhao, J. (2020). The fit between market learning and organizational capabilities for management innovation. *Industrial Marketing Management, 86*, 223–232.
Yoo, Y., Boland, R. J., Lyytinen, K., & Majchrzak, A. (2012). Organizing for innovation in the digitized world. *Organization Science, 23*(5), 1398–1408.
Zhang, H., & Xiao, Y. (2020). Customer involvement in big data analytics and its impact on B2B innovation. *Industrial Marketing Management, 86*, 99–108.
Zhong, Z.-J. (2011). The effects of collective MMORPG (massively multiplayer online role-playing games) play on gamers' online and offline social capital. *Computers in Human Behavior, 27*(6), 2352–2363.