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Managing Platform-based Ecosystems in B2B Markets – Out-bound Open Innovation Perspective

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Abstract

Technology advancements are underpinning firms in shaping their products and services into digital platforms to foster value co-creation in their platform-based ecosystems. While existing research has mainly focused on business-to-customer (B2C) platforms, relatively little research has been conducted on business-to-business (B2B) platforms. To address this research gap, this study employs a case study approach to collect and examine three out-bound open innovation (OI) application cases in the context of B2B platforms, namely, TSMC, IBM and CNT Tech. The case analysis results show that the coverage of B2B markets can be expanded and diversified by OI. To improve the quality of platform offerings (not only platform services but also complementary innovations), the case firms implemented OI applications comprising two phases that manage knowledge outflows (with boundary resources) and inflows (with input/output controls) across their organisational boundaries. Knowledge sharing provided a B2B platform owner new market creation opportunities, and complementors combined and pivoted some of the platform owners' core technologies, consequently diversifying the platforms' applications and making platform ecosystem more dynamic and vibrant.

Keywords: platform-based ecosystems; digital platforms; out-bound open innovation

1. Introduction

Advancements in digital technologies, such as mobile networks, cloud computing, and big data, have transformed industries (Fichman et al., 2014, Karimi and Walter, 2015, Tilson et al., 2010, De Reuver et al., 2018, Zott and Amit, 2010). These technological disruptions have led to new innovations and appropriation pathways which enable a firm to shape its products or services into digital platforms that integrate various actors (e.g. users and complementors) into its value co-creation process (Chesbrough, 2017, Fichman et al., 2014, Karimi and Walter, 2015, Nambisan et al., 2017, De Reuver et al., 2018, Hein et al., 2019). A digital platform is built on technical infrastructure and serves as a foundation on which several external complementors (organised as an ecosystem) can develop complementary products, services, and technologies (Chesbrough, 2017, Evans, 2003, Fichman et al., 2014, Gawer and Cusumano, 2014b, Hagiu and Wright, 2015, Karimi and Walter, 2015, Ondrus et al., 2015, Hein et al., 2020). For instance, Apple shaped its iOS mobile operating system into a digital platform to encourage the creation of complementary innovations (e.g. applications) and coordinate interactions between heterogeneous groups of actors, such as smartphone users and application developers (Kenney and Pon, 2011).

Digital platforms and their ecosystems of key actors continue to play an important role in the contemporary economy, and this area has received considerable scholarly attention (Chesbrough, 2017, Eisenmann, 2008a, Gawer, 2014, Hagiu and Wright, 2015, Hein et al., 2020, De Reuver et al., 2018). Since the majority of services and products in business-to-consumer (B2C) markets are built on digital platforms, for example, mobile applications for the Android mobile operating system, cases that are often cited and discussed in research are B2C platforms (i.e., a platform connects organisations with individuals) (Loux et al., 2020, Hein et al., 2019). Yet, in recent years, digital platforms have become increasingly popular in business-to-business (B2B) markets (Loux et al., 2020). Although value co-creation with a B2B

platform-based ecosystem is a common practice, research in this area is still limited (Loux et al., 2020, Hein et al., 2019).

There are differences between the characteristics of users of B2C and B2B platforms (Hoejmose et al., 2012, Rauyruen and Miller, 2007, Loux et al., 2020, Hein et al., 2019). Users of B2B platforms usually act as legal organisations, purchasing large volumes of products and services by using a platform for business-critical processes and leveraging the close buyer-seller relationships (Hoejmose et al., 2012, Lee and Park, 2008, Rauyruen and Miller, 2007, Loux et al., 2020, Hein et al., 2019). Thus, in such situations, the quality of platform offerings can influence B2B platform users' adoption decisions (Mcintyre and Srinivasan, 2017, Zhu and Iansiti, 2012). Accordingly, fostering value co-creation in a B2B platform-based ecosystem is more complex than that in its B2C counterpart (Loux et al., 2020, Hein et al., 2019) and constitutes challenges to B2B platform owners (Hein et al., 2019, Loux et al., 2020).

Existing research on B2B platform-based ecosystems has mainly explored a platform owner's actions by stressing the self-reinforcing effects of networks (Blaschke et al., 2018, Hein et al., 2019, Loux et al., 2020), but it has neglected to discuss how B2B platform owners make their platform ecosystem 'sustainable and dynamic' by co-creating new values with their platform acceptors (complementors). When considering the impact of platform quality on platform performance (Mcintyre and Srinivasan, 2017, Zhu and Iansiti, 2012), it is vital for B2B platform owners to improve the quality of platform offerings to address the two most important challenges in platform - attracting more complementors for higher network effect and identifying new opportunities for sustainable growth. OI stresses the purposive use of internal and external knowledge not only for the focal firm but also for its partners (Enkel et al., 2009, Chesbrough and Brunswicker, 2014, Ahn et al., 2018), so this interactive cooperation can create new synergy necessary for the enhancement of platform offering. In this context, OI can provide this research a useful analytical lens to explore how a B2B platform owner

considers the market dynamics in orchestrating its value co-creation on the platform. To explore this issue, a case study approach is employed for collecting and analysing the research data. Three case studies, namely, International Business Machines (IBM) Corporation, Taiwan Semiconductor Manufacturing Corporation (TSMC), and CNT Tech, are undertaken.

The remainder of this paper is organised as follows. In section 2, a review of existing research on digital platforms and open innovation is presented to clarify the main concepts of this research and identify the research gap. Section 3 elaborates the details of the research methodology and design adopted. Section 4 provides a description of the case evidence. Finally, discussions and conclusions are presented in section 5.

2. Background Literature

2.1. Digital Platforms and Ecosystems

A large number of high-tech products and services are built on digital platforms, such as Uber and Airbnb (De Reuver et al., 2018, Hein et al., 2020, Nylén and Holmström, 2015, Tilson et al., 2010). A digital platform refers to a core product, service, or technology that is built on technical infrastructure and entails a modular architecture that facilitates interactions between multiple groups of actors and complementary innovations (Gawer and Cusumano, 2014b, Ondrus et al., 2015, Tiwana et al., 2010, Tsai, 2018, Tura et al., 2018). Such technical infrastructure plays a key role in the design of digital platforms and consists of basic information technologies and organisational arrangements that underpin the platform's functioning (Tilson et al., 2010).

A digital platform-based ecosystem usually comprises a platform owner that uses governance mechanisms as well as boundary resources to underpin value co-creation on its digital platform with autonomous complementors (Constantinides et al., 2018, Gawer and

Cusumano, 2014a, Hein et al., 2020, Hein et al., 2019, Kapoor, 2018, Mcintyre and Srinivasan, 2017, Tiwana, 2015). The premise of a digital platform-based ecosystem is the presence of complementarities and interdependencies between actors (Kapoor, 2018). Within the ecosystem, actors on one side of the platform play the role of complementors and use boundary resources, including software development kits (SDKs), helpdesks, and consulting support, provided by platform owners to develop related complementary innovations (Foerderer et al., 2019, Hein et al., 2020). The creation of complementary innovations potentially leads to the generation of network effects (Cusumano, 2010, Gawer and Cusumano, 2014b, Hagiu and Yoffie, 2009, Meyer and Seliger, 1998, Ondrus et al., 2015). Such network effects can support a platform owner in locking its platform users when they highly value the number of existing platform users and the variety of complementary products, services, and technologies available (Cennamo and Santalo, 2013, Cusumano, 2010). For example, Microsoft developed its Windows operating system into a digital platform and provided third-party developers (viewed as complementors) with boundary resources to build on related software and applications (Cusumano, 2010). These applications increased users' willingness to adopt personal computers and notebooks powered by the Windows operating system.

The chicken-and-egg problem is a key challenge for a platform owner because the platform needs both complementors and users on board to succeed and ensure a good value proposition (Hein et al., 2020, Loux et al., 2020, Mcintyre and Srinivasan, 2017). To maintain the platform-based ecosystem's health, the owner has to implement appropriate platform strategies, focusing on two dimensions: architecture and governance (Gawer and Cusumano, 2014b, Tura et al., 2018, Constantinides et al., 2018, Eisenmann, 2008b, Tiwana, 2015).

First, architecture is regarded as a conceptual blueprint that illustrates how a platform-based ecosystem comprising a variety of key actors is built on a relatively stable digital platform (Helfat and Raubitschek, 2018, Tiwana et al., 2010, Tura et al., 2018, Eisenmann, 2008b).

Researchers separate the architecture of digital platforms into three types: transaction (when a platform facilitates transactions among platform users), innovation (when a platform encourages innovation by complementors), and integrated (when a platform supports both transactions and innovation) (Evans and Gawer, 2016, Hein et al., 2020).

Second, governance refers to control mechanisms, platform rules, and boundary resources employed by a platform owner to encourage desirable behaviours of complementors and manage the value co-creation process within the platform-based ecosystem (Constantinides et al., 2018, Song et al., 2018). For managing the knowledge boundaries of a digital platform, a platform owner can increase the level of platform openness by enabling the ecosystem participants to co-create value and provide various resources at the boundary, including information portals, toolkits, documentation, helpdesks, and alignment workshops (Benlian et al., 2015, Foerderer et al., 2019, Parker and Van Alstyne, 2018, Ghazawneh and Henfridsson, 2013, Hein et al., 2019). If a platform owner does not address and manage these knowledge boundaries effectively, the success of the platform could be endangered (Benlian et al., 2015, Foerderer et al., 2019, Parker and Van Alstyne, 2018). In this context, boundary resources can be viewed as governance mechanisms representing standardised processes that improve flexibilities between various actors of the ecosystem and the digital platform (Hein et al., 2020, Foerderer et al., 2019). In addition to the use of boundary resources, the literature suggests two main control mechanisms, that is, input and output controls, which can help platform owners further manage complementary innovations (Tiwana, 2015, Ghazawneh and Henfridsson, 2013, Eisenmann, 2008b). The former is defined as screening in which extensions are allowed in the platform-based ecosystem, and the latter refers to the verification of complementary innovations (Gawer and Cusumano, 2014b, Ondrus et al., 2015, Tiwana et al., 2010, Tsai, 2018, Tura et al., 2018, Tiwana, 2015).

Digital platforms have received acceptance in the B2B and B2C markets. However, cases that are often used in research are B2C digital platforms (Gawer and Cusumano, 2014b, Karimi and Walter, 2015, Tura et al., 2018, Loux et al., 2020). Studies on the orchestration of B2B platform-based ecosystems are limited (Loux et al., 2020, Hein et al., 2019). The B2C digital platforms are closely linked to network effects, and users usually value the variety and number of complementary innovations (Cennamo and Santalo, 2013, Cusumano, 2010, Zhu and Iansiti, 2012). Owing to the presence of network effects, platform competition in B2C markets usually has a winner-take-all (WTA) or winner-take-most outcome (Cennamo and Santalo, 2013, Cusumano, 2010, Zhu and Iansiti, 2012) and the platform with the largest number of users often achieves success (Mcintyre and Srinivasan, 2017). In this context, B2C platform owners often pursue aggressive strategies (called WTA strategies) to expand their installed base of users rapidly to win the platform battle (Cennamo and Santalo, 2013, Cusumano, 2010).

Importantly, fostering value co-creation in B2B platform ecosystem is more complex (Loux et al., 2020, Hein et al., 2019), because there are two unique features of B2B platform – sustainable expansion and new opportunity seeking. First, like B2C platform, to survive in fierce competition, B2B platform must achieve sustainable growth, i.e., it must attract as many complementor (platform users) as possible to be a clear dominant design in the market. However, the characteristics of B2B platform users are distinct from those of B2C platform users (Hoejmose et al., 2012, Rauyruen and Miller, 2007, Hein et al., 2019, Loux et al., 2020). In fact, B2B platform users engage as legal organisations and use the platform for business-critical processes (Hein et al., 2019, Loux et al., 2020). Put differently, B2B platform users are not end-users but (in most cases) B2C platform firms that must create new additional values for their own businesses. In this situation, platform quality can influence the adoption decisions of B2B platform users (Mcintyre and Srinivasan, 2017, Zhu and Iansiti, 2012). WTA strategies

(rapidly increasing the variety of complementary innovations) cannot be universally beneficial to B2B platform owners, who must observe the requirements of B2B platform users in implementing platform strategies. Because the necessary values to be created are different from B2B platform users and users, B2B platform offering must be diversified and adapted to be fitted to each user's business target. Second, no matter how successful a platform may be, it must evolve to remain competitive in fast changing business environment (West, 2003). Particularly, when a market is saturated, a platform firm must consider the market diversification. B2C platform firms may easily sense this necessity by monitoring end-users. However, this task is not easy for B2B platform firms in that they are in an upstream of value-chain, which making them sluggish.

2.2. Open Innovation

OI (open innovation), a term suggested by Chesbrough (2003), emphasises knowledge swap through permeable organisational boundaries; this unique feature has extended its practical applications to various industries, non-profit organisations, and even platforms (Ahn et al., 2019). Although there are many classifications of OI modes, OI can be categorised into in-bound and out-bound according to the direction of knowledge flow. For example, if a B2B platform reveals its core knowledge to attract more platform users, this would be out-bound OI in that new value is created by external partners (i.e., platform users) outside the focal B2B platform firm. For a successful dominant logic, a platform owner must meet an optimised balance between appropriability and adoption (Gawer and Cusumano, 2014b, Ondrus et al., 2015, West, 2003). A platform owner must have a clear dominant design; however, at the same time, it must protect the core part of the technology secret to maximise economic benefits and not lose its influence and leadership in the platform-based ecosystem (West, 2003, Hein et al., 2019, Loux et al., 2020, Henkel, 2006). When a platform firm use out-bound OI, it can examine

the potential of disruptive technology via external partners or consolidate its platform dominance by embracing them. The virtue of out-bound OI lies in the fact that it expands the boundary of both knowledge and network by identifying and seizing external opportunity, and, because of this broader view, out-bound OI would be well related to the sustainable expansion and new opportunity seeking. OI can help B2B platform owners address this problem while creating synergy in the context of B2B platform-based ecosystems in three parts.

First, out-bound OI not only helps firms to bring ideas to markets by sharing knowledge with external partners but also supports both value co-creation processes and market exploitation (Enkel et al., 2009, Henkel, 2006, Henkel et al., 2013). Moreover, it can ease the process through which a platform owner attracts external complementors. Some scholars explored various co-creation processes in the B2B platform-based ecosystem (Blaschke et al., 2018, Hein et al., 2019, Loux et al., 2020). They mainly investigated platform owners' actions in facilitating knowledge outflows across organisational boundaries to support value co-creation processes (Blaschke et al., 2018, Hein et al., 2019, Loux et al., 2020). If the concept of digital platforms is combined with out-bound OI in implementation, this will not only accelerate the process of critical mass formation but also facilitate value co-creation in the platform ecosystem. As mentioned in the preceding sections, the success of a digital platform depends on whether a platform owner can gather a sufficient number of complementors and users, thus granting the owner a dominant position in the market (especially, B2C platforms) (Ondrus et al., 2015). Although a platform owner shares boundary resources with complementors, this may not be adequate for establishing a sustainable platform. To create a sustained competitive advantage, a platform owner must provide the necessary resources and create new pathways for value co-creation considering the market dynamics, and this offering is consistent with the essence of out-bound OI aimed at mutual benefits (Chesbrough and Brunswicker, 2014, Parker and Van Alstyne, 2018, Enkel et al., 2009). The concepts of platform and out-bound OI could

be misinterpreted as identical (or similar) for giving priority to knowledge sharing. However, the relationship among organisations in the out-bound OI paradigm is more complex. For instance, B2B platform owners can employ servitisation to coordinate interactions between external complementors and platform users (Hein et al., 2019). However, in addition to the use of knowledge outflows, managing knowledge from complementors is important for enhancing platform offering quality (Tiwana, 2015). In a platform, complementors passively absorb technology; therefore, knowledge flow would be unidirectional. However, if out-bound OI is used in a platform, this integrative utilisation can widen the direction of knowledge flow and make it both interactive and bidirectional (i.e. knowledge outflow and inflow[1]). Given this situation, complementors are no longer passive absorbers, but actively leverage platform owners' knowledge to seek new opportunities and satisfy market dynamics. Out-bound OI expands the boundaries of innovations and the application of a digital platform surpasses its original expectation by supporting market exploitation. This indicates that, as shown in Figure 1, the use of out-bound OI in B2B can be understood as an innovation ecosystem development activity.

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Second, the concepts of a digital platform and out-bound OI offset their weaknesses. To profit from the platform, concealing its essence is imperative; however, value sharing is inevitable to attaining critical mass (West, 2003). To address this paradox of openness, an optimised equilibrium point that simultaneously addresses an appropriation issue and a

[1] Internal knowledge flows from the B2B platform firms to complementors (i.e., out-bound OI). However, to utilises the new value created by complementors, B2B platform firms must react to feedbacks from complementors. Thus, from the perspective of the B2B platform firm, the process is initiated by out-bound OI revealing its internal knowledge, but it is terminated by in-bound OI absorbing upgraded knowledge.

revealing dilemma is critical (Kim and Ahn, 2019). As noted by Laursen and Salter (2006), Laursen and Salter (2014), extreme openness is detrimental not only to innovation performance but also for knowledge appropriation (Henkel, 2006). Admittedly, various appropriation schemes, such as intellectual property (IP), cross-licensing, and informal approaches (e.g. secrecy or complex design), can be used for knowledge protection (Enkel et al., 2009, Henkel, 2006, Henkel et al., 2013). Firms may have to spend substantial resources to develop complicated designs of appropriation strategies. However, a digital platform shares unique architectural knowledge formed by a set of specific subsystems and interfaces (Yang and Jiang, 2006, Hein et al., 2020, Henkel, 2006), and this unique characteristic of a platform offsets the weakness of openness. As businesses in complementors are developed following this unique architectural knowledge, asset co-specialisation occurs between a platform owner and complementors. Thus, when a platform owner opens the innovation process, its adopters (complementors) are locked into the owner's core technology (Gawer and Henderson, 2007). Given this situation, the integration of out-bound OI and platforms results in semi-OI, which establishes a platform owner-centric innovation ecosystem. A certain level of openness is achieved and knowledge flows ambi-directionally (Henkel, 2006), but platform adopters (complementors) remain close to the platform owner owing to their resource co-specialisation. As noted by Di Minin et al. (2010), allowing external partners to utilise internal knowledge can help a firm to identify new application opportunity, while increasing interdependency between the firm and its partner. Although internal knowledge becomes open, the knowledge remains inside the platform ecosystem due to symbiotic relationship via the platform. Consequently, knowledge retention is achieved from the perspective of B2B platform firm, which address the paradox of openness (Laursen and Salter, 2014) and the difficult equilibrium of platform appropriability (West, 2003). This knowledge retention diminishes the dilemma of openness, while enabling the platform to expand its influential boundary.

Third, out-bound OI can contribute towards establishing a vibrant innovative ecosystem through platform diversification. If a platform is opened, adopters (complementors) can enjoy the mutual benefits of collective learning (Von Hippel and Von Krogh, 2006). Accordingly, rapid performance enhancement would be possible as external partners can contribute to the development of new products/services (Allen, 1983, Nuvolari, 2004). When a platform owner deploys out-bound OI to manage knowledge across the organisational boundary, it can capture value from the platform and consolidate the platform's dominance (Enkel et al., 2009, West and Bogers, 2014, West and Gallagher, 2006). The virtue of out-bound OI is that it expands the boundary of both knowledge and networks by identifying and seizing external opportunities (Ahn et al., 2016). By using out-bound OI, a B2B platform owner can conduct an organisational experiment regarding the platform and it can be applied to different business domains. To influence a new market, a B2B platform owner can use complementors to create a new network node in a different market domain. For example, a B2B platform owner can invite or invest in new B2C firms (viewed as complementors). Subsequently, through co-specialisation (i.e. modular knowledge sharing), new complementors can access and exploit a B2B platform owner's technologies in different ways, thus empowering the core firm to tap into the new market with low risks. This platform diversification process mutually benefits both the B2B platform owner and complementors.

Overall, out-bound OI links market exploitation to the process of value co-creation with external partners by managing both knowledge outflows and inflows across organisational boundaries (Enkel et al., 2009, West and Bogers, 2014, West and Gallagher, 2006). The concept of out-bound OI can support the orchestration of B2B platform-based ecosystems and provide an analytical lens to explore the related issue.

3. Data and Methodology

The choice of study methodology is driven by the research objective (Miles and Huberman, 1994). The study focuses on exploring the issue of managing B2B platform-based ecosystems from the perspective of out-bound OI. In this context, this study is exploratory. Considering the complexity, this study follows a qualitative research method and employs a case study approach to clarify the dynamics presented within single settings through an in-depth analysis of a small number of cases (Eisenhardt, 1989, Flyvbjerg, 2006, Thomas, 2011, Easterby-Smith et al., 2012).

3.1. Case Selection and Data Collection

Considering Yin (2009) recommendations, this study uses a multiple holistic design to investigate the out-bound OI actions of each case in fostering value co-creation processes in its B2B platform-based ecosystem. The reasons for case selection are twofold. First, TSMC, IBM, and CNT Tech have developed their businesses in B2B markets (semiconductor manufacturing, cloud computing service, and online food ordering platforms, respectively) and have provided customers with both products and services. Second, these firms have shaped their products and services into B2B digital platforms (connecting organisations with other organisations) and applied out-bound OI for managing their platform-based ecosystems. Analysing three cases of B2B platform deployment provides important insights.

Different sources were used for ensuring data triangulation. Research data were collected from both primary sources (e.g. semi-structured interviews) and secondary sources (e.g. media releases, internal annual reports, external audit reports, and articles from management journals). These documents helped in identifying the case firm's strategic decisions, familiarising with its innovation history, and understanding its technology and platform architecture. The interviews targeted top managers of TSMC, IBM, and CNT Tech.

The selection process considered an interviewee's experience, background, and knowledge to ensure that detailed and useful information could be gathered. As incentive, interviewees were assured anonymity. Furthermore, to structure data collection, a case study protocol was developed. The researcher followed a certain set of questions to conduct semi-structured interviews to ensure a replication logic in gathering primary data, primarily to enhance key aspects such as validity and reliability of the research.

In total, 20 interviews (see Table 1) were conducted with respondents from TSMC, IBM, and CNT Tech for understanding platform implementation in B2B markets. At the outset, interviewees were asked to offer general information about their firms, such as history, organisational structure, and the industry in which they operate. They were queried about out-bound OI actions adopted in orchestrating their platform-based ecosystems. Later, the interview reports were presented to the interviewees for verification. Additionally, given that CNT Tech's chief executive officer (CEO) is experienced in operating start-up accelerating programmes to foster a platform-based ecosystem on a regular basis in his firm and a domestic cable TV, three non-participant observations of the programme were conducted to understand the firm's activities. During these observations, the researcher's understanding of the start-up programme, for example, how CNT Tech used its incubating programme to identify potential partners, improved.

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3.2. Data Analysis Approach

This research deployed within-case and cross-case analysis, consistent with Eisenhardt (1989). Within-case analysis consists of detailed case study write-ups. For drawing insights from each

case study, initial data coding was performed and categorised into actions to architect and control a platform-based ecosystem, including boundary resources and input and/or output controls. The data were then progressed to themes (architecture and governance of a B2B platform-based ecosystem) and dimensions (orchestration of knowledge outflows and inflows across organisational boundaries) to support the cross-case analysis. Therefore, deployment of digital platforms in each case was examined and investigated. Furthermore, cross-case analysis was conducted to identify similarities and differences between the three case studies.

4. Case Illustration

4.1. TSMC

Case Description:

Founded in 1987, TSMC (Taiwan Semiconductor Manufacturing Corporation) was the first dedicated semiconductor foundry in the world (Yang & Jiang, 2006). Focused on strengthening its manufacturing capabilities, TSMC built a variety of production lines to manufacture chips for fabless integrated circuit design companies (B2B firms). The firm's manufacturing services revolutionised the semiconductor industry and provided fabless integrated circuit design firms with capabilities and opportunities to compete with fab-owning integrated circuit design companies such as Intel.

First-movers benefited from a major advantage in the semiconductor manufacturing industry. Therefore, TSMC improved its manufacturing technologies continuously and maintained robust relations with integrated circuit design companies that considered TSMC as a reliable partner. Subsequently, TSMC built a large user base and emerged as a leader in the semiconductor manufacturing industry (viewed as a B2B market).

Owing to increasing competition, TSMC developed its service into a B2B innovation platform (open innovation platform) to encourage the development of complementary innovation. The platform design is described below:

Platform Architecture and Governance:

Taiwan Semiconductor Manufacturing Company's (TSMC) *B2B innovation platform* facilitates the reuse of chip intellectual property (IP). Such chip IP was developed by TSMC's existing business customers (e.g. fabless integrated circuit design firms) and was based on its manufacturing technology. The firm's existing business customers can design and share their chip IP on the platform, which can be licensed to TSMC's existing and potential business customers (licensees).

Interestingly, TSMC's business customers, for example, fabless integrated circuit design firms, value the quality of semiconductor manufacturing services. To improve the quality of platform offerings, TSMC collaborated with its existing business customers (*input control*) and verified the chip IP licensed on its platform to ensure that such IPs can function efficiently using TSMC's manufacturing service (*output control*). Licensees can use the IP on TSMC's B2B platform to create chips and employ TSMC's semiconductor fabrication service to accelerate time-to-market. Furthermore, since designing chips is a complex process (Chesbrough, 2017), TSMC has provided its business customers (integrated circuit design firms) with *boundary resources (e.g. a variety of design tools, process recipes, reference designs, consulting services)* to improve chip design efficiency, ensure the designs function correctly with TSMC manufacturing services, and reduce the risk of redesigning chips.

To conclude, TSMC deployed out-bound OI (by revealing tis internal resource) to connect market dynamics with value co-creation in its platform-based ecosystem. The firm considered its business customers' requirements to carefully manage knowledge outflows (e.g.

using boundary resources) and inflows (e.g. input and output controls) to enhance the quality of its platform offerings.

4.2. IBM

Case Description:

When mainframe computers became popular during the 1960s, IBM decided to build its mainframe computer business (Cortada, 2009). In effect, IBM employed the principle of modularity to create design rules and instructions that determined how different modules of machines work together (Baldwin and Clark, 2003). Consequently, IBM introduced its mainframe computer named System/360 (Edwards, 2011; West, 2003). The System/360 consisted of several core components, including an operating system and a compatible processor that served to increase interoperability between software and hardware components (Bartlett and Spainhower, 2004, Hamilton, 1996, Humphrey, 2002). These core components were viewed as platforms within a firm that enabled several IBM design teams worldwide to develop distinct modules, thus reducing the development costs of both hardware and software (Baldwin and Clark, 2003, Gawer, 2014).

Later, microprocessors stimulated the development of microcomputers, which satisfied user demand for small and low-cost computers (Garnsey et al., 2006, West, 2003). Predictably, microcomputers received considerable attention from end-users and attracted IBM's attention (Garnsey et al., 2006). However, IBM was a late entrant in the microcomputer industry. To accelerate the development of its microcomputers, IBM launched technical specifications to collaborate with its supply chain partners (Garnsey et al., 2006). Some core components, including a microprocessor and an operating system, were outsourced to Intel and Microsoft, respectively (Gawer, 2014, Gawer and Cusumano, 2014b). In 1981, IBM launched

its microcomputer or the personal computer (Bass and Christensen, 2002, Gawer and Phillips, 2013).

The IBM personal computer received wide acceptance for having good upward and backward compatibility. In addition, IBM did not restrict its supply chain partners, that is, Intel and Microsoft, from selling their products to other personal computer clone manufacturers (Gawer and Phillips, 2013). This decision resulted in the growth of IBM's personal computer clone market (Bass and Christensen, 2002). Subsequently, core component manufacturers, for example, Intel and Microsoft, started playing important roles in the personal computer industry. To regain its control over the latter, IBM launched a new computer line called the Personal System/2 (PS/2), which employed proprietary chips and interface standards (Garnsey et al., 2006). Nonetheless, this action only increased the sales of IBM's personal computer clone manufacturers and led to a turning point wherein IBM could no longer control the industry (Gawer and Cusumano, 2014b).

To recover from its losses in the personal computer industry, IBM rebuilt its business model around enterprise services (viewed as a B2B market) and sold its personal computer hardware business to Lenovo (Cusumano, 2011, Edwards, 2011). Since IBM had expertise and experience in business and technology management, it focused on selling not only high-end hardware (e.g. servers) and proprietary applications running on top of Linux but also offered consulting services and strategic solutions to business customers (Samuelson, 2006). Consequently, IBM expanded its market share in the enterprise service industry.

Over the past few years, benefiting from advances in digital technologies, enterprise services that are delivered through the Internet and based on service providers' data centres have become viable; they can be termed as cloud computing services and comprise three parts: infrastructure as a service (IaaS), platform as a service (PaaS), and software as a service (SaaS) (Doelitzscher et al., 2011). IaaS is a basic cloud service, for example, data storage. PaaS is a

category of cloud services where service providers offer a computing platform comprising operating systems, programming languages, servers, and databases. Using such a computing platform, business customers and independent software vendors can design, test, and run their applications without building their own data centres. SaaS refers to business applications delivered as services. Business customers can employ SaaS-based applications that operate on service providers' computing platforms.

Platform Architecture and Governance:

The growth of cloud computing services threatens conventional enterprise service providers, such as IBM. To develop its cloud computing service business, IBM has leveraged its existing data centres worldwide to underpin its services comprising basic cloud services (IaaS), a computing platform (PaaS), and SaaS-based business applications. Additionally, IBM has developed its computing platform into a B2B innovation platform.

Notably, the computing platform serves as a foundation for IBM, its business customers, and independent software vendors to develop SaaS-based business applications. Thus, IBM's business customers can employ these SaaS-based applications by paying a subscription fee. Moreover, these business customers usually use IBM's platform for business-critical activities and prioritise the quality of enterprise services. In this context, considering the characteristics of business customers, IBM has deployed a specific platform design to foster value co-creation processes with its ecosystem participants.

For satisfying business customers' requirements and building an ecosystem around its computing platform, IBM has used *boundary resources* to support the development of SaaS-based business applications. In fact, IBM's computing platform is based on its proprietary data centres and runs on the Linux operating system to create distinctions beyond those of competitors and to improve the security and stability of its cloud computing services. Moreover,

IBM has used *input control* by controlling independent software vendors' access to its computing platform, thereby strengthening the quality of related SaaS-based business applications. In fact, IBM has carefully selected independent software vendors who can provide high-quality business applications and has helped them profit from the SaaS model. These selected independent software vendors can, therefore, develop business applications for IBM's SaaS.

4.3. CNT Tech

Case Description:

CNT Tech is a leading Korean food ordering and delivery platform that was established in 2003 and has 234 employees and 1,200 call centre staff. Since 2013 food ordering and delivery market has been growing with annual growth rate 30%, so this market is estimated over 3 trillion USD with 25 million customers in South Korea. As a food-tech firm, CNT Tech manages orders received via phones, the Internet, and mobile applications using its digital platform. The company's call centre coordinates food delivery orders, and additional data, including information on geographic or brand loyalty points (e.g. supermarket royalty programmes, such as a TESCO club card), are incorporated into the integrated data analysis process to allocate the received orders to local franchise branches.

Targeting franchise restaurants that offer home delivery services (e.g. pizza, Chinese food), CNT Tech provides an integrated ordering platform. This digital platform is considered a B2B transaction platform that connects franchise restaurants with end-users via its platform users. Being in the black-ink balance for thirteen consecutive years, CNT Tech has achieved 97% domestic market share in the food ordering platform industry using the following core technologies.

(1) Communication middleware server (an integrated ordering platform): CNT Tech's core technology transmits all food delivery orders from a call centre and the Internet to a store-side point-of-sales (POS) system quickly, safely, and accurately. The data accumulated through this technology are used for franchise management consulting.

(2) Geographical information system (GIS): CNT Tech has built an electronic map system by computerising addresses and building location information throughout the country. When an order is taken, the system displays location information on 34,000 local franchise restaurants and matches the nearest restaurant to the consumer for accurate and quick delivery.

(3) Call centre: CNT Tech operates its own call centre with the necessary professional staff to support its customers. This call centre, which is the largest in the franchise support service market in the country, has 1,100 customer service representatives (CSRs) as staff.

(4) Big data analysis: CNT Tech can forecast accurate call volume and sales by analysing big data that have accumulated over the past ten years. This technology allows CNT Tech to anticipate the number of orders depending upon time, location weather, and sports events, and the accuracy of this forecasting system is approximately 91%.

(5) Artificial intelligence (AI) customer service representatives (CSRs): CNT Tech provides AI CSRs based on its own voice recognition technology. AI CSRs (such as Apple's 'Siri') handle addresses and menus and support payment with a voice recognition technology.

The above five technologies comprise the core competence of CNT Tech's digital platform. Each technology plays an important role in its smooth operation. As a platform owner, CNT Tech has offered its digital platform to food franchise brands (i.e. B2C firms), such as KFC and Domino's pizza, and has successfully built a platform-based ecosystem involving

B2C firms in the B2B market. CNT Tech has eleven patents related to its core technologies and has twelve trademarks regarding its service.

Platform Architecture and Governance:

With increasing competition in the food ordering platform industry, CNT Tech recognised the need to diversify its digital platform. It actively implemented out-bound OI and emphasised identifying new opportunities beyond the food delivery field. The firm developed its transaction platform into a *B2B innovation platform*. It clarified the *platform architecture* by deploying its own start-up accelerating programme to discover new platform application opportunities.

Sharing its core technologies, CNT Tech has offered *boundary resources* to creative start-ups for value co-creation. Boundary resources include one-on-one customised support, business mentoring, financial support, and software development. Using CNT Tech's five main technologies, these start-ups have created new technological combinations that underpinned CNT Tech in extending its business to different markets. In addition, CNT Tech has implemented *input control* and nurtured over 50 creative start-ups by allowing them to access its software resources and related technologies. The firm has provided these start-ups with business model development consulting services while holding around 8%–12% of their equity on average. In this process, using CNT Tech's technological resources, these start-ups (B2C firms) have secured initial investment and developed their own innovations.

In summary, CNT Tech has deployed out-bound OI to diversify its platform by incorporating B2C firms into its ecosystem. It has successfully used boundary resources and input controls to orchestrate its platform-based ecosystem. The representative examples are listed in Table 2 and show how start-ups have built new technological combinations and subsequently contributed to the development of CNT Tech's competitive advantage.

--- INSERT TABLE 2 AROUND HERE ---

5. Discussion and Conclusion

5.1. Cross-case Analysis

Table 3 summarises the differences and similarities between the value co-creation processes in the three platform-based ecosystems. The case study findings show that these three case firms followed out-bound OI, which comprises two phases, to successfully facilitate value co-creation within their B2B platform-based ecosystems. The out-bound OI has addressed the relationships between market dynamics and the orchestration of organisational knowledge outflows and inflows.

--- INSERT TABLE 3 AROUND HERE ---

First phase of Out-bound OI in Managing a B2B Platform-based Ecosystem

In the first phase, the emphasis is to facilitate organisational knowledge outflows through the use of architectural rules and boundary resources, and this serves to underpin value co-creation processes within the platform-based ecosystem. A B2B platform owner can architect its ecosystem by encouraging multiple heterogeneous groups of external complementors, such as third-party developers, to interact with other platform users and create new value. Furthermore, a B2B platform owner must focus on protecting its own advantages while securing the interests of external complementors who contribute towards value co-creation on its digital platforms. It must provide these complementors with boundary resources, such as software development kits, helpdesks, and consulting services, to support the development of complementary

innovations. Therefore, the scope of a digital platform can be diversified and extended into new domains.

The three case firms referenced here shared main boundary resources (e. g., application development tools, guidelines, and consulting support) with external complementors—existing business customers for TSMC, independent software vendors for IBM, and innovative start-ups for CNT Tech—to accelerate the development of complementary innovations on their digital platforms, for example, SaaS-based business applications in the case of IBM, IC designs in the case of TSMC case, and innovations based on CNT Tech's core technologies. According to a manager in TSMC's Embedded Technology Division:

> *TSMC has launched its Open Innovation Platform, aiming to break down the boundaries between integrated circuit design firms and to build an ecosystem around TSMC's manufacturing services.*

Considering that CNT Tech has used knowledge outflows to diversify its B2B platform, a few creative start-ups, such as 'Medicomes' and 'Super-delivery', have underpinned CNT Tech to discover unidentified platform applications. These start-ups have created new business opportunities for CNT Tech, and its core platform technologies extend into healthcare and local supermarket delivery markets. What "Medicomes" and "Super-delivery" did was the internal resource reallocation and further refinement for CNT Tech. Typically firms do this organisational experiment internally. Yet, instead of this traditional approach, CNT Tech has made platform users (i.e., the start-ups participating in CNT Tech's venture accelerating programme) do this function. This can be an effective strategy, in that CNT Tech can reduce

uncertainty and risks of the platform diversification whilst maintaining access to the benefits of results. Since CNT Tech and related start-ups are loosely coupled by equity and vertical relationships which are established between them, it can retain newly explored knowledge around its B2B platform. Accordingly, CNT Tech has strengthened its competitive advantage by taking advantage of the entrepreneurial characteristics of innovative and creative start-ups to support value co-creation within its B2B platform-based ecosystem.

Second Phase of Out-bound OI in Managing a B2B Platform-based Ecosystem

The second phase steers knowledge inflows from external complementors by governing a B2B platform-based ecosystem to address the market dynamics. This phase plays an important role in orchestrating B2B platform-based ecosystems. From an examination of the three case studies, it appears that business customers (B2B platform users) highly value the stability and quality of platform offerings (including related complementary innovations) and the market dynamics are likely to be quality driven. As explained by the account manager of Software at IBM:

> *Business customers prioritise the quality and security of cloud computing services. In addition, the reliability of SaaS-based business applications is a determinant of successful cloud computing services.*

To meet the requirements of business customers (B2B platform users) and produce positive and favourable network effects within their ecosystems, the three case firms implemented input and/or output controls to improve the quality of their platform offerings. As stated by the account manager of Software, IBM,

We collaborate with independent software vendors, which can provide high quality business solutions and applications and help them profit from the SaaS model. We support these independent software vendors in developing applications on our computing platform.

Governance underpins a B2B platform owner in ensuring that external complementors are aligned with the best interests of its digital platform. Collaborating with selected business customers, TSMC used both input and output controls to verify their innovations to ensure that the chip IP licensed on its platform can function appropriately using TSMC's manufacturing services. Furthermore, IBM employed input control by managing independent software vendors' access to its computing platform, thereby strengthening the quality of related SaaS-based business applications. IBM carefully selected a set of independent software vendors, who can provide high-quality business applications, as partners and helped them profit from the SaaS model. Implementing input control, CNT Tech cooperated with qualified creative start-ups and invited them to participate in its own start-up accelerating programme.

To conclude, out-bound OI can support B2B platform owners by considering the market dynamics in orchestrating the value co-creation processes with their ecosystems. It provides B2B platform owners with two phases to organise knowledge outflows (first phase) and inflows (second phase) across their organisational boundaries to successfully foster their ecosystems.

5.2. Implications

Digital platforms that received acceptance from several industries have an important role in the present economy (Constantinides et al., 2018, Hein et al., 2020, Hein et al., 2019, Scholten and Scholten, 2012). However, existing research on digital platforms has mainly analysed B2C

platforms, and B2B platforms have attracted relatively little attention (Hein et al., 2019, Loux et al., 2020). To address this issue, this research employs the out-bound OI perspective in analysing B2B platform-based ecosystem management. The research outcome indicates that owners of B2B platforms can leverage out-bound OI to facilitate value co-creation on their platforms and the establishment of a platform-centric innovation ecosystem.

The key contributions of this research are threefold. First, this research contributes to the knowledge on digital platforms. The research outcome provides insights into the orchestration of B2B platform-based ecosystems. The literature indicates that there are differences between customers in B2B and B2C markets, and B2B customers usually act as legal organisations and use digital platforms for business-critical activities (Hein et al., 2019, Loux et al., 2020). In this context, the orchestration of B2B platform-based ecosystems is more complex than that of its B2C counterpart (Hein et al., 2019). However, relatively little research has been conducted on the importance of platform quality in influencing platform performance and the orchestration of B2B platform-based ecosystems (Hein et al., 2019, Loux et al., 2020, Mcintyre and Srinivasan, 2017). The findings from the three case studies also offer supportive evidence and show that business customers highly value the quality of platform offerings. In this context, market dynamics are likely to be quality-driven. To satisfy the requirements of business customers, the use of out-bound OI helps B2B platform owners to efficiently manage value co-creation within their ecosystems by deploying the market dynamics in steering knowledge outflows and inflows across their organisational boundaries. Boundary resources and control mechanisms, especially input and output controls (e.g. platform access limitations and complementary innovation verification), are significant in such a value co-creation process and support B2B platform owners in increasing the quality of platform offerings. An increase in the quality of platform-based innovation can enhance business customers' willingness to

adopt the platform. As stated, orchestrating knowledge flows can help B2B platform owners maintain the health of their platform-based ecosystems.

The second contribution is to the relationships between out-bound OI and digital platforms. The integration of digital platforms and out-bound OI enables firms to establish vibrant innovation ecosystems. External complementors further develop the original platform components, and this entrepreneurial extension enhances the innovation content in the ecosystem. For example, in the case of CNT Tech, Map4everyone provided end-users with centric map services based on CNT Tech's GIS solutions. Through its collective intelligence system, new locational information was added by end-users to create a better map. This updated geographic information was re-integrated with CNT Tech's GIS to improve the quality of the original platform. In this process, the start-up harnessed the platform owner's core technology and secured initial financial investment, while the platform owner acquired novelty from the start-up's creation. Owing to the sharing characteristics of OI, technological compatibility between platform owners and complementors is achieved, underpinning the establishment of a symbiotic innovation ecosystem and mutually evolving for achieving a common goal. The relationship between platform owners and ecosystem participants is complementary, and this platform diversification can be interpreted as the evolutionary spiral development of the innovation ecosystem. There are two unique features of B2B platform – sustainable expansion and new opportunity seeking, and our results show that OI can address these challenges by enhancing the quality of platform offering and identifying new applications of platform technologies.

In addition to the above theoretical implications, this study also makes practical contributions by providing B2B firms with guidelines for practicing the digital platform concept. Platform practitioners must consider the impact of market dynamics in managing their

platform-based ecosystems and use boundary resources and input and output controls appropriately to improve platform quality.

5.3 Limitations

Despite interesting findings and implications, this research has certain limitations. First, an explorative case study has enabled us to explore interesting cases. However, to determine whether this use of OI in the platform context can be generalised, it is necessary for future research to investigate several similar B2B cases or conduct a quantitative analysis. Second, this study focuses on the motivation for deploying OI in platform providers, that is, why the (out-bound) OI approach is beneficial to them; however, there are various implementational challenges in the process of revealing platform knowledge and orchestrating platform adopters. For example, deciding an optimal point of knowledge sharing can be an interesting future research topic.

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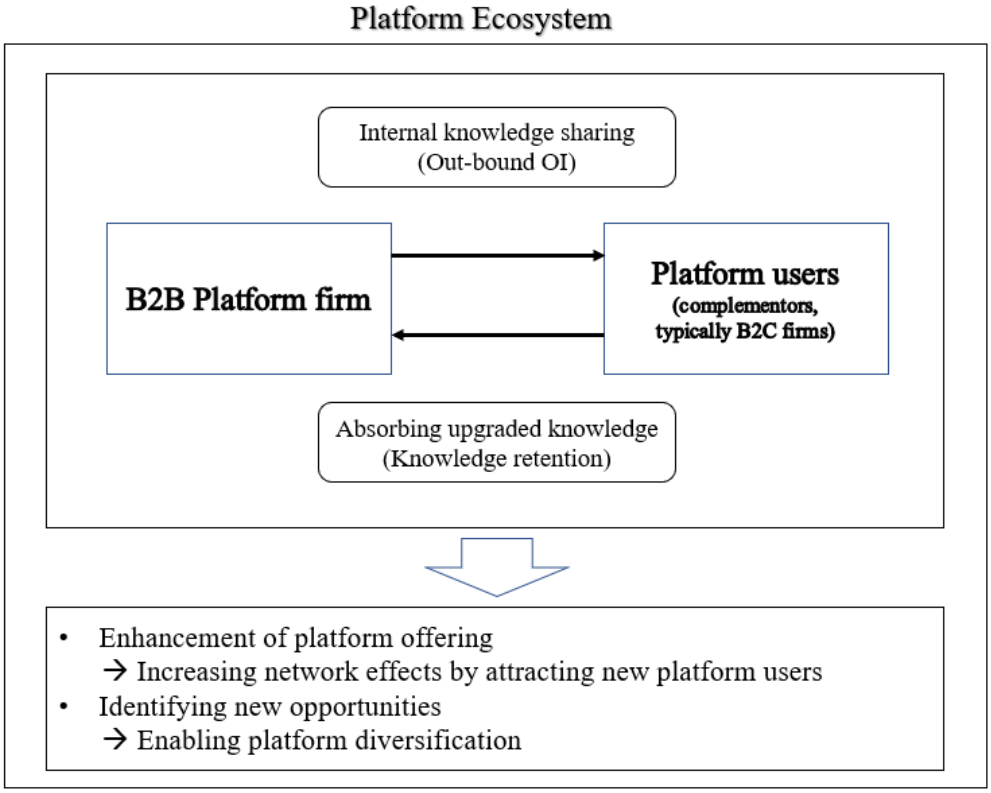

Figure 1 The use of out-bound OI for B2B platform (Source: the authors)

Table 1 List of interviews

Firm	Number of Interviews	Interviewee	Average Duration
CNT Tech	8	CEO	One and a half hours
	2	R&D Manager	One hour
	2	Accelerating Program Manager	One hour
IBM	1	Advisory Client Representative	Two hours
	2	Account Manager of Software	One and a half hours
TSMC	2	Manager of Embedded Technology Division	One and a half hours
	2	Principal Purchasing Specialist	One hour
	1	Operation Supervisor	One hour

Table 2 The representative examples of start-ups supported by CNT Tech

Start-up (Complementors)	**Targeted customers**	**Complementary innovation**	**Consequence**
Muglau	Franchise restaurants	Based on CNT Tech's big data analysis technology, Muglau has provided an inventory automation solution, which helps a franchise restaurant to forecast the necessary amount of food item to be purchased. Mugalu's business is a new domain and it can be easily integrated with CNT Tech's current platform.	Platform offering enhancement
Medicomes	Small and medium-sized hospitals	This firm is a spin-off start-up from CNT Tech. It has provided a small and medium-sized hospital reservation service, which is based on CNT Tech's integrated ordering system, call center and AI CSR. Its platform enables patients to make reservations for small and medium-sized hospitals. CNT tech was able to identify a new possibility of its platform application, and now it is collaborating with Medicomes for this platform diversification.	Platform offering enhancement, Platform diversification
Map4everyone	End-users	This firm is a map service start-up using collective intelligence system based on CNT Tech's GIS solution. New locational information is added by users to make a better map, and this updated information is integrated with CNT Tech's GIS.	Platform offering enhancement
Super-delivery	Local supermarkets	This firm has provided a home delivery service for local supermarkets, and its service is based on CNT Tech's integrated ordering platform and GIS solution.	Platform offering enhancement, Platform diversification
Grid-it	End-users	This firm has provided an eating out platform called What should we eat today. This service is based on CNT Tech's big data analysis technology and GIS solution. Through using the locational information of users and analyzing the users Facebook postings, Grid-it helps users to find restaurants nearby and offers recommendations.	Platform offering enhancement
One-play	End-users	This firm has offered a mobile app, 'Food-taker', which supports users in searching the location, price and menu of take-away (or take-out) restaurants. This service is based on CNT Tech's integrated ordering platform and GIS solution.	Platform offering enhancement

Table 3 Cross-case analysis

Case	TSMC	IBM	CNT Tech
Architecture	Semiconductor manufacturing service (innovation platform)	Cloud computing platform (innovation platform)	Food ordering platform (innovation platform)
Governance (first phase of out-bound OI): Managing knowledge outflows to foster innovation ecosystems	• Leveraging existing customer base to foster ecosystems • Releasing boundary resources, e.g. design tools, reference designs and process recipes, to underpin the chip design process	• Leveraging existing infrastructure and customer base to foster ecosystems • Supporting independent software vendors in profiting from the SaaS model with boundary resources	• Revealing existing platform technologies to foster ecosystem • Supporting and incubating platform adopting start-ups by providing mentoring and accelerating programs (boundary resources)
Governance (second phase of out-bound OI): Managing knowledge inflows from external complementors	• Verifying the IP produced by complementors (output control) • Collaborating with existing business customers (input control)	• Collaborating with selected independent software vendors, which can create high-quality business applications (input control)	• Selecting promising and potential start-ups (B2B/B2C firms) by acquiring their equity and collaborating with them (input control)
Consequence	• Platform offering enhancement	• Platform offering enhancement	• Platform offering enhancement, Platform diversification

Author Biography

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