From Suppliers to Complementors: Motivational Factors for Joining Industrial Internet of Things Platform Ecosystems

Christian Marheine
University of St.Gallen
christian.marheine@unisg.ch

Tobias Pauli
FAU Erlangen-Nürnberg
tobias.pauli@fau.de

Emanuel Marx
FAU Erlangen-Nürnberg
emanuel.marx@fau.de

Andrea Back
University of St.Gallen
andrea.back@unisg.ch

Martin Matzner
FAU Erlangen-Nürnberg
martin.matzner@fau.de

Abstract

Spurred by the internet of things, industry firms are increasingly establishing platforms that animate an ecosystem of external actors to provide complementary offerings. But why do independent firms decide to join these ecosystems and to become complementors? The goal of this study is to disentangle their motivational factors in the context of the industrial internet of things. A theoretical framework is developed a priori based on the knowledge-based view of the firm and complementary logics. The framework is empirically explored using a case study design. Our results indicate that financial, technology, and knowledge gains positively influence the decision of complementors to join the ecosystem. Yet, our interviews reveal relative differences in motivations based on complementors' uncertainty. Our findings contribute to the research on joining nascent digital platform ecosystems from a complementor perspective and the growing stream of research on industrial internet of things platforms.

1. Introduction

Digital platform ecosystems have seen considerable growth during the past years [1], recently especially in the industrial internet of things (IIoT) domain [2]–[4]. IIoT platforms, like technology or innovation platforms [5], [6], shift the locus of innovation from within the firm to an ecosystem of independent third-party firms—so-called complementors. They develop technical artifacts on top of a platform and become innovators for its owner. Prominent examples like Siemens' MindSphere or PTC's ThingWorx empower firms to (1) connect and manage various devices, (2) store and analyze data in a cloud, and (3) develop additional IIoT services, such as predictive maintenance, on top of the platform to serve different industry verticals [7]. But why do firms decide to join these platform ecosystems and to become complementors? Which factors influence their decision? Are there variances in aspirations between different types of complementors or IIoT-specific ones?

In this study, we refer to a firm's decision to join an IIoT platform ecosystem as becoming part of a group of firms (i.e., complementors) that focus parts of their business activities on developing and commercializing technical artifacts associated and compatible with the platform as the core technology [8], [9]. Complementors leverage the platform by increasing technological variety that, in turn, serves the value propositions of others and raises technology adoption [1], [10], [11].

So far, prior information systems (IS) literature has mainly examined the impact joining had on the firm performance of complementors with proxies like sales [9], [12], [13]. If these effects studied equal the expectations complementors had before joining, they offer good indications on the motivational factors that caused their decision to join a priori. Accordingly, most studies have reported that gaining access to the platform's customer base is the strongest incentive to join [9], [14], [15].

However, we see three gaps that make it worthwhile to conduct this research. First, scholars have not provided many insights from the complementors' perspective [16]. Second, most studies focus on complementors that are essentially software developers (e.g., [9], [17]). Although this type of complementor is often found in consumer platforms, it does not draw the full picture in complex domains such as the IIoT. In the latter, typical complementor roles involve manufacturing, connectivity, data analytics, and software providers [18]. We thus consider the IIoT domain as an interesting domain to learn more about the characteristics of complementors and platforms hoping that these insights may contribute to our innovation platform knowledge in general [5]. Third, while prior work has explored complementors' choice of specific platform ecosystems [11], we take a step back in this paper to uncover firms' motivational factors for becoming complementors in the first place.

URI: https://hdl.handle.net/10125/71341
978-0-9981331-4-0

Additionally, given the nascent character of the domain [2], [4], we are interested in the effect of uncertainty when firms extend or switch their business model from supplier to complementor. Thus, as an in-depth extension of a previous study [11], this article addresses the following research question: *Why do firms join IIoT platform ecosystems and how does uncertainty in the IIoT domain affect their decision?*

To address this research question, we analyze the IIoT platform ecosystem of a multinational German automation technology firm. We conducted 18 interviews with both platform managers and complementors who recently decided to join the platform ecosystem. We found evidence for all three proposed incentives that explained the complementors' motives to join an IIoT platform ecosystem: (1) financial, (2) technology, and (3) knowledge gain. In addition, we examine relative differences in complementors' uncertainty to join functioning as a moderator of our proposed incentives. Our findings contribute to the literature on platform ecosystems in the IIoT domain by highlighting that while all complementors are attracted by the proposed incentives, they are weighted differently depending on complementor-specific factors. We thus recommend platform managers to address these differences in their governance practice.

The remainder of this paper is structured as follows: In section 2, we introduce our research model, present the theory, and develop our propositions. The method is described in section 3. Section 4 presents our findings. We then discuss our findings in section 5 and conclude with the study's limitations and avenues for future research in section 6.

2. Theoretical Background

The theoretical framework of this study is built on prior findings on the commercial interest in platform ecosystems (financial gain) [9], [13], the boundary resources theory (technology gain) [4], [19], and the knowledge-based view of the firm (knowledge gain) [20], [21]. In addition, the theoretical model includes complementors' uncertainty in their joining decision as the IIoT domain is considered an uncertain environment [22]. In Figure 1, our model is illustrated.

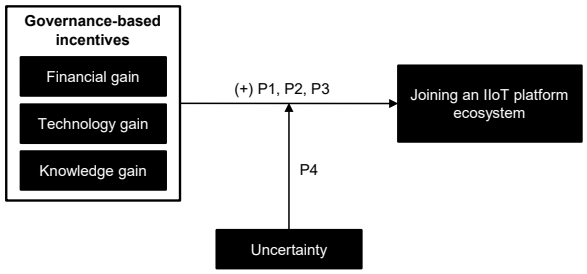

Figure 1: Theoretical model

2.1. Joining IIoT Platform Ecosystems

We conceptualize an *IIoT platform ecosystem*, a close relative of a digital platform [1], [23] and business ecosystem [24], as a corporate network that is centered around an industrial firm's digital platform [25]–[27]. Participating firms can develop and exchange technical artifacts via the platform and thus add functionality in the form of peripheral modules [28]–[30]. These modules include generic functional specifications and can be customized to meet the needs of various industrial end-customers, e.g., to enrich IIoT data with data of different information systems [3], [4], [18]. To theorize why complementors decide to join IIoT platform ecosystems and what factors might influence an objective decision, we began our reasoning by looking at prior literature—literature that examined not just platforms in the IIoT domain [11], but in all domains related to digital platforms, such as mobile devices (e.g., [31]) or enterprise software (e.g., [9]). Here, we studied both papers focusing on the complementor as well as the platform owner perspective. The latter was helping us to grasp the governance decisions made by platform owners, which in turn, establish the incentives for complementors to join [8], [9], [18]. We define *platform governance* as the rules and regulations designed by the platform owner that stipulate complementors' development and commercialization opportunities [19], [32]. These incentives influence the "yes or no decision" of complementors. In general, governance mechanisms can be classified into architectural and relational ones [33]. While architectural mechanisms target the platform's properties and functionalities, such as application programming interfaces (APIs) or software development kits (SDKs) [29], relational mechanisms focus on the alignment and intensity of ties between vendors and partners [7], [12]. For example, Apple's success in attracting millions of third-party developers is enabled through its architectural and relational governance decisions it has made. Apple built a large user community for its well-designed products like the iPhone (financial gain), created a platform architecture that allows third-party developers to develop complementary iOS apps (technology gain) and managed the relations and learning journeys of its third-party developers with mechanisms like its Worldwide Developer Conference (knowledge gain).

2.2. Commercial Interest

In general, we assume that technology does not exist independent from commercial interests. Accordingly, our theoretical model acknowledges that all complementors that are thinking about joining an IIoT platform ecosystem seek to profit from their (future) technological artifacts and to access a network of firms that

have adopted the platform (cf. [13]). As networks, platform ecosystems are characterized by firms of complementary strengths, trust, and interdependence [26], [34]. In (growing) networks, the joining decision is often motivated by the financial gain that comes with it, as has been shown in prior studies. For example, in studies of the enterprise software domain, Kude et al. [35] have explored how partner managers leveraged their complementors' business opportunities while balancing against inflating coordination costs. Moreover, scholars found that joining SAP's platform ecosystem increased complementors' sales and the likelihood of an initial public offering [9], [14]. In addition, researchers found that the decision to join is mainly advantageous to demonstrate compatibility with the platform in large user networks. This way, complementors can exploit a large installed base, again increasing sales [15]. While the IIoT experiences limited scalability in terms of numbers of users yet [2], firms can profit from heterogeneous industry verticals with little competition. Heterogeneity also enables complementors to project an IIoT solution to other fields or to leverage value capturing based on the number of connected devices (or transactions) rather than users [11]. Thus, the first proposition is put forth.

> **P1:** *Financial gain is a significant incentive that fosters a complementor's decision to join an IIoT platform ecosystem.*

2.3. Boundary Resources

As mentioned before, platform research has coined the concept of *boundary resources* as the technical and social software-based tools a platform provides to its users [19], [36]. They characterize the arms-length relationship between the platform and its ecosystem through the use of SDKs or APIs. Boundary resources seek to support the development endeavors of complementors. During the process of development and based on other users, that interact with them, they can evolve through the process of distributed tuning [31]. "The boundary resources can enhance the scope and diversity of a platform" [4, p. 506] through the process of resourcing like in the case when Siemens introduced Mendix, a low-code tool, to lower the entry barriers for app-developing complementors [3]. The process of securing helps the platform owner to reinforce control over the services [19]. Thus, boundary resources influence the potential scope and scale of innovation by third-parties. Accordingly, the likelihood of firms to contribute to a platform rises with its utility, i.e., how popular and expandable is the platform, how easy is it to work with, and how many users have adopted it? Taken together, complementors require a stable core technology (platform), resources to utilize them (boundary resources), and various actors who bring in individual domain-knowledge and innovation capabilities (ecosystem) that foster the speed of device integration, data analytics or software development (value cocreation) [7], [29]. This technology-related observation leads to the second proposition.

> **P2:** *Technology gain is a significant incentive that fosters a complementor's decision to join an IIoT platform ecosystem.*

Recent research analyzed knowledge boundaries in enterprise software platforms [20]. While this study addresses the question of how a platform owner can design knowledge boundaries, it remains unclear how a platform ecosystem's extent of knowledge influences the decision of complementors to join.

2.4. Knowledge-Based View of the Firm

The knowledge-based view (KBV) of the firm is a theory that originated from its predecessor—the resource-based view (RBV) [21]. While the RBV considers resources as the critical input in production and as the primary source of value and competitive advantage [37], the KBV assigns this role to knowledge [21]. The KBV proposes that each firm is defined by its unique set of human resources and their respective knowledge. Differences between firms stem from knowledge asymmetries and their "relative efficiency of knowledge utilization" [21, p. 119]. This includes the knowledge transferring and integration capabilities of a firm. In domains like the IIoT, where much customer-specific knowledge is needed to perform innovation or service creation tasks, complementors decide for those platform ecosystems that offer the best opportunities to learn and absorb knowledge that will eventually result in complementary offerings to the platform and commercial success. Since IIoT complementors have different levels of experience (e.g., data analytics start-up versus long-term supplier), their ability to absorb customer or industry-specific knowledge likely varies—a factor we account for in our theoretical model. Accordingly, the following effect is proposed.

> **P3:** *Knowledge gain is a significant incentive that fosters a complementor's decision to join an IIoT platform ecosystem.*

2.5. Impact of Uncertainty in the IIoT Domain

A complementor's decision to join an IIoT platform ecosystem, as compared to consumer platforms, brings about unique challenges related to uncertainty [22]. Although previous studies have argued that the uncertainty

construct is elusive [38], scholars still resort to it to emphasize the idiosyncratic nature of decision making in an uncertain environment [27], [39]. The IIoT represents a nascent and uncertain domain, that is, scholars have found that IIoT platforms and "the ecosystem is uncertain and difficult to predict" [22, p. 11], e.g., what types of complementing partners are already part of the ecosystem, what and whom do they know, how strongly are they tied to the platform owner, and how will the platform evolve.

We structure our reasoning for the impact of uncertainty on a complementor's decision to join using the tripartite framework of Lusch and Nambisan [27], i.e., ecosystem, platform, and value cocreation. First, as the firms in IIoT ecosystems have different value propositions (e.g., manufacturing, consulting, analytics) and operate in diverse verticals (e.g., agriculture, chemical engineering, automotive), profiting from knowledge sharing and cocreation projects is uncertain (**ecosystem**) [7]. Second, complementors may be uncertain whether an IIoT platform is generic enough to be compatible with a broad range of hardware (e.g., sensors, machines) and software (e.g., communication protocols, enterprise systems) and specific enough to bear a value for its customers' verticals [7]. Platform uncertainty may also depend on the degree of complementarity (e.g., unique or supermodular) [25] or trust in its longevity (**platform**). Third, value cocreation and capture are uncertain in the IIoT because of the diversity of industries and heterogeneity of customers and devices, which requires complementors to have the appropriate domain know-how and the capabilities to implement end-to-end (E2E) solutions with different integration, security, and reliability requirements (**value cocreation**) [2], [4], [7]. Accordingly, the following moderating impact is proposed.

> **P4:** *The positive impact of financial, technology, and knowledge gain on a complementor's decision to join an IIoT platform ecosystem is moderated by the degree of uncertainty—high degrees decrease and low degrees increase the decision to join.*

3. Method

For scrutinizing the research framework on joining an IIoT platform ecosystem, a case study approach was chosen [40], [41]. This approach seemed to be particularly appropriate for answering our main research question on how and why firms decide to join these ecosystems and to become complementors [40], [42]. The utilization of the case research methodology follows a widely recognized positivist research approach [42], [43]. It seeks to provide valuable insights into proposed interactions [42]. Instead of testing our propositions with a survey-based method, we treat each complementor's incentives to join as a separate test (or small case) of the theoretical model [40]. Comparing previously developed propositions against the empirical results will increase generalizability through a replication logic [40]. Since the constructs, such as technology and knowledge gain as well as uncertainty, would have been difficult to access quantitatively, the empirical case study approach seemed appropriate for examining our theoretical model. Moreover, the qualitative approach allowed us to explore how the positive impact of incentives provided by the platform owner (i.e., financial, technology, and knowledge gain) on the complementors' decision to join will be moderated by the level of complementors' uncertainty. Adding this exploratory view to our positivist case study helped us in staying flexible and challenge or add constructs as the field of IIoT platform ecosystems is still emerging (cf. [44]).

3.1. Sampling and Data Collection

We pursued a purposeful case selection and (complementor) sampling strategy to stay in line with our research objective [42], [43]. The research employs a case study design in which the unit of analysis is a single IIoT platform ecosystem. Our case is an internationally operating industrial automation firm with three years of experience as an IIoT platform and ecosystem provider. For reasons of anonymity, we name the case firm AutoCorp and its IIoT platform JOIN. AutoCorp tapped into the IIoT platform business in 2017 with its platform JOIN. Its major business, among other things, is to provide products and services for factory automation. AutoCorp intends to connect all industrial things (e.g., machines, controllers, sensors) to JOIN to exploit and leverage the vast amounts of data for the optimization of manufacturing processes as well as other industry verticals. Today, JOIN does not only serve as central cloud storage for machinery data but as an industrial operating system (or innovation platform) that serves complementors as the basis to develop and commercialize their additional services and products. By interviewing complementors that have already decided to join JOIN, we control for potential bias due to the single research site.

In addition to three partner managers of AutoCorp (cf. [45]), we collected 15 semi-structured interviews with complementors between the end of 2018 and 2019 (cf. [11]) (see Table 1). While the partner manager interviews exposed the key incentives established by the platform owner, the complementor interviews queried the fit between platform engagement and their current business model as well as anticipated business model innovations. As a result, we could examine if the platform owners' incentives mapped to the complementors' motives to join their platform ecosystem. Both median and

average of our interviews were at approximately 37 minutes. Length ranged from around 20 to 60 minutes. The interviews were based on an interview guideline including questions about general business information as well as questions regarding the constructs of our theoretical framework (cf. [11]). We interviewed partner managers (including "head of" or "vice president"), sales managers, project managers, or executive managers (e.g., CEO) of firms with various business backgrounds. A typical complementor role is *consulting,* which in most cases is connected with a software development role. Based on the interviews, we learned that consulting is an enabler for both customer-specific software projects and for developing generic applications. We refer to a *data analytics* role when firms integrate technologies like artificial intelligence (AI), blockchain, or security in the platform. *Device providers* have a focus on (producing and) distributing hardware components to clients. *Connectivity* partners provide both hardware and software to connect industrial customers' assets to the platform. Lastly, *industry service* providers are industry experts, i.e., they focus their value proposition on automation technology in a specific industry, such as automotive.

Table 1: Overview of interview data

ID	Firm size	Year joined	Partner main role	Interviewee	Minutes
PO A	Large	2017	N.A.	Partner Manager	41
PO B	Large	2017	N.A.	Partner Manager	60
PO C	Large	2017	N.A.	Partner Manager	47
CO A	Large	2018	Connectivity	Sales Manager	29
CO B	Large	2018	Consulting	Project Manager	26
CO C	Large	2019	Consulting	Executive Manager	37
CO D	Large	2017	Consulting	Sales Manager	49
CO E	Large	2017	Consulting	Executive Manager	21
CO F	Large	2018	Device provider	Sales Manager	42
CO G	Medium	2018	Industry service	Analytics Manager	35
CO H	Medium	2018	Industry service	Managing Director	38
CO I	Medium	2018	Data analytics	Partner Manager	37
CO J	Small	2019	Connectivity	Partner Manager	43
CO K	Small	2018	Consulting	Managing Director	21
CO L	Small	2018	Data analytics	Partner Manager	30
CO M	Small	2018	Data analytics	CEO and Co-Founder	29
CO N	Small	2019	Data analytics	Manager and Founder	45
CO O	Small	2018	Data analytics	Manager and Founder	43

Note: The table describes the empirical sample of our interview study (cf. [11]). PO stands for platform owner. CO stands for complementor. Firm size is coded based on the number of employees (small<50, medium<250, otherwise large).

3.2. Data Analysis

All 18 interviews were recorded and transcribed. The transcripts were structured and coded using the software Atlas.ti. The coding procedure was done as follows: First, the second and third author read and coded the interview transcripts by identifying text passages that included information about the constructs of the theoretical model. In addition, uncertainty-related constructs, such as "platform survival" and "customer-centricity" emerged in the process of data collection and analysis. They represent additional IIoT-specific characteristics that we explored in the data. Following the coding by the second and third author, the first author likewise coded the transcripts. After that, the codes were examined to agree on a final code-matrix that was used for the data analysis. To increase internal validity, we not only performed a pattern matching between our theoretical constructs and the interviewees' statements but also by examining statements that by themselves included causal linkages [41]. Table 2 summarizes the constructs we examined based on our research model.

Table 2: Incentives for complementors to join

Construct	Description and conceptual source
Financial gain	The extent to which a firm can benefit from selling its products and/or services in an IIoT platform ecosystem [9].
Technology gain	The extent to which a firm can benefit from utilizing the platform and its boundary resources in an IIoT platform ecosystem [19].
Knowledge gain	The extent to which a firm can benefit from absorbing the information and competencies of other actors in an IIoT platform ecosystem [20].
Uncertainty	The extent to which a firm is uncertain about the sustained benefits of an IIoT platform ecosystem on the ecosystem, platform, and value cocreation level. [27].

4. Results

A first look in the case data revealed that all three incentives proposed have positively influenced the interviewed complementors' decisions to join AutoCorp's platform. Next, we examine Propositions 1 to 3.

4.1. Explaining the Decision to Join an IIoT Platform Ecosystem

Financial gain. Our data clearly indicates that all complementors decided to join AutoCorp's JOIN platform to access new customers and to benefit financially (Proposition 1). In the case of AutoCorp, its brand image, market position, industrial anchorage, and continuous leadership in automation technology have mainly attracted complementors of all kinds. Many firms mentioned AutoCorp's superb global brand image and large customer base, which has its automation devices in use, as the most dominant factor to join.

"We chose JOIN because of AutoCorp's footprint worldwide. We got access to customers which we would not have gotten because of our small size, but JOIN was the enabler."—CO L

In addition, many firms saw a chance to develop a new service-based business model—ranging from hardware-as-a-service, consulting, and selling generic apps via JOIN's app store to developing, deploying, and managing end-to-end IIoT solutions.

"JOIN changes our business model in terms of projects, because before we were selling apps directly to the customer. Now, with the JOIN partnership, we are part of a huge ecosystem selling apps via the platform. We are also working with our partner manager for new go-to-market strategies."—CO I

Furthermore, all interviews indicated that the IIoT is very customer-driven. If customers decided for JOIN, complementors naturally saw a financial gain in following their lead and scaling their business too.

"We chose JOIN as we can scale much easier. If we develop a product for a customer and this customer uses JOIN already and the customers of our customer also rely on JOIN, it is really easy to get the data available. When JOIN becomes the standard in the industry, it makes scaling really easy for us."—CO M

Our data also indicates that a few larger firms have extended their partner-role from being a supplier only to becoming a complementor. While this transformation is already reflected in their desire to profit from new business models and innovation, the finding emphasizes the importance of prior business relationships as stated by some larger firms. Thus, business relationships denote a strong motivator for firms to join.

Technology gain. We also found evidence for the technology gain incentive (Proposition 2). To accelerate the value capture process from joining a platform, complementors must be able to develop and commercialize their value offerings against the costs of affiliating with it. This value capture potential depends on a platform's technological maturity. As a leader in automation technology, AutoCorp develops, sells, and services many of its controller devices. In addition to its industrial expertise, AutoCorp has built a solid software portfolio on top of its industrial product portfolio. On that basis, complementors can focus on developing further offerings without having to set up their own infrastructure.

"Basically, the main value in this cooperation is for us the connectivity, availability, and security of the data which AutoCorp brings to our partnership. It is a strong enabler to jumpstart training algorithms."—CO I

Yet, few complementors also mentioned technological drawbacks that were connected with the flow of data, only going to the cloud and not back to the devices. This way, automated predictive maintenance services, which trigger the regulation of a machine when certain values are exceeded, cannot be developed.

"Currently, we cannot make our energy control solution available on JOIN because the edge agent between the control and JOIN does only allow the consumption of data, but not the way back. So, playing back data to the controller and optimizing the machine is not possible."—CO N

In addition, two platform managers revealed other technological incentives working in the background of JOIN, but differentiate many current offerings in terms of quality and utility for new business models like selling IIoT apps via an app store. For example, JOIN offers a low-code tool that enables beginners to program and a billing service that allows partners and customers to focus only on value creation projects.

"When a developer builds an app on our platform, it's actually a lot of stress to rent things, do the licensing management, write invoices, etc. and that's just something we offer as a service."—PO A

Knowledge gain. Besides the perception of one industry service provider, there was clear evidence that complementors joined AutoCorp's ecosystem to access valuable information and to learn (Proposition 3). In the data, the interviewees often mentioned the words "competency", "capability", or "expertise" which we associated with their ambition to absorb knowledge in the ecosystem. While broadcasted information about the platform's roadmap is needed to align strategies with the platform owner, the complementors hoped to get more tailored information that would accelerate their business growth. Yet, complementors did not only decide for JOIN to access AutoCorp's knowledge repository but that of other partners too. In particular, many firms—smaller ones especially—were seeking partners' skills and more tailored information for learning faster and to cocreate solutions with them.

"A JOIN partner is an expert in data analytics and AI-based algorithms. With our collaboration, we can extend our solution with competencies we don't own. In turn, our partner doesn't have the domain know-how for automation industry applications and benefits from our expertise in this field. Together, we can target customer-specific IIoT solutions."—CO O

However, we identified missing staff as a recurring theme in the data that sometimes led to early endings of promising projects, as reported by a managing director.

"We wanted to work together with other JOIN partners in terms of shared resources and skills. For exam-

ple, we worked with a JOIN partner with similar competencies because, as a small company, we didn't have the manpower to do it alone."—CO K

4.2. Exploring the Impact of Complementor-Specific Uncertainty

During the interviews, however, it became clear that the decision to join an IIoT platform ecosystem because of financial, technology, and knowledge gain was also dependent on complementors' uncertainty. As perceptions of uncertainty are enacted by the perceiver, we explored each complementor's uncertainty-related factors which either increased (low degree of uncertainty) or decreased (high degree of uncertainty) their willingness to join. We structured the factors along with the tripartite framework of Lusch and Nambisan [27]: (1) ecosystem, (2) platform, and (3) value cocreation.

Ecosystem. Although most firms decided for JOIN to be granted access to its ever-growing partner ecosystem and knowledge-base, some reported that AutoCorp keeps the partner ecosystem non-transparent in terms of who is part of it and what capabilities they possess, etc. Without these insights, complementors' uncertainty may increase and the likelihood to join might decrease.

"We don't have a transparent overview of the roles and competencies of other participants."—CO B

A few firms, however, did not care about the benefits a large partner ecosystem was offering, as their primary motivation was the financial gain. One executive manager of a large consulting firm said:

"In the end of the day, we want to earn money, so the customer-centric approach without the involvement of other companies is the best one."—CO E

Moreover, while most partners did not mention that competition was affecting their decision to join, the founder of a small data analytics firm stated concerns in this regard, emphasizing the danger of losing customer-attention among many partners in the ecosystem.

"Potential customers have due to the broad partner ecosystem a large offering which could have the effect that we get lost in the shuffle. We could lose potential customers to partners only because of more attractive marketing."—CO O

Platform. Many complementors stated concerns in regards to platform survival and the decision authority of their industrial customers. The complementors we interviewed did often not decide for JOIN to extend their business, but to sustain it by following their customers' decision of adopting JOIN. Our data indicate a highly customer-centric decision making in favor of or against a particular platform as long as it does not take away the flexibility to switch platforms or to multihome.

"We also use two other IoT platforms. [The first] has a strong footprint in the US-market, so most of our US-customers prefer it over JOIN. As mentioned before, the customer decides which IoT platform is used in the end, also depending on the region he is from."—CO E

Accordingly, a customer's platform decision bears greater risks in affiliating its machines and devices with it in comparison with a complementor. Complementors seek flexibility to serve their customers independent of their platform choice.

"It finally depends on the infrastructure the customer has and wants. If the client already has a specific IoT infrastructure, we need to use the infrastructure he wants. We need to be flexible there."—CO K

Also, platform survival and market consolidation became a recurring theme that increased uncertainty of a few firms but strengthened others' willingness to join.

"Besides, we really believe in JOIN's longevity and survival as a dominant IoT platform [...] We also think that the market will consolidate. There will only be a few IoT platforms survive in the market and JOIN is going to be one of them. That is why we adopted JOIN as our main platform for our manufacturing clients."—CO D

Value cocreation. Uncertainty was also prevalent in the value cocreation opportunities of complementors. While some complementors were seeking to create joint solutions, tight resources proved to be a bottleneck.

"We also considered working with a [competitor platform], but as we are a small company, the collaboration plans were put on-hold because it wasn't manageable in parallel. We thus concentrated on JOIN, because our resources are quite tight."—CO J

In addition, value cocreation in the IIoT is highly dependent on customer projects. Customers require E2E solutions and are not interested in generic apps as they—standalone—do not generate any value in use. Hence, joining an IIoT platform without any project inquiry can increase uncertainty. Besides, developing a generic app requires an upfront investment with no secure return.

"The financial investment with application development can be a six-digit amount, the lead time for a

project is approximately 12 months. This leads to high risks, and thus we develop an application only if there is a real customer project"—CO C

Finally, we found that a firm's degree of experience in an industry can create an advantage, whereas little experience may lead to uncertainty. Experienced firms are rather independent in developing their E2E solutions. Having little or no experience in the IIoT domain may, in turn, increase uncertainty as both clients and partners would have high costs for knowledge transfer before the project could start.

"A main reason we do not have a joint solution is the speed of deployment, because our goal is to go quite fast with applications. From our experience, if we add some more actors into the projects, it takes much longer to develop the solution."—CO I

5. Discussion

This study was motivated by the need to improve our understanding of why complementors join IIoT platform ecosystems and to better understand what factors lead to variances in their motivations to join. While previous literature has mainly focused on the effects of joining and did not differentiate between different types of complementors [9], [14], [46], our study concentrates on the key incentives (and moderators) that caused their decision to join. Our insights provide evidence for all three proposed incentives: (1) financial, (2) technology, and (3) knowledge gain (Propositions 1 to 3). Table 3 also indicates that all the incentives were, on average, mentioned more often by digital firms (i.e., data analytics and consulting firms). Moreover, physical product-oriented and automation technology firms—as opposed to digital firms—had a strong focus on financial gain. This seems logical as a large part of their business is to build, sell, and install machines and devices. However, due to the smaller number of product firms in our sample, we want to state this observation carefully. In addition, our study showed that these incentives are moderated by complementors' idiosyncrasies and their decision-making uncertainty. We explored the different uncertainty-related factors of complementors along with the tripartite framework of Lusch and Nambisan [27].

Table 3: Number of quotes

Construct	Impact on complementor types				
	Industry service (n=2)	Device provider (n=1)	Connec-tivity (n=2)	Consult-ing (n=5)	Data analytics (n=5)
Financial gain	4	5	8	21	19
Technology gain	3	1	3	11	13
Knowledge gain	3	2	5	13	16
Total	10	8	16	45	48
Average	5.0	8.0	8.0	9.0	9.6
Note: The average indicates the total number of quotes divided by the number of interviewed complementors of that type (n).					

5.1. Building Incentives to Join an IIoT Platform Ecosystem

Our study contributes to the literature on partner management [35] in nascent platform ecosystems [22], particularly in the context of IIoT platform ecosystems. Prior work has documented the importance of partner management as an instrument of platform governance from various perspectives including an architectural view on boundary resources and modularity ([19], [31], [47], [48]) and an relational view on value cocreation and strategy (e.g., [9], [27], [35], [49]). Yet, a comprehensive picture of the complementors' incentives to join did not exist. Our theoretical model sheds light on the causes and uncertainty-related differences between complementors to join IIoT platform ecosystems and thus extends prior findings (e.g., [11]). In this context, differences and dependencies appeared rather related to organizational relationships than architectural decisions—especially as value cocreation is mainly dependent on the customer's willingness to execute cost-intense IIoT projects. With our findings, we underline the reason why generic apps in the IIoT are for one thing difficult to develop and for another thing difficult to scale [7].

In addition, while prior studies, which looked at the complementor perspective, have only focused on independent software vendors, our sample also includes those focusing on industry services, device manufacturing, and connectivity. While for the latter, the financial gain was of utmost importance, firms that rather had digital offerings were motivated by all three incentives, smaller ones especially by knowledge gain (see Table 3). With these results, we confirm existing studies in that previously established incentives are primarily attracting software developers on the one hand and show that IIoT platform managers should establish new incentives for (smart-) product firms on the other hand. Creating transparent ecosystems could support (small) firms in finding their niche, connecting with partners, and starting projects. By implementing these measures, complementors and customers could better engage in value cocreation projects in the IIoT domain.

5.2. Looking Beyond the Complementor

Our interviews show that two-thirds of the complementors have joined multiple IIoT platforms and thus engaged in multihoming. While previous studies have shown that multihoming—if not associated with considerable costs—is common among both consumers and complementors, it is an undesired behavior from the perspective of the platform owner [49], [50]. Hence, platform owners try to decrease multihoming tendencies of consumers and complementors through locking-in users

by increasing switching costs, e.g., through the use of exclusive contracts [51]. Therefore, both lock-in effects and multihoming seem to be less vibrant for complementors as compared to customers. As complementors follow the lead of their customers, building solutions for the platforms they chose, owners need to extend their focus to customers as they seem to represent the strongest incentive to join. As opposed to demand-side economies of scale, where the value of the product or service is contingent on the number of users [51], in the IIoT, it is contingent on the industry customer, the number of connected devices, and the data volume transferred.

6. Limitations and Future Research

Our study is subject to limitations. First, although our results follow a replication logic, generalizing them based on a single case study is challenging. We have studied what incentives positively influenced the joining decision of different types of complementors of a single IIoT platform ecosystem. In other domains, such as healthcare, relationships between complementors and platform owners could have different characteristics. Second, our sample includes firms that have already decided to join an IIoT platform, not those that refused to join—possibly due to uncertainty-related factors. Third, the study covers a relatively short period. A longitudinal design could yield more details in the idiosyncratic decision-making process of complementors.

Finally, we suggest two avenues for future research. First, applying our research model in other domains or to IIoT customers for analyzing their incentives to join could strengthen the validity of the three key incentives we proposed. The results could help platform owners to attract more customers and complementors to join. Second, we suggest examining how platforms should be designed to gratify the needs of different types of complementors (see an analysis of IIoT stakeholders [18]) and the project-oriented nature of current IIoT apps [7]. Overall, our study answers a call for research on the incentives of joining digital platform ecosystems [16].

References

[1] M. de Reuver, C. Sørensen, and R. C. Basole, "The Digital Platform: A Research Agenda," *J. Inf. Technol.*, vol. 33, no. 2, pp. 124–135, 2018.

[2] E. Sisinni, A. Saifullah, S. Han, U. Jennehag, and M. Gidlund, "Industrial Internet of Things: Challenges, Opportunities, and Directions," *IEEE Trans. Ind. Informatics*, vol. 14, no. 11, pp. 4724–4734, 2018.

[3] D. Petrik and G. Herzwurm, "IIoT ecosystem development through boundary resources: A siemens mind sphere case study," in *Proceedings of the 2nd International Workshop on Software-Intensive Business*, 2019.

[4] A. Hein, J. Weking, M. Schreieck, M. Wiesche, M. Böhm, and H. Krcmar, "Value co-creation practices in business-to-business platform ecosystems," *Electron. Mark.*, vol. 29, no. 3, pp. 503–518, 2019.

[5] A. Gawer and M. A. Cusumano, "Industry platforms and ecosystem innovation," *J. Prod. Innov. Manag.*, vol. 31, no. 3, pp. 417–433, 2014.

[6] M. A. Cusumano, A. Gawer, and D. B. Yoffie, *The Business of Platforms: Strategy in the Age of Digital Competition, Innovation, and Power*. Harper Business, 2019.

[7] C. Marheine and T. Pauli, "Driving Generativity in Industrial IoT Platform Ecosystems," in *Proceedings of the 41st International Conference on Information Systems*, 2020.

[8] E. J. Altman, "Dependencies, Complementor Evolution, Response Strategies: Joining a Multi-Sided Platform Ecosystem," in *Academy of Management Annual Meeting Proceedings*, 2017.

[9] M. Ceccagnoli, C. Forman, P. Huang, and D. J. Wu, "Cocreation of value in a platform ecosystem : The case of enterprise software," *MIS Q.*, vol. 36, no. 1, pp. 263–290, 2012.

[10] D. Tilson, C. Sørensen, and K. Lyytinen, "Platform complexity: Lessons from the music industry," in *Proceedings of the 46th Hawaii International Conference on System Sciences*, 2013, pp. 4625–4634.

[11] T. Pauli, E. Marx, and M. Matzner, "Leveraging Industrial IoT Platform Ecosystems: Insights from the Complementors' Perspective," in *Proceedings of the 28th European Conference on Information Systems*, 2020.

[12] Sarker, Sarker, Sahaym, and Bjørn-Andersen, "Exploring Value Cocreation in Relationships Between an ERP Vendor and its Partners: A Revelatory Case Study," *MIS Q.*, vol. 36, no. 1, p. 317, 2012.

[13] S. Koch and M. Kerschbaum, "Joining a smartphone ecosystem: Application developers' motivations and decision criteria," *Inf. Softw. Technol.*, vol. 56, no. 11, pp. 1423–1435, 2014.

[14] P. Huang, M. Ceccagnoli, C. Forman, and D. J. Wu, "When do ISVs join a platform ecosystem? Evidence from the enterprise software industry," in *Proceedings of the 30th International Conference on Information Systems*, 2009, pp. 1–18.

[15] R. K. Chellappa and N. Saraf, "Alliances, Rivalry, and Firm Performance in Enterprise Systems Software Markets: A Social Network Approach," *Inf. Syst. Res.*, vol. 21, no. 4, pp. 849–871, 2010.

[16] A. Hein *et al.*, "Digital platform ecosystems," *Electron. Mark.*, vol. 30, no. 1, pp. 87–98, 2020.

[17] A. Tiwana, "Platform desertion by app developers," *J. Manag. Inf. Syst.*, vol. 32, no. 4, pp. 40–77, Oct. 2015.

[18] D. Petrik and G. Herzwurm, "Towards the iIoT Ecosystem Development - Understanding the Stakeholder Perspective," in *Proceedings of the 28th European Conference on Information Systems*, 2020.

[19] A. Ghazawneh and O. Henfridsson, "Balancing platform control and external contribution in third-party development: The boundary resources model," *Inf. Syst. J.*, vol. 23, no. 2, pp. 173–192, 2013.

[20] J. Foerderer, T. Kude, S. W. Schuetz, and A. Heinzl, "Knowledge boundaries in enterprise software platform development: Antecedents and consequences for platform governance," *Inf. Syst. J.*, vol. 29, no. 1, pp. 119–144, 2019.
[21] R. M. Grant, "Toward a knowledge-based theory of the firm," *Strateg. Manag. J.*, vol. 17, no. S2, pp. 109–122, 1996.
[22] D. Hodapp, F. Hawlitschek, and D. Kramer, "Value co-creation in nascent platform ecosystems: A Delphi study in the context of the internet of things," in *Proceedings of the 40th International Conference on Information Systems*, 2019.
[23] P. Constantinides, O. Henfridsson, and G. G. Parker, "Introduction—platforms and infrastructures in the digital age," *Inf. Syst. Res.*, vol. 29, no. 2, pp. 381–400, 2018.
[24] J. F. Moore, "Predators and prey: a new ecology of competition," *Harv. Bus. Rev.*, vol. 71, no. 3, pp. 75–86, 1993.
[25] M. G. Jacobides, C. Cennamo, and A. Gawer, "Towards a theory of ecosystems," *Strateg. Manag. J.*, vol. 39, no. 8, pp. 2255–2276, 2018.
[26] R. Adner, "Ecosystem as Structure: An Actionable Construct for Strategy," *J. Manage.*, vol. 43, no. 1, pp. 39–58, 2017.
[27] R. F. Lusch and S. Nambisan, "Service Innovation: A Service-Dominant Logic Perspective," *MIS Q.*, vol. 39, no. 1, pp. 155–175, 2015.
[28] L. Selander, O. Henfridsson, and F. Svahn, "Capability search and redeem across digital ecosystems," *J. Inf. Technol.*, vol. 28, no. 3, pp. 183–197, 2013.
[29] A. Tiwana, B. Konsynski, and A. A. Bush, "Research Commentary —Platform evolution: Coevolution of platform architecture, governance, and environmental dynamics," *Inf. Syst. Res.*, vol. 21, no. 4, pp. 675–687, 2010.
[30] T. Pauli and Y. Lin, "The Generativity of Industrial IoT Platforms: Beyond Predictive Maintenance?," in *Proceedings of the 40th International Conference on Information Systems*, 2019.
[31] B. Eaton, S. Elaluf-Calderwood, C. Sørensen, and Y. Yoo, "Distributed tuning of boundary resources: The case of Apple's iOS service system," *MIS Q.*, vol. 39, no. 1, pp. 217–243, 2015.
[32] A. Tiwana, "Evolutionary competition in platform ecosystems," *Inf. Syst. Res.*, vol. 26, no. 2, pp. 266–281, 2015.
[33] M. W. Van Alstyne, G. G. Parker, and S. Paul Choudary, "Pipelines, platforms, and the new rules of strategy," *Harvard Business Review*, vol. 2016, no. April. pp. 54–60, 2016.
[34] W. W. Powell, "Neither market nor hierarchy: Network forms of organization," *Res. Organ. Behav.*, vol. 12, pp. 295–336, 1990.
[35] T. L. Huber, T. Kude, and J. Dibbern, "Governance practices in platform ecosystems: Navigating tensions between cocreated value and governance costs," *Inf. Syst. Res.*, vol. 28, no. 3, p. 563, 2017.
[36] A. Ghazawneh and O. Henfridsson, "Governing third-party development through platform boundary resources," in *Proceedings of the 31st International Conference on Information Systems*, 2010.
[37] J. Barney, "Firm resources and sustained competitive advantage," *J. Manage.*, vol. 17, no. 1, pp. 99–120, 1991.
[38] W. R. Scott, *Organizations: Rational, Natural, and Open Systems*, 5th ed. Routledge, 2001.
[39] V. Krishnan and S. Bhattacharya, "Technology selection and commitment in new product development: The role of uncertainty and design flexibility," *Manage. Sci.*, vol. 48, no. 3, pp. 313–327, 2002.
[40] R. K. Yin, *Case Study Research and Applications: Design and Methods*, 6th ed. SAGE Publications, Inc, 2017.
[41] M. B. Miles, A. Michael Huberman, and J. Saldaña, *Qualitative data analysis: A methods Sourcebook*, 4th ed. SAGE Publications, Inc, 2020.
[42] L. Dubé and G. Paré, "Rigor in information systems positivist case research: Current practices, trends, and recommendations," *MIS Q.*, vol. 27, no. 4, pp. 597–635, 2003.
[43] A. S. Lee, "A scientific methodology for MIS case studies," *MIS Q.*, vol. 13, no. 1, pp. 33–50, 1989.
[44] J. Dibbern, J. Winkler, and A. Heinzl, "Explaining variations in client extra costs between software projects offshored to India," *MIS Q.*, vol. 32, no. 2, pp. 333–366, 2008.
[45] C. Marheine, "Governance Strategies to Drive Complementary Innovation in IoT Platforms: A Multiple Case Study," in *Proceedings of the 15th International Conference on Wirtschaftsinformatik*, 2020.
[46] J. Wareham, P. B. Fox, and J. L. Cano Giner, "Technology Ecosystem Governance," *Organ. Sci.*, vol. 25, no. 4, pp. 1195–1215, 2014.
[47] C. Y. Baldwin and K. B. Clark, "Managing in an age of modularity," *Harv. Bus. Rev.*, vol. 75, no. 7, pp. 84–93, 1997.
[48] Y. Yoo, O. Henfridsson, and K. Lyytinen, "Research commentary —The new organizing logic of digital innovation: An agenda for information systems research," *Inf. Syst. Res.*, vol. 21, no. 4, pp. 724–735, Dec. 2010.
[49] K. J. Boudreau, "Let a Thousand Flowers Bloom? An Early Look at Large Numbers of Software App Developers and Patterns of Innovation," *Organ. Sci.*, vol. 23, no. 5, pp. 1409–1427, 2012.
[50] C. Cennamo, H. Ozalp, and T. Kretschmer, "Platform architecture and quality trade-offs of multihoming complements," *Inf. Syst. Res.*, vol. 29, no. 2, pp. 461–478, 2018.
[51] A. Hagiu and J. Wright, "Multi-sided platforms," *Int. J. Ind. Organ.*, vol. 43, no. November, pp. 162–174, 2015.