Multi-sided platforms in B2B contexts: the role of affiliation costs and interdependencies in adoption decisions

Patrick Loux, corresponding author
EM Normandie Business School, Métis Lab
64 Rue du Ranelagh
75016 Paris, France
ploux@em-normandie.fr

Mathilde Aubry
EM Normandie Business School, Métis Lab
9, rue Claude Bloch
14052 Caen Cedex 4, France
maubry@em-normandie.fr

Sébastien Tran
Léonard de Vinci Pôle Universitaire
De Vinci Research Center (DVRC)
92 916 Paris La Défense, France
sebastien.tran@devinci.fr

Emmanuel Baudoin
Univ Evry, IMT-BS, Université Paris-Saclay
91025 Evry, France
emmanuel.baudoin@imt-bs.eu

ABSTRACT
Multi-sided platforms, enabling interactions between different user sides, hold an important place in the contemporary economy. Current literature, focusing on established and successful platforms, has neglected to study B2B multi-sided platform adoption decisions. In this article, we examine the main factors that influence these decisions by investigating the case of dematerialization platforms for B2B transactions between the multiple actors involved in public works contracts. Various qualitative materials, including 28 semi-structured interviews, were gathered over a thirty-month period. Adopting a business user perspective, this study contributes to the literature on multi-sided platforms in various ways. We show that platform adoption, in project-based B2B contexts, is mainly constrained by a high level of affiliation costs and the existence of tight-interdependencies between users' activities at project level. Thus, a consecutive adoption path would result in negative cross-group network externalities and undermine the platform's attractiveness. Conversely, a concurrent adoption path would activate positive network externalities and encourage platform adoption decisions.

Keywords: Multi-sided platforms; affiliation costs; B2B; architectural innovation; dematerialization; construction industry

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1. Introduction

As early as 2006, Eisenmann, Parker and Van Alstyne pointed out that many of the products and services making up the modern economic environment share the characteristic of linking two or more distinct user groups. The trend then increased, with a growing number of industries organized around two-sided platform-based markets (Kang & Doning, 2015), especially "*new economy*" industries (Hagiu, 2009, p. 1) that relied on digitization. Researchers in industrial economics and management science have been interested in two-sided markets (or, more generally, multi-sided markets) (Rochet & Tirole, 2003, 2006) since the turn of the century. According to Sriram, Manchanda, Bravo, Chu, Ma, Song, Shriver and Subramanian (2015, p. 142), two-sided platforms "*refer to intermediaries that facilitate economic interaction between two sets of agents wherein the decisions of one set of agents are likely to have an effect on the other via direct and/or indirect externalities.*" Examples of two-sided platforms include credit cards and video game consoles. Platforms become multi-sided when they bring together more than two sides of users, such as social media platforms (users, advertisers and content developers), online marketplaces (sellers, buyers and advertisers), and integrated ride-sharing and food delivery platforms (drivers, riders or customers and merchants).

The various sides of users are interdependent insofar as the advantages that one group gains from using the platform depend on the number of users that join the platform in the other groups (Armstrong, 2006; Rochet & Tirole, 2006). Therefore, the main challenge to successful adoption for multi-sided platforms is to get the two (or multiple) sides "*on board*" (Rochet & Tirole, 2006, p. 645). Previous research on multi-sided platform adoption dynamics suggests that an effective solution to this issue is first to attract one of the sides on the platform and then to leverage cross-group network effects to get the other sides on board (Hagiu, 2006; Hagiu & Wright, 2015; Muzellec, Ronteau & Lambkin, 2015). Most studies focus on pricing structure as a key factor in platform adoption (Armstrong, 2006; Cabral, 2019; Hagiu, 2009; Liu, 2010; Rochet & Tirole, 2006). In particular, a suitable price discrimination strategy may be to subsidize one user segment while making a profit from the other sides (Sriram *et al.,* 2015).

Three limitations can be identified in this literature. First, while authors agree that many markets are multi-sided (with several segments of interdependent end-users), the theoretical literature mainly focuses on two-sided markets for expositional simplicity. Researchers tend to consider that the insights obtained for two-sided platforms also apply more generally to multi-sided ones (Rochet & Tirole, 2006). In similar vein, most of the empirical literature investigates cases of two-sided platforms (Kumar, Lahiri & Dogan, 2018; Muzellec *et al.*, 2015; Sriram *et al.,* 2015). However, multi-sided markets are "*more complex in that they serve a variety of distinct entities with diverse interests*" (Tan, Lu, Pan & Huang, 2015, p. 250). Second, the examples that are most often given in research on multi-sided markets are C2C platforms (when a platform connects various individuals, such as platforms for exchanging services between individuals or online dating platforms) or B2C platforms (when a platform connects organizations with individuals, such as online search engines connecting firms that display adverts with individuals looking for information, or recruitment platforms that connect firms offering jobs with job seekers). Studies focusing on B2B platforms, where a platform connects organizations with other organizations, are far scarcer. Few cases have been studied to date, apart from the noteworthy exception of the research by Tan *et al.* (2015). Third, most papers based on formal modeling have focused on characteristics of established, successful platforms, and not on the launch of new platforms (Evans & Schmalensee, 2010), even though "*failure to launch*" is a critical issue (Cabral, 2019, p. 3). Similarly, most qualitative empirical research has investigated successful platforms (Muzellec *et al.*, 2015;

Tan *et al.*, 2015). Conversely, platforms that have to deal with difficulties at launch have not received much attention, despite the fact that they illustrate the challenges inherent in successful adoption.

The present research attempts to fill these gaps by analysing platform adoption mechanisms in a B2B multi-sided context. To address this issue, we empirically investigated the perplexing case of dematerialization platforms in French public works contracts. By replacing paper documents with electronic ones from the call for tenders through to payment, these platforms should offer significant productivity gains to the different business participants involved in a contract. Yet, our empirical analysis shows that these platforms face important adoption issues, while providing insights into the underlying reasons. Most literature on multi-sided platforms tends to analyse the orchestration strategies that are (or should be) implemented by platforms, sometimes leading them to become platform leaders (Gawer & Cusumano, 2014; Helfat & Raubitschek, 2018), rather than the difficulties that potential users have to handle for adopting a specific platform. Examples of multi-sided platform leaders include Amazon, Alibaba and Google's Android operating system and store. Our approach is different as we report a case in which we thoroughly take the business users' point of view into consideration beyond the platforms' perspective. In addition, there was no clear platform leader in the sense that the users' perceptions and behaviors towards dematerialization platforms were not being driven and aligned in an integrative way by a strategizing architect.

Our study contributes to the literature on multi-sided platforms in various ways. First, we question the importance of pricing policy to drive platform adoption in the presence of high affiliation costs (Hagiu & Wright, 2015). Our findings allow to better understand why affiliation costs arise in a B2B context, and how they may undermine the adoption of a multi-sided platform. Second, we highlight the importance of additional interdependency issues in project-based B2B contexts beyond the number of users on each side of a platform, and explain how they may impact cross-group network effects. Third, we show that under tight interdependency constraints, failure to attract the various sides of users at the same time can make a multi-sided platform less and less attractive even as the user base grows. In complex project-based B2B contexts, getting one side on board before attracting the others may not be the best solution to stimulate platform adoption.

The paper is structured as follows. We begin with a brief literature review on the topics of two-sided and multi-sided platforms. The next section describes the methodology adopted and details the data collected. We then provide an in-depth analysis of the main findings, discuss the conceptual insights derived from them, and assess the theoretical and managerial implications. Finally, limitations and further research avenues are identified.

2. Literature review

This section, dedicated to the theoretical framework of multi-sided platforms, is broken down into two parts. We first define multi-sided platforms and then present the main factors influencing the platforms' adoption path.

2.1. Multi-sided platforms: definition and nature of the issue

The Economics and Management literature puts forward various more or less inclusive and more or less precise definitions of multi-sided platforms (Armstrong, 2006; Caillaud & Jullien, 2003; Evans & Schmalensee, 2008; Hagiu & Wright, 2015; Rochet & Tirole, 2006). However, three main characteristics stand out in particular.

The first characteristic is that multi-sided platforms enable direct interactions between two or more types of economic agents (i.e. two or more distinct sides) (Hagiu & Wright, 2015) that

make all users better off (Evans & Schmalensee, 2013). From this perspective, they act as intermediaries (Eisenmann *et al.*, 2006), providing a common (real or virtual) meeting place for entities that "*need each other in some way*" (Evans & Schmalensee, 2008, p. 667). To illustrate this, Evans & Schmalensee (2008) propose examples of four different types of two-sided platforms (the simplest form of multi-sided platforms): exchanges for matching activities (e.g., dating services, employment services and e-commerce websites like Ebay), advertising-supported media (magazines, newspapers, free television…), software platforms (central in major industries like video games or personal computers) and transaction systems (e.g., payment methods such as credit cards). Dematerialization platforms belong to the latter category, as they provide infrastructure and services to facilitate interactions and exchanges between distinct groups of entities (Eisenmann, Parker & Van Alstyne., 2009). The second characteristic is that each side is affiliated to the platform. This means that "*users on each side consciously make platform-specific investments that are necessary in order for them to be able to directly interact with each other*" (Hagiu & Wright, 2015, p. 163). The investment or affiliation costs could be a fixed access fee, but also resource-related expenditures (time and money needed to learn to use it) and opportunity costs. Management scholars have recently pointed out that a multi-sided platform can sometimes present the characteristics of an ecosystem defined as "*a set of actors with varying degrees of multilateral, nongeneric complementarities that are not fully hierarchically controlled*" (Jacobides, Cennamo & Gawer, 2018, p. 2264). Nongeneric complementarities require platform participants to make specific investments that are not perfectly fungible in a context of strong interdependencies (Jacobides *et al.,* 2018). Finally, most multi-sided platforms are also characterized by the presence of cross-group network effects or cross-group externalities between the two or more customer groups participating on the platform (e.g. Armstrong, 2006; Caillaud & Jullien, 2003). A cross-group network effect means that the utility to users in at least one group depends on the number of users in the other group that joins the platform (Rochet & Tirole, 2006; Roson, 2005).

At its early development stage, the theory of multi-sided markets (Armstrong, 2006; Caillaud & Jullien, 2003; Parker & Van Alstyne, 2005; Rochet & Tirole, 2003, 2006) was closely linked to the theories of network externalities initiated by Katz and Shapiro (1985, 1986). In most cases, cross-network externalities are positive. For instance, in the video game industry, greater involvement by video game developers materializes in more games, which increases a console's value for players (Lee, 2013). However, externalities may also be negative. According to previous studies, two main factors can generate negative network externalities: the quantity and the quality of other platform users (Akerlof, 1970; Evans, 2012; Rochet & Tirole, 2006). In the first case, a growing number of platform users can harm the platform's utility for other users. One example is a freemium on-demand music platform where the number of advertisers has a negative impact on audience size (listeners are ad-adverse), while audience size has a positive effect on advertiser demand (advertisers are viewer-loving, they like to get a large audience) (Reisinger, 2004; Wilbur, 2008, quoted in Sriram *et al.*, 2015). In the second case, a declining overall quality of platform users can harm its utility for other users. Examples of this could include dating platforms that attract a growing number of false profiles or a videogame platform that offers an increasing number of low-quality games.

2.2. Solving the chicken-and-egg problem

The main issue that multi-sided platforms have to tackle is to find solutions to solve the chicken-and-egg problem. When a platform is also an ecosystem (i.e. presence of high nongeneric complementarities), an additional issue lies in creating a specific alignment structure to address the need for coordination among the actors (Jacobides *et al.,* 2018).

Caillaud and Jullien (2003) summarize the chicken-and-egg problem in the context of an exchange platform: "*to attract buyers, an intermediary should have a large base of registered sellers, but these will be willing to register only if they expect many buyers to show up*" (Caillaud & Jullien, 2003, p. 1). In other words, platforms have to figure out how to get the two (or multiple) sides "*on board*" (Rochet & Tirole, 2006). However, multi-sided platforms "*generally face a critical mass constraint that must be satisfied at launch if the business is to be viable*" (Evans & Schmalensee, 2010, p. 1). This constraint corresponds to a minimum number of participants above which network effects will drive the platform's growth, and below which network effects will drive a downward spiral toward zero participation. In the context of two-sided platforms, the critical mass constraint can be either one-dimensional or two-dimensional. In the first case, it applies to one side of the market only (either the chicken or the egg side); in the second case, it applies to all sides of the market (both the chicken and the egg sides).

The Economics literature considers price structure as a solution to this chicken-and-egg problem. This research stream is based on the assumption that the price structure set by a platform is non-neutral since it affects the volume of transactions on the platform (Rochet & Tirole, 2006). An astute pricing structure can attract one side of the market and then allow the platform to develop through network effects. For example, instead of charging each end-user a similar price, a platform can demand payment from one user segment (the money side) to obtain the right to access the platform which subsidizes the right for the other user segment (the subsidy side) to access the platform (Armstrong, 2006; Eisenmann, 2008). Investing in one side of the network may benefit the other side(s) as well through cross-group externalities (Bakos & Katsamakas, 2008). The choice of which segment to subsidize depends on the relative network externality benefits (Parker & Van Alstyne, 2005). The segment that makes the biggest contribution to attracting the other side is the one that should be subsidized. Thus, it may be rational to subsidize or even distribute a platform to one of the end-user segments free of charge. If this stimulates demand from the other end-user segment, the loss recorded on one side of the market will be more than offset by the gain generated on the other side.

Researchers in strategic management and marketing have pointed out that the majority of existing studies that deal with the adoption process of multi-sided platforms tend to focus on pricing policy (Gawer & Cusumano, 2014; Tan *et al.,* 2015), despite a number of other strategic levers that may also play a role. The best strategy to stimulate adoption may need to evolve over time, adapting to the different stages of the platform lifecycle (Muzellec *et al.*, 2015; Tan *et al.,* 2015). For instance, at the nascent (or emerging) stage of development, a platform's emphasis should be on attaining a critical mass (Evans & Schmalensee, 2010). Indeed, analysing five case studies of newly established Internet business ventures, Muzellec *et al.* (2015) showed that they offered their services for free at the emerging stage in order to ensure end-user participation and thereby attain the critical mass needed. In a complementary way, they also used a push communication strategy on social networks. The role of advertising or viral marketing to attract the end-user side is also underscored by Evans and Schmalensee (2010), while Eisenmann (2008) suggests that securing the exclusive affiliation of well-targeted users that have the ability to act as early catalysts and attract many other users can be an effective strategic move. In the empirical context of Alibaba, Tan *et al.* (2015) highlight the role of coring and tipping strategies (Gawer, 2009; Gawer & Cusumano, 2008) at the nascent stage. The first "*refers to the set of activities a sponsor can use to identify or design an element (a technology, a product, or a service) and make this offering fundamental to the platform*"(Tan *et al.*, 2015, p. 252). The second "*refers to the set of activities or strategic moves that sponsor can use to shape market dynamics and gain momentum*" (Tan *et al.*, 2015, p. 252). In the next stages toward maturity, the platform needs to reinforce its position (Eisenmann, Parker & Van Alstyne, 2011) and attract new users or new sides

(Muzellec *et al.*, 2015; Tan *et al.,* 2015) in order to foster more value-enhancing interactions. For example, Tan *et al.* (2015, p. 268) propose a meshing strategy as "*a means of coordinating the activities of platform members in lieu of feasible mechanisms for direct management because it fosters mutual dependencies that promote solidarity and collective action (Adler & Kwon, 2002) and that provide the foundation for stability, productivity, and creativity in the platform (Iansiti & Levien, 2004)*". As a complement to the identification of different strategic moves, Helfat and Raubitschek (2018) suggest that the ability of platforms to create and capture value lies on three critical dynamic capabilities : innovation capabilities in their core products, environmental scanning and sensing capabilities, and integrative capabilities for ecosystem orchestration. The main goal of integrative capabilities is to enable the alignment of activities and products with and among ecosystem members, as well as to stimulate new product introductions throughout the ecosystem (Helfat & Raubitschek, 2018). Overall, the two-sided and multi-sided platforms literature suggests that the number of participants on each side has a considerable influence on platform adoption. It creates a key issue known as the chicken-and-egg problem at a platform's nascent stage. To overcome this problem, previous research has underscored the role of the pricing policy and other strategic actions to increase the number of users on the different sides. In turn, attaining a critical mass of users enables the activation of positive cross-group externalities that support the growing adoption dynamics. Within this literature, few studies have examined whether platforms that bring together more than two sides of business users (i.e. B2B multi-sided platforms) face specific adoption issues. A notable exception is provided by Tan *et al.* (2015) who reported that the ability of Alibaba to lower their platform affiliation costs through specific IS capabilities contributed to the success of its B2B platform. This suggests that affiliation (i.e. platform-specific) costs may represent an important and underestimated constraint for business users. Although most research on two-sided and multi-sided platforms recognizes the existence of affiliation costs incurred by users (Hagiu & Halaburda, 2014; Hagiu & Wright, 2015; Rochet & Tirole, 2006), their role in platform adoption has been under investigated to date. For instance, Rochet & Tirole (2006, p. 651) state that "*only total transaction-insensitive cost matters to the end-user, and so we need not be concerned by our making this artificial distinction between fixed fees and fixed technological costs*." However, while platforms can easily modify their price structure, their ability to influence other affiliation costs for their users is more complex and less direct, which makes the qualitative distinction between fees and costs useful. In this study, we explore further what leads affiliation costs to emerge and rise in a complex and project-based B2B context, and investigate their effects on multi-sided platform adoption decisions.

3. Methodology

We opted for a qualitative case study since qualitative data can be used for descriptions and explanations that are both rich and solidly grounded in a local context (Miles & Huberman, 2003)[1]. The case study method was selected because the research problem is empirically novel and theoretically vague (Eisenhardt, 1989). Case studies are a research strategy used to explore complex, little-known phenomena in order to capture their richness and to identify patterns, with the perspective of generating a theory (Eisenhardt, 1989; Yin, 2003). A case study can be defined as "*an empirical survey that examines a contemporary phenomenon within its actual context […], for which multiple sources of data are used*" (Yin, 2003, p. 17).

3.1. Case selection

[1] 'Another characteristic of qualitative data is their richness and encompassing character, with high potential for decoding complexity' (Miles & Huberman, 2003, p. 27)

In order to better understand B2B multi-sided platform adoption mechanisms, we adopted a typical case purposive sampling (Silverman, 2000). Our case study is the dematerialization of documents in public construction projects through platforms in the French Region of Lower Normandy. Organizations participating in public construction projects constitute the unit of analysis for our research. They form the ecosystem of dematerialization on the territory. The study was part of a research contract called Egovbat funded by the ERDF[2] and the Region Basse Normandie (Region of Lower Normandy). The contract lasted two and a half years (from March 2013 to August 2015) and was labeled by the French competitiveness cluster called Transactions Electroniques Sécurisées[3] (TES). Its aim was to find solutions to facilitate interactions and information exchanges between players in both public and private organizations in the construction industry in Lower Normandy (France). Public works contracts account for the majority of public procurement contracts in France, and thus represent an important sector[4]. They involve many players who are highly regulated and controlled.

This case was selected because it reflects the 'average' situation of our phenomenon of interest (Patton, 1990). It can be used as illustrative to other similar samples (Silverman, 2000), for example in other sectors or other regions. Two main reasons convinced us to choose this case related to an example of a situation with B2B multi-sided platforms at their nascent (emerging) and growth stages of development.

First, as shown in fig. 1 below, the full dematerialization of exchanges in the construction industry requires a multi-sided platform used by the various sides of business participants.

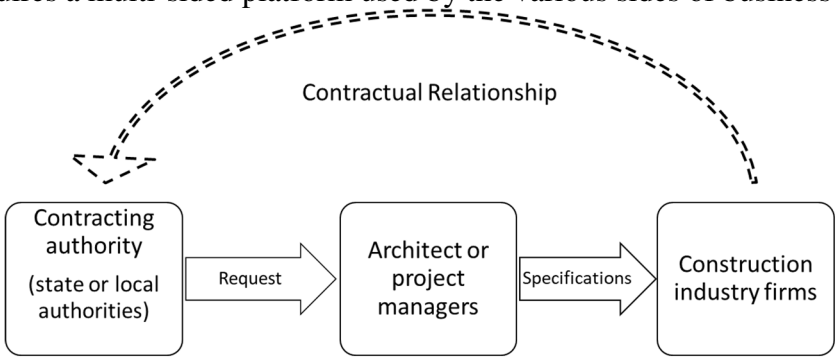

Fig.1. Simplified description of the relationships between the main business participants in the construction industry.

Many documents and a great deal of information must be exchanged at different sequenced stages. Each of them inevitably involves several players who are therefore interdependent despite having different work process and information system organization and structures. When a public works contract is being performed, four types of players have a significant role and are brought together through a dematerialization platform: the public contracting authorities, construction industry firms, the project manager, and finally, government services. These different types of players correspond to the main sides of the dematerialization platforms used in the implementation of public works contracts. The needs of public contracting authorities are formalized through specifications, while the construction industry firms conduct the construction and renovation work on behalf of their state client.

[2] European Regional Development Fund
[3] Secure Electronic Transactions (SET)
[4] *www.e-marchespublics.fr/*

Project management is often entrusted to an architect's office that will act as the interface between the public contracting authorities and the selected construction industry firms. The project manager's main role is to monitor the worksite to ensure that it is progressing according to the contractual provisions of the specifications. The latter also validates the invoices issued by the construction industry firms before sending them to the public bodies. The government services regularly check the administrative documents with help from the French prefectures (local government authority) in order to ensure that the worksite is progressing in compliance with the regulations in force at the time. Finally, the municipal government finance offices are in charge of paying the firms for their services once the instructions for payment and supporting documents have been sent by the public contracting authorities.
Second, the dematerialization of public procurement contracts is an emerging market. When we conducted our research, there was no fully established platform yet. Several platforms had recently been introduced in the market but they were encountering difficulties to attract new users and were not able to manage, in a dematerialized way, all the exchanges and documents related to the works contracts. This market benefits from regulatory support at European level: the dematerialization of the entire contract award procedure exceeding the sums of money dictated by European thresholds became mandatory in 2018. The lead for this came directly from European directives to encourage the modernization of public actions. Using electronic media to process, publish, interchange and store information is seen as a way to simplify purchasing operations for public bodies (Assar & Boughzala, 2006).

3.2. Data collection and analysis

The empirical study followed an abductive research approach. This approach is defined by Dubois and Gadde (2002a) as "*a process that often leads to redirecting the study and generating 'a new view of the phenomenon itself*"". It is based on an interweaving dialog between theory and empirical findings (Dubois & Gadde, 2002a).
As existing theoretical frames and preconceptions did not seem to offer an adequate explanation concerning B2B multi-sided platform adoption mechanisms, abduction appeared as the best solution: "*Abduction is the process of providing a theoretical explanation for* [such an] *empirical puzzle*" (Piekkari & Welch, 2018). It leads to integrate "*insights from the data that lie outside the initial theoretical frame*" (Lonsdale, Hoque, Kirkpatrick & Sanderson, 2017). Thus, abduction "*assumes extensive familiarity with existing theories at the outset and throughout every research step…*[without] *advocating a return to deduction based on existing theories*" (Timmermans & Tavory, 2012, p. 173). In our case, we referred to the two-sided and multi-sided platforms literature in economics and, with further guidance from researches on the same topic in strategic management and marketing, we refined those theories iteratively as the data analysis unfolded.
As the research contract lasted for around two and a half years, it enabled different sources of data to be gathered over a relatively long time frame. Data sources (see Table 1) comprised semi-structured interviews, observations and secondary sources. This allowed us to obtain a more complete view of the situation, as well as to triangulate and check the statements made by the interviewees (Yin, 1994; Stake, 2000).

Table 1

Presentation of data sources.

	Objectives	Data analysed	Types of source
Data set linked to dematerialization	Understanding the ecosystem of dematerialization and the issues of dematerialization platforms adoption in the construction industry	28 semi-structured interviews sometimes with several interviewees per interview: Semi-structured interview guide, recordings and transcriptions of interviews, data encoding	Primary data
		Note-taking during the Dematech conference on dematerialization in the construction industry (21/11/2013, Alençon)	Primary data
Data set linked to the prototype	Understanding the needs and expectations of dematerialization platforms' business users	Minutes of 9 steering committee meetings and of technical meetings: Content analysis of discussions and media distributed (PowerPoint documents…)	Primary and secondary data
		Observation of a user training session on how to use the prototype (on 19/09/2014 on the TES cluster premises) : Recordings and note-taking	Primary data

Twenty-eight semi-structured interviews were conducted on a face-to-face basis utilizing an interview guide (Miles & Huberman, 1994). They lasted between 45 minutes and two and a half hours. Informants were identified in the case study by the snowballing technique, whereby the first interviewees were asked to name persons from their network who could contribute to our research. Every type of stakeholder involved in public works contracts was questioned. These included members of the *FFB* (French Construction Industry Federation), construction industry firms, public authorities, technical and legal experts in dematerialization, a bank, a consultancy firm, a payment solutions consultant, an architect and a SME specialized in dematerialization. The latter was, during our research period, responsible for an electronic platform prototype development project. This development project was a part of the Egovbat research contract. It was the first project having the ambition to manage in a dematerialized way all the exchanges and documents related to the works contracts on the territory. We questioned the respondents about dematerialization relying on their previous experiences (if any) or their expertise. The diversity of positions and standpoints of our respondents enabled us to capture different and cumulatively complete perspectives of the research topic (Dubois & Araújo, 2007; Hartley, 2004) related to dematerialization platform adoption mechanisms. Seven main questions were used to structure the interviews, covering various areas such as the advantages and disadvantages of dematerialization and elements that facilitate or inhibit the adoption of a dematerialization platform. The interview data was fully recorded and transcribed and the resulting corpus of more than 500 pages of data was analysed thematically (Miles & Huberman, 1994) with the help of theoretical categorization. However, in line with abductive reasoning, new topics and results were also permitted to emerge from the data (Timmermans & Tavory, 2012). The data analysis was facilitated by the computer-based software tool NVivo.

In addition to interviews, the prototype development project provided us with a broad set of secondary data (see Glueck & Willis, 1979) comprising minutes of steering committee or technical meetings, internal documents, and reports on dematerialization. This data was not analysed as systematically as the interview data; rather, it was regarded as a complementary data set, enabling us to understand the context and the way organizations work together. Moreover, we also accessed primary data by having the opportunity to observe a variety of meetings and discussions between stakeholders and a training session on the prototype in

development. These observation sessions gave us access to their perceptions of a full dematerialization platform. They allowed a better understanding of the needs and expectations of potential users and a better knowledge of the desirable functionalities of such a platform. Finally, analyses resulting from the study were given to the respondents as reports to ensure the accuracy and validity of the findings.

4. Findings

A legal framework was first introduced in France in the late 1990s to allow actors involved in public works contracts to dematerialize documents. Since then, several platforms have been developed to enable client organizations to dematerialize specific documents. Some platforms are dedicated to the dematerialization of calls for tender, while others focus on the dematerialization of invoices. During the course of the study, a few with an integrated approach were under development to help client organizations to dematerialize all the documents liable to be produced in the lifecycle of a public works contract. Actors from various kinds of organizations highlighted several advantages that would result from replacing paper documents with electronic ones. First, substantial efficiency gains could be achieved by economizing on the significant volume of paper documents and related storage space typically associated with public works contracts. Dematerializing documents would also enable the processing chain to be automated, hence eliminating the burdensome tasks generally required with printed documents. Second, dematerialization would make data and documents easier to manage. Frequently mentioned examples include accelerated information search, real-time traceability, data security and reliability. Third, dematerialization can facilitate interactions between actors, even within the same organization, through better information transparency. Some actors also believe that such transparency could eventually reduce the risk of late payment.
In spite of these benefits that should naturally motivate actors to replace their printed documents with electronic ones, our data suggest that the dematerialization platform adoption process in the context of public work contracts is stuck in a state of paralysis. Indeed, many actors are reluctant to dematerialize documents, and continue to use paper documents exclusively. Other actors dematerialize documents at the stage of the call for tender, and then use printed documents during the execution stage of the contract, especially for invoices. During our study in the region of Normandy, we found no instances of actors involved in public works contracts that had dematerialized all of their documents. The paralysis observed in the rate of dematerialization platform adoption appears to be related to the significant costs that would be incurred by any organization wishing to replace printed documents by electronic ones. Our findings indicate that one part of these costs is linked to the technological change caused by platform adoption, while another part depends on the adoption decisions made by the business partners of any focal organization.

4.1. Costs independent of adoption decisions by business partners

4.1.1. Equipment costs

In addition to the price paid by client organizations to use a dematerialization platform, they also need to invest in the specific equipment needed to use the platform correctly. This mainly covers electronic signatures, software for editing and processing electronic data, and appropriate hardware for storing electronic documents. Additional equipment may include digital tables to facilitate readability and teamwork on electronic documents such as architectural plans. These extra costs represent a non-trivial expense in contrast to continuing

to rely on printed documents alone, both for typically small-sized construction firms and for public clients where new expenditures need to be validated through formal procedures.

Now, we're going to have to pay 2,000 or 3,000 euros a year for a remote transmission system. Electronic signatures didn't exist, but now they do… 180 euros every two years for each signature. All these costs add up. […] when you have to present your budget for year N+1, there are extra lines that need explaining. (Director of Information Systems for a municipality).

Using dematerialization platforms and the related equipment also requires proper adaptation in terms of both procedures and individual skills, involving substantial reorganization, learning and training costs.

4.1.2. Reorganization costs

Replacing printed document management processes by dematerialized document management implies a major change in the in-house processes and new technologies to be mastered by both firms and public authorities.

So, we talk about it [Note: dematerialization] as if it's simple, but it's actually complicated for small players that aren't used to it […]. These are tools that they're not familiar with, it's going to take them longer. They're bound to be reluctant. It's easy to send paper documents. (Director of the finance department of a city and urban community).
[Dematerialization] also involves the implementation of a system to validate documents, […] something which doesn't yet exist and which I think may be a source of error. It's mainly used to streamline procedures and make them more transparent, and this needs a lot of reorganization. (Person in charge of the public procurement department of a region).
There also need to be operational methods afterwards. How to reject documents, how to request changes… Operational methods need to be introduced so that each player knows what's to be done, how and when… (Director in charge of public procurement in a city hall).

Collective operational methods also need to be adapted to dematerialization. This involves creating new standardized procedures to manage each dematerialized transaction between the players. The example of collective invoice management is a good illustration. When using printed documents, firms edit and send their invoices to the project manager (usually an architect) who performs the first control. The invoices are then sent to the contracting authority (a public authority) which also performs several in-house controls. The invoices are finally sent to a municipal government finance office which performs the last control before proceeding with the payment due to the firm. Any errors noted at each stage of the control process are often corrected manually and sent to the next department without the firm having to re-edit the invoice, unless the errors are considered to be too significant. In contrast, if invoices are dematerialized, these collective coordination procedures for editing and processing them need to be totally redefined. One interviewee explained this as follows:

I think that we can organize it. […] But it will require a change in the organization. […] This means that we'd have to totally change strategy, invoices would have to be issued by the project manager and no longer by the firm… If we did that, the firms would just accept. Or maybe the contracting authority could be in charge of pre-invoicing, issuing the pre-invoices that the firm would accept as it's in possession of all the contracts, etc. It's a different logic. […] Or every player would add a document, and the last document would be the one that

triggers payment, that could be a solution. I don't know, we'd have to look into it… (Director of legal resources and public procurement for a public authority).

4.1.3. User learning costs

Some productivity loss seems inevitable in the process of learning to work efficiently with electronic documents. For example, reading, analysing and checking dematerialized documents can take longer than with printed documents. As a result, the use of a dematerialization platform tends to reduce operational efficiency for individuals accustomed to working with paper documents.

It's not easy for everyone to read on a screen. It involves a lot of visual work. (Director of the finance department of a city and urban community).
It takes us 10 minutes to check a hard-copy application and […] sometimes one hour to check an electronic application; honestly, it's a real handicap" (Director of the procurement contract administration of a city).
I think that we'll still have to print off the hard-copy of an invoice to check it for major operations, because when we check it on screen, it's not at all the same as when we check it on paper. (Representative of a regional council).

The people we interviewed often mentioned that employees must be updated and trained to use a dematerialization platform and its related equipment.

This requires consultation and time to explain the project upstream.[…] We then need time for training, because these are tools that they're not used to handling, even if they're not necessarily against it. (Person in charge of the procurement contract department of a city and urban community).

Conversely, failure to dedicate sufficient learning and training time can result in serious mistakes. Construction firms may even run the risk of losing opportunities to win bids, for example.

Another problem is that we reject firms upstream because they haven't dematerialized all of their bids by not signing them electronically. They've scanned the documents before putting them on the platform, which means that they're not valid. (Person in charge of public procurement for a public authority).

4.1.4. Transaction costs

When they start using a dematerialization platform, users are often confronted with additional transaction costs that are proportionate to the number of documents interchanged per contract. First, using a dematerialization platform is considered as likely to expose a player to reliability issues when transmitting electronic documents. In particular, a document sent may not be received by the recipient, it may be received too late, or it may be damaged during transmission. For instance, one of the most frequently reported issues is that of tender packages, correctly sent before the deadline, but not being received in time by the public contracting authorities. This may be due to a technical problem in the dematerialization platform or communication infrastructure. If a package is received after the deadline, it is purely and simply rejected. This is both a potential revenue loss and a significant waste of

resources for the unlucky firm, as it will have put a lot of work into preparing the tender package (typically several weeks or months).

And if they see it a bit late or if ever there's a problem with the flow or a virus, it [Note: the firm's bid] will automatically be rejected by the system. (Person in charge of public procurement for a public authority).
We've seen firms that have told us, for instance, […] "we had to submit a dematerialized bid by 5p.m. on a Friday, we submitted our package, it didn't go through the pipeline and it arrived at 5.01 p.m., only to be rejected!" We know when it's submitted, but we have no guarantee about when it arrives. (Representative of a construction industry federation).

Second, some interviewees express a lack of confidence in dematerialization platforms as they fear their partners may behave in an opportunistic manner, which could also increase transaction costs. For instance, when construction firms send their tender packages through a platform, one perceived risk is that some of the strategic information in electronic format may be disclosed before the deadline to the benefit of a competitor. Another concern is that the different parties tend to share more information during the execution of a contract in order to better preserve their interests. The resulting information overload can increase information processing costs for all the partners involved.

We get caught up in information, because whenever some event happens, there's more information (…). It follows that you're updated for legal reasons, so this means you have to look at and check everything that's happening, it's a kind of lottery (…) Whoever sends it tries to protect himself and floods everyone with a pointless torrent of information (Representative of a construction industry federation)

Finally, some construction firms fear that public contracting authorities may take advantage of the platform to pay them late. To illustrate:

In the past, we've had to use software for dematerialized pay requests […] As the amendments weren't drawn up by the local authority or the Government, they claimed that they didn't have to pay our requests, when in fact they were responsible for the fact that the amendments hadn't been drawn up […]. Just because such and such a document hadn't been drafted by the authorities, the software didn't validate the requests we sent. We ended up being paid really late! (Director of a construction industry firm)

4.2. Costs that depend on the adoption decisions of business partners

Public works contracts involve a variety of interconnected actors, especially construction firms, architects, public authorities, prefectures and municipal finance offices. Our data shows that an organization willing to dematerialize documents would incur significant costs if its diverse partners continued to work exclusively with printed documents. As a consequence, the decision made by any organization to use a dematerialization platform largely depends on the decision made by its potential business partners to adopt such a system or not.

Everyone must accept the rules of the game. (Director in charge of public procurement in a city hall)

This issue arises both at the level of analysis of a specific construction project and at the level of analysis of a set of potential construction projects in any given region.

4.2.1. Duplication costs at the level of one construction project

Over the course of a public works contract, if one organization dematerializes documents in an isolated way while others continue to use printed documents, the focal organization will end up having to duplicate dematerialized documents in paper format. Managing transactions in both paper and electronic formats requires more time and money compared to using printed documents exclusively. Duplicating documents in two different technological formats thus generates additional costs. As an illustration, an informant described the problems involved when a public client is the only organization to dematerialize documents:

To begin with, switching from printed documents to 100% dematerialization implies that we only receive dematerialized bids. This means that all the players must also be involved in the chain. (…) If we consider that we receive paper-based bids that need to be dematerialized then rematerialized in-house, we will effectively spend time doing this which will involve human resources, physical resources, storage space, etc. It's the transition from a printed document to a dematerialized version… that then may be rematerialized when a document is sent to the sub-prefecture (administrative city of a particular region). This means a lot of to-ing and fro-ing between digital and paper documents. […] If we're the only ones fully committed to dematerialization, it won't be the best solution, and it will mean a lot more work for us for little benefit. (Person in charge of general administration and procurement contracts for a public authority).

In addition, having more players that dematerialize documents over the course of a construction project does not reduce the duplication problem if at least one organization in the complete chain is not equipped with a dematerialization platform. Indeed, several redundant transactions involving paper documents will be added to the electronic ones for all the other players, generating significant costs. To illustrate, construction firms that dematerialize their tender package documents or invoices face this common problem. In the best-case scenario, architects and public clients will be able to receive and process the electronic documents correctly, but prefectures (local government authorities) and municipal finance offices will only accept printed documents. As a result, construction firms, architects and public clients have to duplicate native electronic documents in printed format (i.e. process the same documents twice, in two different formats) to enable downstream partners to accept and process these documents. An informant reports this issue and explains the importance of having all the players participating in a project committed to dematerialization:

Because we have to send it (note: the firm's package) later to the sub-prefecture as a printed document, we ask the firm to sign bids by hand that it has already signed electronically. (…) We have to rematerialize everything to send it on to the sub-prefecture, so we have to ask for another signature. We have the proof that we received a signed bid when the bids were submitted, so legally speaking, the bid is valid, we can prove it by computer. However, when we rematerialize, you can't see it on the paper document (…) Of course, the administrative formalities seem complicated when we do this. But that's because the chain is incomplete between the players: firms, local authorities… and the prefecture. (Person in charge of general administration and procurement contracts for a public authority).

As a result, it appears that document dematerialization is of little interest if the parties involved in a public works contract are not jointly committed to the approach. It therefore

follows that the interest of using a dematerialization platform depends on the willingness of the other actors to adopt similar behavior.

4.2.2. *Technological diversity costs at the level of several construction projects*

4.2.2.1. Heterogeneity in the degree of dematerialization use

Moving from the level of analysis of a specific public works contract to that of several potential construction projects within a region, additional interdependency issues arise regarding dematerialization platform adoption. At least three sides of potential dematerialization platform users involved in construction operations - construction firms, architects and public contracting authorities - are fragmented markets. These markets are hence characterized by a high number of small and medium-sized players within a specific geographical space such as a French region. As a consequence, an organization will typically be confronted with a mixed situation in which the use of dematerialization by business partners will depend on the nature of the construction operation. In other words, organizations may experience different situations where the business partners will either use printed documents only or will use dematerialized documents. A technical and legal expert summarized the issue from the firms' viewpoint:

The problem is that not all public contracting authorities adopt it at the same time, so firms are confronted by some authorities saying: "We're ready, great, let's go," and others in the same region saying: "Definitely not."

He also stressed that public contracting authorities encounter the same problem:

If the public contracting authorities feel that there's no response from the firms, I don't see why they would commit to it.

The weak diffusion of dematerialization in organizations within a region is considered to be a serious problem for all categories of players. Indeed, it compels many organizations ready and willing to engage in dematerialization to continue using printed documents for many construction projects. It follows that such organizations have to manage both paper and digital document management technologies simultaneously in order to meet the requirements of different projects. The resulting internal complexity and additional costs are perceived as an impediment to the adoption of a dematerialization platform. According to one well-informed respondent, some organizations have tried, sometimes enthusiastically, to use a dematerialization platform for a certain period of time and have later given up and returned to printed documents after experiencing the "*prevailing mess*". As a consequence, firms tend to respond passively to dematerialization due to the weak degree of adoption by public contracting authorities. In a similar and reciprocal manner, many public contracting authorities have put off the transition to dematerialization in response to the wait-and-see attitude of firms. The observed inertia is clearly expressed in the following quote :

Everyone's waiting for everyone else and it's not working, or not working well. (Technical and legal expert).

4.2.2.2. Heterogeneity of dematerialization platforms

Construction firms interacting with public contracting authorities are confronted with an additional problem related to the coexistence of different dematerialization platforms, as acknowledged by an informant working for a large public authority:

Each commune is likely to have a different platform. This is one of the main obstacles to dematerialization. (…) Each firm may be confronted with a different platform, depending on whether it's submitting a bid to the City Hall, the Regional Council, Montville, or the middle of nowhere. (Person in charge of public procurement for a public authority).

This situation is mainly due to the regulatory environment. Indeed, under certain conditions, French public bodies have an obligation to dematerialize tender documents, which compels them to choose a dematerialization platform.

As far as contracts are concerned, the impetus is going to be more at the level of the regulatory codes and constraints that we may be subject to. This is more a question of the legal framework for procurement contracts. We don't anticipate the obligations that will be imposed on us regarding contract dematerialization. For example, we have to dematerialize 95% of our tender documents for contracts worth a minimum of 90,000 euros, we don't do more than that. (Person in charge of general administration and procurement contracts for a public authority)

However, at the time of the study there was no obligation to adopt a specific platform or technological standard. As a result, the autonomous investment decisions of public bodies had generated a proliferation of different platforms.

If we had to assess what exists at the moment, […] there's no coordination […]. Each public authority has been left to its own devices to find a dematerialization platform. […] So, it's obvious that the chosen service provider won't be the same everywhere, insofar as we haven't consolidated coordinated orders between all the public authorities, and as each authority launches its tenders individually." (Person in charge of general administration and procurement contracts for a public authority).

This variety of platforms is seen as a major drawback by construction firms. Indeed, each time a firm is given a works contract with a public authority equipped with a different platform, some of the operation's methods have to be modified or new ones have to be learnt. This is exemplified by the following quote :

People who are used to one platform […] are going to [be] completely lost on another. (Representative of a construction industry federation).

As a result, firms have to bear platform switching costs, in particular the learning efforts involved, proportional to the number of distinct platforms used by the public bodies in a particular region. This led some construction firms to voice their concern within their federation, as reported by an informant:

The interest of firms (…) was to say: "I'm not going to learn again like we did in the tendering sector each time I change a public contracting authority, I'm not going to learn a new way of invoicing." (Technical and legal expert)

5. Discussion

Our empirical findings underscore two main characteristics of dematerialization platforms. First, they can be conceptualized as an architectural innovation in inter-organizational projects. For the users, they represent an investment decision that changes internal and inter-organizational processes, and generate significant costs in addition to the price of the platform itself. Second, they bring together several (more than two) sides of business users that are sequentially interconnected, or tightly coupled, at project level. It follows that the decision to invest in this kind of platform is made in a complex and interdependent context as the gross utility and costs incurred by any one user will depend on all the other users' adoption decisions.

5.1. Dematerialization platforms as an architectural innovation in inter-organizational projects

Architectural innovations are defined as a category of "*innovation that changes a product's architecture but leaves the components, and the core design concepts that they embody, unchanged. The essence of an architectural innovation is the reconfiguration of an established system to link together existing components in a new way*" (Henderson & Clark, 1990, p. 12). In the context of inter-organizational projects, an architectural innovation would redefine the linkages between the actors without changing their core roles and activities or eliminating any of them. Our findings show that dematerialization platforms produce this kind of reconfiguration in construction projects, and expose organizations to a paradoxical situation. On the one hand, successful adoption of the platform would enhance overall productivity in a systemic way. On the other hand, such an outcome initially involves start-up costs for all participants as well as changes to their processes and practices.
This paradox can be summarized by breaking down the net utility of a dematerialization platform as the difference between its gross utility (benefits for the user) and costs. A minor part of net utility is derived from using the platform in an individual way without considering the number of reciprocal users and the possibility of interacting with them via the platform. A major part of net utility comes from the potential to interact with other users in new ways through the platform. The net utility of a dematerialization platform can thus be expressed as the sum of independent net utility and interdependent net utility (equation 1).

Net utility = independent net utility + interdependent net utility (equation 1)

The independent net utility of a dematerialization platform is negative as the benefits obtained from individual use are limited, while the affiliation costs are substantial. These costs include the price of the platform together with the related equipment costs, reorganization costs, user learning costs and transaction costs (equation 2).

Independent affiliation costs = platform price + related equipment costs + reorganization costs + user learning costs + transaction costs (equation 2)

Interdependent net utility corresponds to cross-group network externalities: the difference between the benefits and the costs that depends on the number of members from other sides that use the same platform. While an increase in the number of other users generates benefits for any one organization by allowing more transactions to be dematerialized, it can also increase duplication costs as well as technological diversity costs (equation 3). Duplication costs arise when there is technological discontinuity in the use of dematerialization between actors at the level of a construction project. Technological diversity costs occur when an

organization has to deal with different document management technologies at the level of several projects that include both paper-based documents and various dematerialization platforms.

Interdependent affiliation costs = duplication costs + technological diversity costs (equation 3)

A direct implication of these conclusions is that the incentive effect of pricing policy in the decision to adopt a dematerialization platform is reduced. A platform can thus result in significant costs for an organization, even when its adoption is subsidized by charging zero prices for all sides. It follows that the ability of platforms to grow their user base via their pricing policy is considerably diminished.

5.2. Cross-group network externalities in tightly coupled inter-organizational projects

Our case study highlights two kinds of interdependence between the players involved in public works projects when it comes to assessing the utility of dematerialization platforms. The use of a dematerialization platform is not seen as an attractive option for a specific organization: 1) when the number of members from other sides is perceived as insufficient at the level of a set of potential projects and 2) if at least one other actor continues to use paper documents exclusively at the level of a construction project.
This is consistent with the analysis of the construction industry made by Dubois and Gadde (2002b, p. 626) when they concluded that "*The pattern of couplings in construction is characterized by tight couplings in individual projects and loose couplings in the permanent network*." Our empirical findings allow us to identify two dimensions that influence the sign and size of cross-group externalities. The first dimension is the aggregate number of individual organizations that are members of a platform from different sides (the x-axis in the matrix). This dimension captures the classical view of cross-group externalities and reflects the loose coupling between the different sides of actors. The second dimension is the proportion of participating organizations that use the same platform at project level (the y-axis in the matrix). It reflects the fact that inter-organizational projects in construction are tightly coupled because the activities performed by the various specialized actors are directly and sequentially connected and have a strong degree of interdependence (Beekun & Glick, 2001; Dubois & Gadde, 2002b; Orton & Weick, 1990). The matrix obtained by crossing these two dimensions reveals two main platform adoption paths (see fig. 2).
A consecutive (or sequential) adoption path occurs when an increase in the aggregate number of platform users on the different sides is not linked to a growing number of projects where all participating organizations use the same platform. Such a dispersed or fragmented pattern of adoption, where the different sides of actors do not adopt a platform at the same time, results in cost inefficiencies in a growing number of inter-organizational projects (from case 1 to case 2 in the matrix). Actors involved in public works contracts experience such inefficiencies when some of them autonomously adopt a dematerialization platform while others continue to use paper documents. The tight couplings that characterize the interactions between the players require technological consistency that is disrupted in a systemic way by the combined use of paper and dematerialization technologies. Increasing negative cross-group network externalities are likely to occur and the platform's diffusion is likely to be paralyzed. This adverse scenario helps to explain the reciprocal wait-and-see attitude showed by the different categories of players regarding the adoption of dematerialization platforms.
On the other hand, a concurrent (or simultaneous) adoption path occurs when an increase in the aggregate number of platform users from the different sides is associated with a growing

number of projects where all participating organizations use the same platform (from case 3 to case 4 in the matrix). In these projects, the absence of technological diversity to manage interactions between the players removes cost inefficiencies while increasing the benefits for all actors. The net utility of a platform is probably negative in case 3 because of the initial investment incurred. However, this situation validates the proof of concept and allows early adopters to experience the potential benefits of the platform in a credible way. In turn, this can convince other potential organizations to adopt the platform through a similar pattern, leading to more and more projects offering the opportunity to work with the same platform. Increasing positive cross-group externalities are therefore likely to occur.

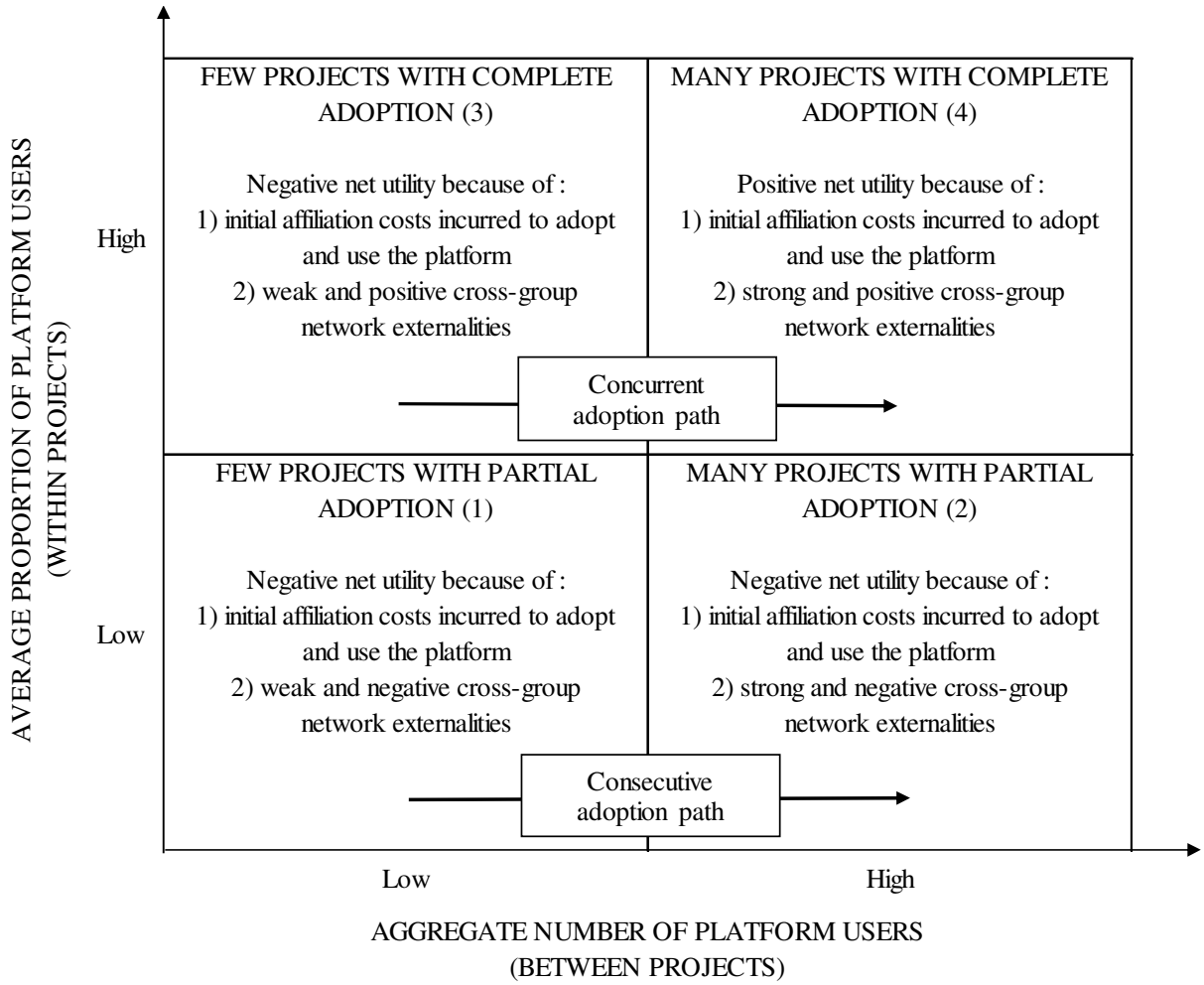

Fig. 2. Concurrent and consecutive platform adoption paths.

6. Conclusions

6.1. Theoretical contributions

Overall, this paper makes three contributions to the research stream on multi-sided platforms. First, our findings suggest that the incentive effect typically attributed to a platform's pricing policy is weakened under certain conditions. The existing literature on multi-sided markets considers that the decision to join a platform is mainly influenced by the number of members on the other sides and on the platform's pricing policy (Cabral, 2019; Rochet & Tirole, 2006), especially the price structure (i.e. allocation of the aggregate price level between the different sides). Many papers (e.g., Hagiu & Wright, 2015; Rochet & Tirole, 2006) recognize that costs may have to be incurred by new members on the user side, but they offer no further

implications from this insight. In contrast, we show that two kinds of affiliation costs may arise in B2B contexts, with significant implications regarding platform adoption decisions. First, independent affiliation costs are incurred as soon as a business user adopts a platform. These costs can be significant if platform adoption involves a change in the internal and inter-organizational processes. Second, an organization may have to deal with interdependent affiliation costs that directly depend on other users' adoption decisions. These costs are a result of both within-project technological inconsistency and between-project technological diversity. An organization wishing to participate in many projects with such technological characteristics would experience an increasing, and discouraging, level of these costs. The limited role attributed to affiliation costs in platform adoption decisions may be related to the nature of the platforms generally studied in the two-sided and multi-sided markets literature. The latter are often modular platforms that can easily be connected to the user's existing practices and processes without requiring significant internal and inter-organizational adaptation. In other words, such platforms do not seem to involve high nonfungible investments (Jacobides *et al.*, 2018). Examples include videogame platforms, smartphone platforms, online recruitment platforms, online marketplaces and payment systems. In contrast, architectural platforms that require organizations to change internal and inter-organizational processes lead to costly adaptation issues, especially when the participating organizations are tightly coupled. This corresponds to a situation where strong interdependencies coupled with substantial nonfungible costs produce high nongeneric complementarities (Jacobides *et al.*, 2018). In such contexts, our findings suggest that the role of pricing policy as an incentive mechanism to stimulate adoption is less important. This compels the platform to envisage and activate other levers that can ease the adaptation endeavors of client organizations.

Second, we extend prior research on cross-group network externalities by showing that the (average) proportion of participating organizations which use the same platform at project level serves as a moderator in the link between the aggregate number of users on the different sides of a platform and its net utility. According to previous studies, two main factors can generate negative network externalities: the quantity and the quality of the other platform users (Akerlof, 1970; Evans, 2012; Rochet & Tirole, 2006). In addition, the proportion of organizations that use the same platform at project level can also influence the sign of cross-group network externalities. Our findings suggest that this phenomenon occurs when three conditions are met: 1) the platform is used in a project-based industry, 2) the platform represents an architectural innovation that redefines the linkages between users, and 3) organizations that participate in a project are tightly coupled. In such settings, a platform that changes the linkage architecture between organizations cannot be adopted in an isolated way without systemic adverse consequences. Therefore, cross-group network externalities can either be positive or negative depending on whether an increase in the aggregate number of users translates into a growing number of projects where all the actors use the same platform.

Third, and linked to the previous point, we advance understanding of multi-sided platform adoption dynamics by suggesting that a platform adoption path can either be consecutive or concurrent. Most existing studies suggest that the chicken-and-egg problem can be solved through a consecutive pattern of adoption. Within this logic, platform adoption can occur sequentially between the different sides in a mutually reinforcing circular growth process. Basically, a platform tries to get a first side on board and to form a minimum user base. This in turn activates positive externalities that run across markets to attract the other side(s). More users on the other side(s) triggers positive externalities that run back to the first side and attract new users, and the process continues back-and-forth (Hagiu, 2006). Discounting one market in order to grow both (Parker & Van Alstyne, 2005) illustrates this underlying logic. In the related empirical literature, Muzellec *et al.* (2015) report that internet ventures attempt

to attain critical mass (Evans & Schmalensee, 2010) at the end-user side in a first stage of development, and then shift their focus to business partners in a second stage by exploiting positive cross-group network externalities. Tan *et al.* (2015) show how Alibaba evolved from a two-sided platform at nascent stage bringing together merchants and buyers, to a mature multi-sided platform that brought application developers, banks and advertisers on board. In contrast, our findings suggest that a consecutive pattern of adoption can make a multi-sided platform less and less attractive as the aggregate user base grows in the presence of tight couplings between the users' activities. In such contexts, the multiple sides need to be brought on board in a concurrent way at project level to foster further platform adoption. Simultaneity between the different sides at project level therefore appears as a critical condition for the process of adoption to succeed.

6.2. Managerial implications

Our recommendations are directed at three major players: platform providers, public clients and governments.

In order to limit the risks related to technological discontinuity, platform providers should propose an integrated platform for the dematerialization of all documents needed in a construction project and a centralized information-sharing system, from the call for tender stage through to invoicing. In addition, they should encourage and facilitate access to this integrated platform and the associated services for all the actors involved in a specific project. Consequently, the sales policy should be designed with a project perspective in mind rather than targeting individual organizations. This kind of approach has three major implications. First, platform providers should contract with public authorities. The latter represent the money side, while the project manager and construction companies represent the subsidy side. Second, platform providers should set a price that takes into account all of the equipment, training for all users and follow-up during implementation for the entire project. In addition, there could be a sliding scale price policy according to the number of projects whose transactions are to be dematerialized via the platform. Third, platform providers could organize and offer all actors free presentations and group training sessions regarding the platform in question. This would promote collaboration and the development of new collective procedures. It would also allow participants to put forward modifications and improvements to shape the platform to their needs.

To strengthen the effectiveness of the platform providers' endeavors as outlined above, public clients could stipulate in the call for tender that the dematerialization and use of a specific platform is mandatory for the project. In addition, they could act as ambassadors and promote the dematerialization process to reduce reluctance on the part of employees and partners. Public clients could also play a role in promoting adoption of dematerialization at the level of a specific area (e.g., a region in France). Indeed, the public authorities in the area in question could cooperate to select a common platform. This would be materialized through collective and synchronized procurement from the same platform provider, leading to an increase in the number of public contracting authorities equipped with the same platform in a same area. Two beneficial outcomes would follow for the other users: first, a reduction in switching costs and, second, an increase in the benefits derived from dematerialization.

Finally, our study shows that certain decisions taken by governments concerning dematerialization are not optimal and may even be risky. First, some legal obligations appear to have ambiguous outcomes. They compel public authorities to find technological solutions in order to comply with the regulatory framework, leading to the rapid adoption of dematerialization for this category of actors. However, as public authorities tend to make autonomous procurement decisions, the legal obligations also lead to the risk of increasing the

number of distinctive and competitive platforms. As a result, firms would be exposed to significant switching costs, unless the legal obligation in question is accompanied by well-defined technical standards. Second, governments generally focus on large-scale projects by legally requiring public authorities to dematerialize above a certain amount. Our study suggests that it would be better to focus initially on smaller projects since such projects involve a limited number of actors, thereby reducing the risk of technological discontinuity (as when an actor is not equipped or not ready to accept dematerialization). Such small projects would give actors more potential to experience dematerialization in a positive way before transitioning to large-scale projects.

6.3. Limitations and future research

There are two main limitations to our research. First, our research design is based on a single case study that impedes the generalizability of the findings. The singularities inherent to the construction industry, the region where we collected the data as well as the experiences and discourse of the interviewees regarding dematerialization might either be negligible details or major idiosyncrasies. An interesting singularity is that our findings derive from an empirical setting characterized by the absence of platform leaders (Gawer & Cusumano, 2002; Helfat & Raubitschek, 2018). This can be explained by the emergent nature of the French market for dematerialization services in public works contracts created under the impetus of public regulators. Previous research has stressed the importance of platform leaders to orchestrate ecosystems (Helfat & Raubitschek, 2018). As architects of their ecosystem, platform leaders generally play four major roles (Gawer & Cusumano, 2014; Gawer & Cusumano, 2002; Gawer & Philipps, 2013) : 1) they bring a welfare-enhancing vision of the collective ecosystem; 2) they build consensus around their platform; 3) they shape the trajectory and architecture of the overall ecosystem within which they offer a core product that solve technical problems for other ecosystem members; 4) they facilitate and drive the emergence of complementary innovations (around the core product) developed by ecosystem members called "*complementors*". Had a platform leader purposefully orchestrated its dematerialization ecosystem, the dynamics of platform adoption might have been different.

Further empirical research is thus needed to statistically investigate the validity and transferability of our main findings to other contexts, especially regarding the role of pricing policy on platform adoption, the conditions that produce positive or negative cross-group network externalities, and in presence of platform leaders who implement deliberate ecosystem orchestration strategies. Multi-sided platforms that represent architectural innovations, either in tightly coupled or in loosely coupled inter-organizational networks, are good candidates. Examples of project-based empirical settings where such platforms could be studied further include aerospace, defense, car, motion picture, video-game and pharmaceutical industries. Blockchain could also represent a relevant area of empirical investigation in this respect (Iansiti & Lakhani, 2017).

Second, we point to a distinction between concurrent and consecutive adoption paths, but we do not investigate the mechanisms that would enable and facilitate a concurrent pattern of adoption. An interesting agenda for future research could therefore be to identify and classify different strategies that support a concurrent adoption path. In addition, Quintens and Matthyssens (2010) highlight the importance of time as a multidimensional variable (frequency, order, pace, timing, duration etc.) to enhance management research. In this regard, our paper focuses on the *order* in which adoption decisions occur, but other dimensions of time could be analysed to better understand platforms' dynamics and strategic moves as well as platform members' behaviors and interdependencies. For example, intense competition and short product lifecycles could put high pressure on the required *pace* at which a multi-sided

platform should attract new users. If this conjecture is correct, analysing how to stimulate and sustain a high *pace* of adoption or how to achieve a critical mass under a specific and limited time frame deserve further inquiry.

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