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Abstract

Many firms have to use more than one inter-organizational information system (IOS) to support their communications with partners. The use of multiple systems can reduce the full benefits of IOS adoption. To account for this, we introduce a new concept: the landscape of inter-organizational information systems. Relying on collective action theory, we describe how opposing strategies of actors shape the IOS landscape and preclude the business community from attaining the landscape which represents collective level optimum because of the exclusive nature of this public good. Individual firms, alliances, and community representatives push the IOS landscape either towards more standardization, more hub-type connections, and less substitutable IOSs, or towards less standardization, more point-to-point connections, and more substitutable IOSs. Certain interests can prevail for a while but in practice there seems to be no equilibrium state for the business community IOS landscape which can be sustained for a prolonged period of time. We support our theoretical propositions with evidence from a case study in a seaport setting.

Keywords: inter-organizational information system, EDI, information infrastructure, business community, case study, seaport, transportation industry

Introduction

Inter-organizational information systems (IOSs) are used as means for information exchange between many firms nowadays. A company has to interact with a variety of organizations to support its operations. For example, it interacts with suppliers to get goods and services, with customers to sell produced goods and services, with banks to arrange financial affairs, and with governmental organizations to comply with regulations [33, 51]. Accordingly, IOSs support a variety of business processes. These include buying and selling transactions between manufacturers and their suppliers [4, 55, 43], electronic transmissions of payments information between payers, payees,

and their banks [49], and tracking and tracing goods movements along transportation chains [45]. So far there have been no reports that a single IOS can support the complete variety of a company's inter-organizational processes. Thus, many companies have to use more than one IOS [51, 59, 35].

The majority of IOS studies, however, focus on a single IOS or on the comparison between IOSs rather than on the organization and the variety of IOSs it uses. This precludes them from investigating how the IOS already in use affects the company's decision to adopt a new IOS [35], and which IOS characteristics need to be considered when adopting a new IOS. To addresses this gap, we introduce a new concept of the IOS landscape, which can be categorized along the following dimensions: the number of the IOSs, their architectures, their interoperability, and their substitutability. We support the relevance of the new concept by theorizing how the landscape dimensions can influence the benefits that a firm can achieve from IOS adoption.

We demonstrate the practical relevance of the concept in the setting of the Rotterdam port business community. Today IOSs can have a big impact on the international competitive position of port business networks. Firstly, efficient information exchange inside and among the companies allows minimizing documents processing delays that restrain the flow of goods [2]. This decreases the time for which goods are constrained from moving and increases ports productivity. Secondly, better coordination within and among the companies brings about decrease of resource consumption and higher reliability [16, 25]. Thirdly, information systems can make supply chains more transparent for the customers[52]. Thus, IOSs can increase the quality of the services provided by port cluster and improve a port's competitive position. However, the interplay between existing IOSs should be considered if the port is to leverage these opportunities.

In order to understand which forces influence the formation of the IOS landscape, we

use the collective action theory lens. This perspective allows us to analyze the variety, and often contradictory, interests of actors in the development of the IOS landscape. Furthermore, the dynamics of the collective action of the interaction between the collectives allows us to describe the role that alliances and business community representatives play in forming the IOS landscape.

In this paper we make three main contributions. Firstly, we demonstrate the importance of recognizing that modern firms use more than one IOS in their practices at the example of the port business network. Secondly, we introduce the concept of the IOS landscape and its dimensions. The use of this construct can enrich future studies of IOS development and adoption because it takes into account the interplay between different IOSs. Thirdly we describe the dynamics of the IOS landscape formation. We show how the interplay between different organizational interests at various levels affects the IOS landscape dimensions using an example of the Port of Rotterdam. Previous research has stressed the advantages of common standards and the use of IOSs with shared neutral hub architectures [37, 48]. We demonstrate that the convergence of many different players and their interests is required to achieve such a state because of the exclusive public good nature of this type of IOS landscape. The competitive nature of individual companies ensures that such an equilibrium is not stable. Once the shared IOS is in use by the majority, companies have to think of new ways to distinguish themselves from the competition. As a result, new IOSs are developed and the proliferation of different systems and standards starts again.

The rest of the paper is organized as follows. We start with the introduction of the concept of the IOS landscape, the role of collective action in its formation, and its main characteristics. Then we present the propositions linking the interests of the business community members and the IOS landscape dimensions. In the fourth section, we discuss the method used in this research project. Afterwards, we describe

the findings of our case study of the IOS landscape of the Port of Rotterdam and reflect upon our propositions in the discussion section. In the final section, we present our results, consider their implications for IOS research and practice, and discuss their limitations.

The landscape of inter-organizational information systems

IOS landscape formation as a collection of collective actions

The development of an IOS requires the participation of multiple organizations. Previous research has successfully used the lens of the public goods and collective action theory to describe the process [39, 37, 32]. Collective action theory studies groups which are defined as collections of individuals with a common interest [42]. A common, collective, or public good is any good such that, if any individual consumes it, it cannot feasibly be withheld from the others in that group [42]. A collective good possesses two defining characteristics: impossibility of exclusion and jointness of supply [39]. The members of the collective cannot be excluded from using the good even if they have not contributed to its production; the use of the good by one member does not diminish the amount of good available for other users [39]. An IOS is not a collective good, but the functionality that it provides to its participants is. This functionality can be the ability to reach other members of the collective via electronic channels or the access to the information shared by other users [39]. Sometimes an IOS possesses only one of these characteristics of a public good: it is either non-exclusive or non-rival. For instance, in the case of CLUE (an insurance claims database that provides insurance applicants' claims history to the participating company [32]), the use of the database by insurance companies does not reduce its usefulness to individual users. The system is non-rival. However, access to it can be limited by the system's owners. In such situations an IOS is considered to be an

impure public good. Still the main properties of pure public goods are transferable to impure public goods as well because their nature demands joint actions from different organizations.

The problem with the production of a collective good is that each member of the collective decides to participate or not based on individual gains and costs. Members do not take into account the benefits that their participation will bring to the others. For this reason, a collective good is often under-produced. The characteristics of participants, their interests in consuming the public good, the available resources, and their costs and benefits are important predictors for the production of a collective good [38, 39]. Olson [42] has demonstrated that larger groups face more difficulties with collective goods production because with the growth of the group's size the individual reward relative to the total gain is falling which lowers the chances of individuals participating in the common cause. Moreover, the larger the group, the greater the organization costs of collective good production. An IOS is usually developed within an alliance of organizations [39, 37, 32, 35]. Hence, the more organizations are required to participate in an IOS development, the lower the chances that the system will be actually created.

Previous research has identified a wide variety of interests that participants can pursue with respect to IOS development [5, 8, 44]. A single firm can participate in the development of multiple IOSs and accordingly belong to multiple alliances [35]. Inter-organizational information systems have been studied with the lens of the collective action theory before [39, 37, 32, 12]. However, the focus of all these studies have always been on one IOS, one set of standards or one alliance. Khanna [29] noted that a firm's decision to participate in an alliance can be affected by its activities outside of the alliance because those activities can affect the stream of participation benefits. Accordingly, a firm's decision to adopt an IOS can be affected by the other

IOSs that it is already using [35]. In this paper we widen the scope of our research from an individual IOS that is being used by a firm to the variety of IOSs by which it is surrounded. We define the IOS landscape of a firm as the collection of all inter-organizational information systems that a firm can potentially use in order to connect to its existing and prospective partners (e.g. customers, suppliers, and government organizations). The information exchange between organizations, i.e. which information is available to which partner, and the quality of this information, is shaped by the IOS landscape.

The firm can either use an existing IOS developed by others or join an IOS alliance and participate in the IOS development. Thus, the IOS landscape of a firm is being shaped by both, IOS alliances in which the firm participates and IOS alliances which the firm does not belong to but which develop IOSs which could be useful for the firm. The second kind of alliances can be formed either by firm's information exchange partners (i.e. business and government organizations alike) or by firm's competitors. An IOS landscape is a collective level construct which structure is shaped not only by the actions of individual organizations but also at the higher level by the actions of organizational alliances. Morgeson and Hofmann [40] note that collective action can be conceptualized at different aggregation levels. Various IOSs are developed as a result of interactions between organizations. The subsequent interactions between different IOS alliances compose the wider IOS landscape. Thus, the formation of IOS landscape is dependant on the actions of many different actors, individual organizations and their alliances alike.

The unit of analysis for studying the IOS landscape should be shifted from the traditional ecosystems to business communities [36]. Following Markus and Loebbecke [36] an ecosystem is "an orchestrator's extended network of partners" while a business community is a "set of possibly overlapping ecosystems in a defined area of business

activity". This wider unit of analysis allows taking into account that the actions of a firm belonging to a specific ecosystem may have effects that extend beyond its own ecosystem. Accordingly the IOS landscape of a firm can be influenced by firms outside of its own ecosystem. Markus and Loebbecke [36] point out that business communities are not collective actors and accordingly they do not have strategies. However, previous research has demonstrated that the business community as a whole can benefit from an IOS landscape which is based on common standards [37, 48]. Furthemore, Steinfield [48] demonstrated the advantages in using shared neutral hub systems in the context of extended supply chains.

Analogous to IOS case [39], the IOS landscape itself is not a collective good but the functionality that it provides is. The main IOS landscape functionality is to provide an ability to reach any prospective partner for a firm and to access the information shared by others. This functionality is an impure collective good because it requires the participation of many different firms in order to create it (i.e. jointness of supply) but it does not possess the impossibility of exclusion characteristic because it is rather easy to limit access to the IOS landscape (at least certain parts of it) to the individual firms. Certain IOS landscapes are superior to others with respect to the costs of getting the required information through or from them or with respect to the information quality that they provide [48]. Based on previous research we determined a number of characteristics that allow differentiating between different IOS landscapes and evaluate their cost of use for individual firms. The formation of the IOS landscape happens naturally as firms within a business community develop different IOSs. However, the formation of the IOS landscape with desired characteristics becomes a collective good problem because it requires coordination between all those firms and alliances. Furthermore, we show that there is only one IOS landscape structure that would represent the common interests of the business community. The

functionality of the IOS landscape that answers to such joint interests is a pure public good because the members of the community cannot be excluded from using it even if they did not contribute to its development. Otherwise, the IOS landscape characteristics will not meet the community goals. Next we discuss what might be the desired IOS landscape characteristics from the point of view of an individual user and based on that derive the IOS landscape characteristics that would represent the common interests of the business community.

IOS landscape characteristics

We propose to characterize the IOS landscape according to the number of IOSs, their architecture, their interoperability, and their substitutability. These dimensions were derived based on previous research and based on the inherent demands of the construct. Many authors have pointed out the role that IOS architecture and interoperability levels have on the benefits that a firm can get from the IOS adoption [52, 48, 60]. Steinfield et al [48] demonstrated that these dimensions play a role not only at the individual firm level but also at the level of business communities. The number of IOSs as a landscape dimension is a natural extension of the IOS landscape definition. Finally, IOS substitutability did not get much attention in previous research mostly due to the focus on the IOS rather than on the firm and the variety of IOSs that it can use. However, once the focus is shifted we believe that immediately the question arises whether available IOSs perform the same functions or not. Next we dive deeper in each of these landscape dimensions and discuss the firm's preferences regarding each of those.

We distinguish three types of IOS architectures depending on the number of actors that have access to one of its channels: point-to-point, private hub, and neutral or shared hub [48, 52]. When we consider the IOS landscape of a firm, we can distinguish two types of connections only: point-to-point and one-to-many

connections. Depending on which side of the private hub the firm is on, the private hub IOS can provide one-to-many connection (for the owner) or point-to-point connection (for non-owners). Neutral or shared hubs always provide one-to-many connections for all of their users. The number of connections that a firm requires to connect to its partners influences the costs that it incurs to facilitate inter-organizational communication. Each channel requires investment into specific hardware and software to support it [11, 18]. Furthermore, the higher the number of channels, the higher the risk that additional costs are incurred to ensure the integration between internal and external systems which affects performance gains from IOS use [50]. A higher number of communication channels also increases the risk of having to support multiple standards in the communication with firms' partners because each channel can be potentially based on a different standard. The hub architecture of an IOS does not ensure that it can support communication between a firm and all of its partners. An IOS traditionally focuses on connecting specific types of roles and specific types of transactions [4, 7]. Thus, a firm could use two or more neutral hub IOSs: one for communication with its suppliers, another for communication with its buyers and so on. The higher the number of partners one channel can support, the lower the number of channels that the firm has to support. We can distinguish two extreme situations for the IOS landscape architecture dimension: on the one extreme, all of its channels can be point-to-point connections, on the other extreme, the firm can use one channel to connect to all of its partners. An IOS is based on a set of standards called a B2B framework. This is a generic template that provides functions enabling businesses to communicate efficiently over computer networks [46]. Standardization of process and content interfaces requires agreement on the syntax, semantics, and pragmatics aspects of documents that are to be exchanged [18]. If a company uses IOSs which are based on different syntax or

semantic standards, an additional application may be needed to translate messages from one IOS to the other. Even if those IOSs only communicate with internal systems, it still means that the costs of ensuring interoperability will be higher if the IOSs are based on different standards. Efforts are required to make each of the systems interoperable with the internal system. The higher the number of different standards that have to be incorporated, the more expensive it is to ensure the interoperability. Each IOS represents an inscription of certain business practices [19]. For instance, B2B frameworks can have different approaches towards describing how and when information should be exchanged [41]. Thus, it is crucial for a company using multiple IOSs that the business rules inscribed in those systems and the approaches used to describe them can be integrated. Otherwise the user may need to make additional investments for such integration in the form of business processes re-engineering [10, 60]. The interoperability dimension of a firm's IOS landscape has two extreme points: on the one extreme, all the IOSs that a firm uses are based on different B2B frameworks, on the other extreme, all the IOSs that a firm uses are based on a single B2B framework. In practice, IOS architecture and standards are correlated. The systems with private hub architectures tend to rely on proprietary standards customized to the needs of the system owner [28, 18]. Neutral or shared hubs tend to rely more on industry standards and non-proprietary e-business software capabilities [28, 48] and can thus be integrated with internal systems more easily and more cheaply. [6, 57].

A firm is usually involved in a variety of inter-organizational processes and it needs a variety of inter-organizational information services to support them [51]. These services can be characterized along two dimensions: roles that they connect and processes that they facilitate [20]. Roles are distinct, technologically separable, value-added activities undertaken by firms or individuals in a given business network

[27]. Two or more IOSs can offer similar kinds of inter-organizational information services. We define two of these services as substitutes if they connect the same business network roles and support the same business processes. As an IOS can contain more than one inter-organizational information service [26], the two IOSs are substitutes only if all the services provided by one have a substitute among the services provided by another. The IOSs can be partial substitutes if some of the services that one provides have substitutes among the services that the other provides but not all of them. Finally, IOSs are considered perfect substitutes if they connect the same business network roles, support the same business processes, and provide equal access to any trading partner (i.e. not limited to a specific set of companies). The presence of IOS substitutes within a company's IOS landscape can have multiple consequences. If the company has a choice between IOSs that are perfect substitutes, then the situation is favorable for the firm because it can choose the IOS that better matches its requirements (e.g. price, quality). But if the company is operating in an environment where the substitutes are not perfect, it will either have to invest in multiple systems to connect to multiple trading partners, or it will have to commit to one IOS only and give away part of its trading power because of the limited number of trading partners that support that IOS [7, 21].

To sum up, a single firm can have the opportunity to adopt multiple IOSs which form its IOS landscape. This IOS landscape affects the benefits the firm can reap from IOS adoption. In other words, the IOS landscape dimensions such as the number of IOSs, their architecture, their interoperability, and their substitutability play an important role in determining to what extent the full benefits of IOS adoption can be achieved. An individual firm would ideally operate in the IOS landscape which consists of a single IOS that provides access to all of its partners which is possible only if the IOS landscape of the whole business community consists of a single IOS. Thus, the

common interests of the business community are best served by a single IOS with a neutral hub architecture which is based on international standards (in case the firms need to communicate with the companies outside of the business community). The formation of the IOS landscape with such desired characteristics is a collective action problem because it requires the coordination of different firms and alliances when they develop individual IOSs. It is important to consider the multi-level nature of the IOS landscape formation because in most cases IOSs are developed within firm alliances and the main decisions regarding the IOS architecture, standards framework, and functionality are taken within those alliances. Hence, it is not enough to consider the actions and interests of individual firms.

In this paper we analyze what the chances are of the IOS landscape being formed in accordance with the common interests of the business community. Olson [42] demonstrated that for the case of large groups that do not invoke special coercion or incentive mechanisms to act in the common interests the following characteristics are important in order to predict whether the common good will be provided: 1) individual rewards for group-oriented actions; 2) presence of an individual actor or a small group of actors that could provide the collective good by himself or themselves; 3) the size of the organization costs. In this paper we focus on the first point by considering the individual interests of different actors which influence the formation of the IOS landscape. Constantinides and Barrett [12] demonstrated that varying individual strategies can either hinder or sustain the production of the collective good in the IOS context. Wigand et al [56] showed how industry level change is moderated by the technological choices made by organizations. We investigate the individual interests as a precursor for forming a respective strategy by an actor. As the IOS landscape formation is a collective good problem at the collective level, the actors that we should study are not only individual organizations but also their alliances.

Moreover, even though the business communities do not have strategies there exist certain actors which are supposed to represent common interests of a wider variety of community members (e.g. industry associations, government or semi-government organizations). Accordingly, our analysis of individual interests that influence IOS landscape formation of a business community was organized along three levels: individual organizations, organizational alliances, and community interests representatives. Next we discuss the interests of various individual actors that operate on different aggregation level and that affect the formation of the IOS landscape and accordingly the chances of the IOS landscape satisfying joint community interests being developed without special incentive mechanisms in place.

Individual interests shaping the IOS landscape

Firm interests

Traditionally the benefits that IOS adopters can expect have been divided into two groups — direct and indirect benefits [24, 44, 31]. Direct benefits include reduced transaction costs, improved cash flow, reduced inventory levels, and higher information quality [24]. Indirect benefits include better customer service, increased ability to compete, and improved trading partner relationships [24]. The indirect benefits do not stem from IOS implementation alone, but also from the opportunities arising from related business processes re-engineering and strategy alterations.
The direct benefits from IOS adoption accrue at the operational level and increase as the number of the firm's trading partners using the same IOS increases. Assuming the system works perfectly, the more partners using the IOS, the lower the firm's transaction costs, the larger the amount of high quality information in the system, and the better the financial and operational planning of the firm. Theoretically, the greatest operational savings can be obtained if all companies in the firm's business network use the one and only IOS that has a shared hub architecture. In such a case,

all the trading partners rely on the same B2B framework and there will be a perfect interoperability among them.

Proposition 1.1. The interests of companies to increase operational efficiency and reduce costs through IOS lead to a decrease in the number of IOSs in the landscape, an increase in the number of IOSs with shared hub architecture, improved interoperability, and lower substitutability in the IOS landscape of a business community.

However, companies could also focus on the indirect benefit of strengthening their competitive position, and this could push IOS development in another direction. When all organizations use the same IOS, there is a level playing field [9]. To stand out in the competitive field, companies must offer something their competitors cannot or do not offer. Resourceful companies can afford to develop their own IOS and supporting standards, and enforce adoption to gain a competitive edge. Examples include DaimlerChrysler and General Motors procurement systems and American Airlines booking system [59, 7]. These systems can limit the number of trading partners that are allowed to use them, and can positively influence partner relationships. Such closer relationships have the potential to foster innovation, establish trust, and improve flexibility and responsiveness among adopting organizations [3]. The more companies that want to gain a competitive advantage via an IOS, the more systems there will be, and the higher the chances of these systems being at least partial substitutes. Furthermore, a firm using a B2B framework which is different from its competitors cannot only improve its performance vis-à-vis them but can also lock-in its business partners and improve the company's bargaining power by creating switching costs [26].

Proposition 1.2. The interests of companies to gain a competitive advantage through IOS lead to an increase in the number of IOSs and in the number of point-to-point connections in the landscape, lower interoperability, and greater substitutability in the

IOS landscape of a business community.

Thus, at the level of individual organizations there are two contradicting forces that influence IOS landscape development depending on the benefits companies wish to achieve from IOS adoption. If the strategy is to increase operational efficiency through IOS, a shared hub standardized IOS which can be used by all business partners would be the best choice. However, if the strategy is to gain a competitive advantage through IOS, multiple IOSs, each with distinguishing standards and functionality, would be a better choice. This will differentiate the companies from each other and improve their competitive positions vis-à-vis each other.

Alliance interests

The majority of companies are not resourceful enough to individually develop an IOS and ensure its adoption. They need to form alliances. We distinguish three types of IOS alliances depending on the roles of the participating actors: a competitive alliance, a value chain alliance, and a mixed alliance [39, 20]. Participators of a competitive alliance perform common value activities and compete for customers in the product or service market. An example of a competitive alliance is a common claims database maintained by firms in the insurance market [32, 39]. Members of a value chain alliance belong to the same value chain but perform different roles in it. The most straightforward example is a point-to-point EDI integration between a buyer and a supplier like in the case of Vendor Managed Inventory [57]. Finally, a mixed alliance contains both competitors and companies along the value chain. Most e-markets have this kind of structure because they either have many suppliers and at least one customer like in the example with proprietary e-procurement systems of DaimlerChrysler and General Motors, or they have multiple customers and multiple suppliers like in the example of Covisint's platform [59].

Competitive alliances are created to improve the operations of all participating members. Their aim is not to gain advantage vis-à-vis another competitor but to develop community wide innovation. Therefore, IOSs are designed to be highly interoperable with other systems to ensure that all alliance members can use them and benefit equally. The shared hub architecture is the most convenient choice for a competitive alliance as it ensures equal access for all members at low cost. Finally, cooperation among competitors reduces the chances of another IOS with the same functionality being developed. Thus we can formulate the following proposition:

Proposition 2.1. The formation of a competitive alliance within a business community leads to improved interoperability, lower substitutability of the business community IOS landscape, and the creation of a shared hub IOS.

Value chain alliances are formed to improve competitive positions of their members. Such an advantage can be created by offering new services or products through an IOS or by improving service levels [57]. Alliance participants are likely to develop their own standards rather than use the ones available for everyone in the industry. Proprietary standards help the participants "stand out from the crowd" and ensure commitment by creating a lock-in situation [47]. The IOS is likely to have a point-to-point architecture. Some of its functionality can duplicate the functionalities of the other systems that are used by the companies outside of the alliance. The same holds true when one dominant party forms an alliance with multiple partners that perform the same role like in the case of the proprietary e-procurement system [28, 59]. The only difference is that these systems have a private hub architecture which is still a point-to-point type of connection for everyone except the owner of the system.

Proposition 2.2. The formation of a value chain alliance or a mixed alliance with one dominant party within a business community leads to lower interoperability, higher substitutability of the business community IOS landscape, and a higher number of

point-to-point connections.

A mixed alliance without a dominant party can be formed to increase the efficiency of the operations community wide [37, 59] or to increase the competitive position of the business community vis-à-vis other communities [52]. For such consortia, ease of access for all the participants is important, therefore they are more likely to choose a shared hub architecture rather than point-to-point connections. Ease of adoption by all members can only be ensured by using standards that are available for everyone inside the business community. This leads to improved IOS interoperability [61]. In mixed alliances, participants can also compete with one another. This is likely to reduce the number of IOSs which perform the same functions.

Proposition 2.3. The formation of a mixed alliance without a dominant party within a business community leads to higher interoperability, lower substitutability of the business community IOS landscape, and the creation of a shared hub IOS.

Community representative interests

Commercial companies are not the only members of a business community. Institutional agencies such as government organizations and industry associations also play a big role in IOS development [14, 13, 15, 1]. These institutional actors usually have more organizational resources and can therefore exert more influence on other organizations. They do not pursue the interests of individual companies or alliances, but represent the interests of the community in general. Government agencies are interested in supporting the competitive positions of business communities because they provide jobs for their constituents. Industry associations aim to promote common goals for companies belonging to a certain industry.

In the IOS research field, the role of government has been mostly studied in relation to electronic data interchange (EDI) diffusion. Damsgaard and Lyytinen [14] describe

the limited direct involvement of the Finnish government in EDI diffusion in the country during the 1990s. Andersen and Hendriksen [1] report on the EDI action plan developed by the Danish government in 1996 and its limited impact on EDI diffusion within the country. Based on these studies of the role of government in the EDI diffusion process, we suggest that any governmental involvement (direct or indirect) in IOS development in a certain business community would foster cooperation among companies rather than favor one company because the boundaries of a business community are usually limited to a single state.

Proposition 3.1. Efforts by government agencies (if any) tend to aim at ensuring IOS interoperability and reducing the number of IOSs in the business community. They tend to support the development of shared hub IOSs and to aim at eliminating multiple systems that perform the same functionality.

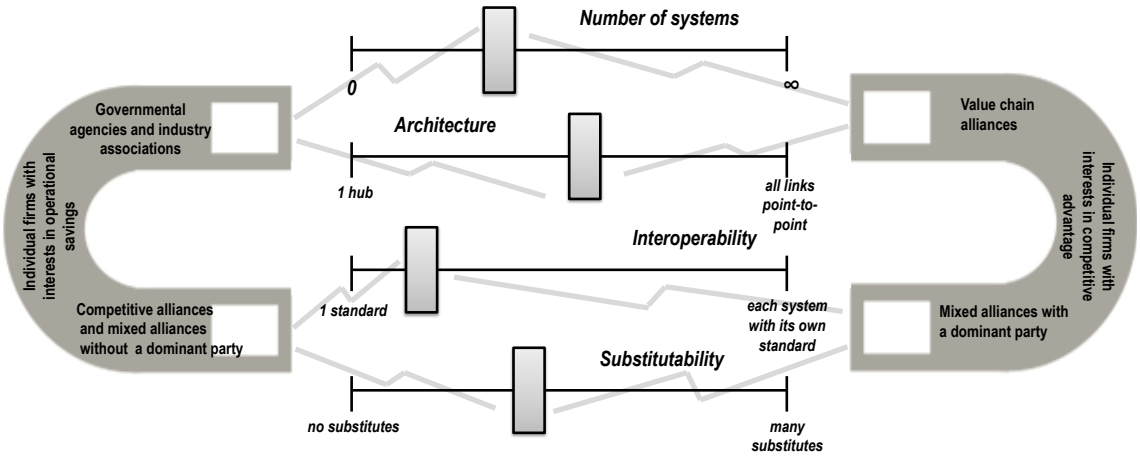
Industry associations are generally formed to promote the common interests of the organizations belonging to a specific industry or performing a specific role within it. Damsgaard and Lyytinen [15] investigate the role of industry associations in the EDI diffusion process in the grocery sectors of Hong Kong, Denmark, and Finland. They find that these institutional agents were critical in knowledge building, knowledge deployment, and standard setting. Taking into account that the goal of industry associations is to promote cooperation, we believe that the following proposition should hold regarding the influence that these associations can have on the landscape of a business community.

Proposition 3.2. The efforts of industry associations (if any) tend to aim at ensuring IOS interoperability and reducing the number of IOSs in the business community. They tend to support the development of shared hub IOSs and to aim at eliminating multiple systems performing the same functionality.

Figure 1 summarizes our theoretical framework. The IOS landscape can be

categorized along four dimensions: the number of IOSs, their architecture, their interoperability, and their substitutability. Each of the last three dimensions has two extreme points which can be rarely observed in practice. The number of systems can be anywhere between zero and infinity. Usually the IOS landscape characteristics are somewhere in between the extremes. Multiple players, such as individual firms, alliances, institutional agents, can influence these four levers of the IOS landscape. Individual firms with interests in operational savings, competitive alliances, mixed alliances without dominant parties, governmental agencies, and industry associations affect the landscape so that the levers are moving in the direction of lower number of systems with hub type architectures, higher interoperability, and lower substitutability. On the other side, individual firms with interests in competitive advantage, value chain alliances, mixed alliances with a dominant party attract the levers in the opposite direction of multiple inter-organizational systems many of which are substitutes to each other and based on point-to-point connections and different B2B frameworks.

Figure 1: Conceptual model. The tug-of-war for IOS landscape.



Given the diverse and often opposite interests of individual actors within a business

community it is highly unlikely that an IOS landscape with characteristics which represent business community joint interests can be achieved in practice. Olson [42] distinguished between exclusive and inclusive collective goods. For inclusive collective good the supply of the collective good automatically expands with the growth of the group. For exclusive collective good the benefit that can be derived from the collective good has a limit which motivates the group members to reduce the size of the group. For exclusive groups it is almost always essential to achieve 100% participation of those who remain in the group. Even one non-participant can take all the benefits brought about by the action of the cooperating firms for himself. We believe that the IOS landscape with characteristics that represent the joint interests of the business community is closer to being the exclusive collective good. It requires the cooperation of everyone in the business community to use a single centralized IOS for all information exchange. Furthermore, if even one company would decide to develop its own IOS with extra functionality to stand out in the competition (i.e. does not cooperate) then the IOS landscape becomes skewed in favour of the non-participant which can benefit both from shared hub and private hub systems. Such situation cannot be tolerated by competitors. Hence, we believe it is highly unlikely that the common interests will be fully realized in the case of the IOS landscape.

From the perspective of an individual firm the IOS landscape formed by one IOS with the private hub architecture is ideal because it could access all its partners via the system and exclude the competitors by this sustaining the competitive advantage. However, usually the competitors also have enough resources to develop their own IOSs (either jointly or individually). As a consequence, the IOSs start proliferating within a business community. Smaller firms which do not possess resources to develop their own IOSs can provide the push towards more standardization and the use of centralized IOSs by organizing alliances or with the help of government agencies and

industry associations. Thus, the IOS landscape becomes a battle between different interests the prevalence of which depends on the resources available to the respective actors. We believe that the equilibrium is possible when there is one actor within a business community resourceful enough to develop a private hub IOS by him- or herself which would reach everyone within the community and simultaneously all the other actors even if they form alliances will not possess enough resources to develop their own systems. This situation is possible in theory but is highly unlikely in practice. In the next part of this paper, we study an example of the IOS landscape formation of a specific business community and consider to what extent our propositions can be supported by observations from practice.

Methods

In this paper, we introduce a new concept of the IOS landscape and develop a number of propositions on how the influence of different actors shape its characteristics. We conducted an exploratory longitudinal case study to support our arguments and to demonstrate that this new concept is relevant for practice. An exploratory case study is a good method for theory building because it ensures that the resultant theory is testable, relevant, and valid [17, 58]. Furthermore, the case study provides support for some of our theoretically derived propositions. Validating such propositions would require comparative analysis which demands data collection across multiple organizations, alliances, and business communities. In our study, we focus on a single business community which serves as an embedded case study with multiple units of analysis within it: individual organizations and alliances. Such embedded single case studies can provide useful insights on important issues when available data on multiple cases are limited [48, 58]. The longitudinal aspect of our case study allows us to see how the interests of actors prompted changes in the IOS landscape.

The container transportation network of Rotterdam seaport was chosen as the setting

for our analysis. The case study satisfied both theoretical sampling [17] and convenience criteria. The active development of the IOS landscape of this business community started around 10 years before we started data collection which provided us with ample evidence for our analysis. Moreover, the companies in our analysis are still active in IOS development as they recognize the benefits of further improving existing communication channels. The Dutch government and affiliated organizations play an active role in the development of the information infrastructure which allowed us to study their interests as well. Therefore, the setting allowed us to examine both current strategies of various players with respect to IOS development as well as the results of their previous efforts.

We identified the key group of actors in the port network based on the analysis of the port information exchange carried out by Van Oosterhout et al [54]. We limited our analysis to the companies that play a central role in the port network to ensure a deep understanding of these organizations. We focused on the companies with a crucial role in the exchange of information in the Port of Rotterdam, and those that unambiguously belong to the port business community. Organizations such as river police, banks, insurance agencies, shippers, and consignees belong to the network periphery and were excluded from our analysis.

We conducted in-depth, semi-structured interviews to collect data on the key milestones in the development of the IOS landscape of the Port of Rotterdam. We asked respondents to reflect on the decisions made by their organizations and to state what kind of strategy the company pursued with respect to the development of each IOS. We also reviewed the web-sites of the port companies and agencies because in many cases they describe the information communication technologies that the organizations use and support. In some cases, we gained access to the internal documents of the companies describing their information infrastructure. The use of

multiple data sources allowed us to triangulate the data and so to strengthen the accuracy of our case study. In total, we conducted thirteen interviews: four with representatives of the port community system, three with representatives of various industry associations, one with a representative of a shipping line, three with representatives of terminal operators, one with a representative of a freight forwarder, and one with two Customs representatives. Table 1 provides the overview of our respondents, their company affiliation, and their position within the company.

Table 1: Company representatives and their positions

Company	**Role**	**Representative position**
ECT	Terminal operator	Business Development Manager
APMT	Terminal operator	Commercial Manager
Terminal A	Terminal operator	Manager Applications & Customs
Yang Ming	Shipping agent	Deputy General Manager
Freight Forwarder B	Freight forwarder	Head Customs Controlling & Projects
Customs	Customs	Senior Policy Advisor IT
VRC	Industry association	Secretary & General Manager
VRTO	Industry association	Secretary General
KNV	Industry association	Secretary General
Portbase	Port community system	Former CEO, Strategy & Business Development Manager, Strategy & Business Development Consultant Director Marketing & Sales

All interviews were recorded and transcribed. The transcripts were coded in accordance with the constructs and propositions presented in the previous section. The interviews gave us information about key events, about past and present initiatives in IOS development in the port area, and about the companies' strategies behind these initiatives. We illustrate our findings with quotations from interviewees, who reviewed this paper for factual accuracy.

Findings from a Case Study: IOS Landscape of Rotterdam port

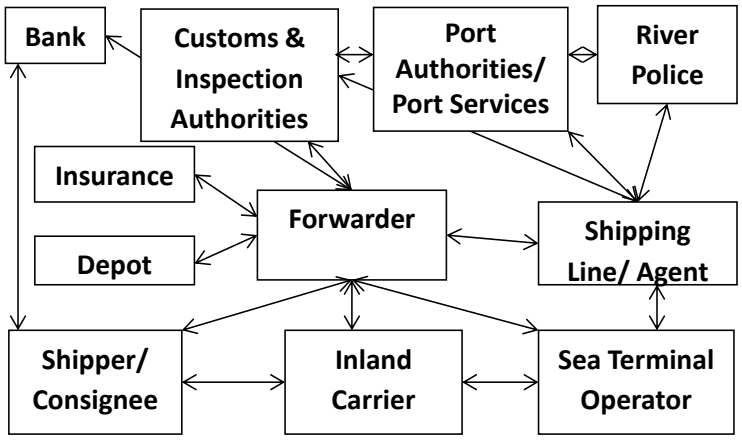
The case study describes the information exchange in the Port of Rotterdam, and the inter-organizational information systems that were used to support this exchange as of May 2014 (the month when the data collection was finished). In 2004, the Rotterdam Port Authority established a neutral standard-based hub-type information system, a port community system, to support the competitive position of the port. This standardization of information exchange and more efficient routing of information flows between the various actors would enable a faster flow of containers through the port [52]. However, the convergence of the IOS landscape to use the port community system has, as yet, not been very successful. Multiple IOSs with similar functionalities are still in use in the port network. This case study investigates the interests of actors in the port network in the development of the IOS landscape and how these interests influence the shape of the landscape.

Information exchange in the port network

Port business networks include various organizations. We focus on the container transportation network within the port clusters. Shippers (companies sending the goods) or consignees (companies receiving the goods) are the final customers of the container transportation industry. The main actors involved in the physical handling of containers are shipping lines, terminal operators, inland carriers, and government inspection agencies. Shipping lines transport the cargo over the sea. Terminal operators are involved in the first point of cargo discharge at land side in case of import or the last point of cargo discharge in case of export. They are responsible for the loading and unloading of containers. Inland carriers, like truck carriers, and barge and rail operators, deliver the cargo from the port to its final destination in case of import or from the point of origin to the port in case of export. Many more

organizations are involved in the transactions related to the goods movement through the port. Freight forwarders are the experts in the logistics networks and organize shipments for shipping companies and consignees. They contract with carriers to move cargo and monitor cargo movements along the chain. Shipping agents represent general interests of shipping lines at ports and can also perform the activities similar to those of freight forwarders. Various government agencies are also members of port community. Customs plays a major role in supervising cargo flows between nations. Other agencies, such as the Veterinary Inspection, also have authority over certain types of cargo and can introduce additional checks and barriers to cargo movement. Port authorities monitor the movement of dangerous goods and provide additional services. Figure 2 illustrates the interactions between the organizations that facilitate the movement of containers.

Figure 2: Information exchange ties between different roles in the port of Rotterdam (adapted from Van Oosterhout [54] with modifications)



The rest of the case study consists of two parts. The first focuses on how the inter-organizational solutions that facilitate information exchange between terminal operators and their main partners were developed. The second part describes how the solutions for the communication with the authorities were introduced. In both parts,

we focus on the interests of the actors, the interactions among them, and how these frictions influenced the common IOS landscape.

Terminals and their partners

Seaside and landside Electronic Data Interchange(EDI)

Shipping lines, terminal operators, and inland transporters have to coordinate their actions to facilitate a smooth flow of containers from the ships to their final destination points. The majority of shipping lines are global companies that offer regular services on specific routes. A shipping company is represented by an agent at each port it visits regularly.

The Port of Rotterdam currently has three major terminal operators: ECT (market share around 65%), APM Terminals (market share around 23%), and Terminal A (market share around 7%). These terminal operators belong to big global companies. The digitization of information exchange among the port companies started with the introduction of EDI messages that facilitated communication between terminal operators and shipping lines. In 1987, the User Group of Shipping Lines and Container Terminals (SMDG) was formed to develop and promote UN/EDIFACT EDI-messages for the Maritime Industry [53]. The initial development process was slow, but by the late 1990s almost all of Rotterdam based terminal operators and respective shipping lines used the following EDI messages: BAPLIE (Arrival, Forecast and Actual Departure), MOVINS (Discharge/Loading Instructions), TANSTA (Tank Status), COPRAR (Container Discharge/Loading Order), COARRI (Container Discharge/Loading Confirmation), COPARN (Container Announcement), COREOR (Container Release Order), CODECO (Container Gate In/Gate Out Report). The number of messages defined by the UN/CEFACT framework for ship planning and container handling is constantly growing. It contained more than twenty messages at the time of publication.

At present, the scope of the information exchanged via EDI connections can be smaller or wider, depending on the level of integration between the terminal and the shipping line. The exact level of integration is the commercial secret of the terminal operators. However, we have one example of tighter integration: Maersk Line and APM Terminals have the same parent company and share information via EDI about the mode of transport for containers in Rotterdam hinterland. This information helps the terminal to optimize its stowage plan.

In early 1995, inspired by the EDI success at the sea side, ECT started a pilot project to exchange EDI messages with the inland side as well [53]. In the Port of Rotterdam, there are three inland transportation modalities. Cargo can be transported inland by road, barge, or by rail. In 2012, 54% of the containers were transported by truck, 35.3% by barge, and 10.7% by train. The number of companies per modality differs significantly. There are 28 rail operators in the port, around 60 barge operators, and about 500 trucking companies. Because of this large diversity, it is much more difficult to organize the community and to ensure the successful adoption of EDI messages, especially by smaller trucking companies and barge operators. Furthermore, unlike shipping lines who usually only visit one terminal operator at the port, inland transporters pick up cargo from all operators. As the pioneering EDI efforts were limited to ECT and did not include the other terminal operators, it was rather difficult to persuade inland transporters to use EDI messages. The rail operators were the most successful in adopting EDI because there were relatively few rail operators in the port, and because they only picked up cargo at the ECT terminal. Thus, it was much easier to ensure their cooperation.

In the early 2000s, the spread of Internet offered a new way of digital connection for terminal partners: web-portals. At present, all three terminal operators offer the opportunity for inland transporters to report their arrival and to check the status of

containers via their portals.

Port Community System

In 2004, the Port of Rotterdam Authority (PRA) established a neutral coordination hub, which also offered services to support information exchange between hinterland companies and terminal operators. The terminal operators had not been very successful in achieving high EDI adoption among inland transporters, and this initiative by the PRA forced operators to adjust their strategies.
The port community system expanded rapidly and over the last 10 years it has developed 40 information services that it offers to the community. The system has enjoyed the support of industry associations:

> In general, the PCS is much better for the port community. It's more efficient to have a single interface for declarations instead of each company — ECT, APMT, Rotterdam World Gateway — having its own website. It works but it's not efficient because each party is trying to optimize its own business. Information about the whole supply chain of the port is incomplete. (VRTO Terminal Association Representative)

All barge and terminal operators have successfully adopted the barge planning service which means that there is now a single information service that handles all related operations in the port. Even though the companies acknowledge the benefits of the common system, they have financial concerns. For instance, shipping agents can use the port community system to communicate with terminal operators but they prefer to use their own EDI connections for the exchange of the information with the terminals because it is free, whereas they have to pay subscription and traffic fees to use the community system. Terminal A also decided that it is too expensive to use Portbase pre-announcement services for truckers. Instead, truckers have to use Terminal A's web-portal when they report their arrival.
APMT and ECT now support two options for road pre-arrival notifications: truckers can use either the port community system or the terminals' web-portals. APMT

would prefer everyone to use the port community system but they are reluctant to enforce its use:

> We stimulate the use of Portbase for our existing terminal. We are not going to enforce it because quite a lot of companies are not members of the Portbase community. Membership is quite expensive. Because it's a competitive environment, management doesn't want to make it obligatory. We don't want to lose our partners. (APMT representative)

Even though the PCS has been in use for 10 years, and most companies acknowledge its benefits, it has not become a common standard. The coming changes in the competitive landscape for terminal operators pose additional challenges, and offer new opportunities for the PCS to become the standard for information exchange.

Future developments

Over the past 10 years, the Port of Rotterdam Authority has been working on a land reclamation project Maasvlakte II. Two new container terminals will begin operations in 2014. One will be operated by APM terminals. The other, Rotterdam World Gateway, is jointly owned by a global terminal operator, DP World and four shipping lines. These two new terminals are expected to significantly affect the market, and to damage the competitive position of ECT. These changes will considerably influence the terminals' strategy in IOS development.

Representatives of all terminal operators believe that in the future Portbase will be at the core of the communication with the hinterland companies. However, APMT is actually actively working on promoting the use of PCS among smaller members of the port network, whereas ECT feels it is being pressurized to use the system:

> I think the market, our customers, our partners, and the community will probably pressurize us to use Portbase ... And especially when the new terminals use Portbase ... I think we'll feel that pressure indirectly. (ECT Representative)

> Our new terminal will exclusively use Portbase. We will use all its functionalities. We are in close contact with Portbase about developing new functionalities and improving the existing ones. We are now implementing new procedures at our new terminal. This

> means reaching out to about 5000 hinterland organizations: barge, rail operators, inland terminals, but especially logistics service providers. I think about 30% of these companies are not connected to Portbase. That is something which needs to be done. (APMT Representative)

These differences in the perception of the port community system can be attributed to the differences in the competitive positions of the terminal operators. ECT is a company that has enjoyed its dominant position in the Port of Rotterdam for decades. APMT is the newcomer who is currently actively expanding its operations. From the point of view of ECT, the port community system is leveling out the playing field:

> You now see that the new terminals fully go for Portbase... And I can understand this because we have existed for like 45 years. We developed these services in the last 10–15 years. That took a bit of time. So if you're the new kid on the block here in Rotterdam, I can fully understand that you ask Portbase to develop these services for you because that's an easy way and it might be cheaper as well. (ECT Representative)

The representative of Terminal A also believes that Portbase is the best way for communication in the future and that their customers and their partners will probably make more use of Portbase services.

Both ECT and APMT find it difficult to decide whether to develop a new e-service so that it is available via the port community system or not. ECT has already transferred one of its services for Customs to Portbase. But they do not consider this to be a default option:

> [I]nformation services can also be strategic. You can distinguish yourself from other companies in the port. So this is always the trade-off we have to make: can we cooperate with Portbase and offer exactly the same services as our competitors or do we still want to distinguish ourselves? (ECT Representative)

The APMT representative favored wider cooperation in information exchange:

> It's very difficult first to assess in which areas you want to cooperate and in which areas you should compete ... To a certain extent I really have to think what I would do within and without the port community context. The thing is you are connecting to the entire industry. If you create a specific solution for very specific kind of things you won't reach the entire sector. There are always limitations to a specific solution. So the best thing is to implement a community change, community innovation. (APMT Representative)

At present, both terminal operators are actively developing new hinterland integration

strategies to stand out from the competition. They plan to use their own e-services to support these new strategies. APMT is promoting their barge and rail shuttle connections and will use their own web-portal to concentrate shuttle information from other web-sites. ECT has created an intermodal organization, European Gateway Services, which acts as an organizer of hinterland transportation further inland. To provide this service, ECT formed an alliance with a number of inland transport operators and terminals. The terminal operator is developing a dedicated track & trace services for customers of European Gateway Services as a value added service which is likely to be offered outside of the Portbase platform.

The strategies of the terminal operators serve as a good illustration for propositions 1.1 and 1.2. On the one hand, they understand that the community wide solution is preferable because it provides access to a wider number of actors. On the other hand, they realize that the port community system levels out their competitive field. The companies need to have their own e-services to stand out.

ECT is also offering some additional information to the community through its EGS app. Although the majority of users like this app, some have voiced concerns about the spread of different interfaces in the trucking community:

> We made an app for European Gateway services. And we supply container arrival information and also object arrival information. The app offers nice features also for truckers. Most truckers are very happy with it but some truckers tell us: "Everybody is building their own apps, everybody is building their own services. And our planners have to look for information on several platforms, from several different companies. Actually the only thing we want is a single access point, or even better, direct data feeds into our own system." (ECT Representative)

So the trucking companies would prefer to have one point of access to manage their port visits. Their position is another good illustration for proposition 1.1. However, a single interface to manage all inter-organizational operations is unlikely to be built due to the new hinterland strategies of the terminal operators.

Governmental agencies

Many supervisory agencies, including the Port of Rotterdam Authority, Customs, Food and Consumer Product Safety Authority, and Rotterdam-Rijmond Seaport Police, are active in the port. Here, we focus only on two agencies, the Port of Rotterdam Authority and Customs because they deal with all goods flows whereas the other agencies only have access to parts of these flows. The Port of Rotterdam Authority is a non-listed public limited company. Its shares are owned by the Municipality of Rotterdam (approx. 70%) and the Dutch State (approx. 30%). The Port Authority is the manager, operator, and developer of Rotterdam's port and industrial area. The goal of this organization is "to strengthen the port of Rotterdam's competitive position as a logistics hub and industrial complex of world standing."
In early 2000s, the Port of Rotterdam Authority initiated the development of the port community system with the aim to strengthen the competitive position of the port. Their nearby competitors, the ports in Antwerp and Hamburg already had similar successfully functioning projects. Nowadays, the system is positioned as a neutral hub for all logistics information going through Dutch ports. The system supports both business-to-government and business-to-business communications. Initially the port community system was solely owned by the Port of Rotterdam Authority and was called Port Infolink. In 2009, Port Infolink has merged with the port community system PortNET of the Port of Amsterdam. The new company, Portbase is owned by the Port of Rotterdam Authority (75%) and the Port of Amsterdam Authority (25%) and receives substantial financial support from these organizations. The development of Portbase is a good illustration for our proposition 3.1.
The Harbour Master Division of the Port of Rotterdam Authority ensures the smooth, safe, clean, and secure handling of shipping traffic. Shipping lines have to use Portbase to communicate with the PRA. They notify the authority about arrival

times, the presence of dangerous cargo on board their ships, and about waste disposal activities. The PRA receives messages from the shipping lines via Portbase. An example is the "Notification waste disposal" service. A shipping line can currently fulfill all the obligations associated with a ship calling at the port by using the port community system.

The port community system was not initially meant to become the default way of communication with the PRA. The Port of Rotterdam Authority already had their own system when Portbase was established and they were quite reluctant to abandon it.

> They [Port of Rotterdam Authority] had their own system. They were not eager to develop a new system. They said, "We are doing it ourselves. Whenever we want to change certain things, we would go to our IT department and they would change it, but if we move to Portbase we would have to go to you." (Former Port Infolink CEO)

However, with time the Port of Rotterdam Authority embraced the port community system and outsourced the task of the development of the port information infrastructure to this organization.

Customs traditionally plays an important role in cross-border goods traffic, and needs a lot of information to be able to evaluate the risks, and to determine the legal status of cargo traffic. These authorities have the power to stop the movement of the cargo in case certain documents are missing or have not been filled in appropriately. Historically, in many ports the automation of document exchange started with Customs [34, 30].

In the late 1990s, Dutch Customs developed two portals – SAGITTA and NCTS (for European Community transit declarations) – through which they accept declarations from the trading community. Private software providers and firms from the port network can develop applications based on the standards used within these portals to enable companies to submit declarations using their software. Freight forwarders,

shipping agents, and terminal operators are the three main actors who are responsible for communication with Customs within the network that we consider. Portbase also provides services that facilitate declaration submission to Customs.

Dutch Customs appreciates the work that Portbase does in terms of "orchestrating" the port community. They see Portbase as a single-window system for the communication with seaport traders:

> There are about 3000 companies using Portbase. We are only connected to Portbase. It's just easier to talk to them and let them do all the talking with the traders. For example, if you have a new release, you give it to Portbase and they test it. If you have 3000 companies with their own channels, you have to test all of them. (Customs Representative)

Customs cannot force companies to use Portbase. They have to keep a neutral position, otherwise they could be accused of monopolizing the market:

> You can use other declaration systems. It is not mandatory to use Portbase and you can always have your own direct channel. And I guess some of the big ones have. Because they, for instance, don't want to pay for their services because they are big enough to do it themselves. (Customs Representative)

Still, Customs took an active role in establishing Portbase:

> Maybe in the earlier days to start it up. One of our directors was on the Supervisory Board of Portbase so there was an obvious connection. But we couldn't make it mandatory, we only stimulate it a bit. Now things are settled and we're happy some activities are now clustered. (Customs Representative)
>
> Customs were important. Although we had two or three projects, but we would never have achieved the position Portbase has now without Customs. (Former Port Infolink CEO)

The role of Customs in the development of Portbase provides support for our proposition 3.1. Although Customs could not enforce the use of Portbase, they stimulated its use to encourage its adoption by the port community. Shipping agents can always opt for direct connection with the Customs interface and some of the big ones do so. However, the community realizes that Customs would prefer them to use the port community system for declaration purposes:

> You can also send your message directly to Customs without using the port community system but they won't be very happy because they will have to deal with lots of clients with different modes of communication. (Yang Ming Representative)

One of the global freight forwarders (the company belongs to the Top 5 in the world) operating in the port supports both communication channels. They appreciate Portbase because it allows them to send one message to the hub which can be then divided over multiple destinations:

> We can send it through our system but it's much easier to send it through Portbase. The message is then split, one goes to the terminal operator, the other to Customs. We have access to more information in Portbase. (Freight Forwarder B Representative)

However, they do not use Portbase for all communication with Customs because their own system is more advanced in terms of functionality:

> [T]hey (Portbase) do not have all the modules to communicate with Customs (such as a module for transit documents, and import and export declarations). We offer a lot of tailor-made solutions in our system and that's why Portbase is not always optimal for all our clients. (Freight Forwarder B Representative)

While the Port of Rotterdam Authority could force shipping agents to use Portbase as the only way of communication, Customs cannot do so. Customs still have to support multiple ways of communication with their systems. Moreover, for some users the Portbase functionality is not advanced enough to support the variety of features that other systems offer.

Thus, the development of the IOS landscape of Rotterdam port started in the late 1980s with the introduction of the first dedicated EDI links between terminal operators and shipping lines. Overtime with the establishment of the PCS, the information exchange in the port was standardized and centralized to a certain degree. However, it took years to achieve the acceptance of the system among the majority of the port companies. Furthermore, due to the new competitive strategies of the terminal operators, new IOSs are being developed. This will lead to the divergence of the IOS landscape once again. Even government authorities like

Customs cannot always enforce the use of the single IOS and have to support multiple ways of communication.

Discussion

Revisiting our propositions

We believe that the case of the Port of Rotterdam network offers evidence in support of the five out of our seven propositions. We could neither support nor disregard propositions 2.1 and 2.3 because we did not find any competitive or mixed alliances in the port network at that time. Proposition 1.1 stated that the interests of companies to increase operational efficiency and reduce costs through IOS lead to a decrease in the number of IOSs in the landscape, an increase in the number of IOSs with shared hub architecture, improved interoperability, and lower substitutability in the business community IOS landscape. In the Port of Rotterdam, many companies support this proposition. APM Terminal promotes Portbase among its hinterland partners to ensure they can all be contacted via one channel. The trucking companies would also like to have one interface to communicate with terminal operators. However, there are still many IOSs in the Port of Rotterdam that are substitutes to Portbase services. This can be explained by proposition 1.2 which posits that the interests of companies to gain a competitive advantage through IOS lead to an increase in the number of IOSs and in the number of point-to-point connections in the landscape, lower interoperability, and greater substitutability in the business community IOS landscape. Certain strategies of terminal operators and freight forwarders support this statement. Freight forwarders do not use the port community service for all their communication with Customs because they can provide better customized services to their customers with their own solutions. Portbase does not allow them to stand out from the competition which results in additional point-to-point connections in the

business community which is a partial substitute for a shared hub system. Terminal operators are developing innovative solutions for hinterland operations to outperform their competitors. This results in additional systems based on proprietary standards to which truckers have to connect to be able to do business in the port.

There are at least two value chain alliances in the port network: APM Terminals and Maersk Line, and the European Gateway Services alliance between ECT and hinterland transporters. Our proposition 2.2 stated that the formation of a value chain alliance or a mixed alliance with one dominant party in a business community leads to lower interoperability, higher substitutability of the community IOS landscape and a higher number of point-to-point connections. Both alliances support this proposition. Closer cooperation between APM Terminal and Maersk is based on the point-to-point connection. They exchange information about the second modality that is not being exchanged with other parties. The companies worked closely together on this solution and had to develop their own standard to support it. European Gateway Services of ECT is also developing e-services that will sustain tighter integration between partnering terminal and transportation providers. Those services are likely to be available only to participating companies and to be based on the private framework. The information is likely be transferred via additional point-to-point connections between the terminal and other parties (i.e. private hub architecture).

Our propositions 3.1 and 3.2 posit that efforts by government agencies and industry associations (if any) tend to aim at ensuring IOS interoperability and reducing the number of IOSs in the business community. They tend to support the development of shared hub IOSs and to aim at eliminating multiple systems that perform the same functionality. In the case of the Port of Rotterdam, the actions of the Port of Rotterdam Authority, Customs, and various industry associations support these propositions. All of the institutional agents promoted the adoption of Portbase, the

system with shared hub architecture and open standards. Certain industry associations are working at shaping a new business culture within a community by advancing the sense of "moral obligation" to use the centralized system. The culture has been shown to play an important role in the collective action propagation [23]. However, it takes a long time to change it. Portbase eliminated the necessity of many point-to-point connections between Customs and shipping agents. ECT terminal operator expects more pressure from its partners to use Portbase. Many companies are slowly transferring their information exchange to Portbase but many alternative ways of information exchange still exist.

In our case study, we have made one additional observation that we have not deduced from the previous literature. Many big companies rely on their own IOS rather than using shared hub systems provided by other companies for reasons of cost savings. Shipping lines prefer using direct EDI messages to terminals rather than using Portbase services; Terminal A prefers its own system to Portbase in its communication with trucking companies. In both cases, it is more expensive for the companies to use the shared system rather than support their own.

To conclude, we believe that the Port of Rotterdam case provides a good illustration of the factors that influence the development of the IOS landscape of a business community. No single commercial organization has complete control over its IOS landscape. The trucking companies have to use multiple appointment systems because it is more convenient for the terminal operators. The terminal operators feel they are being pushed by industry associations representing the interests of truckers towards the use of Portbase. Even Customs cannot enforce the use of Portbase for declarations submission and has to support multiple ways of communication with trading partners. Even though many organizations in the port are pushing towards the convergence of the IOS landscape and towards the use of the single system (Portbase), this seems

unlikely, because other port actors are interested in the competitive advantages that the use of other IOSs can bring. Hence, we conclude that in the Port of Rotterdam business community it is close to impossible to achieve the collective level optimum of an IOS landscape based on a single neutral hub architecture with common standards without introduction of additional incentivizing mechanisms. Individual interests preclude the achievement of collective goals in this case. There are many companies (mainly terminal operators) which are resourceful enough to develop an IOS on their own and which they do to stand out in competition. The exclusive nature of the desired IOS landscape as a collective good requires 100% participation from the business community members which would mean using only Portbase for inter-organizational communication in our case. Clearly there are too many companies with the interests that are diverging the community from achieving this goal. Different organizations have different preferences regarding the configuration of the port IOS landscape. For instance, presently all terminal operators are convinced that in the near future they will have to use Portbase for the standard communication procedure with truckers. Truckers will get the common interface they have been asking for. It took Portbase almost ten years to get here. However, the terminals are already developing new private IOS solutions for hinterland communications in order to stand out in the competitive scene. This means that the tug-of-war for the IOS landscape of the Port of Rotterdam will continue.

Implications for future research

Our case study and literature review have prompted us to formulate two research avenues which we think merit further investigation. The answers to these research questions would provide a valuable contribution to the IOS literature and to the strategies of practitioners.

1. How does the network structure of the business community influence the shape of

its IOS landscape?

In the case of the Port of Rotterdam, it is clear that the number of companies with similar roles in the network and the structure of connections between them influence the IOS landscape of the business community. There are only three terminal operators but many shipping lines. As a result, the number of IOSs that are developed by the terminals (i.e. terminal web-portals) is relatively low compared to the number of IOSs developed by shipping lines (i.e. shipping line web-portals). The linkages between terminal operators and hinterland transporters are much more dense than between terminal operators and shipping lines. Therefore there are more incentives for the terminals to use shared hub solutions for hinterland communication whereas they use dedicated point-to-point connections for communication with the shipping lines. The presence of vertically integrated alliances in the business community increases the chances that IOS alliances are formed. Previous IOS research has linked the choice of IOS type to the network position of the company [22]. It would be a logical extension to investigate further how the network structure of the business community influences the dimensions of its IOS landscape.

Van Baalen et al. [52] provide the descriptions of IOSs functioning in the ports of Singapore, Los Angeles/Long Beach, Rotterdam, and Hamburg. The systems in different ports have diverse origins, functionalities, and coverage. Accordingly the resulting IOS landscapes are quite different. While the IOS landscape in Singapore port is dominated by Portnet, an IOS developed by the Port of Singapore Authority (PSA), the IOS landscape of the port of Los Angeles/Long Beach is more fragmented due to the development of different IOSs by different terminal operators. The business community of Singapore port is organized around one major terminal operator owned by PSA while there is more competition at the terminal operator level in other ports. This suggests us that there is a strong connection between the underlying

transactional network structure of the business community and the IOS landscape of this community.

2. What are the successful strategies for practitioners to influence their IOS landscapes, depending on their position in the business community?

Actors that are interested in sustaining the competitive position of a business community, like the Port of Rotterdam Authority in our case study, need to know how they can influence the IOS landscape. Steinfield et al [48] argue that it is in the interests of supply chain transparency to have a shared hub information system based on open standards as the core of the information infrastructure of the business community. However, as we have already shown, it is difficult to reach such a state because of the varying interests of business community members. Portbase has been trying to accomplish this goal since 2004. Yet, there are still many other IOSs that sometimes perform the same functionality. The Port of Rotterdam Authority have made it obligatory to use Portbase for communication with them, but do not have the power to enforce Portbase adoption by every party in the community. Softer measures are required. For instance, industry associations are now promoting the feeling of "moral obligation" among companies to use Portbase by stressing its importance for port competitiveness. Naturally, the variety of available instruments depends on the member's position in the business network. Further investigation of this issue could help discover other strategies which could be used not only by the institutional agents but also by commercial companies. We believe both theory and practice would benefit from finding the answers to these research questions.

Conclusions

In this paper we introduce a new concept of the IOS landscape. The spread of IOS in the business world has resulted in the large variety of the information exchange solutions that a firm can use for communication with its partners. So far the majority

of IOS studies have analyzed the benefits of IOS adoption independently from the other IOSs that a firm uses. We believe that this approach has a drawback because the characteristics of the IOS landscape in which a firm has to function influence the benefits that it can achieve by adopting a specific IOS.

We characterize the IOS landscape along four dimensions: the number of IOSs, their architecture, their interoperability, and their substitutability. These dimensions reflect how favorable the IOS landscape is for a firm. The higher the interoperability between the IOSs, the easier it is for a firm to reap the benefits from a single IOS adoption. The use of point-to-point architectures vs hub architectures makes the support of IOS communication more costly. The necessity to adopt multiple systems with the same functionality to reach different trading partners also reduces the potential benefits of IOS adoption.

To understand how the IOS landscape of a firm is shaped, we use the collective action framework and shift our level of analysis to the business community. We investigate the opportunities for reaching the shape of IOS landscape which would reflect collective level optimum without the introduction of special incentives. Based on the overview of previous research, we formulate seven propositions that link the interests of different actors to the characteristics of the IOS landscape of the business community. At the individual firm level, the strategy of firms to increase operational efficiency and reduce costs via IOS affects the IOS landscape differently than the strategy of firms to gain a competitive advantage through IOS. At the level of firm alliances, the type of alliance (competitive, value chain, mixed) influences the strategies it pursues in the development of the landscape. Finally, at the business community level, community representatives such as government organizations and industry associations can influence the IOS landscape so that it benefits the community at large. We conclude that IOS landscape which represents community

level goals is an exclusive public good. This means that it requires a 100% participation from the community members in order to be produced which is very difficult to achieve in practice, especially for larger business communities. We believe that our propositions enrich the theory of IOS development by considering the influence that IOSs have on each other (with the help of the landscape concept) and by considering the contradicting interests of business community members.

We investigate our propositions in the context of the Port of Rotterdam business network. In recent years information technologies are playing an ever more important role in determining the competitive position of port networks at the global scene [2, 52]. The port community as a whole could greatly benefit from the establishment of the IOS landscape consisting of a single neutral hub system based on common standards. However, the various interests of port community members preclude that from happening which means according to collective action theory that special instruments should be developed in order to foster the achievement of collective level goals. The case study provides illustration and support for five out of our seven propositions. In addition, the case raises new research questions regarding the role of the network structure in shaping the IOS landscape and the ability of different actors to successfully influence the IOS landscape. Future research is required to answer these new research questions and to test our propositions in other conditions and contexts.

References

[1] Andersen, K.V. and Henriksen, H.Z., B2B e-commerce diffusion: the efficacy of institutional discourse. In G. Doukidis; N. Mylonopoulos; and N. Pouloudi, (eds.) *Social and Economic Transformation in the Digital Era*, pp. 56–73, Hershey, PA: Citeseer, 2004.

[2] Bagchi, P.K. and Paik, S.K., The role of public-private partnership in port information systems development. *International Journal of Public Sector Management*, 14, 6 (2001), 482–499.

[3] Bakos, J.Y. and Brynjolfsson, E., Information technology, incentives, and the optimal number of suppliers. *Journal of Management Information Systems*, 10, 2 (1993), 37–54.

[4] Baldi, S. and Borgman, H.P., Consortium-based B2B e-marketplaces – a case study in the automotive industry. In B. OKeefe, (ed.) *14th Bled Electronic Commerce Conference: e-Everything: e-Commerce, e-Government, e-Household, e-Democracy.*, pp. 25–26, 2001.

[5] Boonstra, A. and de Vries, J., Managing stakeholders around inter-organizational systems: a diagnostic approach. *The Journal of Strategic Information Systems*, 17, 3 (2008), 190–201.

[6] Chau, P.Y. and Tam, K.Y., Factors affecting the adoption of open systems: an exploratory study. *MIS Quarterly*, 21, 1 (1997), 1–24.

[7] Chismar, W.G. and Meier, J., A model of competing interorganizational systems and its application to airline reservation systems. *Decision Support Systems*, 8, 5 (1992), 447–458.

[8] Choudhury, V., Strategic choices in the development of interorganizational information systems. *Information Systems Research*, 8, 1 (1997), 1–24.

[9] Ciborra, C., *From Control to Drift: the Dynamics of Corporate Information Infastructures*, Oxford: Oxford University Press, 2000.

[10] Clark, T.H. and Stoddard, D.B., Interorganizational business process redesign: merging technological and process innovation. *Journal of Management Information Systems*, 13, 2 (1996), 9 – 28.

[11] Clemons, E.K. and Kleindorfer, P.R., An economic analysis of interorganizational information technology. *Decision Support Systems*, 8, 5 (1992), 431–446.

[12] Constantinides, P. and Barrett, M., Information Infrastructure Development and Governance as Collective Action. *Information Systems Research*, 26, 1 (2014), 40–56.

[13] Damsgaard, J. and Lyytinen, K., Governmental intervention in the diffusion of EDI. In K.V. Andersen, (ed.) *EDI and Data Networking in the Public Sector*, pp. 13–41, Dordrecht: Kluwer Academic Publishers, 1998.

[14] Damsgaard, J. and Lyytinen, K., Contours of diffusion of electronic data interchange in Finland: overcoming technological barriers and collaborating to make it happen. *The Journal of Strategic Information Systems*, 7, 4 (1998), 275–297.

[15] Damsgaard, J. and Lyytinen, K., The role of intermediating institutions in the diffusion of electronic data interchange (EDI): How industry associations intervened in Denmark, Finland, and Hong Kong. *The Information Society*, 17, 3 (2001), 195–210.

[16] Douma, A.; Schutten, M.; and Schuur, P., Waiting profiles: An efficient protocol for enabling distributed planning of container barge rotations along terminals in the port of Rotterdam. *Transportation Research Part C: Emerging Technologies*, 17, 2 (2009), 133–148.

[17] Eisenhardt, K.M., Building theories from case study research. *Academy of Management Review*, 14, 4 (1989), 532–550.

[18] Gosain, S.; Malhotra, A.; and El Sawy, O.A., Coordinating for flexibility in e-business supply chains. *Journal of Management Information Systems*, 21, 3 (2004), 7–45.

[19] Hanseth, O. and Monteiro, E., Inscribing behaviour in information infrastructure standards. *Accounting, Management and Information Technologies*, 7, 4 (1997), 183–211.

[20] Hong, I.B., A new framework for interorganizational systems based on the linkage of participants' roles. *Information and Management*, 39, 4 (2002), 261–270.

[21] Howard, M.; Vidgen, R.; and Powell, P., Overcoming stakeholder barriers in the automotive industry: building to order with extra-organizational systems. *Journal of Information Technology*, 18, 1 (2003), 27–43.

[22] Hu, D.; Sun, S.X.; Zhao, J.L.; and Zhao, X., Strategic choices of inter-organizational information systems: a network perspective. *Information Systems Frontiers*, 13, 5 (2011), 681–692.

[23] Hu, H.H.; Lin, J.; and Cui, W., Cultural differences and collective action: A social network perspective. *Complexity*, 20, 4 (2015), 68–77.
URL `http://dx.doi.org/10.1002/cplx.21515`

[24] Iacovou, C.L.; Benbasat, I.; and Dexter, A.S., Electronic data interchange and small organizations: adoption and impact of technology. *MIS Quarterly*, 19, 4 (1995), 465–485.

[25] Imai, A.; Nishimura, E.; and Papadimitriou, S., The dynamic berth allocation problem for a container port. *Transportation Research Part B: Methodological*, 35, 4 (2001), 401–417.

[26] Johnston, H.R. and Vitale, M.A., Creating competitive advantage with interorganizational information systems. *MIS Quarterly*, 12, 2 (1988), 153–165.

[27] Kambil, A. and Short, J.E., Electronic integration and business network redesign: a roles-linkage perspective. *Journal of Management Information Systems*, 10 (1994), 59–83.

[28] Kauffman, R.J. and Mohtadi, H., Proprietary and open systems adoption in e-procurement: a risk-augmented transaction cost perspective. *Journal of Management Information Systems*, 21, 1 (2004), 137–166.

[29] Khanna, T., The scope of alliances. *Organization Science*, 9, 3 (1998), 340–355.

[30] King, J.L. and Konsynski, B.R., *Singapore TradeNet: a Tale of One City (case 9-191-009)*, Boston: Harvard Business School, 1995.

[31] Kuan, K.K. and Chau, P.Y., A perception-based model for EDI adoption in small businesses using a technology–organization–environment framework. *Information and Management*, 38, 8 (2001), 507–521.

[32] Kumar, K. and Van Dissel, H.G., Sustainable collaboration: managing conflict and cooperation in interorganizational systems. *MIS Quarterly*, 20, 3 (1996), 279–300.

[33] Lee, S.M.; Tan, X.; and Trimi, S., Current practices of leading e-government countries. *Communications of the ACM*, 48, 10 (2005), 99–104.

[34] Long, A., Port community systems. *World Customs Journal*, 3, 1 (2009), 63–67.

[35] Lyytinen, K. and Damsgaard, J., Inter-organizational information systems adoption – a configuration analysis approach. *European Journal of Information Systems*, 20, 5 (2011), 496–509.

[36] Markus, M.L. and Loebbecke, C., Commoditized digital processes and business community platforms: new opportunities and challenges for digital business strategies. *Mis Quarterly*, 37, 2 (2013), 649–654.

[37] Markus, M.L.; Steinfield, C.W.; and Wigand, R.T., Industry-wide information systems standardization as collective action: the case of the US residential mortgage industry. *MIS Quarterly*, 30, Special Issue on Standard Making (2006), 439–465.

[38] Marwell, G. and Oliver, P., *The Critical Mass in Collective Action*, Cambridge: Cambridge University Press, 1993.

[39] Monge, P.R.; Fulk, J.; Kalman, M.E.; Flanagin, A.J.; Parnassa, C.; and Rumsey, S., Production of collective action in alliance-based interorganizational communication and information systems. *Organization Science*, 9, 3 (1998), 411–433.

[40] Morgeson, F.P. and Hofmann, D.A., The structure and function of collective constructs: implications for multilevel research and theory development. *Academy of Management Review*, 24, 2 (1999), 249–265.

[41] Nurmilaakso, J.M. and Kotinurmi, P., A review of XML-based supply-chain integration. *Production Planning and Control*, 15, 6 (2004), 608–621.

[42] Olson, M., The Logic of Collective Action. Public Goods and the Theory of Groups. In *Harvard Economic Studies*, volume 124, Harvard University Press, 1971.

[43] Ratnasingam, P., The influence of power on trading partner trust in electronic commerce. *Internet Research*, 10, 1 (2000), 56–63.

[44] Robey, D.; Im, G.; and Wareham, J.D., Theoretical foundations of empirical research on interorganizational systems: assessing past contributions and guiding future directions. *Journal of the Association for Information Systems*, 9, 9 (2008), 497–518.

[45] Rodon, J. and Ramis-Pujol, J., Exploring the intricacies of integrating with a port community system. In *Bled eConference*, pp. 1–15, Bled, 2006.

[46] Shim, S.S.; Pendyala, V.S.; Sundaram, M.; and Gao, J.Z., Business-to-business e-commerce frameworks. *IEEE Computer*, 33, 10 (2000), 40–47.

[47] Son, J.Y.; Narasimhan, S.; and Riggins, F.J., Effects of relational factors and channel climate on EDI usage in the customer-supplier relationship. *Journal of Management Information Systems*, 22, 1 (2005), 321–353.

[48] Steinfield, C.; Markus, M.L.; and Wigand, R.T., Through a glass clearly: standards, architecture, and process transparency in global supply chains. *Journal of Management Information Systems*, 28, 2 (2011), 75–108.

[49] Teo, H.H.; Wei, K.K.; and Benbasat, I., Predicting intention to adopt interorganizational linkages: an institutional perspective. *MIS Quarterly*, 27, 1 (2003), 19–49.

[50] Truman, G.E., Integration in electronic exchange environments. *Journal of Management Information Systems*, 17, 1 (2000), 209–245.

[51] Tuunainen, V.K., Opportunities of effective integration of EDI for small businesses in the automotive industry. *Information and Management*, 34, 6 (1998), 361–375.

[52] Van Baalen, P.; Zuidwijk, R.; and Van Nunen, J., Port inter-organizational information systems: capabilities to service global supply chains. *Foundations and Trends (R) in Technology, Information and Operations Management*, 2, 2-3 (2009), 81–241.

[53] Van Baalen, P.J.; van Oosterhout, M.; Tan, Y.H.; and van Heck, E., *Dynamics in Setting Up an EDI Community: Experiences from the Port of Rotterdam*, Delft: Eburon, 2000.

[54] Van Oosterhout, M., Organizations and flows in the network. In P. Van Baalen; R. Zuidwijk; and J. Van Nunen, (eds.) *Port Inter-Organizational Information Systems: Capabilities to Service Global Supply Chains*, pp. pp. 93–102, Hanover: Now publishers, 2009.

[55] Webster, J., Networks of collaboration or conflict? Electronic data interchange and power in the supply chain. *The Journal of Strategic Information Systems*, 4, 1 (1995), 31–42.

[56] Wigand, R.T.; Steinfield, C.W.; STEINFIELD, C.W.; and STEINFIELD, C.W., Information technology standards choices and industry structure outcomes: The case of the US home mortgage industry. *Journal of Management Information Systems*, 22, 2 (2005), 165–191.

[57] Xue, L.; Zhang, C.; Ling, H.; and Zhao, X., Risk mitigation in supply chain digitization: system modularity and information technology governance. *Journal of Management Information Systems*, 30, 1 (2013), 325–352.

[58] Yin, R.K., *The Case Study Anthology*, Thousand Oaks: SAGE Publications, 2004.

[59] Yoo, B.; Choudhary, V.; and Mukhopadhyay, T., A study of sourcing channels for electronic business transactions. *Journal of Management Information Systems*, 28, 2 (2011), 145–170.

[60] Zhao, K. and Xia, M., Forming interoperability through interorganizational systems standards. *Journal of Management Information Systems*, 30, 4 (2014), 269–298.

[61] Zhao, K.; Xia, M.; and Shaw, M.J., An integrated model of consortium-based e-business standardization: collaborative development and adoption with network externalities. *Journal of Management Information Systems*, 23, 4 (2007), 247–271.