Emergence of information infrastructures: a tale of two islands

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Abstract: The healthcare sector is regarded as a potential benefactor of information infrastructures (II), because of its information intensity. Public and private initiatives push towards integrating heterogeneous information and communication systems. This paper contributes to a better understanding of the emergence of II by tracing the evolution of a set of standards. The pharmaceutical distribution industry in the Republic of Ireland and in Australia provides the empirical background for this paper. The successful standardisation in one case and the continuation of proprietary wholesaler systems combined with different mechanisms to provide interoperability in the other serve as starting points for our analysis. By applying standardisation theory we seek to explain the outcomes in each of the cases and propose several extensions to the theory. At the empirical level, our data show that both solutions are viable options and gateways can become functionally equivalent to standards; thereby shaping emerging II in this sector.

Keywords: IOIS; inter-organisational information systems; information infrastructure; standardisation; electronic ordering systems.

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1 Introduction

The notion of information infrastructure (II) is frequently employed in the public and academic discourse. Especially the healthcare sector is regarded as a potential benefactor of II. Various projects aiming at an infrastructural level are promoted by public as well as private initiatives. Examples range from electronic prescriptions over tracking & tracing systems for pharmaceutical supply chains to nationwide electronic health records.

Yet, infrastructures in general are not created ex nihilo. They are built or better say they grow (Edwards et al., 2009) on existing structures. A green field situation is, if at all, rarely the case (Eriksson and Ågerfalk, 2010). Standards are a constitutive element of infrastructures because they facilitate linkage of heterogeneous ensembles of technology (Hanseth and Lyytinen, 2010). According to Hanseth et al. (1996), standards are a necessary precondition for the emergence of infrastructure. "[…] standards are absolutely necessary for an II to exist, without standards there is no such thing as II" (Hanseth et al., 1996, p.4).

This paper compares two standardisation processes as part of the evolution of information infrastructures. Information infrastructures often rely on existing standards or need to interconnect with existing standards. In their case study of an ePrescription system, Monteiro and Hanseth (1996) report on the conflicts stemming from different existing standards that represent potential candidates for identifying drugs. In a similar vein, Eriksson and Ågerfalk (2010) argue that identifiers are not mere technological specifications but need to be understood as a social construct. IIs emerge by integrating existing isolated systems. Thus, standards for unique identifiers are crucial to facilitate such integration.

Our paper is motivated by the close interrelationship between standards and information infrastructures. In particular, we look at development paths over extended periods of time. We study the emergence of electronic ordering infrastructures in Australia and the Republic of Ireland. We do so by tracing the origins of interface specifications that have been designed to enable electronic ordering of pharmaceuticals for pharmacies from wholesalers. These specifications consist of three components: (a) a product key used for identifying pharmaceuticals, (b) a communication protocol and (c) a product file listing all products available for ordering.

While in Ireland these specifications were developed as a national standard, the specifications were specific to different wholesalers in Australia. As a result we see the emergence of a national information infrastructure for the pharmaceutical distribution industry segment in Ireland and regional information infrastructures in Australia. By applying standardisation theory we are able to scrutinise the development process passing through the phases of initiation, negotiation and diffusion until today. In Australia, despite wholesaler-specific specifications a functional equivalent to a national standard emerged in the form of a gateway. This suggests that both solutions may be viable options. In a cross-case analysis, we explore possible explanations for the different outcomes in the two cases. This leads us to theorise several extensions to standardisation theory.

There is a public discourse about extending pharmacy-related information infrastructures, e.g. ePrescription systems, which address a much bigger stakeholder group and suggest immediate benefits for patients. The mentioned product codes are essential for ePrescription systems as well. Furthermore, pharmacies and their software providers represent a major user group for such extended II. Hence, by historically reconstructing the development process of existing standards and specifications over the last 25 years, we also seek to develop hypotheses concerning the future trajectory of II development.

The contributions of our paper are twofold. First, we test standardisation theory by applying it to two case studies. Moreover, our analysis leads us to propose several extensions to standardisation theory. Second, by exploring possible explanations for the different outcomes in both cases we seek to develop hypotheses concerning the future trajectory of II development.

The remainder of the paper is structured as follows. Section 2 introduces the unit and level of our analysis. Section 3 is devoted to lay down the theoretical framework. Next, in Section 4 our research method is explained. In Section 5, we apply standardisation theory to our two case studies. In Section 6, we explore explanations for the different outcomes by means of a cross-case analysis. The theoretical implications of our findings are discussed in Section 7. This is followed by our main conclusions.

2 Unit and level of analysis

The research presented in this paper covers a period of 25 years. Our project was started in the area of Inter-Organisational Information Systems (IOIS). The aim was to develop theoretical means to explain evolutionary paths of IOIS. While in both cases an electronic ordering system has successfully been established, the elementary building blocks exhibit distinct designs. The explanation of these differences is interesting from an IOIS point of view. However, the introduction of IOIS between individual wholesalers and pharmacies had implications at the industry, or more precisely industry segment level.

The notion of information infrastructure provides us with the conceptual tools to deal with changes at the industry segment level: How does an electronic procurement system evolve into a national system (Ireland)? When regional, proprietary product codes persist, is there still scope for an electronic ordering system at a national level (Australia)?

The set of specifications that are subject to the standardisation process in both cases consists of a product key (denominator for products) and a communication protocol (structure/types of messages). We focus on specifications that were designed to support electronic ordering between pharmaceutical wholesalers and pharmacies in the Republic of Ireland and Australia.

Product codes are at the heart of electronic ordering systems and – if standardised – can form the basis of an information infrastructure for the healthcare system: they are used by multiple stakeholders in various information systems. The threshold for the development of an IOIS is already high, as it assumes the consent of the trading partners. Obviously the consent reflects the economic realities and power relations among the trading partners, which may be coercive relations, as illustrated by various cases such as the FordNet case (see Webster, 1995). Yet, the threshold for a standard development is even higher as it assumes consent among direct competitors.

The individual analysis of each case as well as a cross-case comparison provides a unique opportunity to analyse standardisation processes that took place in a tightly regulated industry.

The mentioned specifications consist of three components, which together represent our unit of analysis. This particular set of specifications is a necessary building block of any electronic ordering system. The electronically communicating partners need to agree on a common designator for the products to be ordered. It needs to unequivocally identify a particular product in an exchanged message. In the following, we will refer to this designator as the *product ID* (1). We have subsumed the different message types that can be exchanged as well as the protocol that governs the communication under the label *protocol* (2). Furthermore, each side needs to have an up-to-date list of all products and their product IDs. This list represents the pool of identifiers currently assigned to particular products. Sender and receiver refer to this assignment and draw on the identifier to compile or process an order message. We will refer to this specification as the *product file* (3).

3 Theory of standardisation

This section outlines the theoretical framework that we will apply to our case studies.

3.1 Two rationalities

Since the 1980s, IT has been discussed as a means to gain competitive advantage. Different types of opportunities have been identified in the literature (e.g. Parsons, 1983; Ives and Learmonth, 1984; Rockart and Morton, 1984). IT has been used to yield positive effects on intra- as well as on inter-organisational aspects of a company. Bakos and Treacy (1986) identify 'comparative efficiency' and 'bargaining power' as IT-related sources of competitive advantage. Johnston and Vitale (1988) extend this stream of research to IOIS. McKessons' Economost and AHSC's ASAP are their prominent examples for successful strategic use of IOIS. Both companies were able to raise switching costs and simultaneously increase internal as well inter-organisational efficiency (Short and Venkatraman, 1992).

The literature acknowledges the role of standards in shaping the character of IOIS in several special issues on standardisation that came forth (e.g. Markus et al., 2006; Nelson et al., 2005). Reimers and Li (2005) argue for a comparison of transaction costs that individual firms incur by engaging in multilateral negotiation in contrast to bilateral negotiations whereby multilateral negotiations are aimed at standardisation. They attribute difficulties in the negotiation phase of a standardisation process to the interest of collaborating competitors to differentiate themselves from others and diverging internal structures that are to be affected by a standard. Commercial interests and strategic manoeuvres impede standardisation processes and the successful development and diffusion of standard candidates. From an individual firm's point of view standards are not per se lowering transaction costs. Rather it depends on the number of competitors (negotiating) and the intensity of competition.

Yet, the IOIS literature is ambivalent about the role of standards in vertical networks, i.e. among business partners on different levels of value system stages. On the one hand, proprietary standards can be promoted strategically to create a power base and to achieve a partner lock-in (e.g. the case of FordNet; see Webster, 1995). On the other hand, standardisation bodies, industry associations or groups of business partners have pushed standardised solutions in order to foster a swifter diffusion of the IOIS due to the positive effects of lower switching costs. The case of DanzLink (Klein and Lindemann, 1997) illustrates the strategy of developing a standard-based IOIS in order to facilitate a faster and broader diffusion of the IOIS and to pre-empt the development of competing IOIS.

3.2 Standards in public choice theory

Collective action theory investigates the rationale of human beings and organisations to form groups. In Olson's (1965) work groups are formed because of the utility emanating from the provision of *public or collective goods*. Public goods, e.g. the air we breathe, are generally defined as exhibiting two characteristics: they are non-rival in consumption, i.e. consumption of the good by one individual does not diminish its availability for others, and their benefits are non-excludable.

In comparison, *common goods* are non-excludable but consumption is rivalrous, e.g. fishing grounds. *Club goods*, e.g. a golf course, are non-rivalrous but excludable.

Considering the examples makes it obvious that the characterisation of the goods is not absolute, but rather represents an approximation to illustrate their specifics. While 'excludability' and 'rivalry' are often portrayed as binary values in a four-field matrix (cf. Table 1), some authors argue for conceiving these traits as continuous variables

(Adams and McCormick, 1987). Extensive pollution will affect the air quality and can create rivalry among polluters. Access to fishing grounds can be regulated by law or international agreements; however, such agreements are difficult and expensive to enforce. The use of a golf course is non-rivalrous within normal limits of use of a restricted number of members; however, effects of extensive use such as waiting times or wearing off certain areas of the green cannot be excluded. It is thus better to speak of a degree of excludability or the feasibility of excluding others from consumption (ibid). Such feasibility is not dependent on intrinsic properties of the good but the institutional context (e.g. existence and enforceability of property rights). The degree of rivalry is likewise dependent on a limit until which consumers can share in the resource without affecting the consumption of others.

Table 1 Types of goods

	Excludable	*Non-Excludable*
Rival	Private Good	Common Good
Non-Rival	Club Good	Public Good

Global standards such as UN/EDICAFT are public goods: their use is non-rivalrous and they are open for use by every interested party (non-excludable). However, Antonelli (1994) conceptualises standards club as goods, and refers to those standards that are controlled or owned by a group of companies (the 'club'):

> "[…] standards can be defined as institutions and more specifically non-pure private goods that: (a) are vectors of technical, commercial and procedural information; (b) emerge in the process of selection and diffusion of technological and organisational changes as the result of the interactive cooperative behavior of learning agents within clubs; (c) change the extent and context of the market and shape the competition process; and (d) affect radically the division of labour and the organisational setup of firms" (Antonelli, 1994, p.197).

The product codes in the Irish case have been based on GTIN, previously called EAN, specifications, which we regard as public goods. However, the specific instantiation and the product catalogue as a collection of product codes relevant for the Republic of Ireland are club goods: their use is non-rivalrous; however, the IPU claims ownership and makes them available to its members only.

3.3 Phases of standardisation processes

Reimers (1995) proposed a three-phase model of standardisation processes (see also Reimers and Li, 2005; Kipp and Schellhammer, 2008):

First, during the *initiation phase* a *consortium* is formed with the goal to develop a standard candidate (during the second phase). The initiation of standardisation processes is a major effort and typically involves delicate political manoeuvring amongst competitors. Early movers may be viewed critically by competitors and potential adopters alike, suspecting hidden intentions and an asymmetric division of benefits. In order to facilitate adoption and diffusion of the standard (during the third phase), the

initiator may try to form a consortium or find partners. The role of an initiator is thus precarious as it entails potentially high costs without any direct benefit, i.e. the whole process may not take off. Given the involved costs and the risks, e.g. being accused of collusion by competition authorities, actors may hesitate to take the initiative during this phase. Each would benefit by assuming a passive – that is non-initiating – role. Therefore, we conceptualise the consortium as a collective good. The initiating group may restrict membership in the standard-setting consortium, which then operates as a club, but has to ensure a reasonable number of members to engage in the second phase and anticipate broader support requirements for the third phase.

During the *standard negotiation phase* the consortium negotiates the design of the standard and proposes – if successful – a *standard candidate*. The negotiation takes place within the consortium, which may restrict access. As such it represents a club-good. The members of the consortium share information and have influence over the design of the standard candidate and may choose to restrict access to the standard candidate to outsiders. Members of the consortium are however non-excludable. Consequently, we conceptualise the standard candidate as a club good.

During the *diffusion phase* the standard candidate is introduced into the market and will become a *de-facto standard*, if adopted. The consortium may serve as a facilitator for its wide adoption. During this phase, it is best characterised as a network effect good. In case access is not restricted and it is widely adopted, it turns into a public good.

Table 2 Standardisation phases and public good theory

Phase	*Outcome*	*Interpretation*
Initiation phase	Consortium	Collective good, Olson type
Negotiation phase	Standard candidate	Club good
Diffusion phase	De-facto standard	Public good, network effects

4 Method

Our research extends over a time span of nearly 25 years. The events under consideration cover the period from the early 1980s until today. In the Irish case, we conducted 16 semi-structured interviews in the years 2005 until 2009. In the Australian case, we conducted 22 semi-structured interviews in three waves (2006, 2007 and 2009). We recruited our interviewees from industry representatives residing mostly on a managerial level. The interviewees came from a broad range of actor groups, which involve in both case studies pharmaceutical wholesalers, manufacturers, software vendors, pharmacies and industry associations.

Almost all interviews were tape recorded, coded and analysed. Two researcher groups evaluated the transcribed interview data independently. A separation of the research team was geared at increasing objectivity and confidence in the findings (Eisenhardt, 1989). All information below has been triangulated by at least two interviewees. Apart from interviews we employed several other data sources; among these are websites, standards documentation and systems documentation.

Table 3 List of interviews

	Ireland	*Australia*
Years	*2005–2009*	*2006, 2007, 2009*
No. of interviews	16	22
No. of interviewees	13	21
With pharmacies	7	9
With software vendors	2	5
With wholesalers	4	7
With others	3	1
Taped & transcribed	15	20

5 Case descriptions and analysis – tale of two islands

The case descriptions and analysis juxtaposes the findings from the two countries, Ireland and Australia. The structure of the descriptions follows the phases of the standardisation process, which are preceded by a reflection on the strategic intent regarding the IOIS.

5.1 First island: (Republic of) Ireland

In a consolidation process that extended over several decades three wholesalers prevailed as nationwide full-line suppliers. Due to regulation of prices and assortment (nationally registered medication), the strategic options in the wholesale pharmaceutical market have been quite limited and wholesalers have put a lot of emphasis into operational excellence and relationship management. The 1980s saw the emergence of electronic ordering systems. United Drug was and still is one of the wholesalers operating in the Republic of Ireland; its management was looking for innovation opportunities in order to extend their market share in the Irish market. Following the US example of AHS (Short and Venkatraman, 1992), the initial idea at United Drug was to establish a proprietary ordering system. Therefore, the final outcome of a successful standardisation process was not evident from the outset. The Irish Pharmaceutical Union, representing about 90% of all Irish pharmacists, became aware of the wholesalers' intentions and assumed a prominent role in the unfolding standardisation process.

The diffusion of the electronic ordering system took place over a ten year period. Today, electronic orders account for 90% of all orders reaching the wholesalers. Pharmacists use a dial-up modem connection to transmit their order to the wholesaler. Out-of-stock as well as bonus items are reported back to the pharmacist. While the technological set-up is far from sophisticated, it has turned out as remarkably resilient and is still operational today.

The choice between proprietary and standard product codes implies a choice about the reach of the codes. In the Irish case, the intended vertical reach was identical for both, the proprietary and the standard version. It covered the relevant market for the wholesalers, which happened to be the national market with all community pharmacies. However, the horizontal reach is wider for the standard solution. While different systems for production, identification and characterisation co-exist in the pharmaceutical market in order to respond to different information needs, such as manufacturers and regulation authorities, the standardised product code is useful for all commercial transactions. In contrast to other industries, the actors in Ireland refrained from using electronic ordering

as a strategic instrument. By excluding the product key and communication protocol from the competitive arena, the actors embarked on a joint standardisation initiative. The underlying strategic rationale was to ensure nationwide adoption and diffusion. This would enable simplification of order and delivery processes and cost savings.

Table 4 Overview of the Irish case (figures from 2008)

	Ireland
Population	4.2 million
Wholesalers	3 full-line wholesalers operating nationwide with similar market shares
Pharmacies	~1400 community pharmacies Ownership of multiple pharmacies not forbidden
Pharmacy groups	Chains ~500 small chains (50% of which consist of 2–4 outlets) Unicare Pharmacy, the largest chain with 61 pharmacies, is owned by one of the wholesalers
Pharmacy association	Irish Pharmacy Union (IPU)
Software Vendors	Three software vendors with varying market shares (55%, 40% and 5%)

5.2 Standardisation process

5.2.1 Initiation

During the 1980s electronic ordering systems emerged. The ordering systems by American Hospital Supply and McKesson became prominent examples in the IS literature (Short and Venkatraman, 1992). At the same time United Drug's (UD) management was looking for innovative options to extend their market share in the Irish market. Given the high operational pressure in wholesaling, the automation of order processing seemed like a promising lever to speed-up operations, accelerate deliveries and simultaneously reduce transmission errors. Until then specifically assigned TeleSales staff would phone each customer on a daily basis to receive orders.

When UD considered the option of a proprietary ordering system, which would differentiate UD against its competitors and lock-in their customers, concerns were raised about the pharmacies' willingness to adopt such a system. A wide diffusion, however, has been identified as a prerequisite for realising the IT-induced efficiency gains.

In terms of the installed base of pharmacy software and hardware, the Irish pharmacy market was perceived as a 'virgin market' meaning that very few pharmacies had any IT-equipment installed. Nonetheless, the response from the pharmacies towards a proprietary system was critical. On the one hand, it would either imply running several ordering systems or modes with different wholesalers in parallel or it would imply a lock-in to one wholesaler. The latter would result in abandoning the established practice of order splitting between wholesalers. Still, order splitting is deemed important from a pharmacist's perspective for several reasons. It provides logistical advantages in case one wholesaler is temporarily out of stock. The order can seamlessly be passed to another wholesaler. This in turn implies a higher service quality (fewer out-of-stocks; faster delivery) for their customers. Moreover, the ability to easily split orders re-enforced the power position of the pharmacies that can take their business to one of the other wholesalers in case of disputes about service quality or prices.

The IPU as the representative body of the pharmacists was aware of the intentions of the wholesalers and perceived proprietary, mutually incompatible systems as running counter their members' interest.

The required specifications of the building blocks needed for electronic ordering were clear to the actors early on. The product code was regarded as the centrepiece. In the US and the UK wholesalers started out to assign proprietary product codes to pharmaceuticals. However, product codes, exchange messages and communication protocols based on EAN standards developed by and for the grocery industry appeared as a viable alternative.

The accounts of the interviewees differed about who took the initiative to establish a consortium. United Drug claims that they had initiated the development of a standard, based on the experience of an employee who was a trained librarian and well-acquainted with the benefits of the International Standard Book Number (ISBN, the standardised product code for books). The IPU claims that they had initiated talks with the wholesalers in order to avoid the introduction of proprietary solutions.

In any case, a consortium was formed consisting of the wholesalers and the IPU as a representative of the pharmacies. Software companies were invited as observers so that they would understand the specifications and support the diffusion of the specifications.

5.2.2 Negotiation

The joint development of the standard candidates gained momentum when the IPU was granted manufacturer status by EAN UK, today GS1 UK and GS1 IRL. This was perceived as a major step forward. At the time, EAN-codes were not routinely printed on packages by manufacturers. The manufacturer's status enabled the IPU to assign its own EAN-conforming numbers to all products sold in Irish pharmacies. However, this exception to existing EAN policies was meant only as a temporary solution until enough manufacturers would employ EAN numbers. It reflected the interest of GS1 because it avoided the introduction of proprietary numbering systems by the wholesalers (as happened in the UK) and aligned the developing IT-systems to the EAN numbering format.

The design of the standard candidates was subject to the negotiations among the wholesalers, which were moderated by the IPU. The software vendors attended the meetings as observers, without playing an active role.

Over a couple of months the necessary specifications were developed. The IPU assumed the role of assigning numbers to all products sold in Irish pharmacies as well as maintaining and updating the product file, which was being issued on a monthly basis by the IPU. The product file does not only contain the product codes but also categorises products and includes manufacturer EAN-codes, if existing, as well as codes for reimbursement and some dispensing information for the pharmacist.

5.2.3 Diffusion

After the successful completion of the design, the thrust of the standardisation process changed from consensus building among the wholesalers to persuasion vis-à-vis their trading partners, the pharmacies, in order to facilitate adoption and diffusion of the system. Up to then, the pharmacies had not been directly involved but represented by the IPU.

Initially, the wholesalers faced some resistance by their customers. The active role of the IPU provided a supportive setting for the subsequent adoption and diffusion of the electronic ordering systems. Still, pharmacists remained hesitant and suspicious that most of the benefits would accrue to the wholesalers. The wholesalers responded with small discounts for electronic orders.

Owing to the attendance of the software vendors at the meetings of the consortium the standard candidate was quickly implemented in pharmacy software. Intense competition between the software companies led to a swift introduction of new features and releases.

One of the wholesalers joined forces with one of the software companies to promote its own pharmacy software in order to facilitate better integration with pharmacies. However, the wholesaler quickly dissolved that joint venture as pharmacists began to take the wholesaler hostage for software malfunctions.

A number of factors facilitated the diffusion process. The IPU assumed the role of a standard custodian and turned the maintenance of the product file into a key service to their constituents. The active role of the IPU signalled support and helped to overcome reservations by the pharmacists. The software vendors quickly adopted the standard, which soon became an essential requirement for pharmacies. The wholesalers did not abandon their telesales-staff but reassigned them to maintain a personal contact with customers in addition to the automated order processing.

The diffusion of electronic ordering systems happened gradually over a period of ten years. During that period the wholesalers met occasionally to negotiate about small adjustments. Today, over 90% of all orders from pharmacies arrive electronically. Despite the proliferation of broadband internet in most areas of the country, the orders are transmitted via modem. The wholesaler systems accept manufacturers' EAN and IPU codes to identify ordered items. Although by now most of the products have manufacturer EAN codes, the IPU continues to assign their own codes to the products. Over the years, the functional scope of the pharmacy software has increased and contains functions like patient medication records and checks for critical interactions. Furthermore, it allows for claims management. For that purpose the product file contains reimbursement codes and prices as well.

5.2.4 Analysis

While the theoretical model suggests, a standardisation process is a precarious process that involves the achievement of several intermediate outcomes, the standardisation process in Ireland appears simple and smooth. In this section, we will analyse the case material in order to find possible explanations for these outcomes.

First of all, the initial conditions or the setting in which the standardisation process started seem to have been favourable. The consortium was facing a green field situation in regard to existing IT-system in pharmacies. Pharmacists mainly relied on handwritten records and placed orders by phone. Hence, the consortium did not need to care about any installed base. Furthermore, at the time pharmacies were rather homogeneous regarding their business model, which made it easier for the IPU to position itself as a legitimate and accepted representative of the interests of pharmacists. This situation is changing today with the emergence of large pharmacy chains and different ownership structures. Most of the wholesalers emerged as cooperatives of pharmacies. In fact pharmacists owned most of the shares of two of the major wholesalers.

The initiation phase is characterised by a succession of different rationales. First, EDI was regarded as a solution to an operational problem faced by the wholesalers. Given the high operational pressure in wholesaling and the limited scope for price competition the automation of the costly order-delivery process seemed like a promising lever. Strategic considerations were superimposed on this EDI-logic. A proprietary ordering system was perceived as a means of differentiation and to lock-in customers. As such it would not only reduce costs through automation but also potentially costly standard development would be avoided. On the other hand, the rationale for standardisation was presented in the discussions as well. An ordering system based on open standards would increase the willingness of pharmacies to invest in the required hardware and software and thus accelerate diffusion. Furthermore, it would allay pharmacists' fears of becoming locked-in.

The negotiations took place among the group of Irish wholesalers under the auspices of the IPU. The challenge was to find an industry-wide consensus and to avoid that individual wholesalers would defect and develop their own system. While the request by pharmacies to endorse order splitting might have been critically perceived as disloyalty by the wholesalers, once the negotiation moved towards creating the basis for nationwide electronic ordering systems a sense of collaborative achievement prevailed. When the consensus among the wholesalers and the IPU emerged, the wholesalers perceived the outcome as an option to defend their position against manufacturers' direct sales to pharmacies. Hence, the consortium represented a club from which the manufacturers were excluded.

The scope of the standardisation effort during the negotiation phase was limited. In terms of the communication protocol, the wholesalers focused on ensuring that the specifications would meet their internal systems' requirements. By relying on EAN-standards for the product code the consortium ensured compatibility with manufacturer-specific codes. In retrospect, the IPU successfully strengthened its power base by assuming the role of a standard custodian. This, however, may have been an unintended result as the role of the IPU was regarded to be a temporary one. Nevertheless, the IPU enhanced the product file from a pharmacy's point of view from a mere dictionary of codes necessary for ordering to a valuable database. Technically, it would have sufficed to provide the pharmacies with a list of ordering codes that identify the exact product in an order. Instead, the IPU added information that is necessary for other pharmacy practices. The design of the communication protocol does not allow price comparisons for pharmacies. As such the management of discounts and promotions was excluded by the wholesalers as a competitive arena. Furthermore, the consortium limited the scope of the system to pharmacies. Other customers of the wholesalers like hospitals or nursing homes were excluded. Moreover, the wholesalers opted against the IPU's wish to extend the standardisation logic to the software as well.

The diffusion phase was not as smooth as the successful outcome of the negotiations suggests. Despite the involvement of the IPU and the wholesalers' refraining from building proprietary system, the pharmacists believed that most benefits would accrue to the wholesalers while they themselves would have to invest in IT. Price incentives for electronic orders, which were abolished after the successful diffusion, as well as the quick development cycles of the software companies eventually facilitated the diffusion and established the specifications as a de-facto standard. Initial attempts by one wholesaler to develop and promote its pharmacy software were abandoned.

5.3 Second island: Australia

Over the last three decades, the three full-line Australian wholesalers have held roughly equal market shares. Due to mergers and acquisitions, the wholesalers evolved from regional to nationwide suppliers during the 1990s. Thus, the need for national harmonisation was not obvious initially. Rather, the wholesalers took different, i.e. proprietary routes in implementing electronic ordering, in particular regarding product codes and pharmacy devices and interfaces. In the early 1980s, the wholesalers introduced mobile devices (called PDEs) to pharmacies for electronic ordering. The PDEs were used to scan wholesaler-specific barcodes printed on pharmacy shelves. When placed in a cradle, data transmission to the wholesaler system was initiated. The codes as well as the messages were proprietary. In fact, the PDE devices were given to the pharmacists by their respective wholesalers. Thus, switching to another wholesaler for the bulk of orders was impeded, as the entire inventory would have to be relabelled. However, once the order was sent, the wholesaler system replied with an invoice and a list with out-of-stock items. This could then be turned into a telephone order to another wholesaler.

From the late 1980s to the mid 1990s, software vendors started to promote POS (Point-of-Sale) software to pharmacies. Due to their customers' request, the software vendors implemented the proprietary protocols of the wholesalers. This enabled pharmacists to seamlessly switch orders from one wholesaler to another. However, the proprietary product codes needed to be converted internally from one scheme to another.

Recently, the so-called PharmX initiative gained momentum and strength. The interview data indicate that major changes are to be expected in terms of electronic prescription systems. At the time of our data collection, the several initiatives started to run pilot projects. Still, the continuing absence of standardised product codes is noteworthy.

Table 5 Overview of the Australian case (figures from 2008)

	Australia
Population	20 million
Wholesalers	3 full-line, nationwide wholesalers with almost equal market shares (30%) ~20 small short-line wholesalers with regional focus
Pharmacies	~5000 independent pharmacies Ownership of multiple pharmacies restricted to 4–5 stores
Pharmacy groups	Banner groups (BG) Majority operated by major wholesalers, Most pharmacies member of BG (subscription-based) Provide joint marketing and advertising services and discounts vis-à-vis wholesalers
Pharmacy association	Pharmacy Guild of Australia, members are owners of 4500 pharmacies (2008)
Software Vendors	~20 software vendors 4–5 largest software vendors have ~90% market share

5.4 Stuttering engine of standardisation

After the introduction of the PDE-devices in the early 1980s, we find a number of different initiatives and indeed (alliances of) initiators, such as software vendors and the government, aiming at dealing with the downsides of the existing proprietary solutions.

The promotion and diffusion of POS software along with order modules allowed pharmacists to place electronic orders with every wholesaler. This enabled the pharmacists to circumvent the lock-in of the PDE. For that purpose the software vendors had to convert proprietary product codes internally in order to comply with the requirements of the receiving wholesaler. Consequently, the software vendors maintained cross-reference tables that mapped the several proprietary product codes on to one another. In order to provide additional functionality like sales history and patient medication records, a proper conversion of product codes was imperative. This spawned a new business for software vendors who started licensing these tables to others.

In the late 1990s, supported by a government initiative (Project Electronic Commerce and Communication for Healthcare – PeCC), the wholesalers developed the so-called Pharmaceutical Extranet Gateway (PEG). While the aim of PeCC was to create a platform for the whole supply chain, PEG was limited to the relationship between wholesalers and suppliers with the possibility of adding hospitals later on; pharmacies where (interestingly) never part of that initiative. While the majority of the orders to the wholesalers' suppliers was subsequently passed through that system, this is not the case for their customers (pharmacies). Although technically feasible, the system was never opened for use by pharmacists because of opposition by the wholesalers. The wholesalers jointly control PEG and pay a subscription fee to the administrating IT-vendor.

The software vendors thus managed to provide pharmacists with a functional equivalent to a standardised ordering solution as pharmacists can seamlessly switch their orders to another wholesaler. However, the proprietary communication protocols and product codes placed considerable burden and cost onto the software vendors.

With the beginning of the new millennium, a South African software company entered the Australian market. It formed a joint venture with one of the largest Australian vendors for pharmacy software. Based on technology developed in South Africa, they planned to establish an order exchange system (xProcure) between pharmacies and all wholesalers. According to our data, the initiative quickly failed for two reasons: first, the joint venture commanded insufficient market power; second, the wholesalers opposed the initiative because the system would allow pharmacies to make price comparisons. Nonetheless, their market entry focused the attention of the other software vendors and triggered a new Australian 'home grown' initiative.

In 2006, the four largest software vendors joined forces in the Pharmacy Exchange initiative (PharmX). The intention was to replace the old modem-based connections by modern WebServices based on broadband technology. Pharmacies would send their orders to a central server which is capable of communicating with all wholesaler systems. Thus, PharmX would serve as a clearing centre. The central server would encapsulate the proprietary protocol specifications of the wholesalers. The old n:m architecture would be replaced by a leaner hub-and-spokes (n:1:m) architecture. The revenue model was based on monthly subscription fees paid by the wholesalers depending on the number of transactions routed through the gateway. In 2006, during our first round of interviews, the project was in a prototype stage and negotiations with the wholesalers under way. At

that time, the initiative was in a precarious situation. It rested on two conditions: first, the willingness of the wholesalers to be connected to the gateway; and second requisite additions to the pharmacists' hardware infrastructure. The latter was strengthened by a governmental initiative that incentivised the adoption of broadband technology in pharmacies. Regarding the former the wholesalers were reluctant at first. Eventually, in 2008 one after another wholesaler signed in to the gateway. Subsequently, several small short-line wholesalers joined as well. However, the costs in form of the subscription fees would be passed on from the wholesalers to the pharmacies intending to use the gateway.

5.4.1 Analysis

In the Australian case, we can observe that the start of a standardisation process is a precarious issue. While several initiatives were formed over the years, electronic ordering, to this very day, relies on the proprietary set of specifications by the wholesalers.

The initial conditions present in the early 1980s favoured the introduction of proprietary ordering systems like the PDEs. From a strategy perspective, two explanations can account for the proliferation of proprietary product codes and communication protocols. First, the wholesalers started off as regional suppliers. Huge geographical distances and regional foci defined the relevant markets for the wholesalers. It took until the 1990s before the wholesalers emerged as nationwide suppliers. Hence, a nationwide standard was not in the focus of the actors at that time. A similar problem can be observed in the Australian railway network (Department of Infrastructure and Transport, 2008). States had opted for different gauges which did not cause problems until a national railway network was built. Second, our interviews indicate that the wholesalers pursued a strategy of maintaining customer relationships. The PDE device was introduced as a premium service to valued customers of the wholesalers. Proprietary specifications resonated well with the strategic rationale of increasing customer retention. Today, the wholesalers do not perceive the once intended technical lock-in to persist. Pharmacies can easily switch between each of them. As a response to dwindling customer loyalty, all of them introduced banner groups as a means to associate pharmacies more closely to them. Our data do not reveal any collective actor (e.g. the Pharmacy Guild) in the Australian case that took a guiding role in developing a standard.

Rather the software vendors addressed pharmacies' desire to gain freedom in routing their orders. They effectively made the different proprietary specifications 'transparent' from a pharmacy's point of view. The costs for integrating incompatible, proprietary specifications were borne by the software vendors and, indirectly, the pharmacies.

Subsequent initiatives like xProcure were blocked by the wholesalers or not supported as a competitive move (by software vendors in the case of xProcure). Only the more recent PharmX initiative gained enough momentum to establish a common gateway. Still, from a wholesaler's point of view there is no economic incentive to invest in standardisation activities that would eliminate their proprietary product codes and communication protocols. In addition to the challenges of starting a standardisation initiative as collective action, previous investments in electronic ordering most likely would have to be written off and opportunities to adopt innovative technologies might be restricted. Moreover, the cost of the existing heterogeneity has been externalised to the software vendors.

The case illustrates that the initiation of standardisation processes is precarious and particularly difficult, once proprietary systems are operational. Several initiatives were

started to mitigate the lack of standardisation. Providing interoperability via gateways seems like an acceptable compromise, yet it has downsides in terms of data integration and analysis. Moreover, it seems to work only as long as the software vendors are willing to push forward in terms of development and operation of the gateway. In contrast, the wholesalers showed little to no interest in bearing the additional costs that come along with maintaining proprietary product costs.

6 Cross case analysis

In the previous sections, we provided an explanation for each of the two cases individually. However, the question remains how to account for the different outcomes we observed? Several arguments can be put forward that contribute to an explanation of the difference.

The market in Ireland is closely linked to Europe and especially Britain. The actors were not only inspired by developments taking place in the USA but also monitored the introduction of proprietary product codes in the UK as well. In comparison we found no evidence that Australian actors had similar experiences and exposure.

This awareness of developments on an international level translates to the national level as well. The *Irish* market was serviced early on by the wholesalers and software vendors as a nationwide market. However, the national market scope might not have been sufficient to prevent the emergence of proprietary systems if the IPU had not forcefully articulated the interests of the pharmacists. The wholesalers' commitment to their customers (and shareholders) obviously made it easier to engage in negotiations with their competitors. We do not have direct evidence about how the consortium dealt with the risk that one or two of the wholesalers could have defected. Two considerations may have mitigated this risk: First, the wholesalers perceived the electronic ordering system as a competitive advantage over the pharmaceutical manufacturers. This became clear much later when United Drug articulated its dissent with the IPU's decision to licence the ordering standards also to manufacturers. Second, as the consortium was a relatively small group, defecting might have prompted retaliatory actions from the pharmacists.[2] In contrast, in the 1980s, the Australian market presents itself as regionally fragmented. This may be an indication that in Australia the national market emerged later as the relevant market. As far as we know, nobody questioned the rationale of wholesaler-specific electronic ordering systems at the time of their introduction. Aiming at national standardisation would have required an additional initiative. The party that would have gained most from that, the pharmacists, were fragmented and their trade association did not pursue this issue on their behalf.

A third explanation rests upon the sequence of events and the economic assessment of past investments. In the *Irish case*, the consortium faced a green field situation. Neither had the pharmacies an installed base of IT nor did the wholesalers rely on previously made investments. Consequently, there were no investments to be protected or faces to be saved as justification for past decisions. Moreover, the focus of the joint standardisation was quite narrow, yet crucial. This left sufficient scope to all parties for their own expansions adaptions or competitive manoeuvres. In contrast, in *Australia* the wholesalers had started to invest in proprietary systems. Moreover, due to the crucial role of the product codes for the wholesalers' information systems, it would have been quite an effort to change the codes. The pharmacy software was introduced after the

introduction of PDE devices. During the software development process the specifications on which the PDE technology rests were not questioned. Instead, later developments depended on these already existing structures.

Table 6 Summary of key arguments

Argument	*Irish Case*	*Australian Case*
Awareness (international)	Open market	Isolated market
Market	National market	Regionally fragmented
Actor constellation	Wholesalers and IPU, manufacturers have been initially excluded	No coordinated action by wholesalers, pharmacists not effectively represented, initiatives by software vendors (on behalf of pharmacists)
Installed base	Green field, standardised product code as basis for subsequent system development	Path dependent: proprietary codes as basis of subsequent development
National infrastructure	Based on standard	Based on gateway enabled interoperability

7 Theoretical implications

So far we have drawn on standardisation theory to analyse and explain the two cases individually and comparatively. Our findings suggest several implications on the theoretical level. In this section, we engage with these implications by considering first the phase schema and subsequently the theoretical frame as discussed in the literature. We conclude this section by formulating extensions to standardisation theory.

7.1 Phase transitions or the shadow of future

Theory suggests (Markus et al., 2006) that the outcomes of each phase serve as inputs to subsequent phases and thereby link the phases. In our analysis, we were able to show that, early on, the actors were well aware of potential difficulties during the diffusion phase. In fact, the threat that pharmacies could choose not to adopt proprietary solutions motivated wholesalers to start the standardisation process in the first place. It also motivated the inclusion of the IPU into the consortium, so that the pharmacies' view would be represented during the negotiations and consensus building within the consortium. Furthermore, the consortium deliberately limited the scope of the standardisation effort, i.e. the wholesalers opposed a standardisation of the entire software on the grounds that it would preclude any benefits from competition among software vendors. Thus, the *shadow of the future* was present in each stage. However, despite anticipating and addressing the challenges of diffusion during the negotiations about the design of the standard candidate, pharmacies initially hesitated to install an electronic ordering system.

The transitions between the phases of a standardisation process have received little attention in the literature so far. They are merely referred to by the outcomes of the phase. Our analysis shows that the character of the processes involved in each phase changes. The initiation phase is characterised by forming a consensus to produce a

collective good. While every actor is in principle free to start a standardisation process, it involves effort and risk. Forming a consortium is a balancing act between identifying sufficiently interested and (economically) motivated parties, who at the same time have the credibility to propose a bipartisan solution, i.e. standard candidate. That is, the standard candidate has to convey to the targeted adopters of the standard candidate that it will yield equal or sufficiently large benefits for them compared to the initiators.

7.2 Collective action, governance and club goods

In the Irish case, we found a dyadic constellation between the wholesalers on the one side and the IPU on the other side. As representative of the pharmacies, the *IPU* gained a powerful role which reinforced consensus building among the wholesalers. Moreover, the IPU foresaw that product code and product file standards would reinforce its own position and economic base. While the role of associations is often contested, even among its members, the role of the standard custodian reinforces IPU's role among its constituency and provides a strong reason for IPU membership. The *wholesalers* have excluded the product code from their immediate competition. Instead it was positioned as a club good for IPU members and wholesalers, so that non-IPU members and manufacturers can be excluded. Whereas the underlying EAN/GS1 specification and governance for the product code is a public good, the specific instantiation and institutional embedding (data structure, design and maintenance of the product code, IPU governance) turns it into a club good. Whereas the wholesalers see themselves as legitimate owners of the standard, the IPU does not share this view and recently has made it available to manufactures. This is in line with its own interest to extend the use of the standard but blatantly against the interests of the wholesalers.

7.3 Standardisation, infrastructure and innovation

Standardisation enabled a relatively swift diffusion of electronic ordering as a national infrastructure in *Ireland*. The standards constituted a platform for the development of POS and inventory management systems for the pharmacies on the one side and order management, warehousing, and distribution systems on the other side. Yet, the scope and design of the standard enabled and reinforced the division of labour between wholesalers and pharmacists: the pharmacists are able to keep low stocks because of the wholesalers' highly efficient distribution systems and frequent deliveries. The successful standardisation raises the costs for proprietary integration between wholesalers and a selected group of pharmacies because that would mean to establish additional processes and systems. Modification or extensions to the standard are limited by the large installed base of electronic ordering systems, i.e. a revised standard would again face a diffusion problem. One might argue that the success of the standard has impeded innovation in terms of, for instance, a closer IT-based collaboration between pharmacies and wholesalers.

In *Australia*, we observe an ongoing process of tinkering, i.e. development and use of different technical and organisational designs. Initially, we can only talk about regional electronic ordering infrastructures, yet over time a national infrastructure has emerged. Even though it has not been based on one standard, but rather on several

versions of a gateway that ensures interoperability across the different electronic ordering systems and thus can be called functionally equivalent. While a standardisation initiative so far was not successful, the Australian case seems more vibrant in terms of innovation. Theoretically, this shows that an industry-wide information infrastructure does not have to be based on standardised interfaces, as claimed by Hanseth et al. (1996).

8 Conclusions

The research on the evolution of inter-organisational systems or infrastructures over long periods of time gains increasing attention in the IS discipline. We have presented a comparative case study and have used and extended conceptual tools to make sense of the different paths and outcomes:

- *Public good theory* clarifies the differentiated roles of standards and their governance. Moreover, we identified different outcomes of the phases of the standardisation process that have different degrees of excludability and rivalry.
- The *phase model of standardisation* provides a powerful explanatory framework to understand the dynamics of standardisation processes driven by heterogeneous actor constellations and the interdependencies between the phases. The initiation phase is widely neglected in standardisation theory. Yet our case description shows the importance and fragility of this phase.
- *Information infrastructures* provide a useful lens and level of analysis beyond the strategic considerations of individual players. It suggests a discourse about systemic or collective benefits.

Our findings highlight two themes:

- *Scope matters*: the design of IOIS is driven by the perception of the relevant market and relevant contexts of analysis. At a time, when the Australian wholesalers still saw the region or state as the relevant market, the Irish wholesalers had already operated at a national level. Currently, we observe a push towards European standardisation of product codes as suggested by the association of pharmaceutical manufacturers (EFPIA) and GS1. Reflecting on our two cases reminds us of the difficulties to drive harmonisation at a European level.
- *History matters*: an installed base and wide diffusion of standards pose obstacles to move into a new direction. Yet, such changes are not impossible as the theory of path dependency would suggest, as we have argued in another paper that builds on the Australian case (Reimers et al., 2013). There is an obvious trade-off between adapting the existing systems and the cost of maintaining complex systems of interoperability (such as matching tables and difficulties to maintain historic records). We have not aimed at evaluating the efficiency of these alternative solutions. Yet, we may add the argument that successful standardisation raises the bar for future innovation.

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Notes

1 During the 1960s, a group of grocery industry trade associations formed the Uniform Grocery Product Code Council (UPCC) and had commissioned the development of the Universal Grocery Products Identification Code (UGPIC). In May 1983, the UPCC agrees to administer the Uniform Communications Standards (UCS), an Electronic Data Interchange (EDI) standard (see http://www.cummingsdesign.com/bar_codes101_UCC_History.htm). In 1974, the first bar-coded products were scanned in a supermarket (Harvard Magazine, September – October 2005).

2 An episode from a late period suggests the retaliatory power of the pharmacies: when – during the 1990s – one of the wholesalers bought a pharmacy chain, this wholesaler lost market share, because the pharmacists perceived it as competitor.