The Impact of Competing Committee Standards: Integrating the Interoperability Perspective

Tineke M. Egyedi

Delft University of Technology

Abstract[1]

There is an on-going controversy about the impact of competing committee standards – i.e., two or more functionally equivalent 'open' standards – on innovation (Blind, 2008; Egyedi and Koppenhol, 2010; West and Fomin, 2011). This paper takes a different angle and focuses on its impact on interoperability (e.g. e-government) and large IT users such as public authorities, in particular. Moreover, it extends the notion of 'competing standards' to include standards change (i.e., different standards versions) as a source of competition next to standards wars.

The conceptual framework on economic functions of committee standards (i.e. information, compatibility, variety reduction; Blind, 2004) is used to analyse relevant literature and reason about the impact of single and multiple competing standards. An economic equation is formulated to capture the cumulative and dynamic effects of competing standards on interoperability.

The literature and theoretical findings indicate that it would be difficult and costly for public authorities to sustain commitment for supporting two or more functionally equivalent standards and maintain long-term interoperability. In the light of the scientific controversy, the paper concludes that tension between innovation and interoperability as well as their mutual effects needs further theoretically and empirical grounding.

Key words: rival standards, interoperability, public IT procurement, e-government, standards wars, standards versions, converters

1. Introduction

During the last decade the European Commission and several EU Member States have installed standards-related policy programs to facilitate digital exchange between public authorities and ease the development and introduction of new eGovernment services for citizens and businesses (e.g. European Interoperability Framework, European Commission IDABC, 2004; NOIV, 2007). Targeted public IT procurement is viewed to play a key role in this process. While interoperability can be achieved by different means (Egyedi, 2011),

[1] This paper is extracted from Egyedi (2012), a report written for the Dutch Forum Standardisation and the Open Forum Academy.

requiring vendors to comply to specific functional and open standards[2] requirements is one of the more systematic and future-oriented means to achieve cross-governmental interoperability (CAMSS, 2011). The problem is, however, that there is an "unmitigated output of standards, especially competing standards" (Cargill and Bolin, 2007, p.310) (The term *competing standards* refers in this paper to two or more functionally equivalent and/or largely overlapping standards.) The question which public authorities then face, is: Should Member States select single standards for the purpose of public IT procurement? Or are there good reasons to support multiple standards?

Past examples of competing open standards are Internet's TCP/IP protocol family versus that of the Open Systems Interconnection (OSI) and HiperLAN versus IEEE 802.11. A more recent example that has sparked new interest in this question is ODF versus OOXML, about which more later. Many European Member States struggle with this question (e.g. Portugal and Denmark). The European procedures drawn up to select standards for public procurement, such as the Common Assessment Method for Standards and Specifications (CAMSS), and the Dutch selection procedure of the Standardisation Forum (Forum Standaardisatie, 2011) offer no clear answers (Egyedi, 2012).

Possibly this lack of clarity can be explained by the tension between interoperability and competition policy that underlies European public tender law (Directive 98/34/EG). The law requires that, in order not to bias the market, public procurement officers must allow their requirements to be met by different technical means. That is, vendors who are asked to comply with a specific standard should also be allowed to meet the required functionality by other means. Doing the latter is not permitted to be a reason for rejection (Notification 2008/140/NL; Hommels, Cleophas et al. forthcoming).

Scientific studies have also done little to clarify the above question. Indeed, a controversy has arisen about the impact of competition between committee standards on technological innovation (Blind, 2008; Egyedi and Koppenhol, 2010; West and Fomin, 2011). Some argue that standards competition hinders the development of markets (Shapiro and Varian, 1999) and innovation (Egyedi and Koppenhol, 2010), while others conclude that it promotes innovation (Blind, 2008; West and Fomin, 2011).

This paper contributes to the discussion by taking the complementary perspective of interoperability rather than innovation to address the question: *In the context of government IT procurement, should governments choose between competing committee standards?* To specify the terms *committee standards,* also called *open*[3]*standards,* these are documented specifications "established by consensus (…), that provide, for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context" (adapted from ISO/IEC, 2004, p. 8). The addition "and approved by a recognised body" is omitted from this definition to widen its applicability from standards of formal standards committees (e.g. International Organisation for Standardisation, ISO) to standards developed by fora and consortia (e.g. World Wide Web Consortium, W3C; Organisation for the Advancement of Structured Information Standards,

[2] E.g. the European Interoperability Framework's (EIF) minimal requirements for an open standard, include the availability of a standard specification document for free or at a nominal charge, the availability of possible patents on a royalty-free basis, and no constraints on the re-use of the standard (European Commission IDABC, 2004, p.9).

[3] The term *open standards* has been introduced to emphasize that these standards are to be non-proprietary and vendor-independent. The royalty-free requirement of open standards, as defined in e.g. the initial EIF is loosened in this study in order not to exclude standards that, in practice, constitute part of the problem of having multiple standards.

OASIS and Ecma International) and professional organisations (e.g. Institute of Electrical and Electronics Engineers, IEEE, an ANSI-accredited standards development organisation).

In contrast to committee standards, *de facto* standards are widely adopted - specifications or company standards that underlie – products or services. Because the latter have a sizeable market share, the underlying technical specifications become points of reference for other market players: the specifications are referred and built to by third parties.

Whereas above attention was drawn to the necessity to distinguish between committee standards and de facto standards where the impact of competing standards on innovation was concerned, where the impact on interoperability is concerned much is to be learnt from de facto standards, as shall be argued in the following.

Furthermore, most of the literature reviewed focuses on *technical interoperability*, that is, on interoperability that "covers the technical issues of linking computer systems and services. It includes key aspects such as open interfaces, interconnection services, data integration and middleware, data presentation and exchange, accessibility and security services." (European Commission IDABC, 2004, p. 16) Therefore, the conclusions in this paper will also be restricted to *technical interoperability*.

In the following, first, the controversy is introduced. Next, a line of reasoning is followed based on the economic functions of standards (section 3), and which addresses key literature on standards competition (i.e. standards wars and standards dynamics; sections 4 and 5), and the feasibility of converter solutions (section 6). The main arguments from these sections are summarized in section 7. In section 8, the conclusions and research recommendations are presented.

2. The Controversy

In a paper called 'A welfare analysis of standards competition: The example of the ECMA OpenXML Standard and the ISO ODF Standard' Blind (2008) poses the question how competing standards should be evaluated theoretically in respect to their effect on innovation.[4] He identifies eight parameters[5] that are relevant and together determine whether - with a view to innovation - one should choose between standards or rather prolong the period of competition before making a choice. He concludes that, irrespective of the type of standard, competition fosters technology innovation.

Blind's paper triggered a response from Egyedi and Koppenhol (2009, 2010). They object not so much to his line of argument but rather to what they see as incorrect underlying assumptions. In their view, in developing his argument Blind primarily analyses problems typical for *de facto* standards and generalizes his findings to committee standards. For example, a recurrent problem addressed in economic literature is the risk that consumers prematurely get locked into a certain technology without really knowing its quality. According to Blind, such uncertainty calls for a prolongation of standards competition until the technologies have taken shape and it has become clear which one is technically superior. Egyedi and Koppenhol objections are, firstly, that in most (de facto) standards wars 'technical superiority', a factor which is difficult to operationalize, is not the defining factor for 'winning' these standards wars (Van der Kaa, 2009). Which technology 'wins' is primarily

[4] "How should multiple parallel existing standards, which exist in the same technological area, be fundamentally evaluated in terms of theoretical – static welfare, and most importantly with respect to their dynamic effect on innovation and competition?" (Blind, 2008, p.1)

[5] The parameters are: "preference for network effects, local network effects, heterogeneity of the preferences, cost of the development and maintenance of standards, uncertainty regarding the technical quality, length of the life cycle, development potential, uncertainty regarding future user preferences." (Blind, 2008, p.7)

attributable to the availability of products, the forming of alliances and successful marketing. They refer to the war between Blue-Ray and HD-DVD in the market for High Density DVDs to illustrate that prolonging the period of competition may even adversely influence the market. In that case, market development stagnated, according to public media, because consumers feared being stuck with a 'losing' system and therefore postponed their purchases.

Secondly, Egyedi and Koppenhol object because, as they argue, *de facto* and committee standards differ fundamentally. While they both function as points of reference in the market, a committee standard is a negotiated agreement whereas a de facto standard is not. See the earlier definition. Where de facto standards emerge from (competition in) the market, committee standards emerge from (competition and negotiations within) committees. The committee outcome, the negotiated specification, is developed to create a level playing field for competition among producers. Competition can then focus on how best to innovate based on the standard. That is, according to Egyedi and Koppenhol, committee standards are intended to be platforms for competition and prospective innovation rather than compete themselves (Egyedi and Koppenhol, 2009, 2010). This conclusion, however, has been criticized by West and Fomin (2011) foremost because too much has been inferred based on one case study, the ODF-OOXML standards war.

3. Economic Framework

Different from the above discussion this paper centres on the impact of competing standards on interoperability rather than innovation. To address the question whether governments should choose between competing committee standards, an economic framework is introduced that looks at the functions and market implications of committee standards, and at what happens if two or more such standards are in place (section 3.1).

3.1 Functions of Standards

From an economic perspective, committee standards perform different functions. They provide information, foster compatibility and reduce variety (Blind, 2004; Table 1, first column). Regarding their informative function, standards make life easier because we can refer to them and thus reduce informational transaction costs (Kindleberger, 1983). Such costs entail, for example, the time and resources required to establish a common understanding between parties in the market. Standards reduce the costs of negotiations because "both parties to a deal mutually recognize what is being dealt in" (Kindleberger, 1983, p. 395). They reduce the search costs of customers because there is less need to spend time and money evaluating products (Jones and Hudson, 1996). In particular in markets where consumers cannot easily recognize the quality of a product, such as the IT market, consumers have a significant information disadvantage vis a vis producers. An information asymmetry exists (Akerlof, 1970). In such situations market failure will occur more easily (e.g. too little IT functionality for too high costs). Standards notably address market failure in two ways. First, standards make it easier for consumers to compare products (e.g. standards for measuring the CO_2 emission of cars). The information provided by standards increases market transparency (Reddy, 1990; e.g., in a market where producers of paint conform to the standard RAL colour). Standards thus help to correct the occurrence of 'adverse selection'. Adverse selection takes place if the supplier of an inferior product gains market share through price competition because the supplier of a high quality product has no means to signal this information to potential consumers. Standards that contain information about a product's quality (e.g. re-use of material resources and power use of mobile phone chargers) will support suppliers in signalling this information and minimize the likelihood that consumer selection is based on the wrong assumptions. Moreover, because of increased market

transparency, standards facilitate trade. They do so in particular in anonymous international markets, where parties to the transaction do not know each other.

Functions of committee standards	**Effect on the market**	
	One standard	**Two or more standards**
Information	Increases market transparency Reduces transaction costs (e.g. reduces information asymmetry) Corrects adverse selection Facilitates trade	Reduce market transparency Increase transaction costs (e.g. costs of converters and converting) Make comparison of product quality more difficult Hinder trade by increasing e.g. informational transaction costs
Compatibility	Creates network externalities Increases competition (i.e., increases number of producers, quality and choice of products, lowers prices, provides an incentive for innovation) Decreases vendor lock-in (e.g. decreases costs of switching vendors and of maintenance)	Reduce interoperability Involve switching costs Reduce network externalities Decrease competition (higher barrier to market entry for smaller players; higher prices) Increase likelihood of standard-based lock-in (fragmented market) Need for converters, etc. to recreate interoperability (extra complexity and risk of decreased functionality)
Variety reduction	Allows economies of scale Facilitates building a critical mass	Less variety reduction, smaller markets, and therefore: Reduced economies of scale Reduced chances of building a critical mass

Table 1: Main functions of compatibility standards and the market effects of having either one or more standards (based on Blind, 2004; Egyedi and Blind, 2008; Egyedi and Muto, 2011)

Second, compatibility standards provide a platform or 'infrastructure' (Swann, 2010) to compete and innovate upon. The desired economic effect of committee standards is to support 'full competition in the marketplace for suppliers of a technology and related products and services' (Ghosh, 2005). The level playing field lowers the threshold for new producers, provides incentives for innovation, leads to a better price-performance ratio and leads to a larger variety of products for consumers. Moreover, standards facilitate the emergence of

clusters of new economic activity. Examples are the cluster of paper processing equipment and office products (e.g. printers, copiers, fax machines, binders) that has developed around the A-series of paper formats (ISO 216); and the vast amount of Internet services based on the TCP/IP protocol family. Because, for example, interfaces and formats are standardised, consumers can switch more easily between providers and products and are less easily locked-in (Farrell and Saloner, 1985).

The third economic function of committee standards is that of variety reduction. The principle aim of committee standards is to reduce needless and unhelpful variety by agreeing on a specification that can serve as a shared point of reference. An early definition of the Dutch standards body, which says as much (Van den Beld, 1991), underscores that variety in itself is not of intrinsic value to consumers (e.g., few people will value using both the metric and imperial units of measurement). Moreover, from the producer's side, because of reduced variety, standards mitigate economies of scale (i.e., cheaper units) and help build the critical mass required for markets to take off. Again, by reducing needless and unhelpful variety, the market becomes more transparent (information function of standards) and runs more efficiently (compatibility function).

3.2 Market Effects of Multiple Standards

What happens to the market if two or more largely overlapping standards are in place? The welfare gains from standards variety then need to be weighed against the sum of costs. Table 1 summarizes the effects for consumers and suppliers. The Table builds upon the economic functions of committee standardisation as discussed in the previous section (first column of Table 1), and their market effect (second column of Table 1, based on Blind, 2004; Egyedi and Blind, 2008; Egyedi and Muto, 2011). Inductive inference is used to identify per economic function what the impact is of having multiple, functionally equivalent standards (third column of Table 1).

For consumers, here: government authorities and their interactions with citizens and companies, there would seem to be few benefits. Since the competing standards are functionally equivalent, having a choice would only be meaningful if the standards strongly differ in other respects (e.g., quality). More likely, two or more functionally equivalent standards will

- reduce market transparency;
- decrease overall interoperability, decrease network externalities (to be discussed in the next section) and decrease ease of use;
- fragment the market, possibly leading to submarket lock-in and – if there is a risk of insufficient competition per submarket - vendor lock-in and monopolies (i.e., welfare losses, higher costs and less technology diffusion); and
- increase transaction costs (e.g., extra costs of competing standards including costs of converters and converting; barrier to exit/ switching costs).

That is, reasoning from the economic functions of standards, the market and interoperability impact of multiple committee standards suggests that public authorities should try to avoid supporting two or more competing standards. As we shall see in the next section, empirical studies on standards wars partly confirm the inferred market effects.

4. De Facto and Committee Standards Wars

A growing number of economic, technology management and innovation studies on standards wars has emerged (Stango, 2004; Van der Kaa, 2009). Some are historical accounts and have become classic exemplars such as the Qwerty vs. Dvorak keyboard layout (David, 1985), the competing video recording systems of Betamax, VHS and Video2000 (Shapiro and Varian, 1999), the battle between Alternating Current and Direct Current (McNichol, 2006), and Open Systems Interconnection (OSI) versus Internet (Hanseth et al., 1996). Of more recent date are the wars between proprietary platforms (West, 2003); the war between HiperLAN versus IEEE 802.11 wireless LAN (Jakobs, 2008); the standards war on DVD recordables (Dranove and Gandal, 2003; Gauch, 2008); the war between the Dutch e-purse systems of Chipknip and Chipper (De Vries, 2006); and between W-CDMA and CDMA, 2000 in mobile telecommunications (Grindley et al., 1999). All these battles involve rival technologies, but some involve products (i.e., de facto standards) and take place in the market, while others concern negotiated agreements and take place in and between standards committees.

In such rival revolutions type of standards wars two factors determine the stakes and their dynamics (Shapiro and Varian, 1999). First, the rival technologies are *incompatible*. This is a defining factor not only for de facto standards wars like Blu-Ray versus HD-DVD, but also in wars between committee standards. Some of the latter involve the –sometimes contested – fast tracking of consortium standards or industry specifications by formal standards bodies. Examples are the wars on 56K modems (Shapiro and Varian, 1999), DVD recordables (Gauch, 2008), and document formats (Blind, 2008; Chappert and Mione, 2008).

A second and related defining factor in standards wars is the role of *network externalities* (Shapiro and Varian, 1999). Externalities are the costs or benefits of a transaction incurred or received by members of society but not taken into account by parties to the transaction (Lipsey and Steiner, 1979).[6] In the context of standards wars, 'positive network externalities' are particularly relevant, that is, the increased value of a network with every new connected network user (Farrell and Saloner, 1985; Katz and Shapiro, 1985). These can be *direct* (e.g. every new fax machine increases the reach of the network) or *indirect* network externalities (e.g. if everyone buys the same car brand the number of dealers and the availability of spare parts will be higher). Network externalities require compatibility. The absence thereof, as is the case with incompatible rival technologies, reduces the externalities of the networks involved. This can be illustrated with incompatible standards for pallet sizes. Multiple standards force traders to carry a stock of pallets of different sizes, which poses a particular problem for the developing countries where there is neither a rental market, nor an exchange market for pallets (Raballand and Aldaz-Carroll, 2007).

While one might expect a single standard to result in areas where there are strong direct and indirect network effects (Weir, 2007), this need not be the case. Similarly, standards wars need not necessarily end up in a 'winner-takes-all' situation (Singh and Dahlin, 2009), which would have solved the problem of incompatibility and reduced positive network externalities. Under certain circumstances, Singh and Dahlin argue, there may be room for two standards and/or a niche standard. If there is no clear 'winner', incompatibility will lead to market fragmentation. In the consumer electronics market, for example, "[t]here's no denying that consumer electronics format wars are a nuisance. The rules of engagement are particularly cruel for the buying public, asking them to make an expensive bet on a technology that could

[6] Externalities disappear when they are included in the cost estimate and become internalized. Externalities can be negative, e.g. the polluting industry bringing down the value of houses in the area, or positive, e.g. a well-maintained park increasing the value of houses in the neighbourhood (Lipsey and Steiner, 1979).

be obsolete in a few years' time. They emerge with remarkable frequency: 78 rpm discs versus 45 rpm in the 1940s, 8-track versus cassette in the 70s, Betamax versus VHS in the 80s, digital audio tape versus the compact disc in the 90s. Not to mention, of course, the on-going QuickTime versus Windows Media versus RealMedia struggle" (Warner, 2008).

If a 'winner' nonetheless emerges, this need not be due to its alleged technical superiority. For example, the 'winning' Qwerty keyboard was not most suited for speed typing, according to David (1985). Nor was the VHS video recorder the most advanced system technologically, according to proponents of Philips' Video, 2000. In short, the causal link between 'superior quality' and 'winning a standards war' seems to be a weak one. The argument to prolong competition between committee standards in order to allow the technically superior one to emerge – and thus minimize the risk that consumers prematurely get locked into a technology of which the quality is not yet evident (Blind, 2008) - therefore needs more study. NB: Note that the underlying line of reasoning, i.e., that competition can spark innovation, can has merit. Competition between standards may constitute an incentive for competing committees to improve their standard's performance (e.g. in terms of speed or capacity). In the case of the DVD recordables competition between committees has led to a race of new standards versions (Gauch, 2008).

The uncertain outcome of rival revolution type of wars is a key intermediate factor in determining their impact. Uncertainty undermines competition (Farrell and Saloner, 1986). It leads to a hold–up of investments by third parties (Williamson, 1979): producers will try to postpone investments for fear of investing in a 'losing' system and having to write off sunk costs (i.e., costs that are specific and irreversible and therefore cannot be retrieved). The same hesitations exist on the side of consumers. They will postpone their purchases. Accordingly, the market will stagnate.

For government procurers, certain aspects of the above discussed standards wars are particularly relevant. First of all, the defining problems of incompatibility and lack of (positive) network externalities also apply to competing committee standards. They lead to fragmented markets, extra efforts to bridge these markets and user inconvenience on all levels. Furthermore, uncertainty about whether a 'winner' will emerge or multiple committee or de facto standards will exist next to each other, can hold-up third party investments and consequently slow down innovation. Transposing this insight to public IT procurement, clarity about whether governments will select among competing standards and their criteria for selection are highly relevant for both investors and end-users.

5. Standard Versions: Competing over Time

Comparable to competing standards, different versions of the same standard could also be said to be 'functionally equivalent' in the sense of addressing overlapping functionalities. Rivalry can arise between them, as the IPv4 and IPv6 protocols illustrate (Vrancken et al., 2008), and lead to interoperability problems equal to those between competing standards, as the literature on standards dynamics shows (Egyedi and Blind, 2008). In this section, these problems as well as ways to deal with incompatibility are examined more closely.

Standards change and renewal occurs among proprietary standards as well as non-proprietary committee standards. It comes in various shapes: new editions, revisions (new versions, technical corrigenda, amendments, annexes etc.) and new standards. Usually the new standard is developed to offer additional functionality and/or a performance improvement. Therefore, new entrants in the market (standards users) will usually implement the later version, the successor standard.

To identify different types of succession and their impact on the market, Egyedi and Loeffen (2008) distinguish three dimensions: (1) does the new technology represent a paradigm shift; (2) is the successor part of the same technological trajectory; and (3) is the successor compatible with its predecessor. They arrive at three types. The Type I succession refers to a *grafting*[7] relation between successors. It is characterised by incremental improvements, trajectory-compliant developments, and backward compatibility. In other words, a specific heritage relationship is at stake: compatible succession. A Type I succession usually has no disruptive impact on the market. For example, the users of the Aachen Wireless LAN had few problems with the transition from IEEE 802.11b to IEEE 802.11g (Jakobs, 2008).

The Type II successor represents an incremental shift. It is paradigm-compliant but incompatible with its predecessor (discontinuous standards development). For example, the Internet Protocol version 6 (IPv6) is not compatible with IPv4 (Vrancken et al., 2008). To recreate compatibility a separate standard on "Transition Mechanisms for IPv6 Hosts and Routers" (IETF RFC 2893) has been developed. That is, IPv6 is a Type II successor, incompatible and discontinuous, but paradigm compliant.

The Type III successor represents a revolution. It introduces improvements that signify a radical paradigm shift (disruptive standards development) and is not backward compatible with its predecessor. In Telefax standardisation (CCITT, 1989-1992), for example, the succession of Group 3 for analogue networks by the Group 4 for digital networks illustrates a Type III succession (Schmidt and Werle, 1998). In these situations, the rivalry that ensues between successors is no different from that which exists between unrelated standards with equivalent functionality. The characteristics that define the dynamics of wars between competing standards, i.e. incompatible technologies and lack of network externalities, typically also apply to Type II and Type III successions.

6. Converters Unproblematic?

There are point ad hoc and systematic ways to deal with the adverse impact of standards dynamics, and solutions that try to prevent problems from occurring (*ex ante)* and those that try to deal with them *ex post* (Egyedi, 2008b). Most relevant for this paper is the category of solutions that recreate compatibility between competing standards *ex post* and *ad hoc* (e.g., the creation of crosswalks between a standard and its successor). Sometimes this seems possible (e.g. from DC to DCQ; Van der Meer, 2008). But more often the results of such efforts are ambiguous (Van der Meer, 2008). That is, while such ex post measures may partly and temporarily solve the adverse effects of standards change, they are usually costly and inadequate.

There are different ways to re-create interoperability between competing standards (Farrell and Saloner, 1992), e.g. converters, plug-ins, bridges, multi-protocol stacks, gateways and routers. Some ease and reinforce mutual coexistence. For example, competing standards are sometimes implemented in single electronic devices (*multiprotocol implementations*, Gauch, 2008); take, for example, equipment that can handle different DVD recordable formats. While it involves extra costs, producers and users of one standard then still have access to the externalities of the competing standard. Such solutions reduce the consumer's fear that the market will tip towards the competing standard leaving them with an obsolete technology. However, these solutions sustain market fragmentation. Since they allow consumers to benefit

[7] The term *grafting* refers to "the process of developing a standard (successor) based on another standard (predecessor) with the intention to improve the latter's functionality and/or usefulness in other respects while preserving compatibility with its predecessor's context of use." (Egyedi and Loeffen, 2008, p. 84)

from the externalities of both markets, there is no urgent need to integrate standards and markets (Gauch, 2008). A similar phenomenon is at stake with dual stack implementations of IPv4 and IPv6 (Vrancken et al., *200*8). Although aimed to ease migration from IPv4 to IPv6, the dual stack allows co-existence and lessens the need to migrate.

Other solutions go beyond co-existence and re-create compatibility. The manner in which this is done can have important implications: “Converters can be one-way or two-way with very different strategic implications." (Shapiro and Varian, 1999, p.286) Shapiro and Varian (p.282) advise vendors "Just don't build a two-way bridge to another region where you face an even stronger rival".

An example of the complexity involved in re-creating compatibility between two committee standards is the committee standards war between the document formats OOXML and ODF, the case on which the ‘controversy on competing standards’ initially focused. The case illustrates that converters increase system complexity and thereby overall system vulnerability, heighten the costs of production and purchase, and often lead to performance degradation (Shapiro and Varian, 1999). This is, for example, illustrated by conversions and roundtrips between document formats (Langer, 2008; Lundell et al., 2011).

7. Variables that Capture Lack of Interoperability

Selection committees for IT procurement not only face the problem of different competing standards but also that each of these standards is likely to develop versions. That is, where $S_{i,j}$ refers to standard i version j, selection committees are faced with different competing standards $S_{i=1..n}$ and different versions of these standards $S_{j=1..n.}$. The more competing standards and standards versions the more converters (i.e. translations, mappings, routers etc.) are needed (i.e., from one standard to the other and vice versa) to bridge the resulting incompatibility. The degree of incompatibility *X* can be operationalized by the number of converters needed. To give an example, in the case of two standards, one with two versions $S_{1,1}$ $S_{1,2}$ and the other with three versions $S_{2,1}$ $S_{2,2}$ $S_{2,3}$, twenty converters are needed. See Table 2.

Standard $S_{i,j}$	$S_{1,1}$	$S_{1,2}$	$S_{2,1}$	$S_{2,2}$	$S_{2,3}$
$S_{1,1}$	-	$S_{1,2}$ x $S_{1,1}$	$S_{2,1}$ x $S_{1,1}$	$S_{2,2}$ x $S_{1,1}$	$S_{2,3}$ x $S_{1,1}$
$S_{1,2}$	$S_{1,1}$ x $S_{1,2}$	-	$S_{2,1}$ x $S_{1,2}$	$S_{2,2}$ x $S_{1,2}$	$S_{2,3}$ x $S_{1,2}$
$S_{2,1}$	$S_{1,1}$ x $S_{2,1}$	$S_{1,2}$ x $S_{2,1}$	-	$S_{2,2}$ x $S_{2,1}$	$S_{2,3}$ x $S_{2,1}$
$S_{2,2}$	$S_{1,1}$ x $S_{2,2}$	$S_{1,2}$ x $S_{2,2}$	$S_{2,1}$ x $S_{2,2}$	-	$S_{2,3}$ x $S_{2,2}$
$S_{2,3}$	$S_{1,1}$ x $S_{2,3}$	$S_{1,2}$ x $S_{2,3}$	$S_{2,1}$ x $S_{2,3}$	$S_{2,2}$ x $S_{2,3}$	-

Table 2: Number of converters needed to bridge the incompatibility between two competing standards $S_{1,1..2}$ and $S_{2,1..3}$ with two and three versions respectively. $S_{i,j}$ refers to standard i version j.

The following equation summarizes the problem of interoperability posed by competing standards. Here the variables that define incompatibility *X*, i.e., the number of possible converters needed to achieve interoperability, are

$$X = n(S_{i,j})^2 - n(S_{i,j}) = n(S_{i,j})[\, n(S_{i,j})-1]$$

where $n(S_{i,j})$ is the total number of different standards i with version j. *X = 0* stands for optimal interoperability, i.e., no converters needed. Applied to the example of two competing standards with two and three versions at time *t1*, respectively, the equation becomes

X= 5 (5-1) = 20

That is, to secure two-way interoperability between different combinations of five standard versions at time *t1* twenty possible combinations must be taken into account if no selection is made.[8]

The equation illustrates that in a static world (i.e. short term view) selecting two or more standards might be an option if their added value is high – and if their implementability (see below) is not a complicating factor. But in the long run different versions are likely to develop that acerbate the interoperability problem and, correspondingly, increase transaction costs. That is, in the field of IT the metaphor of the universal plug, which suggests that overcoming incompatibilities between multiple standards is technically feasible, does not readily apply because the field is too dynamic. Following this reasoning through, selecting two or more functionally equivalent standards for IT procurement would seem difficult to sustain.

In sum, the problematic side of converter solutions, broadly defined, as well as the implications of the lack of interoperability formula warn against trivializing lack of interoperability between two standards and too easy reliance on technically re-creating compatibility (downward/upward as well as converters). The scale of IT use involved in government IT-procurement, and the non-transparency of IT products and services make long-term government support for two or more largely overlapping standards too costly.

NB: Only two sources of incompatibility were included in the equation, i.e. competition between different standards and between successive standards versions. For the sake of completeness, a third source of incompatibility must be mentioned, i.e.: different implementations of the same standard. The phenomenon that two products, which both claim to be standard-compliant, can be incompatible is often puzzling to consumers and can be highly problematic. For example, different implementations of the Z39.50 standard can lead to different query results. If a query result is later needed to account for an important decision and cannot be reproduced, there may be legal repercussions (Van der Meer, 2008). For a more elaborate discussion about incompatible standards implementations, see Egyedi (2008).

8. Conclusion and Recommendations

This paper has tried to contribute to the controversy about 'the impact of competing committee standards' by highlighting the tension between interoperability and innovation. The inferred impact of competing committee standards on the interoperability of large IT infrastructures (e.g. e-government), on the one hand, and the (sometimes uncertain) innovation advantages of prolonging standards competition, on the other, point to

i) the friction between interoperability and innovation aims;
ii) the need to be aware of the context of research and research aims; and
iii) the need to prioritize aims, in particular, in public IT procurement.

[8] Whereas one might question whether all possible combinations between standards and standard versions will actually arise in practice – is it likely that communication will foremost take place between those using (different versions of) the same standard? –the research question is whether government IT infrastructure should aim to support multiple (sub)markets.

8.1 Public IT Procurement: Select or Not?

In the context of a public IT procurement, which aims for a seamless (i.e. interoperable), cost-effective (i.e. vendor-independent) and sustainable government IT infrastructure, *should governments choose between standards that have the same functionality?* This paper concludes that selecting two or more largely overlapping, functionally equivalent standards for government IT procurement is inadvisable for several reasons. Many of the benefits of standardisation get lost with multiple standards. Competing standards will reduce market transparency; decrease overall interoperability, decrease network externalities; decrease ease of use; fragment the market, possibly leading to submarket lock-in; if there is a risk of insufficient competition per submarket, to vendor lock-in and monopolies (i.e., welfare losses, higher costs and less technology diffusion); and increase transaction costs (e.g., extra costs of competing standards including costs of converters and converting; barrier to exit/ switching costs). See Table 1.

The problem of incompatibility between competing committee standards is acerbated by the likelihood that competing standards will undergo changes over time. That is, the incompatibility between competing standards as well as competing versions must then be bridged – in addition to the problem of standard-compliant but incompatible implementations. Standards change should therefore also be taken into the deliberation of whether to select only one or to allow more functionally equivalent standards. The developed formula for lack of interoperability underlines the limits of using converters and other ad hoc and ex post measures to overcome incompatibilities. They involve extra costs, increase system complexity and lead to performance degradation. Moreover, converters and e.g. multiple implementations are likely to sustain competition, prolong lock-in, and thus reinforce long term market fragmentation. While they might represent a partial or temporary solution in a static context and with simple technologies, in the dynamic and complex (as defined by diversity and large scale) field of government IT infrastructure such solutions are less viable.

That is, the potential scale of the problem of lack of interoperability in government IT, the height of transaction costs (financially, functionality and inconvenience-wise), and its possible impact on communication in and between government entities and with citizens and businesses leave little room for *not* selecting between competing standards.

8.2 Research Recommendations

In the light of the scientific controversy, the first steps have been made by Blind (2008), Egyedi and Koppenhol (2010), and West and Fomin (2011) to synthesize the literature and sharpen the arguments. Subsequent efforts should focus on further theoretically and empirically grounding the mutual effect between innovation and interoperability. I further recommend the following topics for follow-up research.

- The market effects of competing committee standards (Table 1, third column), which were inferred inductively and partly confirmed by empirical findings, need to be qualified further.
- Of interest is (a) whether the answer to the research question 'Select or not?' might differ across technologies and types of innovation such as architectural, platform, incremental and radical innovations (Egyedi and Sherif, 2010); and (b) whether the conclusions for technical standards can be generalised to semantic standards (Folmer and Verhoosel, 2011). This requires additional study.

- In their article, Singh and Dahlin (2009) discuss competing standards as potential local optima in a standards convergence trajectory. The idea of looking at standardisation as a two-phased step is an interesting one – although to my knowledge still foremost theoretical. Further research on its applicability and past occurrence is recommended.

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