Standards battles for business-to-government data exchange
Identifying success factors for standard dominance using the Best Worst Method

van de Kaa, Geerten; Janssen, Marijn; Rezaei, Jafar

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Standards battles for business-to-government data exchange: Identifying success factors for standard dominance using the Best Worst Method

Geerten van de Kaa*, Marijn Janssen, Jafar Rezaei

Delft University of Technology, Jaffalaan 5, Delft 2600 GA, the Netherlands

A B S T R A C T

Businesses are obliged to report all kinds of data to the government. In the past this was paper-based, and over time Electronic Data Interchange (EDI) types of solutions have been implemented. The new eXtensible Business Reporting Language (XBRL) standard seems to have replaced EDI types of solutions. This paper applies the Best Worst Method to identify the key factors that lead to the dominance of these business reporting standards. The results show that the key factors for standard dominance are the overall commitment of key stakeholders, timing of entry, and installed base, and suggest that XBRL has the best chance of becoming the dominant standard, replacing EDI as the standard for business reporting. However, this will take time due to the installed base of systems.

1. Introduction

High quality business to government (B2G) reporting is at the heart of strong and successful economies. Electronic reporting of information from B2G is often compulsory and adds to public values like safety, security, and equality. Business reporting aims at improving regulatory compliance and more efficient government communication with businesses (Ghani et al., 2011). Differences in business reporting among various companies and countries require information to be processed in multiple ways, making the process of interpretation extremely difficult (Hoffman and Rodríguez, 2013; Nelson and Winter, 1985), and often extensive. As a result, error-prone manual intervention is often necessary (Eccles and Krzus, 2010). A Standard Business Reporting (SBR) facilitates information exchange between organizational entities by providing standardized processes, data formats, and infrastructures (SBR, 2015). Two standards that facilitate information exchange between entities have been engaged in a battle for dominance for the past decades: the incumbent format Electronic Data Interchange (which often used EDIFACT) and the newcomer, eXtensible Business Reporting Language (XBRL). EDI-based reporting has traditionally been used for all kinds of reporting, whereas XBRL is a more recent phenomenon that has gained momentum in countries including the UK, the USA, Australia, and the Netherlands (Bharosa et al., 2015a; Troshani et al., 2015). EDI can employ various communication protocols, which are outside the scope of this research (see Fig. 1). The focus of this research is on the structured information exchange between systems. We prefer the use of EDI over ebXML, as ebXML refers to a whole suite of standards that go beyond our scope of structured exchange of information between systems. Although EDI is the most used for information exchanges, a worldwide survey, but dominated by responses from North America, shows that approximately 28% of businesses use XBRL in their inhouse systems (Garner et al., 2013). This survey shows that adopters and non-adopters view XBRL as having different benefits. In particular, organizations perceive the potential savings of using XBRL, but they do not see the cost benefits of using it, as changes and investments are needed which might outweigh the short term benefits [ibid]. Thus, currently, two standards (XBRL and EDIFACT) are used which is costly as systems should be able to deal with different standards.

This paper aims to identify the key factors that lead to the dominance of these business reporting standards in the Netherlands. To reach this objective we use factors found in the literature on standard dominance and identify the relevant factors for this battle. Subsequently, we apply a multiple criteria decision-making method, the Best Worst Method (BWM), to determine the importance of these factors and give a first indication which of the two business reporting standards has the best chance of winning the battle. The BWM has shown to be one of the most reliable and most data-efficient MCDM methods which is why it is used in this study.

The theoretical rationale for conducting this study is as follows. While evolutionary economists believe that random events influence the outcome of battles between standards (Arthur, 1989), technology management scholars believe that these events are precursors to factors

---

* Corresponding author.
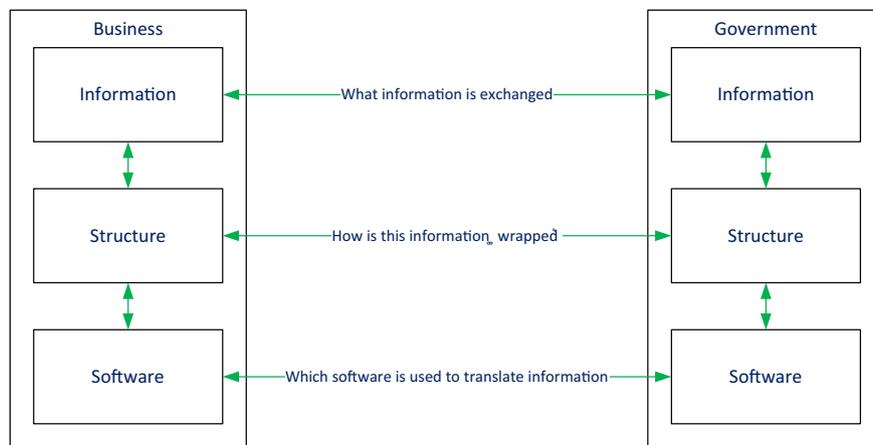   *E-mail address:* g.vandekaa@tudelft.nl (G. van de Kaa).

Fig. 1. A B2G information sharing scheme.

for standard dominance (Schilling, 2002; Suarez, 2004). The underlying premise of our work is that the process of standards dominance can be modeled, and that the outcome of a standards battle can be explained and predicted by examining factors for standard dominance. Empirical proof is scarce, and more studies are needed to examine factors for standard dominance in various arenas. In this paper, we provide empirical proof of the notion that the outcome of the standards battle between EDI and XBRL is not solely determined by path dependencies. Modeling factors, resulting in a preference of one standard over the other, can be used to explain and predict which standard will achieve dominance. As such, we build on prior work (Van de Kaa et al., 2014a) by determining the importance of factors for standard dominance for the case of B2G reporting. Furthermore, we provide a methodological contribution by applying the BWM to the case of B2G reporting, thus validating the method's usability for this specific case and in general.

Our research also has practical relevance. Investing in an unsuccessful standard can result in heavy losses (Shapiro and Varian, 1999). For example, during the battle between Blu-ray and HD-DVD in the 2000s, Toshiba, the backer of the unsuccessful HD-DVD standard, lost about 1.64 billion dollars in attempting to achieve success with its standard (Gallagher, 2012; Kane, 2008). We aim to decrease uncertainty for various institutions such as policy makers or firms with respect to the decision to invest in EDI or XBRL by conducting a thorough investigation of factors for standard success and explaining the reasons why it is likely that XBRL will become the dominant format.

The rest of the paper is organized as follows. Section 2 presents a theoretical background and Section 3 gives an overview of B2G reporting. Our methodology is outlined in Section 4, followed by a presentation of the results. Section 5 discusses the results and concludes.

2. Theoretical background

In various markets characterized by increasing returns to adoption, products increase in value when used by more consumers (Katz and Shapiro, 1985). In these markets, the 'winner takes all' (Hill, 1997; Shapiro and Varian, 1998) and fierce standards battles are often fought. Examples of standards battles include Betamax vs VHS (Cusumano et al., 1992), HD DVD vs Blu-ray (Gallagher, 2012), and QWERTY vs Dvorak (David, 1985). Various scholars from a diverse range of backgrounds have studied such standards battles, applying several theoretical lenses including evolutionary economics (Arthur, 1989; David, 1985), platform economics (Cusumano and Gawer, 2002; Rochet and Tirole, 2003), institutional theories (Garud et al., 2002; Garud and Kumaraswamy, 1993), technology management (Gallagher and Park, 2002; Schilling, 1998), and industrial economics (Farrell and Saloner, 1985; Katz and Shapiro, 1985). Technology management scholars have proposed factors that might influence standards dominance and have

integrated these factors in frameworks (Lee et al., 1995; Suarez, 2004; Van de Kaa et al., 2011).

One of these frameworks was developed by Van de Kaa et al. (2011). It has been successfully applied to various cases to assess its completeness and relevance (Van de Kaa and De Vries, 2015) and to assess the importance of factors for standard success (Van de Kaa et al., 2014b). We apply this framework in our study as it contains the most complete list of factors for standard dominance to date (Van de Kaa et al., 2011). The framework consists of 29 factors that affect standard dominance. We can distinguish two types of factors: (1) environmental factors or market characteristics, such as direct and indirect network effects, that can hardly be influenced by the firm and that have an impact on the speed and likelihood of standard dominance and (2) firm level factors that can be influenced by the firm and, thus, directly affect the chances that standards achieve success. The latter type of factors, firm level factors, has an impact on standard dominance. In the remainder of this section, we briefly present and examine the factors from the framework of Van de Kaa et al. (Van de Kaa et al., 2011). For a detailed explanation we refer to (Van de Kaa et al., 2011; Van de Kaa and De Vries, 2015).

One of the environmental factors, i.e., market mechanisms, is *network effects* which can be observed in markets that are characterized by increasing returns. In these markets, products increase in value the more they are adopted by users (Farrell and Saloner, 1985; Katz and Shapiro, 1985). The effects can be direct and indirect (Katz and Shapiro, 1994). Direct network effects occur in markets that consist of physically interconnected components: the more interconnections, the higher the value of the component. Indirect network effects occur in markets that consist of complementary goods: the more complementary goods available for a certain technology, the higher its value. In B2G information exchange, direct network effects result in overcoming the lack of interoperability between systems. Once others adopt the interoperability cost decreases significantly. An indirect effect is the use of the standards in other domains, which results in lower cost for interoperability in a specific domain. Organizations often have to invest and to change their systems and processes when adopting a new standard, resulting in sunk costs (Varian, 1999). They have to depreciate their existing investment and make new investments to adopt the new standard. When network effects are apparent, this may lead to a bandwagon effect, whereby users quickly follow each other in their decision to adopt the standard. Both network effects and the resulting bandwagon effect can positively influence the speed and likelihood of standard success (Van de Kaa et al., 2011). Furthermore, these environmental factors moderate the effect of the firm level factors (Suarez, 2004). For example, the effect of installed base becomes more relevant when network effects are stronger (Van de Kaa et al., 2011).

Besides network effects and the bandwagon effect, other market

mechanisms include uncertainty in the market, which can negatively affect the speed and likelihood of standard dominance. This uncertainty is affected by both the rate of change in the market and the number of competing standards. The cost to switch from an older technology to a newer technology also negatively affects the speed and likelihood that the newer technology will achieve success (Van de Kaa et al., 2011). For example, the costs to switch from the QWERTY keyboard layout to the DVORAK keyboard layout were so high that the latter layout did not achieve success (David, 1985).

The firm level factors can be distinguished into four categories; characteristics of the actors, characteristics of the standard, standard support strategies, and other stakeholders (Van de Kaa et al., 2011). The characteristics of the actors that develop and promote the standard are important because financial resources are needed to adopt relevant strategies such as pursuing expensive marketing campaigns (Schilling, 1999). Also, the supporter's reputation can be relevant as consumers are more prone to adopt a product from reputable actors (Foray, 1994). Furthermore, operational supremacy, e.g., owning a superior production capacity can tip the balance in favor of a certain technology (Suarez and Lanzolla, 2005). Finally, through learning, actors can apply their past experience and incorporate this knowledge into their new technological endeavors, thereby increasing the chance that these achieve success (Klepper and Simons, 2000).

The characteristics of the standard include aspects that make the standard superior compared to alternatives and may in part contribute to its success (Suarez, 2004). These elements range from astatic qualities to e.g., bandwidth capacity. A standard that is backwards compatible with an earlier generation may increase the standard's installed base considerably as users might be more willing to upgrade to the new technology (Schilling, 2003; Van de Kaa and De Vries, 2015). Various scholars have pointed towards the relevance of availability and variety of complementary goods as this positively influences installed base (Gallagher and Park, 2002; Hill, 1997; Schilling, 2002). A standard's flexibility may also positively influence its chances of achieving success. For example, the actors behind Blu-ray improved the standard far more compared to the actors behind HD-DVD and Blu-ray won from HD-DVD (Van den Ende et al., 2012).

Standard support strategies relate to pricing (e.g., penetration pricing whereby firms may briefly price their technology below its cost price so to increase its installed base quickly (Katz and Shapiro, 1985)). Furthermore, they relate to marketing communications (to attempt to influence expected or perceived installed base (Besen and Farrell, 1994)). Additionally, a timing of entry strategy can be applied (by entering earlier, actors can pre-empt scarce assets and quickly build up installed base (Suarez and Utterback, 1995)), an appropriability strategy may be applied (an open standard that is not protected by intellectual property rights has a higher chance of becoming adopted by users than a closed standard (Garud et al., 2002)), and a distribution strategy may be applied (a strong distribution system can be essential to outcompete rivals (Wonglimpiyarat, 2005)). Finally, past research has shown that actors that are more committed to a standard have a higher chance that their standard achieves success (Van de Kaa et al., 2015).

Finally, the stakeholders involved in the standard may affect standard success. For example, if a large company chooses to adopt a standard, this standard may achieve success instantly (Suarez and Utterback, 1995). A regulator can enforce a standard or a judiciary may introduce laws that prohibit a standard from achieving market dominance (David and Greenstein, 1990). Under the influence of network effects, installed base (both of the current and, possibly, previous generation) positively affects standard success (Schilling, 1998; Schilling, 2002). The effectiveness of the standard development process may also affect its chances of achieving success (Lehr, 1992). A standard has a higher chance of success if more manufacturers of complementary goods support the standard (Cusumano et al., 1992). Finally, the diversity in the network of actors supporting the standard may positively affect its chances of achieving success (Van de Kaa et al., 2015).

3. Business-to-government data exchange

In the 1980s, computers began making an impact in our everyday life. Because of their ability to process vast amounts of information, computers became the means to conduct all kinds of tasks. Business-to-business (B2B) as well as B2G reporting was often performed by computers using Electronic Data Interchange (EDI). The internet boom changed the way of B2G information sharing. Electronic business reporting can generate significant data access and processing efficiencies while enhancing both accuracy and transparency in business-to-government reporting (Ramin and Reiman, 2013; Troshani et al., 2015). B2G data exchange facilitates the exchange of information between businesses and public organizations.

We primarily focus on the data stream from B2G. This mainly entails annual reports, the fiscal domain, and the statistics domain. This makes it different from other B2G information sharing, like tendering and cooperation, because of the primarily one-way traffic nature of information sharing. We decided to focus on the data stream from B2G for two reasons. First, the Dutch programme Standaardisatie Bedrijfsrapportage (SBR) is based on this perspective. SBR, formerly known as Nederlandse Taxonomie Project (NTP), was established to relieve the administrative burden for both businesses and government (Janssen et al., 2010). XBRL was at the basis of this project, which makes this a perfect case study for this paper. Second, this perspective includes activities that all companies are obliged to do on an annual basis with strict rules for all involved. Over half a million companies are active in the Netherlands. This makes it perfect for ICT since vast amounts of data need to be processed, and all the clearly defined rules can be incorporated within the software. Yet B2G reporting is not easy and requires an infrastructure for exchanging information, a structure in which the data and the actual information is exchanged (see Fig. 1). This structure is based on the distinction between the technology, syntactic, and semantic interoperability (Putnik et al., 2005; Wigand et al., 1997). Although there are more fine-grained models, the use of three layers is suitable for understanding the standards battle.

Information sharing starts with the meaningful information that needs to be interchanged between parties. The information can be tax information, certain statistics, annual accounts, or whatever information that is legally required by governmental bodies. It is structured in a commonly agreed format to enable readability by others. In other words, the information is 'wrapped' in certain syntactical structure. This syntax is agreed on semantics so the parties at both ends of the interchange can understand it. Finally, software is needed to translate the information in the commonly agreed structure and exchange the information over a technology infrastructure.

3.1. Alternative standards

In the late 1990s many standards were developed (e.g., verticals, eGov, XML, X12, SGML, XBRL) for information exchange within certain domains, and all were used by groups of users, mostly because of their shared business or interests (Raman, n.d.). Although all these standards are focused on improving the interoperability, their focus is different. The focus of applications domains varies, for example, for transport, government or trade. Some standards focus on technical aspects, whereas others define the data format and the meaning of the data. Also in this period i XML/EDIFACT or ebXML was developed, which was the internet-based version of EDIFACT (ISO, ISO/TS 20625, 2002). The many different standards caused fragmentation resulting in inefficiencies, resulting in a lack of interoperability or a necessity to operate multiple standards (Raman, n.d.). Paper-based exchange still occurs, although more and more has been digitized. XML and XBRL are closely related. XBRL is an XML based technology specifically designed to deal with the features of the reporting domain. The use of the XML standard is less likely in this area as XBRL is better equipped. From the literature (Garner et al., 2013), it is evident that EDI and XBRL are the

two dominant standards. We now examine these two standards in more detail.

Electronic Data Interchange (EDI) consists of system-to-system exchange of structured and standardized business data (Sokol, 1994). One such format is called UN/EDIFACT (Electronic Data Interchange for Administration, Commerce and Transport) maintained by the International Standard Organization as ISO:9735. The EDIFACT standard provides the data structure and meaning of the data for information exchange between companies and governmental organizations.

XML stands for Extensible Markup Language and is used to add mark-up to data, which allow for describing the data elements. XML is human and machine readable, thus making it more flexible and simple. XBRL (Extensible Business Reporting Language) is an open, international electronic business reporting standard that facilitates information exchange between public and private entities and other organizations. It is a derivative of XML and is also flexible, human, and machine readable. XBRL was developed from XML for the reporting arena. It is report oriented instead of transaction oriented enabling drill down to information and it can even transfer complete databases (Grey, 2005). The development of the infrastructure requires trade-offs between keeping options open to ensure flexibility and standardizing, enabling the involvement of a large user base (Winne et al., 2011).

4. Methodology

To identify the key factors impacting the dominance of standards for B2G data exchange, it is important to start with a framework that consists of as many factors for standard dominance as possible so that all possible relevant factors are considered. The framework developed by Van de Kaa et al. (Van de Kaa et al., 2011) satisfies that criterion as it is the most complete framework of factors for standard dominance to date. Similar frameworks have been developed (Hill, 1997; Suarez, 2004) but these are all less complete.

We focus on the 23 firm level factors that have an impact on standard dominance for two reasons. First, the objective of the current paper is to identify key factors that directly lead to standard dominance. The 6 environmental factors of the framework of Van de Kaa et al. (Van de Kaa et al., 2011) do not affect standard dominance directly but have an influence on the speed and likelihood of standard dominance (for example, when network effects so not exists in a market, multiple standards may co-exist in that market). Second, the paper aims to give a first indication which business reporting standard has the best chances of winning the battle. Thus, it would make no sense to include environmental factors in this analysis as the value of the environmental factors such as network effects would be the same when two standards are compared as they compete in the same market.

We determined the relevance of each of these 23 factors. To determine whether a factor was relevant, we conducted two expert interviews with academics in the field of EDI and XBRL and we analyzed secondary sources (e.g., journal articles, news articles, and official websites). We first conducted two interviews with experts with comprehensive knowledge on the topic. The experts were two academics who studied EDI and XBRL in the Netherlands, but were not commercially involved in one of the competing standards and had no stake to favor one over the other. We asked the expert to describe the most important events of the development of the two standards. By asking that question, the experts mentioned several factors explicitly or implicitly. We also explicitly asked whether certain factors mentioned in the framework of Van de Kaa et al. (Van de Kaa et al., 2011) were relevant in the battle. This resulted in a list of factors that were relevant according to the experts. Additionally, we conducted a secondary data analysis using the search terms standards battles, standardization, XBRL, and EDIFACT. We searched for relevant articles in ISI Web of Science, Scopus, and Google Scholar. This search was complemented by newspaper articles that we found or that the two respondents pointed us towards. If factors for standard dominance were explicitly or implicitly mentioned in the secondary sources or one of the two interviews, we included them in our study. The result of this analysis can be found in Supplementary File 2. This first step resulted in 15 relevant factors divided over four categories.

Next, we applied the BWM. We interviewed the two academics again and conducted interviews with two new experts. These four experts determined the weights for each factor and the score of a standard on each factor. One of the criteria for the selection of the experts was that we wanted to include both practitioners and researchers in the study to have both inside knowledge and an objective outside look. Furthermore, the experts had to have ample knowledge about the topic. This meant that the researchers had to have a track record of publications on the standards, and practitioners had to have several years of experience in standardization. To decrease bias towards a certain standard, experts had to have a background in both standards. To find potential experts meeting these criteria, we searched among universities and via LinkedIn. We consulted with the key expert in the area of business to government data exchange and asked him which persons could be considered experts in this area and have comprehensive knowledge on the topic. The authors have closely studied the profile of each of the interviewees and based upon their profile it can be concluded that they are all experts in this area and have comprehensive knowledge on the topic. This resulted in two academics and two practitioners. Table 1 provides background information about our four experts.

4.1. BWM

To determine why a standard achieves dominance, we applied the BWM, which is a type of Multi-Criteria Decision-Making (MCDM). A MCDM problem can be generally described as a matrix as follows.

$$A = \begin{array}{c} A_1 \\ \vdots \\ A_n \end{array} \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & a_{nn} \end{bmatrix} \quad \begin{array}{c} C_1 \ \cdots \ C_n \end{array} \tag{1}$$

where $A_1, A_2, \ldots, A_m$ is a set of feasible alternatives, $C_1, C_2, \ldots, C_n$ is a set of decision-making criteria and a_{ij} the score of alternative i with respect to criteria j.

The goal of BWM is to determine whether XBRL or EDIFACT will become the dominant standard by scoring the factors (above called the alternatives). In reality, not every factor has the same weight. So, to determine the total score for each standard, we used the equation presented below.

$$V_i = \sum_{j=1}^{n} w_j a_{ij} \tag{2}$$

In this equation V_i is the total score for each standard. Various methods have been used to determine the weights w_j. Pairwise comparison method has been widely used, but most MCDM methods have

Table 1
Background, position, and expertise of respondents.

#	Background	Position	Expertise (besides business-to-government data exchange)
1	Academia	Researcher	Process management and standardization, Telecommunications; CDMA and 3G
2	Academia	Full professor	Governance of information exchange
3	Industry	Consultant	Public administration, compliance design & management
4	Industry	Senior managing consultant	Information orchestration architectures
5	Industry	Developers	IT-infrastructure provider
6	Industry	CEO/chair XBRL Netherlands	Software company
7	Industry	Consultant	Information exchange

problems with pairwise comparisons consistency (Rezaei, 2015). The BWM is very reliable and efficient with respect to the data it needs (Rezaei, 2015; Rezaei, 2016). It has been applied to some real-world decision problems such as water resource management (Chitsaz and Azarnivand, 2016), supplier selection and segmentation (Rezaei et al., 2015; Rezaei et al., 2016), innovation management (Gupta and Barua, 2016), logistics performance measurement (Rezaei et al., 2018), R&D performance measurement (Salimi and Rezaei, 2018), and sustainability assessment of technologies (Ren et al., 2017). We use this method because (1) it uses a structured way to gather pairwise comparison data. In other words, asking the respondents to determine the best and the worst and making the pairwise comparison of these two reference points gives a logical structure to the comparisons; (2) it allows us to ask our respondents fewer questions compared to using a full pairwise comparison matrix. For instance, we need $n(n-1)/2$ pairwise comparisons for the Analytic Hierarchy Process, another MCDM method, whereas we need $2(2n-3)$ pairwise comparisons for BWM. (3) It is easy to understand and to revise. Respondents who have participated in surveys including BWM in previous studies have reported this benefit; (4) it produces highly consistent and reliable results.

We used the following steps to determine the preference and the weights for the BWM. Step 1 defines a set of decision criteria. Step 2 determines the best (e.g., the most important) and the worst (e.g., the least important) criteria. Step 3 determines the preference of the best criterion over all the other criteria using a number between 1 (no preference) and 9 (extreme preference). Step 4 determines the preference of all the criteria over the worst criterion. Step 5 determines the weights using the following linear model (Rezaei, 2016).

In order to determine the optimal (most consistent) weights (w_j) with the pairwise comparisons (a_{Bj} and a_{jW}), the maximum distance between the pairwise comparisons and their corresponding weight ratios should be minimized. To this end, the following problem should be formulated and solved:

$$\min \xi$$
s. t.
$$|w_B - a_{Bj}w_j| \leq \xi, \text{ for all j}$$
$$|w_j - a_{jW}w_W| \leq \xi, \text{ for all j}$$
$$\sum_j w_j = 1$$
$$w_j \geq 0, \text{ for all j} \tag{3}$$

Solving problem (3), the optimal weights w^* and ξ^* are determined. ξ^* shows the consistency level of the comparison system. Values closer to zero show higher consistency.

5. Results

5.1. Weights for factors

We used a questionnaire to collect the data from seven interviewees. We used the BWM and found the weights for categories and factors for standard dominance as presented in Table 2.

The results show that, on average, the interviewees rated the format support strategy as the most important category (0.43), followed by other stakeholders (0.25) and characteristics of the format (0.25). The characteristics of the format supporter were rated as the least important category (0.07).

All interviewees rated commitment as the most important factor (0.22). In the literature we can observe that commitment can indeed be crucial (Van de Kaa et al., 2015). However, we did not expect this factor to be the most important in this specific case. Few secondary sources mentioned this factor, and only one expert mentioned it. Expert 3 stated that EDIFACT had the reputation of being an old standard due to lack of commitment of the backing organization. Furthermore, we suspect there is a certain degree of overlap with the factor regulator, as the

commitment of the regulators that chose XBRL for financial B2G reporting was deemed very important. The Dutch Tax and Customs Administration has recently committed to XBRL as the main standard for information exchange and has decided to remove the EDI-based gateway. This means that companies can only report in XBRL in the near future. The regulator made it obligatory to report in XBRL, thereby showing commitment.

The interviewees rated timing of entry and current installed base as the second and sixth most important factors (0.11 and 0.06). Indeed, in the literature it has been argued that firms that enter the market early can pre-empt the market and gain access to installed base of users (Barney, 1991). Although EDI has the highest installed base, XBRL provides certain benefits in terms of flexibility and offers a one-stop shop for providing information to multiple governments at the same time. Initially the introduction of XBRL failed (the NTP initiates), but it has recently become more successful (SBR).

To our surprise, regulator was rated as only the fifth most important factor (0.06). This was unexpected as the government is a key stakeholder in the choice of the standard. One explanation for this is that the role of the regulator is not clear because various ministries are involved (Interior, Finance, and Economic Affairs), which each has different stakes and urgencies for adopting standards. A similar situation can be observed in the case of standards battles that are fought in transition economies such as China (Van de Kaa et al., 2013). Another explanation could be that the factors regulator and commitment are intertwined, as the regulator provides the commitment. When the experts assessed commitment, they actually assessed the role of the regulator.

Technological superiority was expected to be very important due to the large technological differences between the standards, and it was mentioned to be relevant in all primary and most secondary sources. Indeed, one of the reasons why the government supported XBRL was that the taxonomy could be easily updated. However, surprisingly, technological superiority was rated as only the seventh most important factor (0.06). XBRL is considered to be technologically superior compared to EDI due to its ability to be extendable and flexible. It also includes rules allowing automatic exchange and extraction of financial statements across heterogeneous technologies (Bharosa et al., 2015b; Grey, 2005). However, its main benefit is its ability to create a one-stop shop and lessen the administrative burden, which are not properties of the standard, but of the implementation. Another explanation could be that technological superiority is probably very important in the early phases of adoption. However, during later phases, when governments choose a standard, the government's level of commitment is more important than the technical aspects.

5.2. Priorities for standards

Table 3 presents the results of the BWM at the lowest level of analysis. It identifies the difference in contribution to the total score of each of the two standards. EDIFACT's total contribution is 0.37 compared to XBRL's total contribution of 0.63, so it appears that XBRL has the highest chance of achieving success. In the literature we can indeed also see that XBRL has been used more and more frequently in recent years (Bharosa et al., 2018).

Brand reputation and credibility contributes 0.06 to EDIFACT's total score and 0.16 to XBRL's total score. This means that the difference of 0.10 favors XBRL in the battle for dominance. There are two possible explanations. First, XBRL has become more mature and therefore the actors become more credible and reliable. Second, EDI is more fragmented and many actors are involved in the various aspects. In the case of XBRL there are fewer actors that are more easier to recognize.

Commitment contributes 0.02 to EDIFACT's total score and 0.09 to XBRL's total score. This means that the difference of 0.07 favors XBRL in the battle for dominance. Our explanation for this high score is that the large-scale users such as governments were totally committed to XBRL as the future standard, with little chance of an alternative emerging any time soon.

Table 2
Weights for relevant factors.

Factors	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Local average weight	Global average weight
Characteristics of the format supporter	**0.08**	**0.06**	**0.07**	**0.06**	**0.05**	**0.07**	**0.08**	**0.07**	
Brand reputation and credibility	0.20	0.86	0.83	0.86	0.75	0.90	0.14	0.65	0.04
Learning orientation	0.80	0.14	0.17	0.14	0.25	0.10	0.86	0.35	0.02
Characteristics of the format	**0.34**	**0.11**	**0.32**	**0.11**	**0.24**	**0.48**	**0.16**	**0.25**	
Technological superiority	0.28	0.14	0.11	0.14	0.25	0.56	0.18	0.24	0.06
Compatibility	0.32	0.56	0.11	0.56	0.25	0.11	0.12	0.29	0.07
Complementary goods	0.12	0.06	0.56	0.06	0.37	0.22	0.65	0.29	0.07
Flexibility	0.28	0.24	0.22	0.24	0.13	0.11	0.05	0.18	0.05
Format support strategy	**0.13**	**0.57**	**0.43**	**0.57**	**0.36**	**0.35**	**0.60**	**0.43**	
Pricing strategy	0.14	0.11	0.06	0.11	0.05	0.44	0.05	0.14	0.06
Timing of entry	0.28	0.25	0.43	0.25	0.22	0.17	0.11	0.24	0.11
Distribution strategy	0.09	0.06	0.06	0.06	0.29	0.05	0.14	0.11	0.05
Commitment	0.49	0.59	0.46	0.59	0.44	0.34	0.70	0.52	0.22
Other stakeholders	**0.44**	**0.26**	**0.18**	**0.26**	**0.36**	**0.10**	**0.16**	**0.25**	
Current installed base	0.36	0.41	0.05	0.41	0.04	0.12	0.30	0.24	0.06
Big fish	0.20	0.18	0.19	0.18	0.31	0.31	0.27	0.23	0.06
Regulator	0.30	0.26	0.56	0.26	0.11	0.04	0.27	0.26	0.06
Suppliers	0.08	0.11	0.12	0.11	0.31	0.06	0.11	0.13	0.03
Network of stakeholders	0.04	0.04	0.08	0.04	0.23	0.47	0.06	0.14	0.03

6. Discussion and conclusion

There is limited understanding in the importance of factors influencing the adoption and substitution of standards. The goal of this paper was to determine the relevant factors, their importance for standard dominance for the case of B2G data exchange, and to determine the probable winner. By conducting a literature review and interviewing two experts on this topic, we identified fifteen relevant factors, which were used as input for a BWM analysis to determine the weights of these factors. The weights of the factors were determined by our four experts. The factors that give XBRL an edge over EDIFACT are commitment, the regulator, flexibility, and compatibility. These factors can be used to stimulate adoption.

The conclusions of the experts suggest that XBRL will have a high chance of achieving dominance and of replacing EDI as the standard for business reporting in the future. Indeed, we can observe that the market is moving towards XBRL, and our research suggests that it will likely continue to do so. In fact, given the major investments in XBRL for over a decade (Bharosa et al., 2015a; Troshani et al., 2015), one would have expected XBRL to have already achieved dominance some time ago. However, we can observe that successful adoption is just beginning to emerge (Bharosa et al., 2015a; Troshani et al., 2015). The underlying theoretical reason can be that EDIFACT was introduced earlier and has built up a large installed base of EDIFACT based systems. The costs to switch to the new XBRL standard are therefore high. Therefore, it might take a bit longer before XBRL can achieve dominance.

6.1. Contributions, implications, limitations, and areas for future research

We contribute to the literature on standards battles by showing that the process of standard selection can be modeled and that weights for factors for standard dominance can be determined. Our finding suggests that the outcome of a standards battle is not merely dependent on path dependencies and random idiosyncratic events as is argued by evolutionary economists (Arthur, 1989). Other factors can be used to explain the outcome of standards wars. We build on ongoing research that assigns weights to standard dominance factors (Van de Kaa et al., 2014b; Van de Kaa et al., 2014c) by studying these factors in the case of B2G

Table 3
Standard scores for factors.

Factors	Factor weights	EDIFACT standard score	XBRL standard score	EDIFACT contribution	XBRL contribution	Difference
Characteristics of the format supporter						
Brand reputation and credibility	0.04	0.27	0.73	0.06	0.16	0.10
Learning orientation	0.02	0.62	0.38	0.04	0.02	0.02
Characteristics of the format						
Technological superiority	0.06	0.26	0.74	0.01	0.02	0.01
Compatibility	0.07	0.14	0.86	0.01	0.05	0.04
Complementary goods	0.07	0.67	0.33	0.05	0.02	0.03
Flexibility	0.05	0.23	0.78	0.01	0.04	0.02
Format support strategy						
Pricing strategy	0.06	0.31	0.70	0.02	0.04	0.02
Timing of entry	0.11	0.30	0.70	0.02	0.05	0.03
Distribution strategy	0.05	0.39	0.61	0.03	0.04	0.01
Commitment	0.22	0.18	0.82	0.02	0.09	0.07
Other stakeholders						
Current installed base	0.06	0.33	0.67	0.01	0.03	0.01
Big fish	0.06	0.43	0.58	0.03	0.03	0.01
Regulator	0.06	0.41	0.59	0.02	0.03	0.01
Suppliers	0.03	0.47	0.53	0.02	0.02	0.00
Network of stakeholders	0.03	0.52	0.49	0.02	0.02	0.00
Total score				0.35	0.65	

data exchange. Although the BWM has been applied in some case studies (Chitsaz and Azarnivand, 2016; Gupta and Barua, 2016; Ren et al., 2017; Rezaei et al., 2015; Rezaei et al., 2016), it has not been applied frequently, and we illustrate the applicability of the method for the case of B2G data exchange. A practical implication of this research is that we provide a first indication that XBRL will become the dominant standard. As such we decrease the uncertainty for both firms and policy makers in their choice for a B2G data exchange standard.

The main limitation of this paper is that we only interviewed seven experts. Although we tried to limit bias, future research could interview more experts. Furthermore, this paper focuses on the stage at which two standards are fighting for market success. However, as put forth by Suarez (Suarez, 2004), the technology life cycle of a standard involves more stages and the importance of factors for standard success may differ depending on these specific stages. Contextual factors may influence the outcomes of the study and generalization of the findings should take this into account. For example, in some countries the regulator is more prominent and legislation is used to enforce the use of standards. Nevertheless the result might be generalizable to countries taking a similar approach. We recommend conducting cross-country studies to investigate the differences between countries and identify contextual factors.

Future research may apply our method to assign weights to factors for standard dominance in various stages of the technology life cycle. In fact, Anantapantula (Anantapantula, 2017) has shown that this is possible for the battle between EDIFACT vs XBRL for the context of B2G data exchange in India. Future research could study more battles for standard dominance in the area of B2G or business to business data exchange or in other contexts such as block chain technology or additive manufacturing to attempt to assign weights for standard success in these specific contexts.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.techfore.2018.07.041.

References

Anantapantula, A., 2017. Factors Affecting Standard Dominance in the Battle Between EDIFACT Versus XBRL Data Exchange Standards in India. Delft University of Technology.

Arthur, W.B., 1989. Competing technologies, increasing returns, and lock-in by historical events. Econ. J. 99, 116–131.

Barney, J.B., 1991. Firm resources and sustained competitive advantage. J. Manag. 17, 99–120.

Besen, S.M., Farrell, J., 1994. Choosing how to compete: strategies and tactics in standardization. J. Econ. Perspect. 8, 117–131.

Bharosa, N., Van Wijk, R., De Winne, N., Janssen, M., 2015a. Challenging the Chain: Governing the Automated Exchange and Processing of Business Information, Logius & Thauris. Delft University of Technology, Delft.

Bharosa, N., Van Wijk, R., De Winne, N., Janssen, M., 2015b. Challenging the Chain. Governing the Automated Exchange and Processing of Business Information. IOS Press, Delft.

Bharosa, N., Hietbrink, F., Mosterd, L., van Oosterhout, R., 2018. Steering the adoption of Standard Business Reporting for cross domain information exchange. In: 19th Annual International Conference on Digital Government Research: Governance in the Data Age, Delft.

Chitsaz, N., Azarnivand, A., 2016. Water scarcity management in arid regions based on an extended multiple criteria technique. Water Resour. Manag. 1–18.

Cusumano, M.A., Gawer, A., 2002. The elements of platform leadership. MIT Sloan Manag. Rev. 43, 51–58.

Cusumano, M.A., Mylonadis, Y., Rosenbloom, R.S., 1992. Strategic maneuvering and mass-market dynamics: the triumph of VHS over beta. Bus. Hist. Rev. 66, 51–94.

David, P.A., 1985. Clio and the economics of QWERTY. Am. Econ. Rev. 75, 332–337.

David, P.A., Greenstein, S., 1990. The economics of compatibility standards: an introduction to recent research. Econ. Innov. New Technol. 1, 3–41.

Eccles, R.G., Krzus, M.P., 2010. One Report: Integrated Reporting for a Sustainable Strategy. Wiley, New Jersey.

Farrell, J., Saloner, G., 1985. Standardization, compatibility, and innovation. RAND J. Econ. 16, 70–83.

Foray, D., 1994. Users, standards and the economics of coalitions and committees. Inf. Econ. Policy 6, 269–294.

Gallagher, S.R., 2012. The battle of the blue laser DVDs: the significance of corporate strategy in standards battles. Technovation 32, 90–98.

Gallagher, S.R., Park, S.H., 2002. Innovation and competition in standard-based industries: a historical analysis of the U.S. home video game market. IEEE Trans. Eng. Manag. 49, 67–82.

Garner, D., Henderson, D., Sheetz, S.D., Trinkle, B.S., 2013. The different levels of XBRL adoption. Manag. Account. Q. 14, 1–10.

Garud, R., Kumaraswamy, A., 1993. Changing competitive dynamics in network industries: an exploration of Sun Microsystems' open systems strategy. Strateg. Manag. J. 14, 351–369.

Garud, R., Jain, S., Kumaraswamy, A., 2002. Institutional entrepreneurship in the sponsorship of common technological standards: the case of Sun Microsystems and Java. Acad. Manag. J. 45, 196–214.

Ghani, E.K., Laswad, F., Tooley, S., 2011. Functional fixation: experimental evidence on the presentation of financial information through digital formats. Br. Account. Rev. 43, 186–199.

Grey, G.L., 2005. XBRL: Potential Opportunities and Issues for Internal Auditors. The Institute of Internal Auditors Research Foundations (IIARF), Altamone Springs, Florida.

Gupta, H., Barua, M.K., 2016. Identifying enablers of technological innovation for Indian MSMEs using best–worst multi criteria decision making method. Technol. Forecast. Soc. Chang. 107, 69–79.

Hill, C.W.L., 1997. Establishing a standard: competitive strategy and technological standards in winner-take-all industries. Acad. Manag. Exec. 11, 7–25.

Hoffman, C., Rodríguez, M.M., 2013. Digitizing financial reports – issues and insights: a viewpoint. Int. J. Digit. Account. Res. 13, 73–98.

ISO, ISO/TS 20625, 2002. Electronic Data Interchange for Administration, Commerce and Transport (EDIFACT) – Rules for Generation of XML Scheme Files (XSD) on the Basis of EDI(FACT) Implementation Guidelines, in, 2002.

Janssen, M.F.W.H.A., Veenstra, A.F., Groenleer, M., van der Voort, H., de Bruijn, H., Bastiaansen, C., 2010. Uit het Zicht: Beleidsmaatregelen voor het versnellen van het gebruik van ICT-toepassingen voor administratieve lastenverlichting. TU Delft, Actal & HiP Consulting.

Kane, Y.I., February 20, 2008. Toshiba regroups after losing DVD war. Wall Street J. https://www.wsj.com/articles/SB120342115442976687.

Katz, M.L., Shapiro, C., 1985. Network externalities, competition, and compatibility. Am. Econ. Rev. 75, 424–440.

Katz, M.L., Shapiro, C., 1994. Systems competition and network effects. J. Econ. Perspect. 8, 93–115.

Klepper, S., Simons, K.L., 2000. Dominance by birthright: entry of prior radio producers and competitive ramifications in the U.S. television receiver industry. Strateg. Manag. J. 21, 997–1016.

Lee, J., O'Neal, D.E., Pruett, M.W., Thoams, H., 1995. Planning for dominance: a strategic perspective on the emergence of a dominant design. R&D Manag. 25, 3–15.

Lehr, W., 1992. Standardization: understanding the process. J. Am. Soc. Inf. Sci. 43, 550–555.

Nelson, R.R., Winter, S.G., 1985. An Evolutionary Theory of Economic Change.

Putnik, G.D., Cunha, M.M., Sousa, R., Ávila, P., 2005. Virtual Enterprise Integration: Challenges of a New Paradigm. Virtual Enterprise Integration: Technological and Organizational Perspectives. IDEA Group Publishing, Hershey, PA, USA.

D. Raman, How eBusiness standardization can help XBRL, in: Transforming Business Reporting, n.d.

Ramin, K., Reiman, C., 2013. IFRS and XBRL: How to Improve Business Reporting Through Technology and Object Tracking. Wiley, Cornwall, UK.

Ren, J., Liang, H., Chan, F.T.S., 2017. Urban sewage sludge, sustainability, and transition for Eco-City: multi-criteria sustainability assessment of technologies based on best-worst method. Technol. Forecast. Soc. Chang. 116, 29–39.

Rezaei, J., 2015. Best-worst multi-criteria decision-making method. OMEGA Int. J. Manag. Sci. 53, 49–57.

Rezaei, J., 2016. Best-worst multi-criteria decision-making method: some properties and a linear model. OMEGA Int. J. Manag. Sci. 64, 126–130.

Rezaei, J., Wang, J., Tavasszy, L., 2015. Linking supplier development to supplier segmentation using Best Worst Method. Expert Syst. Appl. 42, 9152–9164.

Rezaei, J., Nispeling, T., Sarkis, J., Tavasszy, L., 2016. A supplier selection life cycle approach integrating traditional and environmental criteria using the best worst method. J. Clean. Prod. 135, 577–588.

Rezaei, J., van Roekel, W.S., Tavasszy, L., 2018. Measuring the relative importance of the logistics performance index indicators using Best Worst Method. Transp. Policy 68, 158–169.

Rochet, J.C., Tirole, J., 2003. Platform competition in two-sided markets. J. Eur. Econ. Assoc. 1, 990–1029.

Salimi, N., Rezaei, J., 2018. Evaluating firms' R&D performance using best worst method. Eval. Program Plann. 66, 147–155.

SBR, 2015. Standard Business Reporting | What Is SBR?.

Schilling, M.A., 1998. Technological lockout: an integrative model of the economic and strategic factors driving technology success and failure. Acad. Manag. Rev. 23, 267–284.

Schilling, M.A., 1999. Winning the standards race: building installed base and the availability of complementary goods. Eur. Manag. J. 17, 265–274.

Schilling, M.A., 2002. Technology success and failure in winner-take-all markets: the impact of learning orientation, timing, and network externalities. Acad. Manag. J. 45, 387–398.

Schilling, M.A., 2003. Technological leapfrogging: lessons from the U.S. video game console industry. Calif. Manag. Rev. 45, 6–32.

Shapiro, C., Varian, H.R., 1998. Information Rules, a Strategic Guide to the Network Economy. Harvard Business School Press, Boston, Massachusetts.

Shapiro, C., Varian, H.R., 1999. The art of standards wars. Calif. Manag. Rev. 41, 8–32.

Sokol, P.K., 1994. From EDI to Electronic Commerce: A Business Initiative. McGraw-Hill, New York.

Suarez, F.F., 2004. Battles for technological dominance: an integrative framework. Res. Policy 33, 271–286.

Suarez, F.F., Lanzolla, G., 2005. The half-truth of first-mover advantage. Harv. Bus. Rev. 83, 121–127.

Suarez, F.F., Utterback, J.M., 1995. Dominant designs and the survival of firms. Strateg. Manag. J. 16, 415–430.

Troshani, I., Parker, L.D., Lymer, A., 2015. Institutionalising XBRL for financial reporting: resorting to regulation. Account. Bus. Res. 45, 196–228.

Van de Kaa, G., De Vries, H., 2015. Factors for winning format battles: a comparative case study. Tech. Forcasting Soc. Chang. 91, 222–235.

Van de Kaa, G., Van den Ende, J., De Vries, H.J., Van Heck, E., 2011. Factors for winning interface format battles: a review and synthesis of the literature. Tech. Forcasting Soc. Chang. 78, 1397–1411.

Van de Kaa, G., Greeven, M., van Puijenbroek, G., 2013. Standards battles in China: opening up the black-box of the Chinese government. Tech. Anal. Strat. Manag. 25, 567–581.

Van de Kaa, G., Rezaei, J., Kamp, L., De Winter, A., 2014a. Photovoltaic technology selection: a fuzzy MCDM approach. Renew. Sust. Energ. Rev. 32, 662–670.

Van de Kaa, G., Van Heck, H.W.G.M., De Vries, H.J., Van den Ende, J.C.M., Rezaei, J., 2014b. Supporting decision-making in technology standards battles based on a fuzzy analytic hierarchy process. IEEE Trans. Eng. Manag. 61, 336–348.

Van de Kaa, G., De Vries, H.J., Rezaei, J., 2014c. Platform selection for complex systems: building automation systems. J. Syst. Sci. Syst. Eng. 23, 415–438.

Van de Kaa, G., Van den Ende, J., De Vries, H.J., 2015. Strategies in network industries: the importance of inter-organisational networks, complementary goods, and commitment. Tech. Anal. Strat. Manag. 27, 73–86.

Van den Ende, J., Van de Kaa, G., Den Uyl, S., De Vries, H., 2012. The paradox of standard flexibility: the effects of co-evolution between standard and interorganizational network. Organ. Stud. 33, 705–736.

Varian, H.R., 1999. Intermediate Microeconomics: A Modern Approach. (New York).

Wigand, R., Picot, A., Reichwald, R., 1997. Information, Organization and Management. John Wiley & Sons, Chichester, UK.

Winne, N.D., Janssen, M., Bharosa, N., Wijk, R.V., Hulstijn, J., 2011. Transforming public-private networks: an XBRL-based infrastructure for transforming business-to-government information exchange. Int. J. Electron. Gov. Res. 7, 35–45.

Wonglimpiyarat, J., 2005. Standard competition: is collaborative strategy necessary in shaping the smart card market? Tech. Forcasting Soc. Chang. 72, 1001–1010.

Geerten van de Kaa is Assistant Professor of Standardization and Business Strategy at Delft University of Technology. He holds a PhD from Rotterdam School of Management, Erasmus University. His research interests include platform wars for complex systems; (collaboration) strategies for innovation; energy systems; and (responsible) innovation and standardization. He is the author and co-author of > 75 publications. He has published in high ranking international journals including *Organization Studies*, *IEEE Transactions on Engineering Management*, *Technovation*, *Technological Forecasting and Social Change*, *Telecommunications Policy*, *Technology Analysis* & *Strategic Management*, *Renewable and Sustainable Energy Reviews*, *Computer Standards* & *Interfaces*, and *Journal of Systems Science and Systems Engineering*. He has won several (teaching and research) awards including a best paper award and a best doctoral dissertation award. He teaches courses in the strategic management of technological innovation.

Marijn Janssen is full professor in ICT & Governance. His research is focussed on ICT-architecting in situations in which multiple public and private organizations need to collaborate, in which ICT plays an enabling role, there are various ways to proceed, and socio-technical solutions are constrained by organizational realities and political wishes. ICT-architecting provides principles, patterns and other instruments to guide organizations to design their infrastructure, applications, information, processes and organizations. The landscape is fundamentally changing due to current technology developments like cloud-computing, Software as a Service, blockchain, semantic services, big and open linked data (BOLD) and policy developments like open data and open government. These developments challenge the traditional relationship between governments and the public and new forms of governance are emerging.

Jafar Rezaei is an assistant professor of operations and supply chain management at section Transport and Logistics. He did his Ph.D. at the faculty of Technology, Policy and Management (TPM), Delft University of Technology (TU Delft). He has a background in Operations Research, and has published in several peer-reviewed journals. He is the Editor-in-Chief of Journal of Supply Chain Management Science. In 2015, he developed the Best Worst Method (BWM).