What is the impact of company specific adjustments on the acceptance and diffusion of logistic standards?

Daniel Neuß[1], Samuel Pfister[1], Adrian Hofmann[1], and Axel Winkelmann[1]

[1] Julius-Maximilians-Universitaet, Chair of Business Management and Business Information Systems, Wuerzburg, Germany
{daniel.neuss,samuel.pfister,adrian.hofmann,axel.winkelmann}@uni-wuerzburg.de

Abstract. Transportation Networks and Logistics 4.0 work on the basis of integrated systems. These systems are enabled by standards which are widely used for the communication between IT-Systems. Due to individual requirements, standards are customized by companies. The extent of individualization has not yet been investigated. Therefore, we applied an empirical analysis on two mature logistic communication standards to identify the standard-application gap by calculating the interoperability between the applied standards. Within these results, we expand the standardization theory by simulating the network effects and the standard diffusion and quantify the impact of the company specific individualization of logistic standards. The identified findings help to improve the standard diffusion model and to improve the development of logistic standards.

Keywords: network effects, standardization, standard deviation, diffusion, logistic standards

1 Introduction

Global supply chains work with integrated logistics systems [1]. This integration offers several performance benefits [2], and is necessary for concepts like Industry 4.0 [3]. To accomplish a certain level of integration, standardization is necessary [4], [5]. Standards therefore have economic advantages like positive network externalities [6], [7] economics of scale [8] and the reduction of transaction costs [9], which are widely discussed theories. Theoretical research on standards deals to a large extent with network effects. Participants benefit from the advantages if the number of participants increases [10], [11]. Specifically, this means that the benefit for a standard user grows stronger if more actors implement the standard. This is combined in the standardization model from Weitzel et al. where the adoption decision is taken as soon as the advantages exceed the costs [11]. Consequently, the decision to introduce a standard is strongly linked to the expectation of how the other actors in the corresponding environment (e.g. within a certain industry) decide, which is known as the standardization problem. In conclusion, the adoption of a standard is more influenced by the anticipated diffusion than on

14th International Conference on Wirtschaftsinformatik,
February 24-27, 2019, Siegen, Germany

its actual direct benefit, i.e. its quality [11]. In the theoretical concepts of standardization, deviations have not yet been taken into account. This is based on the assumption that a standard is either not or fully implemented, and then becomes perfectly interoperable (and thus compatible). This simplifying assumption leads to a significant theory-practice gap. Therefore, we want to address the hypothesis that there is a direct impact on the standardization deviation, e.g. network effects, due to an interoperability gap.

In this article, we want to close this gap by extending the standardization model developed by Weitzel et al. Therefore, we introduce the interoperability metric from Zhu and Whu [12] and apply it with real data to derive the real interoperability of EANCOM D.96A standard messages. This mature and widely used standard defines several communication massages which are used in different parts of the supply chain. In the next step, we simulate the impact of this metric on the diffusion of the standards and network effects to conclude with an outlook of our future research.

2 Implications of company specific standard adjustments on network effects

Interoperability describes the agreement which exists if, for example, two business partners use the same standard. In practice, this results in different variants, which means that only a certain part of the defined data elements is used and, if necessary, individually defined elements are added. The incompatibilities are eliminated by bilateral coordination within the implementation of the standard. Interoperability measures the extent to which the data elements of two instances overlap (1) [12]. It describes the interoperability values I_{ij} between two actors i and j, where D_i is the set of data elements required by user i. The interoperability values in this paper are calculated from approximately fifty thousand messages of EANCOM standards and result in the arithmetic mean for orders 0.7842 (ORDERS D.96A) and shipping notifications (DESADV D.96A) of 0.8684. The messages were provided and anonymized by an IT service provider. To investigate the impact of the interoperability on to network effects and therefore on the further adaptation of standards, we use the network model by Weitzel et al. [11] and extend it by including the loss of efficiency produced by a lower interoperability.

$$I_{ij} = \frac{|D_i \cap D_j|}{\sqrt{|D_i||D_j|}} \tag{1}$$

The net gain of the whole network can be calculated as coordination efficiency (CE) which is the sum of the *ex post* network benefits of each actor E_i in a network with n actors, where c_{ij} is the direct network effect if the standard is used between actor i and j when the standard is fully interoperable (2). I_{ij} describes the interoperability of the standard between the actors, x_j is a binary variable that indicates whether j uses the standard and K_i represents the cost for an actor i to introduce the standard.

Table 1. Parameters used for the simulation

	Standard	*Model*	n	$\mu(c)$	$\sigma(c)$	$\mu(K)$	$\sigma(K)$	$\mu(I)$	$\sigma(I)$	$\tilde{I}$
S1	*(ideal)*	Base model	20	1000	200	variable	1000	1	0	1
S2	DESADV	Without I-Anticipation	20	1000	200	variable	1000	0.8684	0.0608	1
S3	DESADV	With I-Anticipation	20	1000	200	variable	1000	0.8684	0.0608	0.8684
S4	ORDERS	Without I-Anticipation	20	1000	200	variable	1000	0.7842	0.0866	1
S5	ORDERS	With I-Anticipation	20	1000	200	variable	1000	0.7842	0.0866	0.7842

$$CE = \sum_{i=1}^{n} E_i \qquad \text{with} \qquad E_i = \sum_{\substack{j=1 \\ j \neq i}}^{n} c_{ij} I_{ij}^2 x_j - K_i \tag{2}$$

To decide if an actor adopts the standard (and therefore the value of x_j), an *ex-ante* calculation of the benefit can be used by each actor. The benefit has to be estimated since the actors don't know in advance who will adopt the standard (3). Here p_{ij} is the probability that actor i estimates for actor j to adapt the standard. ϕ_j is the number of j' s communication partners. In this first simulation we assume a full-density network, hence $\phi_i = n - 1$. To further evaluate the effects of interoperability we examine the effects of the actors knowing of interoperability losses (I-anticipation). In this case $\tilde{I} = I$, otherwise $\tilde{I} = 1$.

$$\tilde{E}_i = \sum_{\substack{j=1 \\ j \neq i}}^{n} c_{ij} \tilde{I}_{ij}^2 p_{ij} - K_i \quad \text{with} \quad p_{ij} = \frac{c_{ji} \tilde{I}_{ji}^2 \phi_j - K_j}{c_{ji} \phi_j} \tag{3}$$

If the expected benefit $\tilde{E}_i > 0$, then actor i will implement the standard and $x_i = 1$. The results of the simulation are shown in Figure 1. Due to the possibility of an actor falsely estimating network effects that exceed the standardization cost, it is possible that the standard is adopted by not enough actors to fully utilize network effects, which leads to a negative net gain of the network. This is referred to as the *standardization gap*. It can be seen, that a lower interoperability impacts the network effects. If the cost for the introduction of the standard is low enough, there is no difference whether I-Anticipation is used or not. It should be noted that, even though standard adoption is higher at lower costs when the actors do not anticipate the interoperability, the standardization gap is more severe without I-Anticipation.

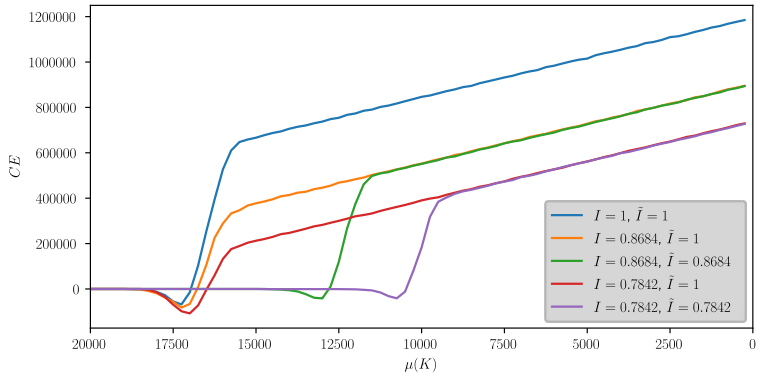

Figure 1. Simulated network effects

3 Conclusion and future work

Within the first simulation we could prove the effect of the interoperability on the standardization gap. In addition, we simulated the scenario with *I*-Anticipation and without. Therefore, we can conclude three major findings.

First, we can prove the hypothesis, that the individual and collectively achieved net benefit effects from a standard introduction with decreasing interoperability are constantly being reduced. Deviations in standards can lead to more or less severe economic losses. The **second** finding is that with medium to low standardization costs, it can provide economic sense to keep the actors unaware of possible interoperability losses. The area in which such a disinformation strategy offers a higher networkwide benefit increases as the expected interoperability decreases. However, in the case of medium-high cost, it is more advantageous for the actors to anticipate interoperability and therefore decide against a standard introduction. In the case of very low or high standardization cost, both strategies achieve identical results (i.e. no or complete standardization). The standardization gap can be divided into a centralization gap that has already been extensively researched and an interoperability gap that is shown for the first time in this paper and depends on the level of anticipated interoperability. This additional gap delays the diffusion of a standard, since the actors only consider an introduction if the cost of standardization is significantly lower, which concludes the **third finding.**

In conclusion there are two main points for further research. First, we want to expand the simulation to different standards to gather more practical insights on the deviation and use them for the simulation. In addition, we want to focus on the company and industry specific standardization gap. In the second step, we want to take the model extensions based on Weitzel et al. into account. These include, for example, the parallel availability of several standards with different interoperability factors, diffusion paths, different network topologies ($\phi_i \leq \mathrm{n} - 1$) or several periods of time in which actors can subsequently make their individual decisions. Nevertheless, it is already clear from this study that losses in interoperability have a lot of theoretical implications for the theories of standardization, standard diffusion and network effects.

References

1. Liu, C.L., Lee, M.Y.: Integration, supply chain resilience, and service performance in third-party logistics providers. International Journal of Logistics Management. 29, 5–21 (2018)
2. Stank, T.P., Keller, S.B., Closs, D.J.: Performance benefits of supply chain logistical integration. Transportation Journal. 41, 32–46 (2001)
3. Lasi, H., Fettke, P., Kemper, H., Feld, T., Hoffmann, M.: Industry 4.0. Business & Information Systems Engineering. 6, 239–242 (2014)
4. Wook Kim, S.: Effects of supply chain management practices, integration and competition capability on performance. Supply Chain Management: An International Journal. 11, 241–248 (2006)
5. Goetschalckx, M., Vidal, C.J., Dogan, K.: Modeling and design of global logistics systems: A review of integrated strategic and tactical models and design algorithms. European Journal of Operational Research. 143, 1–18 (2002)
6. Farrell, J., Saloner, G.: Converters, compatibility, and the control of interfaces. The Journal of Industrial Economics. 40, 9–35 (1992)
7. Katz, M.L., Shapiro, C.: Network externalities, competition, and compatibility. The American Economic Review. 75, 424–440 (1985)
8. Dixit, A.K., Stiglitz, J.E.: Monopolistic competition and optimum product diversity. The American Economic Review. 67, 297–308 (1977)
9. Hudson, J., Jones, P.: Measuring the efficiency of stochastic signals of product quality. Information Economics and Policy. 13, 35–49 (2001)
10. Liebowitz, S.J., Margolis, S.E.: Are network externalities a new source of market failure? Research in Law and Economics. 17, 1–22 (1995)
11. Weitzel, T., Beimborn, D., König, W.: A unified economic model of standard diffusion: The impact of standardization cost, network effects, and network topology. MIS Quarterly. 30, 489–514 (2006)
12. Zhu, H., Wu, H.: Assessing the quality of large-scale data standards: A case of XBRL GAAP Taxonomy. Decision Support Systems. 59, 351–360 (2014)