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ABSTRACT

In this paper we argue that the predominant trust conceptualization in IS has a major weakness when researching trust in IT artifacts and that a theory of explanation and prediction for the formation of trust in IT artifacts is necessary to face the upcoming challenges. Thus, we motivate a trust conceptualization from the HCI discipline, and develop a formative measurement model for trust in IT artifacts to achieve deeper insights on the formation of trust. The results of our pre-study with 102 undergraduate students suggest that the new conceptualization is valueable for creating the desired insights on the formation of trust in IT artifacts. In an upcoming field experiment with about 250 users we expect to gain more detailed and reliable insights in the formation of trust in IT artifacts allowing us to derive a first theory of explanation and prediction for the formation of trust in IT artifacts.

Keywords

Trust, Trust in IT artifacts, Laboratory experiment, Theory of explanation and prediction

INTRODUCTION

The importance of trust for IS research has been shown in different domains, especially in the adoption of new technologies (Gefen, Karahanna and Straub, 2003). To achieve a better understanding of the nature of trust, numerous researchers have called for insights on factors that build and support (Leimeister, Ebner and Krcmar, 2005) trust. Until now, the IS discipline's conceptualization of trust has mainly been built on insights from psychology or management science, e.g., Mayer, Davis and Schoorman's (1995) work. Using this conceptualization, IS researchers have managed to create valuable insights, e.g., on online trust (Benbasat, Gefen and Pavlou, 2008). However, this conceptualization has a major weakness when researching trust between people and IT artifacts, as it is based upon insights on trust in interpersonal relationships, i.e., trust between people or groups of people. Thus, the predominant conceptualization would not be suitable for studying relationships between people and IT artifacts, but insights on trust in IT artifacts are crucial for ensuring the acceptance of future – e.g., ubiquitous – IT artifacts.

The proposition that insights on trust in IT artifacts are crucial is based upon Luhmann's (1979, p. 16) statement: *"One should expect trust to be increasingly in demand as a means of enduring the complexity of the future which technology will generate"*. The increase of complexity is caused by the current trend towards ubiquitous computing (Weiser, 1999) that can be witnessed. The technologies we are using are getting more and more automated and opaque (Lee and See, 2004), and thus we are less and less able to know what exactly happens, e.g., with our personal data or location information. Hence, we are decreasingly able to control the systems we are using.

We need to solve the weakness of the current trust conceptualization to achieve a deeper understanding of the formation of trust to be able to design future IT artifacts in a way that they will be more readily trusted and accepted. The aim of this paper and the subsequent studies is to develop and evaluate a theory of explanation and prediction (Gregor, 2006) for the formation of trust in IT artifacts supporting the call of Gefen, Benbasat and Pavlou (2008) for identifying constructs important for research focusing on trust in IT artifacts. As a first step, this paper motivates the suitability of a trust conceptualization from the HCI discipline for IS research on trust in IT artifacts. As a second step, we have developed and pre-tested a formative first-order, formative second-order measurement model for trust in order achieve insights on the dimensions of trust and the impact of single antecedents.

PREDOMINANT CONCEPTUALIZATION OF TRUST IN IT ARTIFACTS

Since the late 1990s the interest in trust has greatly increased. This is evident in publication of several special issues in major journals in: Management, HCI, and IS (e.g., Benbasat et al., 2008, Benbasat, Gefen and Pavlou, 2010). The main value of trust is that it serves as a mechanism to reduce complexity (Luhmann, 1979). This becomes important for many disciplines because of the increasing complexity of organizations and technology (Lee et al., 2004). With various disciplines using trust in different contexts, trust is widely used, and the interpretations of trust become multifarious (Ebert, 2009) resulting in a plethora of definitions.

The most common approach is to define trust as an intention or willingness to act. This approach is also followed by most IS trust researchers, who rely on the most widely used and accepted definition of trust by Mayer et al. (1995, p. 712): "*trust […] is the willingness of a party [trustor] to be vulnerable to the actions of another party [trustee] based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party*."

The definition by Mayer et al. (1995) and other definitions applied in IS research have their roots in the management discipline, and focus on trust between people, groups of people, or organizations. Thus, they are especially valuable for areas of IS research dealing with different kinds of computer-mediated relationships between people, such as virtual communities (Leimeister, Sidiras and Krcmar, 2006). Consequently, most researchers adapt Mayer et al.'s (1995) three dimensions – ability, benevolence and integrity – to assess trust.

However, IT artifacts are not only used to mediate relationships between people. In many cases, the IT artifact serves as a tool for users to achieve a desired goal. Consequently, a second stream of IS research is researching trust relationships between people and IT artifacts (e.g., Wang and Benbasat, 2005). They adapted the definitions and dimensions of trust used to study computer-mediated trust relationships between people. Due to the fact that IT artifacts are no human beings, they provided arguments for these definitions being suitable for studying trust relationships between people and IT artifacts. Their main argument is that HCI studies purport that people enter relationships with IT artifacts and respond to them in a way comparable to responding to other people (Reeves and Nass, 1996). Thus, they argue that IT artifacts can be compared to humans making the existing definitions and dimensions of trust suitable for researching trust relationships between people and IT artifacts (Wang et al., 2005).

A MAJOR WEAKNESS OF THE CONCEPTUALIZATION AND OUT PROPOSED SOLUTION

Despite the fact that this conceptualization is well accepted in IS research and valuable for studying computer-mediated trust relationships between people (Benbasat et al., 2008), we argue that it has a major weakness. We agree with IS and HCI researchers that people enter relationships with IT artifacts and respond to them in a way comparable to responding to other people. Nevertheless, we argue that dimensions like benevolence and integrity are not suitable for studying trust in IT artifacts, as they rate human character traits. Considering, e.g., the decision whether to keep the interests of trustor in mind or not – this is what benevolence is about (Mayer et al., 1995) – we have to conclude that such a decision cannot be made by an IT artifact, as it follows a specific predefined algorithm or logic, and thus is not comparable to human decision making.

To solve this weakness we suggest using different dimensions of trust, found in the related HCI discipline's literature on trust in automation. Lee and Moray (1992) propose three dimensions for assessing trust: *performance*, *process*, and *purpose*.

The *performance* dimension reflects the capability of the IT artifact in helping the user to achieve his goals. The *process* dimension reflects the user's perception regarding the degree to which the IT artifact's algorithms are appropriate. Finally, the *purpose* dimension reflects the user's perception of the intentions the designers of the IT artifact had (Lee et al., 2004).

In summary, we argue that the three dimensions proposed by Lee et al. (1992) are better suited for researching trust in IT artifacts than the currently used dimensions by Mayer et al. (1995), since they better capture users' beliefs regarding an IT artifact.

TOWARDS A DEEPER UNDERSTANDING OF THE FORMATION OF TRUST IN IT ARTIFACTS

As our aim is to create deeper insights on the formation of trust, we use a formative first-order, formative second-order measurement approach for trust in IT artifacts (Jarvis, Mackenzie and Podsakoff, 2003). This allows us to create detailed insights on the formation of trust in IT artifacts and its dimensions and supports the call of Benbasat and Barki (1994) for creating deeper knowledge on the formation of constructs used in TAM research for deriving design recommendations from theory.

Thus, we use the dimensions of Lee et al. (1992) for the formative second-order part of our measurement. This is in line with Petter, Straub and Rai's (2007) argument that dimensions of constructs need to be used for a formative measurement in order to avoid measurement model mis-specification, and the contributions of Lowry, Vance, Moody, Beckman and Read (2008), and Vance, Elie-dit-Cosaque and Straub (2008) using Mayer et al.'s (1995) dimensions for their formative second-order part of trust.

Additionally, we aim at creating insights as detailed as possible on the formation of trust in IT artifacts and its dimensions, and therefore also need to measure the dimensions itself in a formative way. This is another difference between our approach and those of Lowry et al. (2008) or Vance et al. (2008), who use reflective indicators to capture the dimensions, and thus were not able to find insights on the formation of the dimensions of trust. Our complete measurement model is shown in Figure 1.

We adapted five indicators to reflectively measure trust from Cyr, Head, Larios and Pan (2009), Gefen (2000) and Mayer et al. (1995). This allowed us to run a redundancy analysis for assessing the quality of our formative measurement model for trust in IT artifacts (Cenfetelli and Bassellier, 2009). For finding the formative indicators for each dimension, we used the studies by Muir and Moray (1996), and the literature review conducted by Lee et al. (2004). Latter summarized numerous constructs used in published studies under the three dimensions. Since we were aware of the measurement model mis-specification problem, we checked the constructs summarized under each dimension for their suitability of being a formative indicator for that dimension and for redundancy among the different indicators. After our analysis, we measured the *performance* dimension using the four indicators: *competence* – covering the aspect that the IT artifact in general is able to help achieving the user's goal, *information accuracy* – covering the aspect that the information provided by the IT artifact are accurate, *reliability over time* – covering the aspect that the IT artifact could be relied upon over time, and *responsibility* – covering the aspect that the IT artifact has all functionalities needed to achieve the user's goal. For the *process* dimension, we used the four indicators: *dependability* – covering the degree to which the behaviour of the IT artifact is consistent, *understandability* – covering the aspect how good the user was able to understand how the IT artifact works, *control* – covering the degree to which the user has the feeling to have the IT artifact under control (Shankar, Urban and Sultan, 2002), and *predictability* – covering the degree to which the user has the feeling that the future behavior of the IT artifact could be anticipated. Finally, for the *purpose* dimension we used the three indicators: *motives* – covering the aspect whether the purpose of the designers of the IT artifact was communicated to the users, *benevolence of the designers* – covering the degree to which the IT artifact created by the designers had a positive orientation towards the trustor, and *faith* – covering the general judgment that the IT artifact could be relied upon in the future.

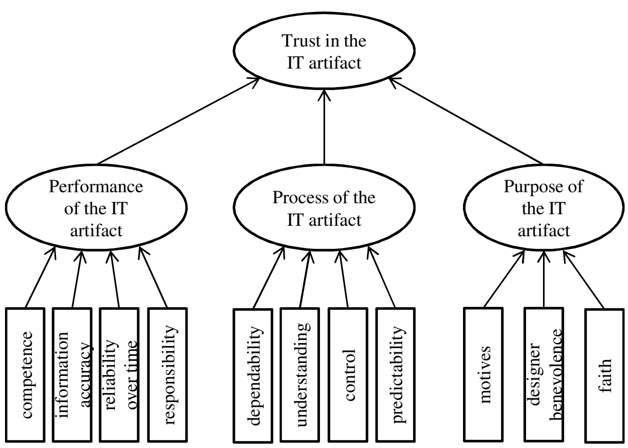

Figure 1. Formative first-order, formative second-order measurement model for trust in IT artifacts

RESEARCH METHOD

To evaluate our measurement model, we ran a laboratory experiment with 102 undergraduate students using our IT artifact, a restaurant finder application which offers recommendations to its user based upon his preferences and the current location. We gave an introduction and presented the restaurant finder, its intended use and an explanation on how to use the application. Afterwards, the students completed three predefined tasks which took on average 20 minutes, which is on average the same amount of time they needed to fill out the questionnaire including the indicators used to evaluate our formative first-order, formative second-order measurement model for trust in IT artifacts. After consistency checks, we included 87 questionnaires in our evaluation. 46 of the included students were female and 41 male. The average age of the included students was 23 years. For our redundancy analysis, we followed Cenfetelli and Bassellier (2009) and used a PLS approach. For the computation of our results, we used SPSS 19 as well as the SmartPLS 2.0 software (Ringle, Wende and Will, 2005).

RESULTS

First, we checked the average variance extracted (AVE), the composite reliability and the indicator loadings as quality criteria (Chin, 1998) to check the quality of the reflective measurement model for trust in IT artifacts because we intend to use it as a benchmark for our formative measurement model (Cenfetelli et al., 2009). Due to the fact that we only have one reflective construct, we do not need to check for cross-loadings or the correlation between the reflectively measured constructs. The evaluation showed that all values were well above the necessary limits. The AVE for trust was 0.7391 (> 0.5), the composite reliability for trust was 0.9340 (> 0.6), and the lowest indicator loading was 0.8287 (> 0.7). Thus, the reflective measurement is suitable to serve as a benchmark for our formative measurement model.

For the evaluation of our formative first-order, formative second-order measurement model of trust in IT artifacts, we followed the guidelines provided by Cenfetelli et al. (2009). According to the first guideline, we checked for multicollinearity by computing the Variance Inflation Factor (VIF). The results show that multicollinearity is not a problem in our pre-study because the highest VIF value (2.284) is below the limit of 3.33 (Diamantopoulos and Siguaw, 2006). According to the second guideline, a large number of indicators will cause many non-significant weights. Despite the fact that we observed non-significant weights, the inclusion of the indicators is based upon theory. Since we observed only four non-significant weights (at the level of 0.10) and following Cenfetelli et al. (2009), we decided not to drop any indicators for two reasons. First, this is the first study of this kind and second, it should be checked whether this lack of significance could be observed in different studies before questioning the relevance of these indicators. The third guideline deals with the co-occurrence of positive and negative weights. Due to the fact that we did not observe any indicator with a statistically significant negative weight, there was no need to worry about this point in our study. Guideline four states that researchers should check the indicator loadings when finding indicators that have only a small indicator weight. As a reason, they suggest that the indicator could have only a small formative impact on the construct (shown by a low weight), but, at the same time, could be an important part of the construct (shown by a high loading). If this is the case, the indicator is important and should be included in the measurement model. Chin (1998) stipulates that a loading of 0.5 is weak but still acceptable. We observed two indicators having neither a significant weight, nor a high enough loading. Nevertheless, we again followed the suggestion of Cenfetelli et al. (2009) and did not drop the indicators because their inclusion is based on trust theory and this is the first study of this kind. Future studies, showing similar results are needed before the two indicators should be dropped. The fifth guideline recommends testing for nomological network effects and the construct portability. They recommend comparing the factor weights of the indicators across different studies. Due to the fact that, to the best of our knowledge, this is the first study using this trust conceptualization of trust in IT artifacts for structural equation modeling, a comparison is not possible. We thus cannot conduct the tests recommended for this guideline in this study. The sixth guideline says that it is necessary to mention that the indicator weights can be slightly inflated when using the PLS technique. Due to the fact that we used the PLS technique, this is a limitation of our pre-study. Thus, the first-order formative measurement models pass the guidelines provided by Cenfetelli et al. (2009) ensuring the quality of the measurement model.

After focusing on the formative indicators, we now need to evaluate the results regarding the formative dimensions of trust in IT artifacts. Like Cenfetelli et al. (2009), we ran a redundancy analysis using the reflective measurement model as a benchmark. We observed a R^2 value of 0.5375 for our formative first-order, formative second-order measurement, which is a good result for a pre-study and between the highest and second highest level according to Chin (1998). Regarding the impact of the single dimensions of trust in IT artifacts we observed that all three dimensions had a significant impact on trust in IT artifacts, with performance being the most important dimension, followed by process (see Table 1). The results are in line with the adaption of Rempel's (1985) theory on trust development in relationships by Muir (1994). They expected that trust in the beginning of the relationship between an operator and an automated system is mainly based on the performance dimension and the process and purpose dimension will become increasingly important as the relationship matures. Due to the fact that the students used our restaurant finder for the first time, and only for a limited time (about 20 minutes), the relationship between the students and the IT artifact had just begun.

In summary, the results show that the used trust conceptualization is suitable for researching trust in IT artifacts. The quality criteria on the measurement are fulfilled and all theoretically proposed dimensions of trust in IT artifact were shown to have a significant and high impact. It explains 53.75% of the variance in trust in IT artifacts which is a good result according to Chin (1998). Additionally, the results offer the desired insights on the formation of trust and its dimensions, since the most influential dimensions and antecedents can be identified.

Dimension	Path Coefficient	p-value
Performance of the IT artifact	0.3359	< 0.01
Process of the IT artifact	0.2945	< 0.01
Purpose of the IT artifact	0.2182	< 0.01

Table 1. Impact of the three dimension on trust.

IMPLICATIONS, CONTRIBUTIONS AND NEXT STEPS

The aim of this paper and the subsequent studies is to develop and evaluate a theory of explanation and prediction (Gregor, 2006) for the formation of trust in IT artifacts. As argued, the predominant trust conceptualization has a major weakness when researching trust relationships between people and IT artifacts. Thus, in this paper we introduced a trust conceptualization from the related HCI discipline and the results of the pre-study indicate that this conceptualization is valuable to research trust in IT artifacts. Using the measurement model we are able to assess the impact of single dimensions and antecedents on trust in IT artifacts in greater detail than before. This supports the call of Benbasat et al. (1994) for shedding light on the formation of constructs like trust for enhancing the design of IT artifacts, and the calls of other research for insights in trust building (Leimeister et al., 2005). The results of the pre-study suggest that all three proposed dimensions have a significant and high impact on trust. Additionally, we were able to identify one or more formative indicators for each dimension having a significant and high impact on its dimension and thus on trust.

As a next step, further literature will be reviewed in order to identify additional facets of trust that should be included in the measurement model as well as possible structural models that could be enriched by the construct of trust in IT artifacts. Afterwards, the models will be evaluated in a larger field experiment. This setting should allow us to achieve a first theory of explanation and prediction for the formation of trust in IT artifacts. In an upcoming project, we intend to use this theory to focus on the most influential facets of the dimensions of trust for deriving theory-based design recommendations that influence these facets helping designers to increase the chance that their IT artifacts will be trusted and accepted by the users.

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REFERENCES

1. Benbasat, I., Gefen, D., Pavlou, P. A. (2008) Special Issue: Trust in Online Environments, Journal of Management Information Systems, 24, 4, 5-11.
2. Benbasat, I., Gefen, D., Pavlou, P. A. (2010) Introduction to the Special Issue on Novel Perspectives on Trust in Information Systems, MIS Quarterly, 34, 2, 367-371.
3. Cenfetelli, R. T., Bassellier, G. (2009) Interpretation of Formative Measurement in Informations Systems Research, MIS Quarterly, 33, 4, 689-707.
4. Chin, W. W. (1998) The Partial Least Squares Approach to Structural Equation Modeling, in: G.A. Marcoulides (Ed.) Modern Methods For Business Research, LEA, London.
5. Cyr, D., Head, M., Larios, H., Bing, P. (2009) Exploring Human Images in Website Design: A Multi-Method Approach, MIS Quarterly, 33, 3, 539-A539.
6. Diamantopoulos, A., Siguaw, J. A. (2006) Formative Versus Reflective Indicators in Organizational Measure Development: A Comparison and Empirical Illustration, British Journal of Management, 17, 4, 263-282.
7. Ebert, T. A. E. (2009) Facets of Trust in Relationships – A Literature Synthesis of Highly Ranked Trust Articles, Journal of Business Market Management, 3, 1, 65-84.
8. Ganesan, S. (1994) Determinants of long-term orientation in buyer-seller relationships, Journal of Marketing, 58, 2, 1.
9. Gefen, D. (2000) E-commerce: the role of familiarity and trust, Omega, 28, 6, 725-737.
10. Gefen, D., Benbasat, I., Pavlou, P. A. (2008) A Research Agenda for Trust in Online Environments, Journal of Management Information Systems, 24, 275-286.
11. Gefen, D., Karahanna, E., Straub, D. W. (2003) Trust and TAM in Online Shopping: An Integrated Model, MIS Quarterly, 27, 1, 51-90.
12. Gregor, S. (2006) The Nature of Theory in Information Systems, MIS Quarterly, 30, 3, 611-642.
13. Jarvis, C. B., Mackenzie, S. B., Podsakoff, P. M. (2003) A Critical Review of Construct Indicators and Measurement Model Misspecification in Marketing and Consumer Research, Journal of Consumer Research, 30, 2, 199-218.
14. Lee, J., Moray, N. (1992) Trust, control strategies and allocation of function in human-machine systems, Ergonomics, 35, 10, 1243 - 1270.
15. Lee, J. D., See, K. A. (2004) Trust in Automation: Designing for Appropriate Reliance, Human Factors, 46, 1, 50-80.
16. Leimeister, J. M., Ebner, W., Krcmar, H. (2005) Design, Implementation, and Evaluation of Trust-Supporting Components in Virtual Communities for Patients, Journal of Management Information Systems, 21, 4, 101-135.
17. Leimeister, J. M., Sidiras, P., Krcmar, H. (2006) Exploring Success Factors of Virtual Communities: The Perspectives of Members and Operators, Journal of Organizational Computing & Electronic Commerce, 16, 3/4, 279-300.
18. Lowry, P. B., Vance, A., Moody, G., Beckman, B., Read, A. (2008) Explaining and Predicting the Impact of Branding Alliances and Web Site Quality on Initial Consumer Trust of E-Commerce Web Sites, Journal of Management Information Systems, 24, 4, 199-224.
19. Luhmann, N. (1979) Trust and power, Wiley, Chichester, UK.
20. Mayer, R. C., Davis, J. H., Schoorman, F. D. (1995) An Integrative Model of Organizational Trust, Academy of Management Review, 20, 3, 709-734.
21. Muir, B. M. (1994) Trust in automation: Part I., Ergonomics, 37, 11, 1905 - 1922.
22. Muir, B. M., Moray, N. (1996) Trust in automation. Part II. Experimental studies of trust and human intervention in a process control simulation, Ergonomics, 39, 3, 429 - 460.
23. Petter, S., Straub, D., Rai, A. (2007) Specifying Formative Constructs in Information Systems Research, MIS Quarterly, 31, 623-656.
24. Reeves, B., Nass, C. (1996) The media equation: how people treat computers, television, and the new media like real people and places, Cambridge University Press, Stanford, CA.
25. Rempel, J. K., Holmes, J. G., Zanna, M. P. (1985) Trust in Close Relationships, Journal of Personality & Social Psychology, 49, 1, 95-112.
26. Ringle, C. M., Wende, S., Will, A. (2005) SmartPLS 2.0, in, Hamburg.
27. Shankar, V., Urban, G. L., Sultan, F. (2002) Online trust: a stakeholder perspective, concepts, implications, and future directions, The Journal of Strategic Information Systems, 11, 3-4, 325-344.
28. Vance, A., Elie-Dit-Cosaque, C., Straub, D. W. (2008) Examining Trust in Information Technology Artifacts: The Effects of System Quality and Culture, Journal of Management Information Systems, 24, 4, 73-100.
29. Wang, W., Benbasat, I. (2005) Trust in and Adoption of Online Recommendation Agents, Journal of the Association for Information Systems, 6, 3, 72-101.
30. Weiser, M. (1999) The computer for the 21st century, SIGMOBILE Mob. Comput. Commun. Rev., 3, 3, 3-11.