Novice User’s Trust on Innovative Technology: A Theoretical Analysis in the Context of Data Mining

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Abstract

Although data mining has been widely and successfully used in businesses, research into how novice end users might make an adoption decision is sparse and much needed. This paper employs a view that trust is generally assumed to be an important precondition for the adoption of any information technology (IT) and provides a theoretical analysis to identify the antecedents of trust in data mining technology synthesizing theoretical frameworks on people’s trust in computer-mediated services as well as multiple anecdotal evidences documented in the literature. A conceptual model of trust antecedents in the context of data mining technology adoption is constructed and presented integrating literature and diverse perspectives. The model illustrates that trust of IT artifact is one of core antecedents to the adoption of data mining technology and trust formation process differently affects novice users. We posit that the successful adoption of data mining technology by novice users is contingent on the level of relevant factors in IT artifact trust formation process. Overall, this article contributes to both theory and practice by shedding light on the largely ignored role of trust in adopting particular IT artifact with the example of data mining technology.

Keywords: Data Mining, Trust, Technology Adoption, Perceived Interpretability, Perceived Accuracy, User Interface

1. Introduction

In recent decades, innovative information technologies (IT) and their applications have profound impacts on many aspects of people’s work and life. The relationship between people and technology is becoming increasingly critical in today’s computerized business environment. Despite management’s desire to better understand such a relationship, this goal remains elusive. This is especially true for data mining technology. As data mining receives greater attention from both industry and academia, it has gained more support in the academic literature and the professional press. However, most studies on data mining investigate the construction and application of new algorithms to extract knowledge from data, largely ignoring organizational context and the relationship between users and technology. In an effort to shed more lights on the underexplored area, prior studies have investigated the adoption and use of data mining technology, demanding more dimensions and angles to address the full picture of data mining adoption phenomenon. One recently emerging approach is utilizing a lens of trust formation in IT artifact to address technology adoption process.

While literature in trust is abundant, very little discussion on the trust of IT artifact has been conducted in the field of information systems (IS) [44]. Existing trust literature mainly concerns trust between individuals or organizations [43]. For instance, research streams on e-commerce trust [7] [9] [23][24][31][32][33][34][36][37][40][45][48][49][50][58][70] primarily focus on the relationship between customers and an e-vendor. Only a few studies pioneered to investigate the trust formation process involved in IT artifact [62][71], illustrating that trust beliefs in IT artifact leads to intention to use and adoption. Although trust is pivotal in ensuring the successful adoption of data mining technology by novice users, literature on trust formation in any type of IT artifact is relatively underrepresented. Hence, the primary purpose of the current study is to propose a trust formation-based framework and model to explain novice user’s data mining adoption.

This study differs from the extant mainstream research on data mining adoption in two different ways. First, most studies in the existing literature does not consider trust formation toward data mining technology. Second, based on the conceptual relationships previously proposed in e-commerce context as well as theoretical frameworks in the trust of IT artifact, this study aims to explain novice user’s behavior in data mining adoption distinguishing between novice and experienced users. Our analysis
focuses on the novice user’s behavior to investigate the reasons why novice business users trust or distrust particular data mining technology. Involved questions include to what extent novice users trust or distrust the given data mining technology, and what factors affect the level of novice user’s trust or distrust. Answering such questions would help organizations enhance the effective adoption of data mining technology for managerial decisions such as buy or sell stocks, accept or decline a loan application, and contact or not contact a prospect to promote a product or service. As such, this research seeks to contribute to the knowledge of data mining adoption as well as trust formation by synthesizing and developing a new conceptual model of trust toward the use of data mining technology. The presented model mainly concerns overall judgment, sentiment, and attitude of users on the data mining technology and examines the antecedents affecting novice user’s trust and resulting adoption of data mining technology. Further, the current research provides a conceptual framework and model to set a ground for future research. It is expected to broaden the scope of understanding the trust of information technology in general.

The paper unfolds as follows. The next section provides an in-depth review of the literature on the relevant fields: technology adoption and trust formation, and synthesizes theoretical frameworks. Thereafter, we develop a trust in IT artifact based framework and propose the model. We also offer suggestions for future research.

2. Multidimensional synthesisization of theories

2.1 Information Technology Acceptance Research

Explaining user acceptance of new technology is often described as one of the most mature research areas in the contemporary information systems literature, resulting in several theoretical models, with roots in IS, psychology, and sociology, which routinely explain over 40 percent of the variance in individual intention to use technology [63]. A recent comprehensive literature review on IT innovation adoption, acceptance, and diffusion research revealed that Technology Acceptance Model (TAM) and its constructs were the most prominent [68]. One stream of research centers on individual acceptance of technology by using intention or usage as a dependent variable [2] [14], while others have focused on implementation success at the organizational level [41] or task-technology fit [25], among others. The role of intention as a predictor of behavior is critical and has been well-established in IS and the reference disciplines [63]. The core constructs as theorized determinants of intention include perceived usefulness and perceived ease of use [18], complexity [60], results demonstrability [46], and outcome expectations [14] among others. Perceived usefulness refers to the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived ease of use refers the extent to which a person believes that using a particular technology would be free of effort, whereas complexity means the degree to which an innovation is perceived as relatively difficult to understand and use. Results demonstrability addresses the tangibility of the results of using the innovation, including their observability and communicability. Finally, outcome-expectation is the performance-related consequence (job-related outcomes) of the behavior. Innovation characteristics, such as perceived relative advantage and perceived result demonstrability, affect intentions to use the innovation in the future [3]. In another literature review on IT innovation adoption and diffusion research, genetic characteristics of the innovation were consistently found as strong predictor of IT adoption [30].

2.2 Trust and Information Technology Acceptance

As with most IS, data mining applications acceptance can be partially explained using the theorized determinants of intention derived from information technology acceptance research. However, models for technology acceptance need to be integrated with trust related constructs when the implicit uncertainty exists [48]. The importance of trust is more elevated in data mining application acceptance because of the high degree of uncertainty and risk present in most information technology innovation. The following several sub-sections discuss the notion of trust in different perspectives and develop the implication of trust in the context of data mining.
2.2.1 Trust in an interpersonal relationship

Trust in an interpersonal relationship takes two forms. The first centers on trust as an expectation regarding the behavior of an interaction partner, whereas the second couples trust with acceptance of and exposure to vulnerability [9]. Three types of expectations in trust have been identified: an expectation of the persistence and fulfillment of the natural and social order, an expectation of the technically competent role performance from those involved with an individual in social relationships, and an expectation that partners in interactions will carry out their fiduciary obligations and responsibilities [8]. During the establishment of the relationship, however, people are increasing their vulnerability to others whose behavior they cannot control [69].

2.2.2 Online Trust

Since the common denominator between offline and online trusts (i.e. both can be hampered by risks, fear, costs, and complexities) exists, studies on offline trust are also applicable to online trust [16]. Although it is not surprising that many studies in online trust resort to existing works on trust in offline setting, one should also note inherent differences between two notions. The technology and its host organization are the proper objects of trust in an online environment whereas a person or an organization is the primary object of offline trust [54].

In the past decade, numerous studies have demonstrated the critical role online trust plays in e-commerce. Various aspects of trust construct, its antecedents, consequences, and impacts, along with the measurements of trust have been proposed and tested. Trust was the top online shopping concern for Internet users [28]. In an empirical study, significant relationship was found between disposition to trust and trust in e-retailer, and between trust in e-retailer and attitude toward buying from the e-retailer [37]. In the context of Internet banking, customer perceptions of security control significantly affect trust in e-commerce, and trust in turn significantly influences e-commerce acceptance [58]. Trust has been integrated with TAM and found to be as important as perceived usefulness and perceived ease of use in explaining online shopping behavior [24]. Trust-promoting seals were found effective at promoting online consumers’ willingness to buy and the effect is most salient for inexperienced users [70].

In electronic market such as eBay, feedback mechanisms prompt calculus-based credibility trust and create price premiums for reputable sellers [7]. Feedback text comments facilitate buyer’s trust in reputable seller’s benevolence and credibility, which produces price premium [49]. In addition to feedback mechanisms, other IT-enabled institutional mechanisms such as credit card guarantees and third-party escrow services engender trust in the community of sellers and reduce perceived transaction risk [50]. The boundaries of the effects of trust and risk on online transaction activity was theorized and empirically investigated in a recent study [23]. Under the condition of moderate degree of situational uncertainty and vulnerability, institutional structures of online marketplaces plays a moderating role on the effect of risk on transaction activity.

Initial trust concerns the beliefs and attitudes toward the other party at the beginning of the relationship, such as when a potential customer visits an e-vendor website for the first time. Gauging a person’s perception of the institutional setting such as safety nets, security from guarantees, and other structures, institution-based trust is instrumental to the initial trust building [36]. A multidimensional model has been proposed to understand initial online trust in e-commerce, which comprises disposition to trust, institution-based trust, trust beliefs, and trust intentions [45]. Trust belief is a multidimensional construct with sub-constructs such as perceived competence, benevolence, and integrity of the other party [45]. While some studies concentrate on understanding the initial online trust formation and the precursors of initial trust, other studies examine the ongoing trust building and maintenance. It has been found that the antecedents of trust formation differ between potential online customers and repeated customers, with customer satisfaction having a stronger effect for repeat customers [34]. In a longitudinal study, trust is found to influence customer’s purchase decision and affect long-term e-loyalty through satisfaction [31][66].

In addition to the mainstream research in e-commerce setting, trust has also been examined in the context of virtual team and virtual organization [19][27][51].

Given its significant theoretical and practical implications in organizational and online settings, trust was being continuously explored from novel perspectives in the IS discipline [10]. With novel method
of functional brain imaging, especially functional magnetic resonance imaging (fMRI), trust and
distrust are shown to have functional distinction at the brain level [20]. Another fMRI study
demonstrated the neural gender differences in online trust [53].

2.3 Toward Trust in Data Mining: Synthesized theoretical lens

In the computing technology credibility literature, credibility refers to human evaluation of a
technology’s perceived quality. In human-computer interaction research, some most common terms for
credibility are “trust the information”, “accept the advice”, and “believe the output” [61]. Credibility
matters in human-computer interactions when computer system provides data or knowledge to users
[61]. Data mining application produces prediction output information and recommends course of action
[72]. If users trust the information, accept the advice, and believe the output, data mining technology
can have real impact on business. Therefore, credibility or trustworthiness of data mining technology is
clearly a significant issue.

The available researches into the different antecedents of trust in electronic systems are primarily
based on empirical investigations on trust in the context of e-commerce, and sporadically, within the
contexts of e-government and e-health. Most of these e-commerce trust studies examine customer’s
trust toward online seller, e-vendor, or e-service provider. Only a few studies investigate trust toward
technological artifacts such as online shopping recommendation agents [38][65]. In the early stages of
trust formation in decision support technologies, positive as well as negative reasons associated with
trust were identified for online recommendation agents [65]. Is there, however, a difference between
how people trust others in an online environment and how they trust an IT artifact such as data mining
technology? In understanding trust in data mining, one should resort to existing works on online trust,
as results of substantial number of studies on trust in online transactions are applicable to trust in any
electronic systems. Both are rooted on a computerized electronic user interface, in which technology is
a critical object of trust. This section discusses the different antecedents of online trust which are also
applicable to data mining setting, focusing on trust in IT artifact.

Perceived ease of use has been one of the important constructs in the studies on technology adoption.
It refers to the degree to which people believe that using a particular system would be relatively easy
[18], and was furthered to address the navigation structure of a system, which includes search
functions, site maps, product indices, and the overall design and organization in the context of
electronic transactions [42]. The role of perceived ease of use on the trust formation has been supported
in multiple empirical studies in e-commerce area [12].

Although system quality is a major component for IS success, research examining system quality
and its component has been sparse over the last decade [62]. The notion of system quality encompasses
broad dimensions including the existence of bugs, the consistency of the user interface, ease of use,
quality of outputs, and quality of the program code. Drawing up system quality literature, the proposed
framework considers accuracy of information a critical construct applicable to the context of data
mining technology. Previous studies suggest that users are likely to trust a system that contains
accurate, current, and complete information [33]. In the context of electronic transactions, customers
require detailed and clear information to decide on the purchase since they are not in the position to
touch and feel the item in online shopping [9]. Apparently, users of any electronic systems including
data mining applications also expect the highest information quality in the resulting model and
prediction.

Lack of knowledge of what a computing system is doing is a common fear of end users [1]. Thus,
comprehensibility is a key challenge for user adoption of innovative computer technology. In a recent
empirical study [6], the trustworthiness of online virtual advisors was found influencing reuse
intentions. Moreover, the perceived transparency of virtual advisors was shown to have a positive
effect on trustworthiness. Transparency refers to the degree to which the inner workings of the online
virtual advisors are exposed to the users. In the context of content-based art recommedner, a more
transparent decision making process, explicating to the users why a recommendation was made, was
shown to improve user acceptance [17].

Variables related to the graphical characteristics of a system are considered in many studies. A study
suggests that the color layout of the interface is important in augmenting customers’ perception of the
trustworthiness in online banking [35]. Although one should be cautious in generalizing the effects of
graphical characteristics on trust in data mining or other IT artifact since it was conducted within a very specific context, these studies significantly contribute to the research into the presentation of data for better interpretability and understandability.

3. A Conceptual Framework, Model, And Propositions

As pointed out previously, an approach lacking the dimension of trust does not adequately explain data mining adoption phenomenon, especially when the novice users and implicit uncertainty are involved. We apply critical theoretical reasoning to identify the antecedents of trust in the context of data mining, synthesizing discussions of both offline and online trust. A set of propositions is formed through the synthesized theoretical lens and depicted in figure 1.

3.1 User-based Factors

Most theories in offline trust are not particularly applicable to the context of data mining because they mainly center on interpersonal relationship. However, they are theoretical underpinnings of user based antecedents of data mining trust. Three candidate trust antecedents derived from the discussion of offline trust are relevant; namely, disposition to trust, personal innovativeness and proficiency in system usage. Disposition to trust refers to the degree to which users display a propensity to trust any system. It is based on the view that people vary in terms of when and how much they are willing to trust. In an effort to measure users’ readiness to embrace new technologies, a multiple-item scale – technology readiness index (TRI) was developed [47]. The four underlying constructs in TRI, namely, innovativeness, optimism, discomfort, and insecurity, can be related to our proposed conceptual model. Optimism reflects a positive view of technology and regards technology essentially as a constructive function in people’s lives. On the other hand, discomfort and insecurity express a feeling of lack of control, being overwhelmed, skepticism and distrust of technology. Therefore, optimism, discomfort, and insecurity can be thought of different spectrums of the construct disposition to trust. Although empirical studies on the impact of disposition to trust on the formation of trust in electronic systems yielded conflicting results [9], the moderation effect of propensity to trust on the relationship between the antecedents and trust formation is widely supported [40]. This leads to the following two propositions.
Proposition 1a: Under conditions of high disposition to trust, the association between different trust antecedents and the formation of trust beliefs in data mining will be (relatively) strong.

Proposition 1b: Under conditions of low disposition to trust, the association between different trust antecedents and the formation of trust beliefs in data mining will be (relatively) weak.

Personal innovation in IT refers to “the willingness of an individual to try out new information technologies” [4][39] and is considered a stable situation-specific trait [39]. Construct innovativeness from TRI [47] describes the tendency to be a technology pioneer and is similar to the construct of personal innovation in IT. Data mining technologies are deemed innovative to the novice business users in the organizations. People with high personal innovation in IT will voluntarily explore this innovation and enjoy the learning experience. Users with a higher personal innovativeness would more likely be willing to experiment with new ways of applying data mining technologies to their business problems. Therefore, we expect that personal innovation in IT moderates the relationship between the antecedents and trust formation, which results in the following two propositions.

Proposition 2a: Under conditions of high personal innovation in IT, the association between different trust antecedents and the formation of trust beliefs in data mining will be (relatively) strong.

Proposition 2b: Under conditions of low personal innovation in IT, the association between different trust antecedents and the formation of trust beliefs in data mining will be (relatively) weak.

User expertise affects how users assess the credibility of computer systems. In general, people unfamiliar with the subject matter tend to regard computer system as more credible [64]. As users interact with a computer system over time, they accumulate more first-hand experiences and people’s experienced credibility toward the system becomes stronger [61]. In other words, proficiency in system usage addresses users’ perception of risks to their levels of experience with an electronic system. The notion of proficiency in system usage is derived from a theory in interpersonal trust, namely, trust as acceptance of and exposure to vulnerability. Studies suggest that user’s level of experience is positively related to the degree of trust in an electronic system [15]. Although other studies find a potentially conflicting result, manifesting that the relationship between system experience and trust is positive only in the case of novice and intermediate users [5]. Corbitt et al. [15]’s finding is relevant to the current study, primarily focusing on novice business users with relatively lower data mining proficiency.

Proposition 3: The relationship between proficiency in system usage and the formation of trust beliefs in data mining is positive.

3.2 Data Mining Application-based Factors

Based on the foregoing discussions of trust in data mining, three trust antecedents in data mining are identified and relevant propositions are formed.

Interface can play a crucial role in inducing users’ trust toward a technology. For example, embodied interface agents influence people’s judgment of technology as more reliable, competent, and trustworthy [11]. Adapting Davis [18]’s framework, we generate the notion of perceived ease of use of a data mining system. It is defined as the degree to which people believe that using a particular data mining system would be relatively easy. It has been widely used in technology acceptance studies [63]. It has been found that the “ease of use” of shopping website is important in forming trust in online shopping setting. We argue that the “ease of use” of data mining technologies, especially the familiar and friendly GUI interface, induces user’s perception of familiarity. For instance, in case of data mining system with familiar user interface, such as Microsoft SQL Server 2012 Data Mining Add-ins for Microsoft Office 2010, user’s attitude and trust might transfer from previously used familiar system – Microsoft Office 2010 – to the currently considered data mining system.
Proposition 4: The relationship between perceived ease of use of a data mining system and the formation of trust beliefs in data mining is positive.

In the context of decision support systems, feedback of the improved model accuracy was shown to increase users’ intention to expend effort and use more complex model [13]. Computer system gains credibility when it offers correct and accurate information to users; on the other hand, it loses credibility when the information provided is found erroneous by users [61]. Thus, it is relatively straightforward to apply the notion of perceived accuracy of information to data mining setting. Perceived accuracy is an overall measure of the utility of the generated data mining model. If a certain data mining model generates out with higher accuracy, it is more likely that the data mining model is perceived useful. It suggests that there exists a linkage between data mining model’s accuracy and user’s calculated trust which derives from internal cognition of careful thought process. The user analyzes the situation and makes rational judgment of the utility of the technology innovation. If the user believes the data mining model is accurate enough (e.g. passing a threshold, satisfactory for bounded rationality [55]), then he/she is more likely to believe that the given data mining model (e.g. artificial neural network) is more trustworthy for the particular problem domain.

Proposition 5: The relationship between perceived accuracy of a data mining system and the formation of trust beliefs in data mining is positive.

Users may be reluctant to accept data mining technology because they may need further insight into the model’s decision. To bridge the gap between the non-expert users and data mining models, users should be provided with additional information about the decision making process of a model [56]. Some data mining methods naturally have simple way of explaining their decisions. For example, information gains of individual predictors can be used to understand the workings of Naïve Bayes classifier and logical decision rule that is followed to navigate from the root to the leaf for a particular instance can be used to explain the prediction of a decision tree [56].

The notion of perceived interpretability of a data mining system parallels that of graphical characteristics of a system to the extent that it is a set of attributes for the presentation of data. Interpretation is an essential step in the overall knowledge discovery in databases (KDD) process and it is critical to make the discoveries more understandable by humans in many applications [21]. For data mining applications used in an organizational setting, model interpretability is often an important requirement, for example to gain a deep understanding of the characteristics of customer clusters or to offer satisfactory explanations to comply with legal obligations [22]. Symbolic based data mining methods such as decision trees and decision rules share some basic principles with human logical reasoning and have the advantage of easy to understand [67]. On the other hand, an artificial neural network (ANN) is considered as a black-box method that does not fulfill the understandability requirement of KDD [52]. When intelligent systems can provide appropriate explanations for their reasoning or justifying their behavior, they are more persuasive and lead to more positive user perception, greater trust, satisfaction and acceptance [26]. In a recent study on how end users interact with machine learning systems, a whole sub-section was devoted to the topic of “explanations” [57]. A data mining technology that facilitates results to be better comprehended is more likely to be trusted [59]. Data visualization can also be used to improve a user’s comprehension [29][59]. Therefore, interpretability of data mining model and results is important in generating trust. Several constructs and measures in the instrument for measuring the perceptions of IT innovation adoption [46], such as result demonstrability, can be potentially adjusted for assessing interpretability.

The foregoing discussion leads to the following proposition.

Proposition 6: The relationship between perceived interpretability of a data mining system and the formation of trust beliefs in data mining is positive.
3.3 Trust in Data Mining Applications

The formation of trust in data mining applications takes two steps, namely, trust belief and trust intention. In the context of electronic transaction, trust intention refers to the willingness to depend or intentions to depend a customer would have if she or he agrees to general statements about volitional preparedness to rely on the vendor, whereas trusting belief is trustor’s perception that the trustee has beneficial attributes to the trustor [45]. Trusting belief relates positively to trusting intention in electronic transaction setting [45]. It is applicable to the context of data mining applications because a user with high trusting beliefs perceives that the particular data mining system has attributes that enable the user to hold a secure willingness to depend on the system. Adapting a confirmed strong correlation between behavioral intentions and actual behavior, we focus on trusting intention rather than trust-related actual behavior.

**Proposition 7:** The relationship between trust beliefs in a data mining system and the formation of trust intention in data mining is positive.

4. Conclusion, Limitation, and Future Work

IT innovation adoption continues to be one of the most important IS issues. This research attempts to contribute to the knowledge base, developing a new conceptual model of trust toward an innovative technology – data mining. The model presented here could provide a glimpse into why novice business users trust or not trust a particular data mining technology and model, eliciting insights on when data mining initiatives fail and what actions can be taken in such occasions.

The study shows that it is particularly important to understand the impact of different dimensions of trust antecedents on the success of data mining initiatives. In terms of limitations, although detailed in several respects, the model does present opportunity for further refinement and enhancement. For instance, factors like personal innovativeness can be considered to explain the trust beliefs. Another limitation is that the current study entirely focuses on the development of theoretical framework and conceptual model to set a first step toward a more complete understanding of trust formation mechanism from the viewpoint of data mining initiative. However, we believe it provides a solid framework and sets the stage to build upon for further research investigations including empirical studies and the identification of other potential candidate factors affecting data mining initiatives.

5. References


[34] Kim, H.-W., Xu, Y., Koh, J. “A Comparison of online trust building factors between potential customers and repeat customers”, *Journal of the Association for Information Systems*, vol. 5, no. 10, pp. 392-420, 2004


[70] Zhang, H. “Trust-promoting seals in electronic markets: Impact on online shopping decisions”, Journal of Information Technology Theory and Application (IJITTA), vol. 6, no. 4, pp. 29-40, 2005