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Rethinking the role of security in client satisfaction with Software-as-a-Service (SaaS) providers

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ABSTRACT

Despite the conceptual importance of security perceptions in contributing to client satisfaction, no study has yet provided empirical evidence of the link. We argue that because security perceptions are highly subjective and depend on the client's experiences, it is necessary to identify the perceived value of security in order to explain its effect on security. We adapt a recent model of SaaS satisfaction to include security and perceived value, and test the model on a sample of 135 SaaS clients. We find a significant positive relationship between security and satisfaction when mediated by perceived value. We also present an unmediated model in which security is not significant.

1. Introduction

Within the next five seconds, 19 new types of malware and 11 new infections of the top five software vulnerabilities will be detected across the globe [65,87]. Within the next 48 hours, 400 new rootkits and 36 new vulnerabilities will be identified in common business software applications [15,66], one of which will be a zero-day attack for which the vendor has not yet released a software patch. Industry evidence shows that the frequency of new network vulnerabilities is increasing [69,83]. These security risks affect SaaS providers and their clients especially because, in contrast to traditional outsourcing, SaaS is heavily dependent on network integrity for service delivery. A key business problem hence lies in the fact that poor security of the SaaS service undermines the client's trust and satisfaction with that service. To this end, Cisco Systems [15] argues, "today's networks are facing two forms of trust erosion. One is a decline in customer confidence in the integrity of products. The other is mounting evidence that malicious actors are defeating trust mechanisms, thus calling into question the effectiveness of network and application assurance, authentication, and authorization architectures". It is becoming increasingly clear that effective understanding of SaaS client satisfaction and trust must involve security.

Unfortunately, SaaS service managers reviewing the published research literature will find conflicting evidence about the role of security in SaaS customer satisfaction. A number of conceptual studies argue that security ought to be important to SaaS customers [45,71]. However, to date there have been no empirical studies identifying the relationship. For example, Wu [94] found no relationship between 'security and trust' and behavioral intention to use SaaS services. Heart [39] surveyed 143 SaaS clients, and found no significant relationship between the perceived risk of data insecurity, and intention to adopt SaaS services. Du et al. [20,21] surveyed 1399 SaaS end-customers and found no significant relationship between security perceptions and intention to adopt SaaS. The enduring gap between the conceptual importance of security and the absence of empirical validation in prior work means that it is critical to understand how security ought to contribute to client satisfaction with SaaS providers. It is the aim of this paper to provide this missing link.

One possible explanation is that security perceptions are subjective to the client's particular situation and do not depend on technical measures alone [78]. Hence, technical measures may not contribute to satisfaction if the customer does not value them. This contention is consistent with emerging consensus in the service management literature that service satisfaction is directly driven by the perceived value of service features [16]. Therefore, our goal in this paper is to develop a model of SaaS satisfaction that incorporates perceived security and perceived value. Building on a recent model of SaaS client satisfaction [13], we show that security has a large positive effect on satisfaction when mediated by perceived value. To our knowledge, ours is the first study to empirically demonstrate this relationship. Further, we present an unmediated model in which security is not a significant direct predictor of satisfaction.

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0167-9236/

This study makes two contributions. First, we contribute to security research by identifying the role of security in the software-as-a-service model. Despite the importance of security, no study has yet empirically validated this relationship. The popularity of the SaaS model exacerbates the adverse effect of vulnerabilities [69]. Understanding the role of security in the SaaS context is useful to researchers in understanding how to limit the extent of these attacks, and their potential effect on client engagement. Our study fills this gap. Second, we contribute to SaaS research by assisting SaaS managers in determining how and where best to focus their developmental efforts. The SaaS model is attractive to client firms because it allows them to maintain a variety of on-demand IT service levels while reducing maintenance roles, management costs and capital expenses [86]. For this reason, spending on "as a service" offerings is forecast to grow to $258 billion in 2020 [27].

The rest of this paper is structured as follows. The next section discusses the paper's theoretical background, by examining satisfaction with SaaS providers, and then security in the SaaS context. The paper then discusses perceived value, before presenting the research model and hypotheses. This is followed by the research method and data analysis. Finally, conclusions are offered.

2. Theoretical background

The Software-as-a-Service (SaaS) model allows client firms to outsource their software application processing requirements. For a fee, a client firm gains access to a variety of software applications and services that would otherwise be too expensive or complicated to administer internally [29]. In order to understand the role of security in client satisfaction with SaaS providers, we first examine relevant theory regarding satisfaction with SaaS providers, followed by prior research on security in the SaaS context.

2.1. SaaS satisfaction

Satisfaction in prior literature is conceptualized as a positive point of view towards a product or service [3,43]. Client satisfaction is important to vendors [34] because clients whose needs are met are more likely to engage in effective system use [7]. By contrast, dissatisfied clients can switch to different providers when the services available to them do not meet their needs and expectations [5,8]. The drive to maintain satisfaction has hence been important in both practitioner environments and the IS literature.

Prior research into client satisfaction with SaaS has focused on identifying groups of factors that influence satisfaction with SaaS providers. However, the relative newness of SaaS means that there have been few empirically validated models of SaaS satisfaction from the client's perspective, with little overlap between models. For example, Lee et al. [58] use a balanced scorecard approach to evaluate SaaS provider satisfaction according to four measures: learning and growth, internal business processes, customer performance, and financial performance. Kim et al. [52] developed a satisfaction model comprising system quality, information quality, and service quality. Susarla et al. [84] developed a model comprising prior systems integration, functional capability, disconfirmation and perceived provider performance. Satisfaction models are so diverse that a recent literature review collated some 200 factors relating to satisfaction with online services [19]. These inconsistent views suggest that new research ought to build on existing work in order to consolidate research directions, rather than opening new fronts.

A recent, parsimonious model of satisfaction in the SaaS context is Chou and Chiang [13]. According to this model, satisfaction with a SaaS provider is driven by trust, and trust is in turn driven by Rapport and Flexibility. Flexibility, defined as "the vendor's capability in fulfilling the outsourced task and providing quality service" (p. 150), describes the service quality received by clients. In keeping with prior work into SaaS satisfaction [6,e.g. 7], this construct would be better labeled as "Service Quality" in order to better describe the degree to which the SaaS offering matches the client's requirements. Rapport, defined as "the vendor's willingness to provide support tailored to individual needs and…personalized service" (p. 150), describes the provider's responsiveness to client requests. To be consistent with prior work into SaaS satisfaction models and other service quality research [7,20], this construct would be better labeled as "Responsiveness" because it describes the degree to which the SaaS vendor responds to provide tailored, custom services to their clients. This model is represented conceptually in Fig. 1 and forms the initial basis of our enquiry into security and satisfaction in the SaaS context.

2.2. SaaS security

Security and the integrity of operations is an ongoing problem in the online services context. Prior work has highlighted the risks to 'always available' online services, particularly when the services become integrated into a client's operations. Despite much prior research, potential SaaS adopters continue to worry about the security of these operations [14].

To better understand current thinking regarding security for online services, we searched for all published journal articles on the topic of security in application service provision (ASP), as-a-service offerings (e.g. SaaS, PaaS, IaaS) and on-demand online services. A summary of the results of this review appears in Appendix A. We identified a number of relevant themes in this prior research.

First, numerous papers have focused on developing secure service features. Many of these papers have designed and developed artefacts to support secure services for SaaS and ASP service offerings. These artefacts aim to protect customers and business proprietors from threats to their operations. However, despite this extensive prior developmental work, there remains very little research on how these various security initiatives contribute in aggregate to client satisfaction. This finding suggests that an important complement to this prior research would be an understanding of how security contributes to client satisfaction, in order to support and further validate these artefactual developmental initiatives.

Second, many papers argue that security is important to customer agreements in the SaaS context, and there are numerous conceptual frameworks that incorporate security as an important component of customer management [e.g. 51,62]. However, as noted earlier, the relationship between SaaS security and client satisfaction has not been well covered in prior work. Our review of prior literature revealed very few studies into the client perspective on the role of security. The few studies that have explored security from the client satisfaction perspective did not observe or did not test a relationship between security and satisfaction. For example, while Benlian and Hess [6] saw a significant second-order relationship between perceived security risks and perceived risk, they did not test a direct path to adoption intention, nor satisfaction with use. Oliveira et al. [72] did not find a significant relationship between security concerns and relative advantage in cloud computing adoption. Benlian et al. [7] included security as part of a second order construct of perceived SaaS quality, but did not test a direct relationship with satisfaction. Du et al. [20,21] found no significant relationship between security perceptions and SaaS adoption intention. This finding suggests that, while authors do believe that security is important to SaaS client satisfaction, they are not sure how this relationship should be formulated and modelled. Therefore, it is necessary to identify how security relates to SaaS customer satisfaction.

Third, there is much evidence that security is highly context-dependent. Prior literature illustrates numerous security initiatives, tools and artefacts for SaaS clients, targeting various aspects of the client relationship in various contexts. Implementing these initiatives is likely to have varying costs, as some clients may already maintain highly adapted and developed security measures, thereby placing lower reliance on the security features of the SaaS provider. This finding

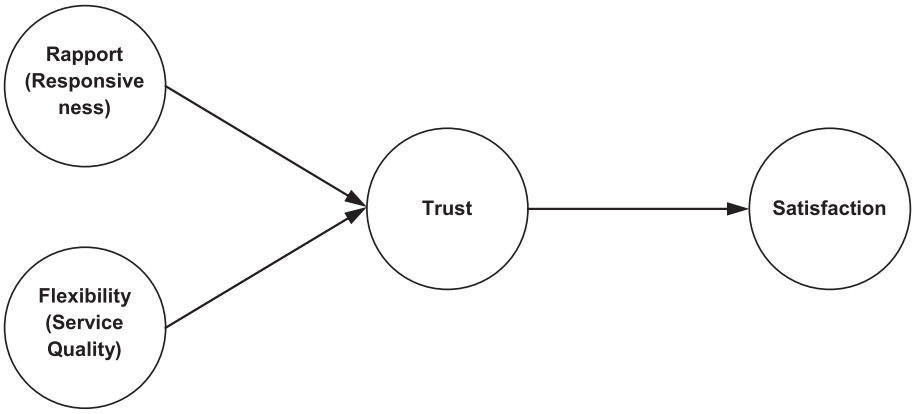

Fig. 1. Initial SaaS satisfaction model (Chou and Chian 2013).

supports the argument in prior literature that users' perceived security or trust is subjective and is not dependent on technical measures alone [74,78,79,93] and depends on the client's needs [50]. Hence, an understanding of the effectiveness of these security initiatives will need to include the degree to which these initiatives are valued.

3. Perceived value

Perceived value is conceptualized as the consumer's evaluation of the utility of perceived benefits and sacrifices [91,92]. In other words, value is seen as the difference between the cost of a product and the benefit obtained from purchasing it [96]. Because perceived value is integral to a customer's product and service perception [10,17], sellers are frequently challenged to increase the value of their product or service by improving its associated benefits or reducing its costs [77].

Value is related to satisfaction, but the two concepts are fundamentally different [85]. Satisfaction does not necessarily capture the utility of the product or service offering [96]. Customers are only likely to be satisfied if they can perceive value in the features available to them [2,23,36,95]. This is because while a customer can perceive value throughout the purchase process, satisfaction typically only occurs following a purchase. Hence, value must be observed while the product is being used, but satisfaction may only develop from the experience of having used the product or service [85]. As a result, valuable features are subjective to the purchaser [9,40], and pertain to the particular features that relate specifically to their needs and preferences. To this end, Woodruff [92] argued, "customer satisfaction management needs to be backed-up with in-depth learning about customer value" (p. 139).

While perceived value is conceptually distinct from satisfaction, the two concepts are frequently linked in prior literature. For example, McDougall and Levesque [67] found that perceived value contributed to customer satisfaction in a number of service delivery contexts. Caruana et al. [11] found that perceived value significantly mediated the relationship between perceived service quality and satisfaction with service marketing. Yang and Peterson [95] found that perceived value significantly influenced customer satisfaction in online services. Lam et al. [54] observed that perceived value had a significant antecedent effect on satisfaction in their study of business to business (B2B) services. Similarly, Liu and Ma [61] argue that, "customers are likely to be more satisfied with an offering as the ability of the offering to provide consumers what they need, want, or desire increases relative to the costs incurred" (p. 1123).

This discussion suggests that perceived value is an important antecedent of satisfaction, particularly when it is necessary to capture the purchaser's subjective perceived benefit of the product or service. Perceived value is formed throughout the purchase process, and pertains directly to the customer's experiences and preferences when using the product. As a result, in cases where aspects of the product or service are subjective to the purchaser, understanding satisfaction with the purchase also requires an understanding of perceived value.

4. Model and hypothesis development

In order to develop our model, we build directly on the recent prior work of [13], shown earlier, and incorporate security and perceived value in order to better understand satisfaction in the SaaS client relationship. As discussed earlier, satisfaction does not necessarily capture the utility of the service, and customers will only be satisfied if they can perceive value in the service features at hand. If security is subjective then it will be necessary to mediate the link between security and satisfaction with perceived value. Fig. 2 illustrates the model used in this study. The hypotheses underpinning this model are discussed below.

We now elaborate on the hypotheses to be tested. First, service quality is conceptualized as the perception that a service meets a customer's requirements [46,63]. In the case of SaaS, service quality describes the perception that the features of the provider match the client's needs [7].

In Chou and Chiang [13]'s model, service quality was hypothesized to have a positive relationship to trust, on the grounds that service quality improves the client's belief that the provider is competent, and reduces perceptions of opportunism. These perceptions build trust on the part of the client. Our model replicates this hypothesis.

Service quality relates directly to perceived value because the client may be satisfied with the services offered by the SaaS without actually benefiting from these services. The SaaS provider can offer client firms any number of services, only some of which are likely to be usable by a given client: "experience-based norms have only limited significance in explaining satisfaction with ASP" [84]. For this reason, many SaaS providers are struggling to determine which services are actually useful to their client user base [44]. As a result, a client may be entirely satisfied with the services available to them, but they may not actually value these services. Chou and Chiang [13] argue that "[service quality] increases customers' perception of the *value* of using SaaS" [emphasis added]. Prior studies also found that service quality was an antecedent of perceived value [12,25]. Thus, this study posits the following hypotheses:

H1a. Service Quality positively affects the SaaS customer's Trust of the provider

H1b. Service Quality positively affects the SaaS customer's Perceived Value of the provider

Responsiveness represents the flexibility with which a service provider adapts and responds to service requests from a customer [89]. Responsiveness reflects the degree of flexibility to customer

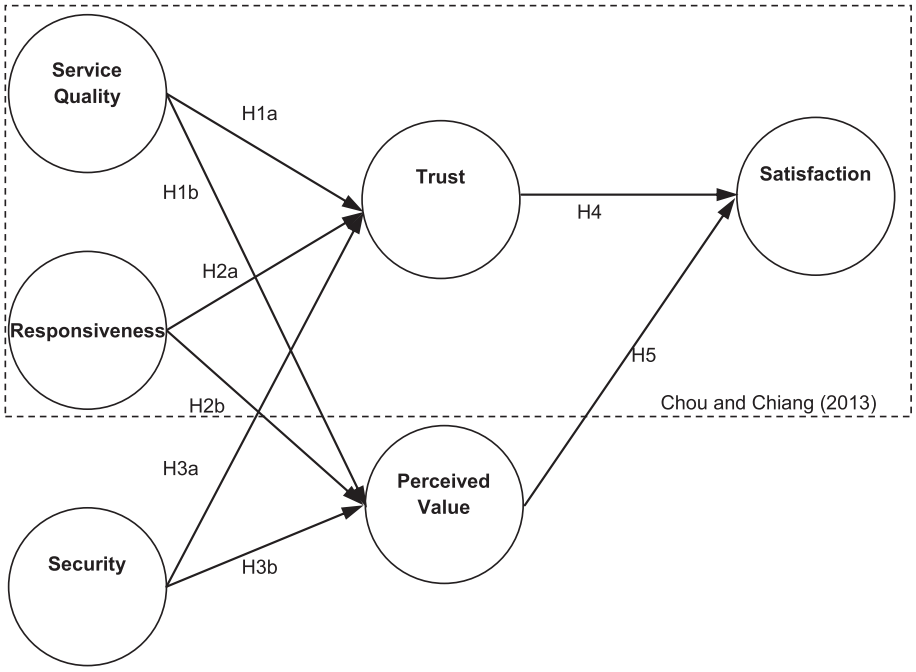

Fig. 2. Research model of SaaS satisfaction.

requests for technical and contractual changes. Responsiveness is also important in the outsourcing context: because outsourcing agreements place critical services outside the firm, there can be a reduction in control over core business activities, such as maintaining operational control [71,75], adapting to changing business needs and meeting the flexibility requests of the client [80].

In the Chou and Chiang [13] model, responsiveness was positively related to trust. While traditional outsourcers could foster a one-to-one relationship with a client, SaaS providers typically service a range of firms at one time [89], so the SaaS provider's clients may not know who else is using the provider's services. Further, in the SaaS context, the provider is separated from the client and so the client cannot easily interact with the system, so responsiveness helps the client see sincerity in the provider's actions. Therefore, the responsiveness of the provider is vital to a harmonious and trusting relationship. Our model replicates this hypothesis.

In the SaaS context, responsiveness has a direct relationship to perceived value, rather than satisfaction, for two reasons. First, client requirements for SaaS provider responsiveness may vary depending on client's ongoing experiences with the service transaction. These on-demand IT services are characterized by frequent service exchanges,[1] and SaaS providers cannot always predict which service is required at a given time [82]. Higher responsiveness gives the client more control over their operations [52,56]. Therefore, a more responsive SaaS provider can more effectively support a client's changing needs, thereby building better value perceptions. Second, SaaS providers typically aim to support as many clients as possible with their service range, while minimizing the cost and effort of tailoring individual service packages [81,89]. As a result, clients may be satisfied with a given level of responsiveness but the service feature does not necessarily add value to the client's specific context. This leads to our second set of hypotheses:

H2a. Responsiveness positively affects the SaaS customer's Trust of the provider

H2b. Responsiveness positively affects the SaaS customer's Perceived Value of the provider

Security is a significant problem facing many online services. Threats to security include data theft, extortion, hacking, process vulnerabilities, and employee and customer fraud [71]. These threats can adversely affect operations by compromising the data, services and companies involved. In the outsourcing context, security of business operations has been a critical concern for some time [57] because of the need to involve an external party in potentially sensitive operations.

Security is positively related to trust. In the SaaS context, security threats are exacerbated because SaaS client-provider relationships are more distant. SaaS providers deploy, host, maintain and manage software application for customers at a centralized facility and provide an environment for remote end user to access their application remotely. This externalization of important IT services reduces the level of personal contact [76] and raises operating risks for sensitive data and services [18]. SaaS providers may service many clients operating over the same network infrastructure while also having access to each client's data: this can adversely affect client perceptions of robustness [52]. Therefore, the ability to actively control for security threats is an important factor in a firm's decision to entrust their IT services to SaaS firms [55,90].

Security directly relates to perceived value, rather than satisfaction, because security is subjectively perceived by the client, depending on their needs. From the client's perspective, security relates specifically to their own operations depending on the threats they face [71]. However, to preserve business continuity, the SaaS provider must enact a portfolio of security measures. Security mechanisms for online services are typically complex and highly interwoven, and the end user is typically only aware of those security mechanisms that directly affect their own service requirements. The other security mechanisms offered by the SaaS provider may be effective and important, but they remain functionally invisible to the client. This discussion leads to the third set of hypotheses:

H3a. Security positively affects the SaaS customer's Trust of the provider

H3b. Security positively affects the SaaS customer's Perceived Value of the provider

Prior research in the outsourcing literature has emphasized the role of satisfaction in the client-provider relationship [63]. Satisfaction arises

[1] We are grateful to a reviewer for this observation.

from identifying and meeting the client's requirements and needs [49], which is fostered by a close relationship between the client and the outsourcing firm [47]. As a result, client satisfaction remains an important goal in many outsourcing arrangements.

In Chou and Chiang [13]'s model, trust is positively related to satisfaction, because trust reflects the customer's perception of a harmonious, long-term relationship. Trust is important to outsourcing arrangements [33,55], which involve close working relationships between firms. SaaS arrangements also involve access to sensitive processes and resources, and both firms must trust each other not to use such sensitive access for self-serving gain. Our model replicates this hypothesis.

As discussed earlier, perceived value is positively related to satisfaction [35]. The service management literature argues that customer satisfaction is the result of a customer's perception of the value received in a transaction or relationship [42,88]. Customers will be satisfied if they can perceive value in the features available to them [2,23,36]. Greater levels of perceived value lead to positive attitudes regarding the service, which builds satisfaction. Thus, this study posits the following hypotheses:

H4. The SaaS customer's Trust in the provider positively affects the customer's Satisfaction with the provider

H5. The SaaS customer's Perceived Value of the provider positively affects the customer's Satisfaction with the provider

5. Method

A questionnaire survey was chosen as the most appropriate data gathering method for this research. First, numerous prior studies into SaaS satisfaction have used the survey method for data collection. The method is often used in information systems research, especially for studies that quantitatively explore the interaction of a range of variables [53]. Also, survey results can be generalized to larger populations [70]. Below we discuss the survey, including constructs, participants and data collection.

5.1. Instrument development and administration

Where possible, we adapted existing survey items from prior literature to develop our survey. As in prior research [e.g. [13], we used items that covered a range of relationship dimensions, referencing the SaaS provider, the relationship, and the client's experience with prior SaaS applications, all using seven-point Likert scales. Table 1 summarizes the construct definitions and the number of measurement items for each construct.

With an initial draft of the instrument, we undertook pretest and pilot test procedures to ensure that the measurement items captured the meaning of the construct. In the pretest, interviews with three MIS experts were held in order to identify and correct problems in the survey items. Based on their feedback, we re-edited our items in order to eliminate ambiguous wordings in our questionnaire. To further ensure the content validity of measurement items, twenty SaaS clients were invited to attend the pilot test to confirm that the survey items were fully understood.

Our target participants were client firms who had purchased services from a SaaS provider and were still using the SaaS during survey period. We used a two-stage process to identify these participants, using a similar approach to prior work such as Ma et al. [63] and Benlian et al. [7]. In Phase 1, we used a business directory to identify the ten largest SaaS providers in Taiwan and invited them to participate by sending our survey to their client base. We received responses from five SaaS providers who were willing to participate. However, due to privacy concerns, some participating SaaS providers were unwilling to deliver the questionnaire directly to their customers. Therefore, in Phase II, we actively broadcast our online questionnaire via SaaS management platforms to their customers. This procedure yielded a sample 248 participants that agreed to receive our survey.

Table 1
Construct definitions.

Latent construct	Definition	Number of items
Perceived value	The benefits perceived by the customer in a SaaS service [22]	3
Service quality	Firm's perceptions on the service provider's service quality [46,55]	2
Security	The extent to which SaaS provider can provide security elements [63]	5
Responsiveness	The extent to which SaaS provider is amenable to modifications [63]	4
Trust	A firm's perception that the SaaS service provider has attributes that is beneficial to the firm [55,68]	3
Satisfaction	Satisfaction is considered as a composite of overall customer attitudes towards the service provider [59]	3

5.2. Participants and data collection

The study received a total of 158 responses via return mail, online submission, and e-mail. Validation of the returned surveys revealed that 23 responses were incomplete, which left 135 responses for a usable response rate of 55.4%. Table 2 shows the demographic characteristics of the respondent group. The sample featured various service applications, including E-commerce (29.6%), groupware (25.2%) and office automation (16.3%). Most of these firms originated from IT/IS industries (40.5%), manufacturing (16.5%), and real estate (13.9%). Although the response rate is over 50%, assessing the potential non-response bias is still required to establish better external validity. To assess the possibility of systematic bias in the respondents, we firstly conducted a comparison of our sample characteristics with the characteristics of other similar sample populations. Based on a chi-square test, there was no difference between responding and non-responding firms for industry type ($x^2_{(2)} = 2.01$, $p > 0.05$). Second, we used late respondents as surrogates for a sample of non-respondents, and compared the differences in the means of early respondents ($n = 101$) and late respondents ($n = 34$) on key variables. The results (see Appendix B) indicated that there was no significant difference in the key variables between respondents and non-respondents. These results indicated that no respondent types are under-represented in this study.

5.3. Assessment of the measurement model

PLS path modelling shares with least squares regression the ability to obtain parameter estimates at relatively lower sample sizes [30], and uses bootstrapping to empirically estimate standard errors for its parameter estimates. We elected to use PLS for three main reasons. First, we adopted PLs in order to be compatible with prior studies in our

Table 2
Demographic characteristics of the respondent sample.

	Variable	Frequency	Percent
Gender	Male	83	61.5
	Female	52	38.5
Length of service	less than 1 year	5	3.7
	1–5 years	40	29.6
	6–10 years	51	37.8
	11–15 years	22	16.3
	More than 16 years	17	12.6
Application service area	Accounting	19	14.1
	Groupware	34	25.2
	Office Automation	22	16.3
	E-commerce	40	29.6
	Others	20	14.8

theory base that also successfully applied PLS, especially Chou and Chiang [13]. Second, PLS exhibits similar analytical power to conventional regression and covariance-based SEM [32,41]. Third, PLS avoids restrictive distributional assumptions when determining path coefficients significantly different from zero [24,30].

Following the two-stage analytical procedure recommended by [1], a measurement model was conducted to assess the convergent validity and discriminant validity, and then the structural relationship was examined. To detect common method variance, we conducted Harmon one-factor testing [38]. In the unrotated factor structure, five factors emerged with eigenvalues greater than one and the first one factor accounted for 43 percent of the variance from the eight constructs. Prior study claimed that common method variance is not a serious issue if more than one factor is extracted from the data and the first factor does not comprise a majority of the variance (less than 50 percent) [48]. In addition, this study employed the method proposed by Liang et al. [60] to further examine the threat of common method variance. We created a method factor comprising all measurement items as a predictor in the PLS model. Common method variance can be identified by calculating the proportion of the explained variances of each measurement item accounted for by its substantive construct and the method factor [60]. As shown in Appendix C, most method factor loadings are not significant, and the proportion of substantive variance to method variance is around 19:1. Given that the magnitude of method variance is small and insignificant, we conclude that common method bias is not a serious issue with our data.

We then constructed a measurement model of the eight constructs using the measurement items. Each construct was modeled reflectively. The results indicated that all factor loadings were above the recommended 0.7 and were significant (see Table 3). However, one item in security (SE5 "Compared to other provider, my SaaS provider can conduct security auditing to my company") revealed a problem in factor loading. This result suggested that this item is problematic in representing the concept of security in SaaS service and the item was excluded from the analysis.

Convergent validity was demonstrated by calculating composite reliability (CR), Cronbach's alpha (CA) and average variance extracted (AVE). Composite reliability and Cronbach's alpha should be greater than the 0.7 threshold, indicating adequate internal consistency among the respective constructs [37]. AVE showing the ratio of the sum of the variance captured by the construct and measurement variance, which was applied as the measures for convergent validity [4]. In this study, composite reliability and Cronbach's Alpha values were above the recommended 0.7, and the AVE values for each construct were greater than the recommended 0.5 level, thereby establishing convergent validity [31].

This study used the estimated correlation between all construct pairs and the shared AVE squared root of each construct as criteria for discriminant validity. The AVE square root of each construct should be greater than its correlation with the other constructs [26]. Table 4 shows that the AVE square root of each construct is greater than its correlation with the other constructs, establishing discriminant validity. We also tested convergent validity and discriminant validity using PLS cross-loading with PLS-Graph 3.0. The results, shown in Appendix D, indicate that all measurement items loaded on their respective constructs above the 0.7 threshold. Loadings were higher than any cross-loadings on other constructs, representing adequate convergent and discriminant validity.

The correlation coefficient between perceived value and satisfaction was 0.78, which may raise a concern regarding discriminant validity. Therefore, we conducted a chi-square difference test for the discriminant validity between these two constructs for both constrained and unconstrained measurement models. We fixed the correlation between two constructs at 1 in the constrained model and freed the correlation in the unconstrained model. The results indicated that the unconstrained model was significantly superior to the constrained model ($x^2_{(1)} = 30.76$, $p < 0.01$), affirming good discriminant validity between perceived value and satisfaction.

6. Data analysis

The structural model depicted in Fig. 3 presents the causal relationships among the constructs and the variation explained.

Tests of significance were performed using a bootstrap procedure with 1000 re-samples. In summary, Service Quality is not significantly related to Trust ($\beta = 0.18$, t-value = 1.86, Std. error = 0.09), and H1a is not accepted. Service Quality has a positive effect on Perceived Value ($\beta = 0.35$, t-value = 4.84, Std. error = 0.07, $p < 0.01$), supporting H1b. Responsiveness has a positive effect on Trust ($\beta = 0.26$, t-value = 2.49, Std. error = 0.10, $p < 0.05$), supporting H2a. Responsiveness is not significantly related to Perceived Value ($\beta = 0.17$, t-value = 1.85, Std. error = 0.09), and H2b is not accepted. Security has a positive effect on Trust ($\beta = 0.41$, t-value = 3.57, Std. error = 0.11, $p < 0.01$) and Perceived Value ($\beta = 0.33$, t-value = 4.29, Std. error = 0.07, $p < 0.01$), supporting H3a and H3b. Trust has a positive effect on Satisfaction ($\beta = 0.22$, t-value = 2.60, Std. error = 0.08, $p < 0.05$), supporting H4. Perceived Value has a positive effect on Satisfaction ($\beta = 0.65$, t-value = 9.47, Std. error = 0.07, $p < 0.01$), supporting H5. The significance

Table 3
Convergent validity, item loadings and normality.

Constructs	Items	Loading	AVE	CR/CA	Zskewness/ Zkurtosis
Service quality	OSQ1 I believe that the SaaS provider's service quality is excellent	0.92**	0.86	0.93/0.85	−2.37/1.89
	OSQ2 Overall, my SaaS provider is outstanding	0.94**			
Security	SEC1 Compared to other provider, my SaaS provider pay attention on data confidentially	0.89**	0.77	0.93/0.89	−2.76/1.20
	SEC2 Compared to other provider, my SaaS provider has proper anti-virus protection	0.87**			
	SEC3 Compared to other provider, my SaaS provider has excellent encryption technology	0.88**			
	SEC4 Compared to other provider, my SaaS provider can provide secure physical environment	0.87**			
Responsiveness	SR1 Compared to other provider, my SaaS provider advance pricing capabilities with the flexibility and scalability	0.88**	0.73	0.89/0.74	−2.10/−0.01
	SR2 Compared to other provider, my SaaS provider has the possibility of modifying the contract	0.82**			
	SR4 Compared to other provider, my SaaS provider delivers the service that comes up to my needs	0.86**			
Perceived value	PV1 Compared to the price we pay, we get reasonable quality	0.91**	0.78	0.91/0.86	−1.34/0.73
	PV2 Compared to the quality we get, we pay a reasonable price	0.84**			
	PV3 The purchasing relationship delivers us superior net-value	0.89**			
Trust	TR1 My SaaS provider is interested in my company's success, not just its own	0.93**	0.84	0.94/0.86	−2.31/2.03
	TR2 My SaaS provider is truthful in its dealing with my company	0.94**			
	TR3 My SaaS provider is competent and efficient in providing information system service	0.92**			
Satisfaction	SAT1 Compared to other provider, I am very satisfied with my SaaS provider	0.94**	0.86	0.95/0.92	−3.63/1.84
	SAT2 Compared to other provider, my SaaS provider always meet my expectations	0.93**			
	SAT3 Compared to other provider, the overall service quality of my SaaS provider is best	0.92**			

** $p < 0.05$, CR = composite reliability; CA = Cronbach's alpha.

Table 4
Discriminant validity.

	Perceived value	Satisfaction	Security	Service quality	Responsiveness	Trust
Perceived value	**0.88**					
Satisfaction	0.78	**0.93**				
Security	0.60	0.53	**0.90**			
Service quality	0.61	0.64	0.51	**0.93**		
Responsiveness	0.55	0.61	0.55	0.54	**0.85**	
Trust	0.59	0.61	0.65	0.52	0.58	**0.91**

Boldface numbers on the leading diagonal are the square root of the variance shared between the constructs. Off-diagonal elements represent correlations among constructs.

of these path coefficients provides additional evidence in support of the research model (see Table 5). Estimated R^2 values for the two dependent variables were quite high, being 50% for perceived value, 51% for trust, and 65% for satisfaction.

We conducted meditation effect tests to detect the significance of indirect effects of perceived value in the relationship among service quality, security, responsiveness and satisfaction. First, we removed perceived value and trust from the structural model so that satisfaction was directly regressed by service quality, security and responsiveness, as depicted in Fig. 4. The estimated R^2 value for Satisfaction was 53%. Second, we calculated the change in R^2 to gauge the variance improvement when the mediator is added. The result indicated a significant F-change when the mediator was added (R-change = 0.12, F = 21.11 (1, 129), $p < 0.01$).

We then used a covariance-based technique to produce 1000 bootstrap samples and requested 95% bias-corrected confidence intervals to detect mediated effects [73]. The p-values for the indirect effect of service quality, security and responsiveness were 0.006, 0.003 and 0.002, indicating that perceived value does have a significant meditation effect.

7. Discussion and conclusions

We have extended prior understanding of the role of security in SaaS client satisfaction. Despite conceptual argument that security improves SaaS client satisfaction, to date, no study has empirically observed the relationship. We advanced an explanation of client satisfaction that was predicated on the perceived value of security as a mediating variable. We adapted a prior model of SaaS satisfaction to include security and perceived value, and tested the model using a survey of 135 SaaS client firms. Our model explained 50% of perceived value which in turn explained 65% of client satisfaction. This study provides evidence of the mediating role of perceived value in the SaaS context, thereby enhancing satisfaction toward an IT application service provider.

We have made a number of findings in this study, which we discuss here. First, our structured review of prior journal articles on security in the SaaS context revealed a predominance of artifact development and conceptual papers. We observed very few empirical works, especially of client-side factors such as satisfaction. We also saw that, while numerous studies argues that security is conceptually important to client satisfaction, we could not find any study that had empirically validated the relationship.

Second, our empirical analysis revealed that security does have a significant effect on satisfaction when it is mediated by perceived value. As has been seen in prior research, our unmediated model revealed an insignificant relationship with satisfaction. Therefore, security perceptions only affect satisfaction when security is seen by clients as a valuable addition to the service complement. Introducing a raft of security features does not necessarily lead to a more satisfied client; rather, the feature's specific contribution to service provision

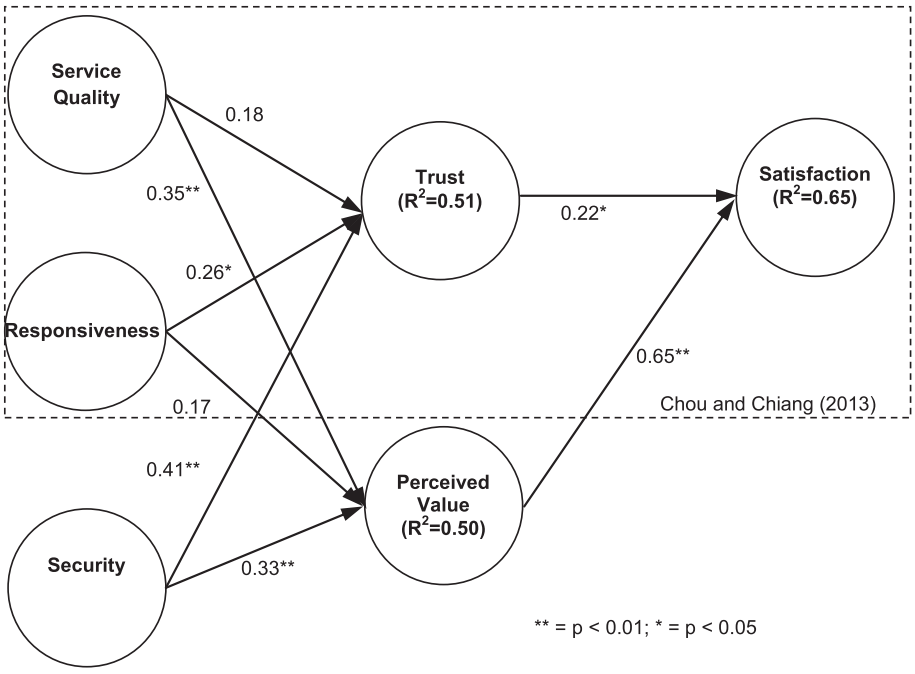

Fig. 3. Structural model results.

Table 5
Hypotheses testing results.

Hypothesis	Statement	Result
H1a	Service Quality positively affects the SaaS customer's Trust of the provider	Not supported
H1b	Service Quality positively affects the SaaS customer's Perceived Value of the provider	Supported
H2a	Responsiveness positively affects the SaaS customer's Trust of the provider	Supported
H2b	Responsiveness positively affects the SaaS customer's Perceived Value of the provider	Not supported
H3a	Security positively affects the SaaS customer's Trust of the provider	Supported
H3b	Security positively affects the SaaS customer's Perceived Value of the provider	Supported
H4	The SaaS customer's Trust in the provider positively affects the customer's Satisfaction with the provider	Supported
H5	The SaaS customer's Perceived Value of the provider positively affects the customer's Satisfaction with the provider	Supported

and continuity must be made clear to clients. However, our finding also suggests that some clients will not perceive security to be important, depending on their particular operating arrangements.

We found that responsiveness was significantly related to trust but not perceived value. This finding suggests that the provider's willingness and ability to modify the service helps the provider see a joint benefit and mutual welfare in the relationship, thereby building trust. Prompt responsiveness also improves control perceptions, in turn allowing the client to continue with its operations without hindrance, thereby improving trust [82]. The need for control is likely to be even more important for highly separated contexts (such as SaaS) [71]. However, this flexibility is not intrinsically valued because the client may not need flexible service arrangements in order to operate.

The analysis also revealed that service quality was related to perceived value, but not trust. This finding suggests that clients value service that meets their operational requirements, but that this does not build trust. It is the delivery of this service that contributes most strongly to satisfaction. In this respect, service quality may be a hygiene factor in that a client expects that a provider is able to meet their expectations from the outset: a provider that does not meet a client's service expectations is not deemed a suitable partner, and hence the client discontinues the relationship. This contention is especially relevant in the SaaS context, where clients can switch between providers much more quickly than in traditional outsourcing arrangements [7].

Fig. 5 shows our revised model of SaaS client satisfaction, illustrating the direct paths between Responsiveness and Trust, and Service Quality and Perceived Value respectively.

The study may be subject to two limitations. One limitation is that only current SaaS customers were surveyed. This means that the results cannot necessarily provide insight into those outsourcing relationships that failed or expired. A second potential limitation is that the sample was restricted to firms in a single geographic area. Studies conducted in other regions may see varying results, however this limitation is likely to affect numerous prior works into ASP and SaaS client activities with a geographical focus [7,39,63].

Our findings have a number of implications for SaaS proprietors. First and foremost, our findings illustrate the delicate path of managing security and the appearance of security in the SaaS context. Our analysis shows that in order to garner maximum satisfaction effects from clients, they must be able to demonstrate the usefulness and value of the security measures that they have in place. It is not sufficient to merely add security features, as this will not directly increase client satisfaction. Rather, the relevance of these measures must be clearly demonstrated to clients. In turn, the value placed on these measures by clients is likely to relate closely to the business preferences of each client. To this end, McAfee Labs [64] argues, "This loss of direct control of the enterprise security perimeter puts tremendous pressure on security leaders and administrators to make sure that the cloud provider's user agreement and operating procedures ensure security measures are both in place and constantly upgraded to meet the evolving threats landscape."

Second, some practitioner literature, such as [28], has advocated introducing new features in order to spur uptake and satisfaction. However, the drive to install new features may be costly and operationally burdensome to the SaaS if clients do not perceive adequate value in

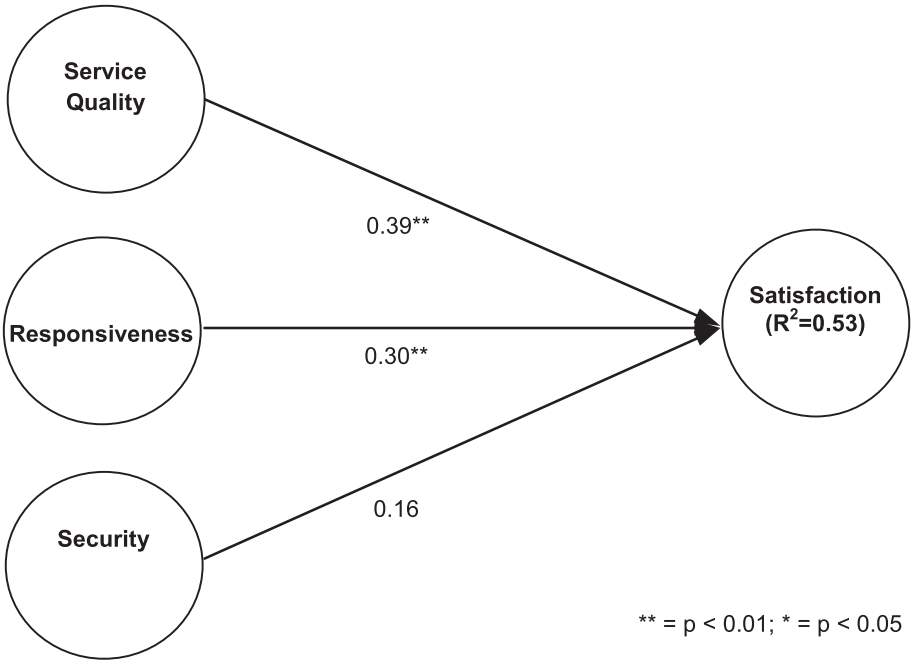

Fig. 4. Non-mediated structural model.

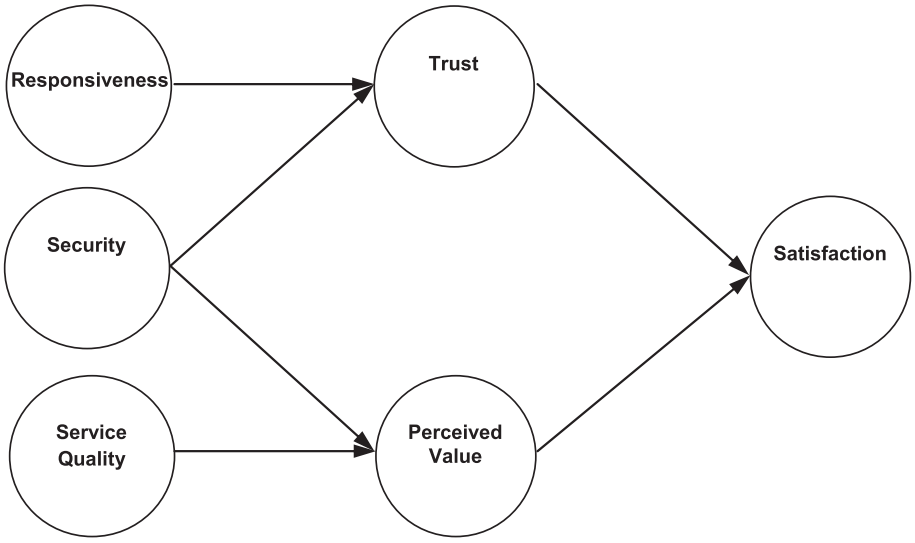

Fig. 5. Revised model of SaaS satisfaction.

these initiatives. Keeping abreast of SaaS customer requirements will help the SaaS in identifying and responding to those customer needs that are likely to yield the greatest value and satisfaction. Such a strategy could assist the SaaS to understand the components of service quality, thereby focusing operational resources on the innovations that are likely to deliver satisfaction outcomes. Managing fewer but more effective innovations is also likely to improve responsiveness levels, another important construct in our model.

Several areas for future research extend from our model. Our literature review revealed a paucity of empirical studies conducted at the client level, and only one from the provider perspective. Future research ought to examine security provisions from the provider side in order to understand how SaaS providers manage security strategy. Our empirical testing revealed two unexpected findings, that responsiveness was related to trust but not perceived value, and that service quality was related to perceived value but not trust. This finding may be due to the highly separated nature of SaaS relationships, or it may also apply to more traditional outsourcing arrangements. This surprising finding begs further enquiry. Finally, we have illuminated the role of security in explaining SaaS satisfaction: it would be useful to apply our model configuration to other important SaaS questions, such as service switching behavior, and co-location arrangements.

Appendix A. Literature review of security in cloud and "as-a-service" offerings

We conducted a structured literature search of all journal articles that examined on the topic of security in application service provision (ASP), as-a-service offerings (e.g. SaaS, PaaS, IaaS) and on-demand online services. We began our search using a variety of keyword queries through Google Scholar and Elsevier Scopus, followed by a citation trail analysis to find additional papers. We sought only scholarly academic works, and excluded conference articles, white papers, book chapters and practitioner papers. The full citation list is available from the lead author on request.

Citation	Context	Artefact	Research Method	Findings
Ekanayaka et al. (2003)	ASP	Conceptual		Develops a customer-focused framework for evaluating ASPs, including on the basis of ASP security.
Soliman et al. (2003)	ASP	Conceptual		Identifies critical success factors for successful ASP operations. Security is seen as a critical problem in outsourcing services via the internet.
Walsh (2003)	ASP	Conceptual		This paper presents an overview of the application service provision model. Security and reliability are seen as the most important characteristics of the ASP provider.
Leem and Lee (2004)	ASP	Survey and framework development	Survey, n = 35 Korean firms	Develops a framework for ASP efficiency based on a survey of firms, including an audit process for identifying and measuring efficiency.
Trickey and Barshefsky (2004)	Network applications	Artefact development		This paper prepares a security architecture for large network applications, allocating roles and users to objects within a hierarchy.
Ma et al. (2005)	ASP	Survey and framework development	Survey, n = 123 ASP clients	This paper develops a list of factors affecting service quality. The paper identifies seven factors, being features, availability, reliability, assurance, empathy, conformance, and security.
Ceselli et al. (2005)	ASPs and data centers	Artefact development		This paper develops a technique for querying databases securely. The approach uses information indexes instead of actual database query text, in order to limit data exposure.
Fu and Zhang (2006)	ASPs	Artefact development		Develops an algorithm that allocates the optimal number of firewalls for an application service provider in order to maintain user quality of service.

(continued on next page)

Appendix A(*continued*)

Citation	Context	Artefact	Research Method	Findings
Ogawa et al. (2007)	ASPs and grid computing	Artefact development		Proposes the GridASP framework, for secure and anonymous ASP service execution.
Kim et al. (2008)	ASP	Case Study	Case study of Korean ASP	Examines factors affecting perceived benefits of an ASP. Security is identified as a factor affecting customer satisfaction.
Li et al. (2009)	Software as a Service (SaaS)	Artefact development		Proposes automated trust negotiation as a solution to middleware security problems in SaaS networks.
Arinze and Anandarajan (2010)	Cloud computing	Conceptual		Discusses the concept of global use of cloud computing. Security is seen as an important component.
Kaufman (2010)	Cloud Providers	Conceptual development and case study		This paper examines security as-a-service offerings for cloud providers. A virtualisation model is proposed, using VMWare VMSafe API as a case study.
Kim (2010)	ASP	Case Study		This paper develops a framework for ASP quality management, incorporating customer and engineer perceptions. Security is seen as an essential component from both groups.
Liu et al. (2010)	SaaS	Artefact Development		This paper describes the development of an application to monitor user-level virtual machine security by way of a reference table to manage the status of executable software
Orakwue (2010)	Private clouds	Conceptual		This paper discusses the adoption of private cloud services in response to security threats.
Julisch and Hall (2010)	Managed Services	Conceptual		The paper advises on moving internally managed security services to the cloud, specifically for protecting outsourced assets.
Heart (2010)	SaaS	Survey and model development	Survey, n = 143 ASP Clients	This study developed and tested a model of SaaS adoption intentions, based on predictors such as trust, reputation, provider capabilities, and perceived risk. Perceived risk and insecurity were negatively related to intention to adopt.
Yagi et al. (2010)	Cloud computing	Artefact development		This paper proposes a mechanism for filtering malicious web traffic by identifying downloads from previously identified malicious sources.
Chonka et al. (2011)	Cloud computing	Artefact development		This paper recreates a Denial of Service (DoS) attack on a cloud computing service and proposes a neural network solution for detecting malicious traffic.
Mahesh et al. (2011)	Cloud computing	Conceptual framework		Develops a decision framework for adopting cloud computing in small business. The framework includes security evaluations as a decision factor.
Benlian et al. (2011)	SaaS	Survey and framework development	Survey, n = 172 SaaS clients	This paper develops a model based on prior SERVQUAL measures, validated with field interviews and focus groups. Security was positively related to perceptions of provider quality.
Pop et al. (2011)	as a service offerings	Conceptual framework		Develops a metric for service dependency. Security contributes to a dependable service environment.
Wu (2011)	SaaS	Model development	Survey, n = 42 SaaS clients	Develops a model of SaaS adoption based on factors of TAM. Security is identified as a factor in client acceptance.
Alali and Yeh (2012)	Cloud computing	Model development	Archival data collection (n = 185 cloud firm-years)	This paper compares the audit risk of cloud and non-cloud computing firms/ Security was not an important audit risk factor.
Baars and Spruit (2012)	Cloud computing	Framework development	Delphi study (n = 17 client firms)	This paper develops an architecture for secure cloud computing, using input from field experts.
Baldwin and Cromity (2012)	SaaS	Conceptual		This paper reviews the viability of SaaS as a cloud business platform. Data security is seen as a perceived disadvantage for clients.
Pathirage et al. (2012)	Cloud computing	Artefact development		Develops an architecture for multi-tenant service management in cloud computing environments. Allows managers to use a single workflow engine across clients.
Bayrak (2013)	ASP	Conceptual		Assesses the advantages and disadvantages of ASP over traditional software models. Security is a significant disadvantage to the application service provider model.
Demirkan and Goul (2013)	Cloud computing	Artefact development		Proposes a broker model for managing processes execution in a cloud environment, based on contracts between clients.
Du et al. (2013)	SaaS	Model development and survey	Four surveys, n = 1532	Service quality, usefulness, and social influence are most important user perceptions for predicting intention to use SaaS services.
Han (2013)	As a service offerings	Conceptual		Reviews approaches to using cloud computing services. Clients are advised to monitor security requirements.
Li et al. (2013)	Cloud computing	Artefact development		Proposes a desktop client for secure virtual desktop sharing in the cloud environment. This supports remote provider diagnosis of client problems.
Lee et al. (2013)	SaaS	Framework development and survey	Survey of 24 SaaS consultants	Paper develops an inventory of SaaS adoption drivers and inhibitors. Security is seen as a major inhibitor of adoption.
Xu et al. (2013)	SaaS	Artefact development		Security risk adversely affects SaaS providers. This paper develops a user authentication service based on proxy signatures.
Mouratidis et al. (2013)	Cloud computing	Framework development and case study	A UK firm supplying electronic POS services	This study develops a framework and modeling language for selecting cloud computing providers according to security requirements, based on threats, goals and vulnerabilities for security and privacy.
Oliveira et al. (2014)	Cloud computing	Model development and survey	Survey (n = 384 SaaS clients)	This paper develops a model of cloud computing adoption, comprising factors of innovation characteristics and technology, organisational and environmental context. Security was not significantly related to relative advantage.

Appendix B. Testing for non-response bias.

Construct	Mean (early respondents)	Mean (late respondents)	Statistical significance
Service quality	4.90	4.94	t-value = −0.186, p = 0.85
Security	5.02	5.22	t-value = −0.884, p = 0.38
Responsiveness	4.71	4.68	t-value = 0.139, p = 0.89
Perceived value	4.71	4.69	t-value = 0.121, p = 0.90
Trust	4.87	5.03	t-value = −0.864, p = 0.50
Satisfaction	4.65	4.62	t-value = 0.142, p = 0.89

Appendix C. Common method bias analysis

		Substantive Factor		Method Factor	
Constructs	Items	Loading	Variance explained	Loading	Variance explained
Service quality	OSQ1	0.92**	0.85	−0.07	0.00
	OSQ2	0.87**	0.76	0.10	0.01
Security	SEC1	0.99**	0.98	−0.10	0.01
	SEC2	0.93**	0.86	−0.06	0.00
	SEC3	0.86**	0.74	0.01	0.00
	SEC4	0.73**	0.53	0.17**	0.03
Responsiveness	SR1	0.72**	0.52	0.15**	0.02
	SR2	0.89**	0.79	−0.14**	0.02
	SR3	0.88**	0.77	−0.12	0.01
	SR4	0.58**	0.34	0.34**	0.12
Perceived value	PV1	0.82**	0.67	0.10	0.01
	PV2	0.90**	0.81	−0.06	0.00
	PV3	0.94**	0.88	−0.05	0.00
Trust	TR1	0.97**	0.94	−0.10	0.01
	TR2	0.94**	0.88	0.00	0.00
	TR3	0.85**	0.72	0.09	0.01
Satisfaction	SAT1	0.97**	0.94	−0.03	0.00
	SAT2	0.93**	0.86	0.72**	0.52
	SAT3	0.71**	0.50	0.24**	0.06
Average		0.86	0.75	0.05	0.04

Appendix D. Item and construct cross-loadings.

		SQ	SEC	SR	PV	SAT	TR
Service quality	OSQ11	**0.91**	0.41	0.43	0.49	0.55	0.48
	OSQ12	**0.95**	0.52	0.53	0.63	0.64	0.49
Security	SEC1	0.41	**0.91**	0.43	0.51	0.46	0.59
	SEC2	0.39	**0.88**	0.47	0.49	0.44	0.50
	SEC3	0.44	**0.87**	0.48	0.53	0.43	0.58
	SEC4	0.53	**0.87**	0.53	0.58	0.53	0.60
Responsiveness	SR1	0.48	0.49	**0.84**	0.47	0.54	0.52
	SR2	0.27	0.32	**0.82**	0.30	0.36	0.39
	SR3	0.35	0.37	**0.77**	0.33	0.32	0.34
	SR4	0.57	0.55	**0.86**	0.57	0.60	0.54
Perceived value	PV1	0.61	0.56	0.50	**0.91**	0.76	0.56
	PV2	0.50	0.55	0.37	**0.85**	0.61	0.48
	PV3	0.51	0.49	0.49	**0.90**	0.69	0.52
Satisfaction	SAT1	0.62	0.48	0.52	0.73	**0.94**	0.55
	SAT2	0.53	0.41	0.49	0.69	**0.93**	0.48
	SAT3	0.64	0.59	0.58	0.76	**0.92**	0.65
Trust	TR1	0.40	0.54	0.44	0.50	0.50	**0.88**
	TR2	0.49	0.62	0.51	0.54	0.56	**0.94**
	TR3	0.54	0.61	0.58	0.57	0.59	**0.92**

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