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Diffusion of innovation: customer relationship management adoption in supply chain organizations

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Abstract

The successful diffusion of innovations in rapidly changing supply chain technological environments is essential to support operations and supply chain management functions. In this paper we conceptualize and develop a framework for research into the diffusion of innovations in organizations pertaining to software adoption in supply chain management. Incorporating Task-Technology Fit theory with a network externalities model, we develop a novel approach in customer relations management (CRM) software adoption. An empirical study using Partial Least Squares (PLS) on data from US supply chain managers is utilized to confirm the usability of the proposed framework as well as confirming the efficacy of the proposed combined methodological approach suggested in this paper. The results also show the direct and indirect network externalities of system quality, ease of use, system reliability, and authority can moderate the CRM adoption relationship in organizations, suggesting the possibility that other moderating network externality variables may impact CRM adoption.

Keywords: Innovation diffusion; Customer relations management; System quality; Software adoption

Background

Organizational *innovation* can be viewed as a value added structure, practice, or technology new to the organization adopting it [75]. Organizational innovation has also been defined simply as "the adoption of an idea or behavior that is new to the organization adopting it" [17]. *Diffusion*, a related subject, is a process by which innovation spreads among or within organizations [63]. Supply chain managers adopt and integrate innovatively new structures, practices, and technologies and diffuse them in areas of responsibility throughout their organizations. In this paper we study the diffusion of an innovation (i.e., a customer relations management (CRM) software application) within supply chain-oriented organizations.

Few business fields require more continuous change, innovation, re-innovation, and subsequent diffusion of those innovations than supply chain management. As Slone *et al.* [67] point out; keeping up with supply chain technologies is essential to achieving supply chain excellence. A key technology element supporting supply chain activities, according to Slone *et al.* [67], is the software systems used to provide information flow on which decisions are made. Supply chain managers employ ERP systems in their supply chains, which utilize a modular set of software applications to support the operations of organizations. One example of a module is *customer relations management* (CRM) software, which in its adoption can constitute an innovation. CRM can be defined as a cross-functional process that seeks to enhance customer value by integrating information technology and relationship marketing strategies [45]. The relationship and importance of CRM to supply chain management is clearly documented in supply chain literature. Kleindorfer and Saad [43] suggest the CRM module in ERP systems is a critical element of a supply chain network. Kleindorfer and Saad [43]; Hvolby [36] also suggest that CRM use represents a growing trend in supply chain management.

Generally, software is a technology that can be evaluated in terms of usability (i.e., fit) and benefits it brings to an organization. One of the evaluation methodologies relevant to this paper is the *task-technology fit* (TTF) model. TTF is an evaluation scheme proposed by Goodhue [28] for evaluating information technology in terms of the task it is expected to perform, the nature of the technology itself, and the individuals who will use it. TTF model conjectures that a better fit between technology functionalities, task requirements, and individual capability will lead to better performance [28]. The better the fit of technology the better the opportunity to enhance or innovate quality results from software. Supply chain benefits of software use, beyond the informational value, include what Katz and Shapiro [39, 40] refer to as *network externalities* (e.g., the value of information technology is dependent on the number of others using it). Network externality posits that the more a technology is adopted, the more value it is perceived to have for any particular user and therefore, the greater the desire to adopt and use it [40, 52]. In this paper, we argue that both the TTF evaluation scheme and the perceived network externality benefits in CRM are critical success factors in any adoption procedure of software in supply chain management.

We selected CRM as a technology adoption in this study because of its current importance as a basis for collaboration between marketing and operations/supply chain management. Collaboration between functional areas, like marketing and operations, is currently the focus of considerable research interest [22, 23, 49, 58]. Relevant to the subject of quality innovation, collaboration and knowledge sharing across organizational boundaries are important factors in broadening the opportunities for innovation in quality management. There is a need for such research considering Li [49] found that the conflict between marketing and supply chain management caused moderating effects in supply chain performance. In addition, both academic [21] and practitioner [31] literature have extolled the critical value of the use of CRM within organizations who view supply chain management as strategically important.

In reviewing CRM adoption literature there appears to be little attention given to the supply chain perspective regarding the innovation diffusion of CRM software selection in ERP systems. Only one paper directly dealt with supply chain management and CRM adoption [10]. Cheng [10] compared institutional theory to organizational learning theory in the context of adopting CRM as a social/behavioral action to legitimize its use. While other reasons, including the acquisition of knowledge, were factors in supply chain software acquisition, Cheng's study did not address the linking of CRM adoption to innovation diffusion in the context of supply chain management.

To fill the research gap linking supply chain and innovation diffusion we developed an integrated model of adoption for CRM in the context of supply chain management. Our integrated model is a viable approach to the adoption of this technology, because it combines TTF quality theory [27] with network externalities [39, 40]. Because CRM is a technology that provides the most value when it is systemic (i.e., other firms also adopt), we argue that network externalities have a distinct moderating effect on CRM adoption.

The rest of the paper is organized as follows. We discuss relevant literature in the second section. In the third section, we explain the specific relationships in our model and describe how network externalities moderate the relationships between the TTF model constructs and adoption. Our survey and our statistical procedures are presented in the fourth section. In the fifth section we present our results. Managerial and research implications are discussed in the sixth section. Some limitations and suggestions for future research are presented in the seventh section.

Literature review

The study of technical innovations has been undertaken using theories that explicitly take into account characteristics of the particular technology [9, 14]. Chau and Tam's [9] study of the adoption of open systems is based on the technology-organization-environment (TOE) framework and notes that "the innovation is primarily of a technical nature" [9]. Elsewhere, an extensive research program to study the adoption of e-business has also applied the TOE framework. Here a technical innovation is defined as the use of the Internet with its associated standards and protocols [78]. The adoption of electronic data interchange (EDI) has been investigated using the diffusion of innovation (DOI) theory [60]. Also, the adoption of computer networks for academic research [32] and EDI [14] has been investigated and been shown to explain how these technologies possess network externalities. While several theories may be appropriate for investigating the adoption of technical innovations, the salient point is that in each of the studies listed above, the authors selected a theory that considers the technical characteristics of the innovation.

Task characteristics, technological characteristics, and task-fit (TTF) theory [28] suggest IT is more likely to have a positive impact on individual performance and will be used if the capabilities of the IT match tasks the user must perform. Goodhue and Thompson [27] developed a measure of TTF that includes eight variables: quality, locatability, authorization, compatibility, ease of use/training, production timeliness, systems reliability, and relationship with users. Zigurs and Buckland [79] extended the TTF model by examining the impact of task-fit on group performance.

We argue the TTF model is a suitable theory for the study of CRM adoption for several reasons. First, our reasoning is based on the relationship between the IT innovation and the primary business process of organizations. A business process is a set of activities or tasks to produce a specific output [18]. In other words a business process serves a particular goal. The primary business process constitutes the core business and creates the primary value stream. Hence, these goal-oriented activities or tasks need to be considered to investigate the adoption of business process IT innovations. In information systems (IS) literature the task-technology fit (TTF) perspective "views technology as a means by which a goal-directed individual performs tasks" [28].

TTF suggests that the better fit between technology and the required task, performance of the organization will be improved. TTF does not look at features of technology in isolation, but rather how these features align with the requirements of a task or tasks to achieve organizational goals. As such, the adoption of IT innovation can be explained by the intention of the organization to improve organizational performance through the fit between task and technology. Secondly, TTF has been mainly used to explain the adoption of IT innovations by individuals [20], while Cooper and Zmud [16] suggest a link between TTF and adoption at the organizational level. Ozdemir and Abrevaya [55] examined the adoption of technology-mediated distance education through a TTF lens. This technology changes how distance education is delivered and therefore, is a business process IT innovation. In addition, while some studies have not used the term "task-technology fit", they still investigate similar constructs as those in TTF. For example, compatibility is often used in innovation adoption studies, specifically, the compatibility between task and technology, which is very similar to the concept of task-technology fit [16]. Thus, the TTF perspective matches well with the characteristics of business process IT innovations that change how goal-oriented tasks are performed. Third, the precedent in prior literature examined interorganizational systems, a type of business process innovation using the TTF theory (e.g. [14, 30]). Because CRM enables the transfer of information to partners along the supply chain, it is an interorganizational system [66]. We, therefore follow the precedent set in prior literature and affirm the arguments of other researchers, who found the adoption of interorganizational systems to be well-explained by TTF theory. Thus, TTF theory appears to be an appropriate choice for this research.

In spite of prior empirical support for TTF theory it has limitations. One limitation we discerned in the theory framework is that while it has been used to investigate interorganizational systems, it does not consider the possible interorganizational impact of a technology. We suggest the predictive power of TTF-based models of adoption can be enhanced by integrating network externalities with the TTF framework, a topic upon which we will expand in the next section as our hypotheses are developed.

Research model and hypotheses development

Research model design

In the present paper we seek to extend the task-technology fit (TTF) theory [28] by integrating the network externalities concept [39, 40] into the TTF model in predicting IT (CRM) adoption. More specifically, we examine how the task-technology fit and network externalities influence the CRM adoption. Further we explore the alignment between the TTF and network externalities and its impact on CRM adoption. All of the above relationships are depicted in Fig. 1.

While the direct link between the task-technology fit and network externalities and CRM adoption are explicit in IT adoption research [28, 65, 79], the theoretical underpinning of the interaction between TTF and network externalities is more implicit and less researched area. We argue that the network externalities and TTF or the fit between CRM system and the major business processes of the firm are not two independent forces driving the adoption of CRM system. The two forces interact with each other. Network externalities moderate the relationship between TTF dimensions and the adoption of CRM system, which serves as an enhancer. In other words, the benefits of TTF will be increased if more firms are using CRM system. Therefore, if a firm believes there is a good

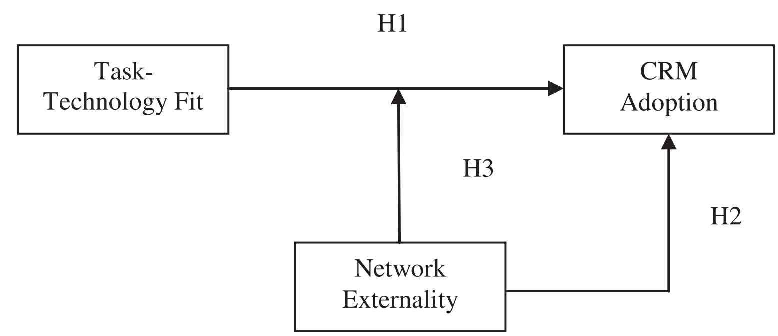

Fig. 1 Research model

fit between CRM system and business processes (TTF) and also see many adopters of CRM system in its network, they will be more likely to adopt the CRM system.

TTF model

Our research was built based of the TTF framework. We tailor our task characteristics, technological characteristics, and task-fit antecedents to the specific context and innovation, as suggested in prior research [9, 27, 65]. We then go beyond existing research, based on the TTF framework, by integrating it with network externalities that moderate the relationships between the TTF factors and adoption. We integrate network externalities with the TTF framework, because CRM is an approximate information technology that provides value to the organization on its own, yet provides even greater value as partner organizations begin to use it. This is particularly true for supply chain-oriented firms who are dependent on supply chain partners. Our research model is illustrated in Fig. 1. Detailed rationales for each of our hypotheses follow.

Building on rational choice theory (i.e., decision maker balances costs against benefits to arrive at action that maximizes personal advantage), Delone [19]; Goodhue [28] argued the antecedents in technology adoption by an organization are the characteristics of the technology as perceived by the organization as a whole. For instance, the task–technology fit model argues that users form an opinion of suitability of a technology based on perceptions of how the technology fits their task requirements [28]. The fit between the task and the technology is also likely to be examined by members during a group interaction process (e.g., [65, 79]). The group's perceptions regarding the fit of the technology for the group's task at hand will positively influence the adoption intent towards the technology. This leads to the following hypothesis:

> ***Hypothesis H1***: *The user's perception regarding the fit of CRM for its task will positively affect the adoption of CRM in supply chain organizations.*

Goodhue and Thompson [27] tested the specific IS properties/technology characteristics, including information quality, locatability, authorization, system reliability, and ease of use. Specifically, Goodhue [28] found the ability to create or innovate with information quality or ease of use facilities could be inhibited or enhanced by perceptions of these technology characteristics. Goodhue [28] also validated the TTF characteristics with an empirical study in manufacturing and supply chain distribution systems as they relate to technology adoption. Others have also tested the characteristics relating to technology adoption supporting a theoretical foundation for the development of further hypotheses. Briggs *et al.* [6] has shown technology adoption can be impacted by the perception of ease of use. Zigurs and Buckland [79] developed a specific theory relating TTF characteristics to technology adoption decisions. Sarker and Valachich [65] found ease of use and other TTF characteristics impacted technology adoption. We treat "locatability" as part of "ease of use". Hence, we include the following four sub-hypotheses:

Hypothesis H1a: *The user's perception regarding system quality will affect the adoption of CRM in supply chain organizations.*
Hypothesis H1b: *The user's perception regarding ease of use will affect the adoption of CRM in supply chain organizations.*
Hypothesis H1c: *The user's perception regarding system reliability will affect the adoption of CRM in supply chain organizations.*
Hypothesis H1d: *The user's perception regarding authorization will affect the adoption of CRM in organizations.*

Network externalities

When the value of an innovation relies on the number of other users who adopt that innovation, positive adoption externalities, also known as network effects or *network externalities,* exist [39, 40]. *Network effects* can be either *direct*, which are the physical effects of being able to exchange information, or *indirect*, which arise from organizational interdependencies in the use of complementary goods [39, 40, 77]. A positive direct network effect is witnessed by the value of a telephone as more users become part of a telecommunication network. A positive indirect network effect is evidenced by how the usage of a complementary product or network (e.g., a faster computer operating system) increases the value of other computer software products (e.g., other software applications). Sahav and Riley [64] have shown pursuing direct network externality effects can help develop indirect network effects in new product development innovation.

Numerous technologies are said to generate network effects, including computer networks for academic research [32], EDI [14], and open-standard interorganizational systems [1, 61, 78]. Choi *et al.* [13] argued that the availability of software (e.g., open source) provided positive network externality effects. In each case the value of being a member of the network of adopters increases with each additional adoption decision. For instance, EDI increases in value as partners in a supply chain adopt it. In contrast if only one firm adopts EDI, it only gains a new data format and new standards. In this case there is no positive network externality effect benefit to be gained by exchanging newly standardized information with partners.

"Technologies that are subject to network externalities, have unique characteristics and traditional explanations of innovation diffusion, do not accommodate those characteristics," [41]. Therefore, we chose to integrate network externalities with TTF theory in our research model, because of the strength of TTF theory for adoption research and its ability to consider organization characteristics. A particular strength of the economic approach to adoption via network externalities is that interorganizational impacts of a technology can be examined. Complementarity between two theoretical approaches can be detected by understanding the fact that organizations adopt innovations when there is a "critical mass" of fellow adopters. This is an idea within organizational research that is markedly similar to network externalities [32, 62]. Thus, an economics approach can be paired with a framework that explains the diffusion of an innovation providing unique insights and developing a comprehensive model of the adoption of innovations [32]. The inclusion of network externalities in our research model enables us to go beyond the TTF theory rationale for organizational adoption to examine how interorganizational effects also contribute to adoption.

CRM is a technology that possesses significant network effects in addition to its stand-alone benefits [48]. CRM, like ERP and other interorganizational systems, allows a firm to benefit from both direct network effects such as exchanging object information with business partners and indirect network effects resulting from interdependency. All direct network effects arise from sharing information. Similarly, as more companies adopt CRM, the prices of hardware, software applications, and middleware should decline as the size of the market increases due to economies of scale, competition, and technological development. Furthermore, the ease with which consulting expertise can be accessed should increase. These benefits are indirect network effects. Therefore, we hypothesize:

Hypothesis H2a: *Higher levels of perceived direct network effects are positively associated with the adoption of CRM in supply chain organizations.*

Hypothesis H2b: *Higher levels of perceived indirect network effects are positively associated with the adoption of CRM in supply chain organizations.*

Moreover, we suggest not only a direct effect of network externalities on adoption, but also an indirect effect as well. Specifically, we posit that direct and indirect network effects will strengthen the positive relationship between the fit of CRM for its task and the adoption of CRM in organizations. While there is no CRM or software-based research to support our posit, prior research on food service has shown traceability can create positive network externalities in a supply chain that can moderate the willingness of manufacturers to pay for technologies needed to undertake the innovation [69]. Also, Wareham *et al.* [76] found that network externalities have an impact on supply chain performance and can lead to more efficient, direct and indirect flows in information.

We argue CRM is a technology that possesses network externalities and therefore, hypothesize:

Hypothesis H3a: *Higher levels of perceived direct network effects will moderate the relationships between TTF and the adoption of CRM in supply chain organizations.*
Hypothesis H3b: *Higher levels of perceived indirect network effects will moderate the relationships between TTF and the adoption of CRM in supply chain organizations.*

Methods

Sample

The unit of analysis in this study is the company and the respondents of the survey include IT decision makers in supply chain companies (e.g., CIO, CTO, or the Director of IT). An initial pool of companies was randomly chosen from the *North American*

Industry Classification System (NAICS) Manual. Validating questions in the survey were used to confirm the strategic importance of supply chain management and the use of information systems to support specific supply chain activities within the sample organization.

We distributed a total of 1,000 questionnaires in a single mailing by US Postal Service. We received 201 responses with 178 usable ones rendering a response rate of 17.8 %. The unusable surveys comprise of those firms that adopted CRM or responses that did not contain adequate data for further analysis. Given the unit of analysis is the firm and the questionnaire involves extensive organizational level questions, the response rate is considered as acceptable [29].

To examine possible non-response bias, we compared the companies that responded with non-responding companies. There is no statistically significant difference (at the $p < 0.1$ level) when comparing the distributions of company size (i.e., the number of employees) showed [25]. Table 1 presents the descriptive statistics of the respondents.

Questionnaire construction and operationalization of constructs

The TTF construct measures were adapted from survey instruments used by Kositanurit *et al.* [46]. There are four dimensions in task-technology fit in their study, including system quality, ease of use, authorization, and system reliability. The perceived value of a network has been explored in various studies ([26, 41]), and perceptual measures have been developed [56, 78]. We adopted both direct and indirect network externalities measures

Table 1 Descriptive statistics of the sample

Characteristics	Number of respondents	Percentage of respondents
Type of industry		
Manufacturing (NAICS 31–33)	60	34 %
Construction (NAICS 23)	35	19 %
Mining, quarrying, and oil and gas extraction (NAICS 21)	32	18 %
Transportation and warehousing (48–49)	28	16 %
Utilities (NAICS 22)	23	13 %
Total	178	100 %
Number of employees		
Less than 500	25	14 %
Between 500 and 1000	98	55 %
More than 1000	55	31 %
Annual sales (in millions)		
Less than 100	23	13 %
>100–500	87	49 %
Between 500 and 1 billion	52	29 %
More than 1 billion	16	9 %
Respondent's job position		
CIO	78	44 %
CTO	59	33 %
IT director	41	23 %
Avg. number of yrs. in position	5.3 years	

from the study by Song *et al.* [68]. There are a total of 18 items measuring 3 constructs (7 variables) in our proposed CRM adoption model. The items from the survey instrument are shown in Table 2. Control variables in our study included firm size, department size, and industry.

We conducted a pilot study by distributing the preliminary questionnaire to IT executives in several supply chain oriented companies located in a midwest city. We asked IT executives to evaluate the degree to which the preliminary questionnaire captured

Table 2 Survey items, reliability, factor loadings and convergent validity

Construct (Reliability α)	Survey items	Indicator	Loadings (**$p < 0.01$)	Convergent validity (t-statistic)
Direct network externality (0.83)	My company would be willing to pay more for CRM system if more people use the system.	Dir1	0.80**	9.83
	Having CRM system is a status symbol for my company.	Dir2	0.75**	8.77
Indirect network externality (0.85)	The more CRM applications available, the more valuable CRM is to my company.	Ind1	0.76**	9.03
	The more CRM middleware available, the more value of CRM is to my company.	Ind2	0.78**	9.91
	There are a lot of companies that have adopted CRM system.	Ind3	0.83**	11.25
	The more companies which have CRM systems, the more valuable CRM system is to my company.	Ind4	0.80**	10.38
Intend to adopt (n/a)	How likely will your company adopt CRM system in the next 12 months?	Int1	n/a	n/a
System quality (0.91)	The data provided by CRM system is up-to-date enough for my purposes.	Curr	0.89**	16.35
	The CRM system available to me is containing critical data that are very useful to me in my job.	Rdat	0.87**	15.21
	The CRM system maintains data at an appropriate level of detail for my group's tasks.	Rdet	0.83**	12.17
	The exact definition of data fields relating to my tasks is easy to find out.	Mean	0.85**	13.36
Ease of use (0.84)	It is easy to learn how to use the CRM system.	Eou1	0.82**	11.34
	The ERP system I use is convenient and easy to use.	Eou2	0.83**	12.12
	There is a lot of training for me or my staff on how to find, understand, access of use the ERP system.	Tran	0.79**	10.84
System reliability (0.80)	The CRM system I use is not subjected to unexpected or inconvenient down times which makes it harder to do my work.	Reli1	0.78**	9.47
	The CRM system I use is not subjected to frequent system problems and crashes.	Reli2	0.81**	10.38
Authorization (0.77)	Data that would be useful to me are available because I have the right authorization.	Aut1	0.75**	8.86
	Getting authorization to access data that would be useful in my job is easy and convenient.	Aut2	0.68**	7.35

the constructs (variables) and to assess the level of difficulties of the preliminary questionnaire. Subsequently, we revised the questionnaire based on the feedback from the pilot study to gather responses from IT executives' supply chain organizations. The dependent variable is "intent to adopt" and it was measured as a categorical variable on a seven-point Likert scale (1–7), where 1 = no plan; 4 = neutral; 7 = definitely. Table 3 shows the correlation matrix.

Instrument validation

To assess the overall instrument validity, we examined scale reliability, unidimensionality, criterion-related validity, convergent validity, and discriminant validity [5, 71]. Cronbach's alpha is the *de facto* method of assessing the scale reliability in information systems research [8, 57]. We calculated Cronbach's alphas for all constructs and variables in the conceptual model [24, 74]. The Cronbach's alpha values shown in Table 2 were all greater than the threshold value of 0.70 for adequate reliability [53]. The scale items used in this research were thus considered reliable.

The unidimensionality test provides evidence of a single latent construct [24]. In this study, we employed Confirmatory Factor Analysis (CFA) to test the unidimensionality of the constructs as CFA is considered as a better technique for assessing unidimensionality than Exploratory Factor Analysis (EFA) [2, 54]. Table 2 shows the CFA loading results ranging from 0.68 to 0.89 (or moderate to high CFA loadings). Additionally, Table 2 also shows *t*-values for scale items were between 7.35 and 16.35, exceeding the 2.0 rule of thumb for significance of scale items. As such, the unidimensionality is confirmed in the study.

Convergent validity concerns the degree to which multiple methods of measuring a variable provide the same results. Stand-alone indices (LISREL) are used to test convergent validity.

Table 4 presents the summary of the CFA fit indices of the research framework for both one-factor and two-factor models. While GFI, AGFI, CFI, and IFI values exceeded the minimum cutoff value of 0.90, values of RMSEA (0.061), χ^2 (significant at level of 0.01), and χ^2/df (2.15) met the requirements for good fit. In addition, the Critical *N*

Table 3 Correlation matrix

Correlations										
Variables	1	2	3	4	5	6	7	8	9	10
1. System quality	1									
2. Ease of use	0.12	1								
3. System reliability	0.34	0.11	1							
4. Authorization	0.24	0.29	0.25	1						
5. Direct network externality	0.22	0.26	0.19	0.23	1					
6. Indirect network externality	0.28	0.23	0.21	0.25	0.29	1				
7. Firm size	0.07	0.05	0.06	0.04	0.06	0.04	1			
8. IT dept size	0.05	0.09	0.08	0.07	0.06	0.03	0.21	1		
9. Industry	0.03	0.04	0.05	0.06	0.04	0.05	0.07	0.06	1	
10. Adopt	0.36	0.31	0.27	0.26	0.32	0.28	0.08	0.05	0.04	1

Table 4 Summary of CFA fit indices

	χ^2 (p<0.01)	df	χ^2/df	GFI	AGFI	CFI	IFI	RMSEA	Critical N
Recommended values			<3.0	>0.90	>0.90	>0.90	>0.90	<0.06	< N
Fit indices values	135.21	63	2.15	0.96	0.93	0.94	0.95	0.061	77

(77) was smaller than the sample size (178), indicating that the research model is a good fit.

The results shown in Table 4 also suggest that for every pair of Stand-alone indices in the measurement model, a two-factor model had a better fit than that of a one-factor model, demonstrating satisfactory discriminant validity [3, 15, 33, 34, 38, 42, 44].

Taken together, the constructs and measuring items in this study have good convergent and discriminant validities.

The structural model

In this study two types of structural equation modeling (SEM) were used in data analyses. While LISREL (i.e., a covariance-based SEM) was used for construct validity tests (see the previous section), partial least squares (PLS) was employed to test the theoretical structural model based on some of its advantages over LISREL [11, 12]. The reasons for using PLS in hypotheses testing are three-fold. First, PLS can be used to model latent constructs as either formative (superordinate constructs) or reflective indicators (unmeasured latent constructs) [12, 72]. Secondly, PLS is a component based approach, and as such, it is relatively robust to deviations from a multivariate distribution not requiring a large sample size [12]. Finally, PLS makes for stronger predictions as compared to LISREL. This research is prediction-oriented in nature.

We used PLS 3.0 to examine the structural model and our hypotheses. The predictive validity of the model was assessed by looking at the R^2, because PLS does not provide an overall goodness of fit index. To estimate the effects of interacting variables, we employed a two-step estimation approach [59]. The first step of the approach involves calculating the loading and error variance for the single indicator of the latent product using measurement model parameter estimates. The second step fixes the loading and error variance at their calculated values in the structural model. For example, in order to test the interaction of system quality with direct network externalities we first centered the three variables: (1) system quality of CRM, (2) direct network externalities, and (3) intent to adopt by replacing raw scores with deviation scores. In the second step we summed scores of each latent variable to form a latent product. Then, the single indicator of the latent product (interaction) was formed by multiplying the totaled scores for both benefits of CRM and direct network externalities.

Results

Table 5 reports PLS results for the SEM analysis, which provided strong support for our hypotheses. Table 5 presents two models: Model (1) shows the results without interaction effects, and Model (2) exhibits results with interaction effects. Model (2) with the interaction effects yielded the highest R^2 values. The significant r values

Table 5 Results of SEM analysis (dependent variable: intend to adopt)

	Model (1)	Model (2)
TTF		
System quality	0.38***	0.41***
Ease of use	0.28**	0.30*
System reliability	0.36***	0.37**
Authorization	0.24**	0.26**
Externality		
Direct externality	0.24*	0.25*
Indirect externality	0.23*	0.24*
Interaction effects		
System Quality x Direct Network Externality		0.25**
System Quality x Indirect Network Externality		0.23**
Ease of Use x Direct Network Externality		0.24**
Ease of Use x Indirect Network Externality		0.20*
System Reliability x Direct Network Externality		0.28**
System Reliability x Indirect Network Externality		0.21*
Authorization x Direct Network Externality		0.19*
Authorization x Indirect Network Externality		0.20*
Firm size	0.07	0.08
IT department size	0.06	0.07
Industry	0.05	0.06
χ^2 Statistic	147.7	167
Degrees of freedom	67	73
Adjusted R-square	35 %	43 %

Where $p < 0.1$, $^{*}p < 0.05$, $^{**}p < 0.01$ $^{***}p < 0.001$

ranging from 0.24 to 0.38 confirm that the four dimensions of the TTF construct pertaining to task characteristics (i.e., system quality, ease of use, system reliability and authorization) are associated with the intention of CRM adoption. This supports the acceptance of *H1a*, *H1b*, *H1c*, and *H1d*, lending credence to our research model and therefore, the use of the TTF theory approach. In addition, the technology characteristics found in the TTF construct dealing with network externalities also had significantly significant *r* values (0.24 and 0.23 respectively). This supports the acceptance found in *H2a* and *H2b*, where higher levels of perceived direct and indirect network effects are positively associated with the intent to adopt CRM in supply chain organizations.

The moderating effect of network externalities on the TTF construct is tested in *H3a* and *H3b*. All the interacting effects were shown significant in model (2) and as such both *H3a* and *H3b* are supported. In other words, the direct and indirect network externalities moderate the relationship between system quality, ease of use, system reliability, and authority and intent to adopt CRM. Moreover, Table 5 indicates that Model (2) research model considering interaction effects of network externalities outperforms Model (1) - model without interaction terms as R^2 value for Model (2) (i.e.,43 %) is great than that of model 1 (35 %). This further supports our argument that the TTF model integrating with network externalities is a viable model for this study.

Lastly, we found no significance among control variables (e.g., firm size, department size and industry) in the research models. This further strengthened our results.

Discussion

The results of the study have implications for researchers and practitioners. This paper makes several unique contributions advancing the diffusion of innovation literature related to software adoption and supply chain management:

1. Demonstrates the use and reliability of the TTF model in CRM adoption and as a potential modeling tool to examine other supply chain technologies,
2. Identifies four characteristics or network externalities (i.e., system quality, ease of use, system reliability and authorization) where the perception of these characteristics is important in implementing or diffusing technology (i.e., software) within supply chains, and
3. Reveals the perception of direct and indirect network externalities having a potential to moderate technology adoption relationships in supply chain organizations, suggesting the impact of other moderating variables should be considered as factors in adoption and diffusion of technologies in supply chains.

The significance of the direct effect of task, technology and fit (in *H1*) on CRM adoption in supply chain organizations is consistent with the expectation of prior interorganizational literature using TTF theory [14, 30, 47, 73]. Unique to this study is the set of four characteristics (i.e., system quality, ease of use, system reliability and authorization) demonstrating a robustness that strongly supports the use of TTF in software adoption and the reliability of the proposed framework.

As previously stated, network externalities alone do not adequately explain innovation diffusion [41]. The significance of the direct and indirect effects associated with the adoption of CRM found in the *H2a* and *H2b* shows that integrating TTF theory with network externalities, as in our model, enables researchers to go beyond TTF theory and examine interorganizational effects that contribute to adoption. The implication for supply chain managers interested in adopting CRM software suggests that the perception of factors such as system quality, ease of use and system reliability are important in implementing or diffusing the software in supply chains. These findings support the innovation adoption diffusion “critical mass” ideas suggested in Gurbaxani [32]; Rogers [62], and in more recent research by Cheng [10], whose use of organizational learning theory suggests adopting CRM is a social/behavioral action to legitimize its use.

Another implication of this study is related to the moderating effect found in the significant outcomes for *H3a* and *H3b*. These results show that the direct and indirect network externalities of system quality, ease of use, system reliability, and authority can moderate the CRM adoption relationship in supply chain organizations, suggesting the possibility that other moderating network externality variables may impact CRM adoption. These results further support the proposed use of network externalities in combination with TTF for use in adoption situations. This is a unique finding that has not previously been observed in the literature and represents a theoretical contribution to the body of research related to TTF [20, 50]. In addition, it extends the supply chain literature related to diffusion of innovation [35, 51]. Melville and Ramirez [51] examined the direct effects of IT adoption and diffusion in the context of supply chain management information needs. Their model suggested higher IT innovation diffusion might exist in industries with higher information processing requirements, whereas our model's moderating results suggest that other direct and indirect network externalities should be considered as factors in adoption and diffusion of technologies in supply chains. Direct network externality such as the status of having software and indirect network externality such as the perception of competitors' adoption of software alter the adoption and diffusion of a software dependent supply chain. This finding may help explain why some supply chain information system adoption and diffusion results are not successful [35].

There are implications for practitioners concerned with CRM adoption as well. The results of this study suggest user's perceptions of the characteristics the system offers are significantly related to the adoption and diffusion of technology in general and more specifically in CRM. In the context of a firm that is dependent on supply chain success, the CRM adoption decision can be influenced by the software decision maker's perception of how the software provides system quality, ease of use, system reliability, and authorization in the transactions that support the firm and its supply chain. Specifically, the more positively perceived these characteristics are in providing service to the organization, the more likely the firm will adopt and successfully diffuse the CRM software. This suggests supply chain managers should focus on promoting and educating potential adopters of the CRM software with regard to these four characteristics to overcome the perception of CRM adoption failure rates ranging from 55 to 75 % [37].

Another unique ramification for practitioners is related to network externalities. Since both the direct and indirect network effects are found to be significant, this suggests both the internal organization software used by a firm, as well as competitors' and supply chain partners' use of software, impact the CRM adoption process. Thus, supply chain dependent firms should not only focus efforts on exploring how CRM fits the firm's internal technology information needs, as Chan [7] suggested, but also how it integrates with external partners in the supply chain. Going beyond current research, the results of our study also appear to suggest that positive network externalities aid in the diffusion of CRM innovation if supply chain personnel understand the software's impact on the industry and its use by competitors. Perhaps the supply chain manager's role in adopting technology should include educating subordinates regarding competitors' usage of the same technology.

Limitations and future research

One limitation of this study is the reliance on executives' opinions about their intentions to adopt a CRM system. While the statistical analyses conducted in the paper tend to support the reliability and validity of the measures derived from the survey data, an intention does not always mean a subsequent action will take place. We believe that additional credibility can be seen in comparing our consistent results using TTF with the findings of prior TTF research. Further, because the sample is multi-industry in character and includes supply chain-oriented firms in both manufacturing and service organizations (specifically, supply chain oriented transportation and warehousing firms), we are convinced the results are generalizable.

Another possible limitation of our study may be its focus on only testing the four characteristics of system quality, ease of use, system reliability, and authorization. Both the type of characteristics and their number may constitute possible limitations. The four selected appear frequently in the literature and are applicable to both IS ([9, 27, 30, 65]) and supply chain [4, 70] studies related to software adoption. It is recommended that additional characteristics be identified and explored utilizing the same methods presented here to both confirm our methodological results and to extend the literature.

Competing interests
The authors declare that they have no competing interests.

Authors' contributions
VCG, MJS, and QC jointly developed the research study, performed the analysis, and drafted the manuscript. All authors have read and approved the final manuscript.

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