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An Empirical Study of Social Network Activities via Social Internet of Things (SIoT)

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ABSTRACT Internet of Things (IoT) is an emerging trend referring to an interconnected network of ubiquitous intelligence. It is a revolution for Internet, computing and communication. Further extensions of IoT, Social Internet of Things (SIoT) provides a platform for people posting messages and photos, sharing knowledge, and connecting with each other. It is effective and efficient for people to manage their interpersonal relations through SIoT, but produces stress and tension issue coincidentally. Therefore, this study explores how users share knowledge through assessment and response under stress cognition. Three demand appraisals and three coping strategies are proposed to discuss user's behaviour on knowledge sharing, and Smart-PLS is used to test the conceptual framework. Results show that self-protection, anxiety, and avoidance increase when members of the community are threatened or injured. Nevertheless, members with high self-efficacy could reduce anxiety production and improve self-protection. Consequently, the purpose of knowledge sharing is achieved. This study discusses users' psychological perspectives when participating in the SIoT. It provides a better understanding of the human activities on the Internet through the SIot. Meanwhile, further prediction of users' behavior of knowledge sharing provides benefits and opportunities for businesses to establish their marketing strategy.

INDEX TERMS Social Internet of Things (SIoT), knowledge sharing, self-efficacy, self-protection.

I. INTRODUCTION

The Social Internet of Things (SIoT) is an integration of traditional peer-to-peer (P2P) networks and social networks [1]. By exchanging interests, messages, and services, objects establish social relationships autonomously through IoT [1]. Benefits and challenges are concluded through SIoT. Previous studies discuss the SIoT focusing on the heterogeneous social network, privacy security, trust management, social structure to the SIoT, etc. People participate in various online communities and share information through the development of social network and different devices [2]. Different from Internet of Things (IoT), SIoT contains various social networks, which characterized the inter-connections, supportive, and immediacy [3]. The posts and reviews on the social network allow objects generating friendships, trust, and influential power. Alternatively, security and privacy issues are aroused via the increasing usage of the SIoT [1]. Personal information, such as user Id and password, are required when using SIoT. However, these information may be generated by the third party at the same time. The data anonymization and the privacy preservation become a challenging and important issue of SIoT.

Currently, the IoT technology has extended from communication between people to people, to people to things and things to things. The SIoT is an extended theory of the IoT. Its main theory focuses on the interaction between people to people and people to things. Along with the existence of smart devices, it has been further discovered that the interactional potential between people to people and people to things increases. Vazquez and López-de-Ipiña [4] proposed the concept of Social Device. The concept uses semantic analysis to embed social ability into smart devices in order to realise the interaction between people to things. This instance broadens the usage of SIoT. Atzori *et al.* [5] introduced the idea of SIoT, similar to Social Network Services (SNS), where we embed the concept of social relationship into the interaction device. SIoT uses the sensor monitoring technology within IoT, to support ordinary objects in our lives to promptly. Informatisation through web technology, cloud computing technology…etc. to achieve interactions.

There are several characteristics for SIoT: (1) Establish social network between things and things, thereby exhibiting an interaction relationship similar to human social networks [6]; (2) Through the connection of IoT to achieve the

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interaction among people to things [7]; (3) Among people, demonstrate a better internet service and user experience through the combination of IoT service and social networking services [8]. The direct way of carrying out SIoT is to combine IoT with SNS. SNS generally obtain a graphical interface, in order to realise the interactions between users, while building custom applications. SIoT provides a user interface to operate the product. Therefore, the product attributes are configured graphically in the SNS, allowing the users to easily understand and operate the product, functions and conversation mode. SIoT is widely applied on social networks, such as: Facebook, Twitter, Myspace, Linkedin, etc. Users can place a personal profile; display a list of social networking encourage content sharing services [9]. Facebook is a social IoT medium that enables people to interact. Through the network establishment of the social IoT, this research can interpret users' knowledge sharing and further extend the scope of social IoT research to better understand users' mentality. This allows the developer of SIoT to understand users' Consumer Psychology and accelerate the product development.

The development of the internet has dramatically increased the population of internet users and the number of personal web pages that drive the network community. The Market Intelligence & Consulting Institute (MIC) conducted a web-browsing behavior survey in 2018 and found that the network communities are the most widely used websites in the world. In the networking site, users discuss issues as well as share the same interests, preferences, and their own experiences, ideas, or solutions to other community members [10] so that other users can obtain the information they need. Thus, a growing number of users join the network community for knowledge sharing and information access [11]. The most common type of network community is the social networking site, which has the highest percentage of Facebook users.

Despite the advantages, the rapid development of the internet has also increased personal data outflows. It can harm people's privacy when they conduct online activities, such as communication in the network community and shopping. The pressure may be perceived when the objects realize the security issue from their online activities. In 2018, Frost and Sullivan reported that the economic losses of companies suffering from cyberattacks are often underestimated. In 2017, Taiwan's total economic losses caused by the information security threat were $27 billion.

Although the network community provides features that protect user information to reduce security risks, such as the content and the setting features of the information security, many users do not understand these features well [12]. Using information security without full knowledge of it and without safety protection can increase the danger. Only when the user's personal privacy is violated does the network community responds to the user after an individual assessment.

The network community is a platform for discussion and communication wherein users can quickly access relevant information. This knowledge-sharing model of the network community can provide community members with the information they need through Social Networking Sites (SNS) [10]. Thus, a growing number of users apply the network community for knowledge sharing and information [11, 13]. The key to the sustainable operation of the social networking site is whether users can attract additional external members through community knowledge sharing [14]. Network community crimes have spread frequently on freely published platforms. It becomes a hotbed of crime that the pressure is perceived higher among community members.

Stress cognition theory states that cognitive appraisal is a kind of demand appraisal and resource assessment. It is a dynamic activity, separate from the monitoring of events [15]. This paper targets the social media users and uses stress cognition theory as the main theoretical framework to explore how people share knowledge through a series of response and management strategies while facing pressure. Stress cognition theory has been widely used in studies worldwide. For example, Lemée *et al.* [16] applied stress cognition theory to determine how residents respond to the pressure of natural disasters. Chen [17] explained the pro-environmental behavior of humans through self-efficacy and collective efficacy. Although many scholars have studied stress cognition theory, most of the studies predict people's behavior under pressure and only a few have indicated that the pressure reduction effect can be achieved through response. Limited attention has been given to discuss users' self-protection and anxiety under the pressure. The current study explores users' self-protection and emotional expression (e.g. anxiety, avoidance) when participating in online community but feeling threatened and hurt. The theoretical contribution will be gained in the internet ecology research.

II. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

A. SOCIAL INTERNET OF THINGS (SIoT)

Social Internet of Things (SIoT) is made via numerous nodes and edges, which compose the graph. The nodes represent objects, and the edges indicate the interrelationship between objects. This relationship is not absolutely static. Nodes are increased when new participants join in the community where edges are established in-between the new and original objects. Dynamic social network is composed by the changes of graphs which is the foundation of the SIoT.

Interactions and relationship build up among objects are one of the key concepts of SIoT. Atzori *et al.* [18] conclude characteristic of SIoT: 1) social structure has been shaped, 2) the design of SIoT is based on the characteristic of IoT, and 3) SIoT is based on the interaction among objects. The social relationship is established when service or information is provided by one object and accepted by another one. The purpose of information and service exchange targets to gain a better solution for the problems and issues, which the objects encounter [1], [18]. Individuals search ''friends'' through the internet, whereas ''friends'' is recognized autonomously via SIoT. SIoT allows individuals to collaborate with each other on the social network and form social relationships [19].

The design of user interface and applications are required into consideration when building SIoT [19]. SIoT is regarded as the community of peer-to-peer owners. The relationship is connected autonomously based on the social regulation and service provision by objects. Chen [13] propose the SIoT is an intelligent system which facilitate individuals share and exchange information and service.

B. STRESS COGNITION THEORY

Lazarus and Folkman first proposed stress cognition theory in 1984 [20]. Baum [21] defined stress as a negative experience, accompanied by predictable emotions from physical, psychological, and behavioral aspects. Lazarus and Folkman [20] believed that people may experience psychological stress if the surrounding atmosphere exceeds their own expectations. People under pressure respond to the environment according to their personal psychological state. Lemée *et al.* [16] indicated that coping strategies are commonly divided into the following. First, active coping strategy refers to proactively solving problems and taking action. Second, passive coping strategy focuses on negative emotions such as anxiety or avoidance and coping with threats and hurt through internal pressure. Previous studies have reported that individuals feel anxious when facing the unknown or a dangerous environment, which is the expected psychological state. Different from fear, anxiety is perceived as a psychometric paradigm and corresponds to an assessment of the severity of the risk.

Krohne [22] argued that individuals facing stress have resources that include social support, resistance, anxiety, avoidance, and self-protection. However, self-efficacy is a personal protection mechanism in response to the environment. Taylor and Stanton [23] argued that stress and response can help assess response processes from stressful situations.

1) RELATIONSHIP BETWEEN THREATS AND RESPONSES

Stress assessment is a process that allows individuals to confirm the importance and controllability of stress [24]. Demand appraisals are perceived to be controlled by the individual's inner condition and well-being, but they can also emerge from threats and harm, which people can overcome through the challenge [24].

Individuals tend to explain the current environment through environmental monitoring [20]. When people consider the current environment as harmful and threatening, it becomes a source of stress [17]. Stress is defined as a feeling after being threatened, destroyed, or harmed, which people perceive under potential or physical conditions [20].

Cognitive stress theory considers demand appraisal as an important factor in stress cognition, which can be generated from relieving stress through the individual response (self-protection, anxiety, and avoidance) [25]. Ning and Wang [8] found that human beings will actively activate self-protection mechanism to resist external threats. Mathews and MacLeod [26] believed that threat and anxiety occur simultaneously. When a person perceives threat, his anxiety will rise accordingly. Chen and Liang [27] pointed out through their experiments that when humans acknowledge the existence of threat, the idea of avoidance shows. As the threat rises, the avoidance rises correspondingly. Therefore, the following hypotheses are proposed:

H1a: Threat has a positive influence on self-protection.
H1b: Threat has a negative influence on anxiety.
H1c: Threat has a positive influence on avoidance.

2) RELATIONSHIP BETWEEN HARM AND RESPONSE

Demand appraisal refers to an individual's monitoring of events [28], which can take the form of threats and harm. Previous studies have suggested that environmental problems are often viewed as threats that can harm individual psychology [29], [30].

Two main directions for people's response to environmental issues include problem-focused coping and emotion-focused coping. Problem-focused coping refers to reducing pain through management and includes self-protection, anxiety, and avoidance. Sedikides and Alicke [31] pointed out that when humans are harmed, they will effectively start the self-protection mechanism to reduce the potential harms to the self. When the damage is greater, automatically, humans' instincts generate anxiety and avoidance strategies to protect themselves. Lazarus and Folkman believed that emotion-focused coping is a kind of pressure reduction or prevention through emotional relaxation. In other words, people can adjust their mood through emotion-focused coping [20]. People adopt problem-focused coping to cope with pressure when they are threatened and hurt [17]. Therefore, compared with emotion-focused coping, problem-focused coping can effectively help people reflect on their current situation and face their problems immediately. Hence, the current paper is guided by problem-focused coping. In relation to the above, the following hypotheses are proposed:

H2a: Harm has a positive influence on self-protection.
H2b: Harm has a negative influence on anxiety.
H2c: Harm has a positive influence on avoidance.

3) RELATIONSHIP BETWEEN ENVIRONMENTAL SELF-EFFICACY AND RESPONSE

Bandura [32] argued that self-efficacy judgments influence the goals that people set for themselves and their emotional responses to the level of performance achieved in different contexts. When a person encounters a particular condition, he/she may adopt a specific coping strategy to deal with the demands or stress that he/she has encountered [33]. Lazarus [28] indicated that self-efficacy can be evaluated for stress sources and then respond through the evaluation process. Chen [17] pointed out that self-efficacy reflects individual beliefs and abilities. It can furthermore be used to meet specific situational demands through positive actions. Burns and Martin [34] have researched the learning behaviour of middle school students. It has been found that when the self-efficacy is low, students tend to lower their learning goals and choose to avoid learning.

The research also pointed out that when the self-efficacy is low, the self-protection mentality will be easier to produce. In relation to the above, the following hypotheses are proposed:

H3a: Self-efficacy has a positive influence on self-protection.

H3b: Self-efficacy has a negative influence on anxiety.

H3c: Self-efficacy has a positive influence on avoidance.

4) RELATIONSHIP BETWEEN RESPONSE AND KNOWLEDGE SHARING

Intention to perform knowledge sharing refers to the idea that users are willing to assist and transfer their skills or abilities to others [35]. Kuo and Young [36] believed that knowledge seekers receive knowledge through different forms, such as knowledge exchange, diffusion, dissemination, transmission, and sharing. Furnell *et al.* [37] pointed out that the development of information delivery technology increases the vulnerability against information security threats of virtual community users, motivating them to develop self-protective mechanisms (self-protection, anxiety, and avoidance) when they are threatened. SNS users can share their knowledge through the delivery services provided by various sites. Reference [38] considered punishment as a motivating factor driving an organization's expected behavioral intention to use SNS but also affecting their usage. By contrast, when punishment exists, individuals tend to feel protected when using SNS; thus, they can easily reflect on their actual usage [39]. In relation to the above, the following hypotheses are proposed:

H4: Self-protection has a positive effect on knowledge sharing.

H5: Anxiety has a positive negative on knowledge sharing.

H6: Avoidance has a positive effect on knowledge sharing.

III. METHODOLOGY DESIGN

A. PRE-TEST AND PILOT TEST

This work was initially conducted with five doctorate students who went through a focused group interview to understand the questionnaire content. They then proposed suggestions that led to the modification of the questionnaire. Subsequently, a total of 100 questionnaires were distributed during the pre-test to further revise the questionnaire content. In the analysis phase of the pre-test, all Cronbach's alpha values and composite reliability of constructs were higher than 0.8.

The main questionnaire collection phase is divided into two parts. The first part extracted the respondents' personal data, and the second part structurally analyzed the model. The measurement scale of threat, damage, and self-protection were mainly based on Chen [17], whereas the measurement scale of self-efficacy was mainly based on Homburg and Stolberg [25]. Anxiety and avoidance were measured following the study of Lee [40], and knowledge sharing was measured following the study of Huang *et al.* [35]. Fig. 1 showing proposed research framework.

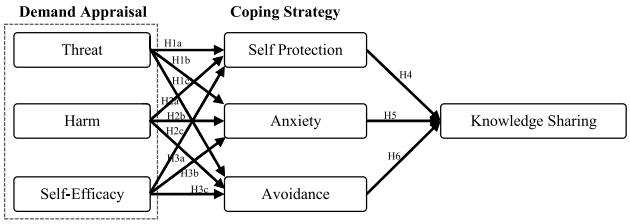

FIGURE 1. The research model.

TABLE 1. Passengers' demographic attributes.

Variable	Frequency(N=964)	(%)
Gender		
Male	489	50.73
Female	475	49.27
Age		
Under 19 year	295	30.60
20~24 year	517	53.63
25~29 year	42	4.36
30~34 year	37	3.84
35~39 year	32	3.32
Over 40 years old	41	4.25
Education level		
Under Junior High School	3	0.31
Senior High School	24	2.49
Junior College/College	818	84.85
Graduate	119	12.35
Daily Hours on Facebook		
Under 3 h	343	35.58
4~6 h	431	44.71
7~9 h	123	12.76
Above 10 h	67	6.95

B. DATA COLLECTION PROCEDURE

This paper aimed to investigate the knowledge sharing behavior of Facebook users under stress cognition. Questionnaire design and statistical analysis were used as measurement tools, and questionnaires were collected through the ''My Survey'' network platform. The testing period was from January 2019 to June 2019, and a total of 1,280 questionnaires were collected. A total of 964 valid samples were finally obtained after omitting 316 invalid samples. Among the respondents, 489 (50.73%) were male and 475 (49.27%) were female. Table 1 presents the results (as shown in Table 1).

C. COMMON METHOD VARIANCE (CMV)

In this section, Harman's single factor test method was adopted to detect the sample data, and the exploratory factor analysis (EFA) was employed on all questions. Results showed that seven factors could be extracted, and the explanatory power of the first factor was 28.72%, which failed to reach 50% (as shown in Table 2). Therefore, no serious CMV was present in the sample data of this study. Table 2 reports the results.

IV. EMPIRICAL ANALYSIS

A. GOODNESS OF MODEL FIT

PLS software was used to test the overall goodness of model fit before measuring the structural models [41]. To evaluate model fit, the PLS software provided standardized root mean square residual (SRMR), normed-fit index (NFI),

TABLE 2. Initial eigenvalues.

Component	Eigenvalues	Variance (%)	Cumulative Variance (%)
1	8.043	28.725	28.725
2	4.903	17.510	46.235
3	3.247	11.598	57.833
4	2.451	8.752	66.585
5	1.784	6.372	72.957
6	1.454	5.194	78.151
7	1.297	4.633	82.783

TABLE 3. Model fit.

Fit Indices	Model fit index
Chi-Square	1568.07
Degrees of freedom	335
Comparative Fit Index (CFI)	0.95
Adjusted goodness of fit index, AGFI	0.869
Bollen (IFI) Fit Index	0.95
Goodness-of-Fit Index (GFI)	0.892
Root Mean Square Rsidual (RMSR)	0.062

and standardized root mean square residual (RMS_theta) as measures of fit [42]. SRMR is an indicator used in evaluating the difference between observed values and predicted results and can be employed as a model and degree evaluation indicator. SRMR value ranges between 0 and 1 and is commonly less than 0.08. The standard value in this study is 0.034. NFI is mainly between 0 and 1 and is commonly greater than 0.9. Furthermore, the standard value in this study is 0.907. RMS_theta is mainly less than 0.12, while the standard value in this study is 0.131—well within the acceptable range. The overall value of fitness is close to the standard value; therefore, the model fitness in this paper is considered as good.

Through AMOS software analysis, the study is mainly verifying the overall Fit model. According to Bagozzi and Yi [43], they indicate the Fit indicator GFI, AGFI are preferably 0.8-0.9, in which more than 0.9 would be much more preferable. RMST should be less than 0.8 [44], [45]. The preliminary results for the study are shown in Table 3. On the whole, this study has reached the overall model Fit adaption standard.

B. CONSTRUCT VALIDITY AND RELIABILITY

Table 4 reveals that all factor loadings are greater than the threshold value 0.7, whereas all the measurement scale items in reflective measurement models exhibit high loading. All of our composite reliability (CR) values are greater than 0.7, which indicates good internal consistency [46]. Cronbach's alpha values are between 0.877 and 0.951, thereby indicating good reliability. All the values of rA are within the threshold value (>0.7) [41]. Similarly, all values of convergent validity are greater than 0.5, thereby indicating good convergent validity (See the table 5).

Table 5 illustrates the discriminant validity section. The Fornell–Larcker criterion is used to evaluate discriminant validity [47]. Table 6 shows that the square root of AVE is higher than the correlation coefficient below the diagonal. Therefore, the model in this paper has discriminant validity. Henseler *et al.* [48] proposed the HTMT ratio of correlations

TABLE 4. Cross loadings.

	Harm (Ha)	Threat (Th)	Anxiety (Anx)	Knowledge share(Ks)	Self-protection (Sp)	Self-efficacy (Se)	Avoidance (Avo)
Anx1	-0.258	-0.190	0.917	-0.253	-0.292	-0.153	-0.035
Anx2	-0.239	-0.183	0.937	-0.239	-0.270	-0.162	-0.028
Anx3	-0.255	-0.194	0.939	-0.257	-0.284	-0.208	-0.015
Anx4	-0.257	-0.222	0.912	-0.308	-0.284	-0.253	-0.029
Avo1	-0.069	0.044	-0.053	0.036	-0.069	-0.029	0.854
Avo2	-0.035	0.051	-0.067	0.045	-0.029	-0.029	0.884
Avo3	-0.027	0.075	-0.051	0.062	-0.034	0.004	0.907
Avo4	-0.069	0.028	0.001	0.093	-0.056	0.019	0.883
Avo5	-0.068	0.085	0.024	0.105	-0.065	0.067	0.922
Avo6	-0.043	0.099	-0.044	0.121	-0.062	0.062	0.910
Se 1	0.207	0.357	-0.190	0.513	0.252	0.860	0.043
Se 2	0.208	0.322	-0.175	0.510	0.233	0.889	-0.034
Se 3	0.155	0.323	-0.200	0.495	0.173	0.862	0.015
Se 4	0.167	0.324	-0.187	0.487	0.177	0.872	0.049
Se 5	0.167	0.308	-0.169	0.470	0.192	0.843	0.055
Sp 1	0.437	0.293	-0.273	0.283	0.912	0.231	-0.048
Sp 2	0.446	0.274	-0.267	0.279	0.939	0.199	-0.064
Sp 3	0.407	0.297	-0.300	0.282	0.900	0.231	-0.057
Ks 1	0.225	0.309	-0.287	0.934	0.293	0.531	0.077
Ks 2	0.248	0.342	-0.273	0.941	0.276	0.533	0.078
Ks 3	0.235	0.330	-0.243	0.936	0.271	0.532	0.116
Ks 4	0.271	0.327	-0.271	0.921	0.303	0.543	0.084
Ha1	0.879	0.281	-0.251	0.238	0.408	0.195	-0.024
Ha2	0.888	0.317	-0.242	0.239	0.392	0.199	-0.031
Ha3	0.919	0.329	-0.242	0.230	0.457	0.173	-0.098
Th1	0.293	0.948	-0.206	0.330	0.280	0.356	0.071
Th2	0.313	0.947	-0.198	0.324	0.269	0.346	0.070
Th3	0.368	0.942	-0.203	0.339	0.335	0.372	0.075

TABLE 5. Construct reliability and validity.

	Cronbach's Alpha	rho_A	Composite Reliability	AVE
Harm	0.877	0.881	0.924	0.802
Threat	0.941	0.947	0.962	0.894
Anxiety	0.945	0.951	0.960	0.858
Knowledge share	0.950	0.951	0.964	0.871
Self-protection	0.905	0.906	0.941	0.841
Self-efficacy	0.916	0.920	0.937	0.749
Avoidance	0.951	0.992	0.960	0.798

TABLE 6. Fornell-Larcker criterion.

	HA	Th	Anx	Ks	Sp	Se	Avo
Harm (Ha)	0.896						
Threat (Th)	0.345	0.946					
Anxiety (Anx)	-0.273	-0.214	0.927				
Knowledge share (Ks)	0.262	0.350	-0.288	0.933			
Self-protection (Sp)	0.469	0.314	-0.305	0.307	0.917		
Self-efficacy (Se)	0.210	0.379	-0.213	0.574	0.240	0.865	
Avoidance (Avo)	-0.059	0.076	-0.029	0.095	-0.061	0.029	0.894

TABLE 7. Heterotrait-monotrait ratio (HTMT).

	Th	Anx	Ks	Sp	Se	Avo
Harm (Ha)	0.377					
Threat (Th)	0.300	0.225				
Anxiety (Anx)	0.288	0.370	0.300			
Knowledge share (Ks)	0.525	0.338	0.330	0.330		
Self-protection (Sp)	0.234	0.406	0.225	0.613	0.261	
Self-efficacy (Se)	0.062	0.075	0.049	0.091	0.063	0.054

as a tool for analyzing discriminant validity of constructs. Hair *et al.* [49] indicated that potential problems of discriminant validity for HTMT values are greater than threshold level of 0.85. As shown in Table 7, all of the HTMT values are less than 0.85, therefore, no discriminant validity problem exists.

C. STRUCTURAL MODEL

After verifying measurement modeling, the potential relationships in the structural model are subsequently confirmed. In this paper, smart-PLS is used for hypothesis verification. To estimate the accuracy, a total 964 samples are used for validation to determine the statistical significance. These results are verified through the bootstrap method 5000 resampling. Hair *et al.* [46] indicated that the acceptance range of path

TABLE 8. Results of proposed model.

	β-value	T value	P value	Decision
Threat →Anxiety	-0.214	5.576	0.000	Supported
Threat →Self-protection	0.400	8.352	0.000	Supported
Threat → Avoidance	-0.098	2.837	0.005	Reject
Harm →Anxiety	-0.089	2.452	0.015	Supported
Harm →Self-protection	0.136	3.711	0.000	Supported
Harm →Avoidance	0.106	2.830	0.005	Supported
Anxiety →Knowledge share	-0.209	5.980	0.000	Supported
Self-protection →Knowledge share	0.249	7.509	0.000	Supported
Self-efficacy →Anxiety	-0.134	3.436	0.001	Supported
Self-efficacy →Self-protection	0.104	3.157	0.002	Supported
Self-efficacy →Avoidance	0.009	0.213	0.832	Reject
Avoidance →Knowledge share	0.104	2.816	0.005	Supported

coefficient is verified by the structural equation model. The acceptable recommended range of p-value must be less than 0.05. Table 8 indicates that the hypothesis is supported. However, self-efficacy exhibits no significant effect on avoidance.

V. CONCLUSION

The structural analysis results of this empirical study conducted in Taiwan are consistent with previous studies, which reported that cognitive theory of stress applied to online communities can effectively explain people's knowledge sharing process. This paper finds that people who are threatened under the stress cognition and demand tend to exhibit anxiety, self-protection, and avoidance. In addition, self-protection is strengthened when threat and harm are increased. Therefore, members of an online community may avoid threat but tend to face it when they are hurt.

Previous studies have reported that an online community is a closed community where members speak up when they are hurt. Therefore, a consensus among members is evident.

In the relationship between coping and knowledge sharing, a high level of anxiety reflects reduced occurrence of knowledge sharing behavior. Moreover, the high level of anxiety reduces knowledge sharing. Therefore, the higher the self-protection mechanism, the easier the knowledge sharing behavior will be. Community members can also easily express their opinions in the community through the self-protection mechanism, and the stress of community members can be relieved by posting. Self-efficacy is an individual's ability and belief to accomplish a task or a goal. When self-efficacy is high, the anxiety is low, but self-protection increases. Self-efficacy can influence the opinions of other community members through positive energy, and this belief allows them to think positively. Therefore, when self-efficacy is high, comments are increased to achieve the purpose of knowledge sharing.

In conclusion, stress cognition theory indicates that when members of the network community are under stress (threat and harm), coping (self-protection, anxiety, and avoidance) slows down the time it takes to achieve knowledge sharing. When the members' self-efficacy is high, the coping is relatively fast, thus facilitating knowledge sharing. Website operators should play the role of manager when the pressure of public opinion is formed and use their own rights to stop inappropriate comments. When a threat or harm occurs, members must exhibit courage to positively comment through self-protection mechanisms so that the website can be sustainable.

APPENDIX

Construct	Item	
Threat	Th1	I am afraid of the consequences of using Facebook.
	Th2	I feel that Facebook has created threat(s) to my everyday life.
	Th3	Using Facebook makes me feel unsecure and/or unsafe.
Harm	Ha1	So far, Facebook has harmed my everyday life.
	Ha2	Facebook makes my everyday life worse.
	Ha3	My social relationship within Facebook has made me lose faith in everyday life.
Self-Efficacy	Se1	Within Facebook, I know how to prevent emergencies.
	Se2	Within Facebook, I know how to find ways to face all kinds of emergencies.
	Se3	Within Facebook, I know how to face new emergencies.
	Se4	Within Facebook, I can manage my personal profile.
	Se5	I believe that I can manage unexpected emergencies within Facebook.
Self-protection	Sp1	I will avoid using Facebook for a long period of time.
	Sp2	When logging in Facebook, I do not save account and password information in the web page.
	Sp3	I do not leave comments on Facebook.
Anxiety	An1	Within Facebook, I rarely worry about being left out.
	An2	Within Facebook, I rarely worry about my friends leaving me.
	An3	Within Facebook, I rarely worry about others abandoning me.
	An4	I believe that within Facebook, my friends like me as much as I like them.
Avoidance	Av1	Within Facebook, I don't like to interact with others.
	Av2	Within Facebook, I don't like to get too close to others.
	Av3	Within Facebook, trusting others is rather difficult for me.
	Av4	Within Facebook, people getting close to me makes me feel uncomfortable.
	Av5	Within Facebook, people getting close to me makes me feel nervous.
	Av6	Within Facebook, others try to get close to me, but it has exceeded my acceptance level.
Knowledge sharing	Ks1	When other members on Facebook ask me a question, I will share my knowledge with them.
	Ks2	When other members on Facebook ask me a question, I always share my knowledge with them.
	Ks3	When other members on Facebook ask me a question, I will try my best to share my knowledge with them.
	Ks4	When other members on Facebook ask me a question, I am willing to share my knowledge with them.

REFERENCES

[1] I.-R. Chen, F. Bao, and J. Guo, "Trust-based service management for social Internet of Things systems," *IEEE Trans. Dependable Secure Comput.*, vol. 13, no. 6, pp. 684–696, Nov. 2016.

[2] S. Madakam, R. Ramaswamy, and S. Tripathi, "Internet of Things (IoT): A literature review," *J. Comput. Commun.*, vol. 3, pp. 164–173, Jan. 2015.

[3] F. Al-Turjman, "5G-enabled devices and smart-spaces in social-IoT: An overview," *Future Gener. Comput. Syst.*, vol. 92, pp. 732–744, Mar. 2019.

[4] J.-I. Vazquez and D. Lopez-de-Ipina, "Social devices: Autonomous artifacts that communicate on the internet," in *The Internet Things*. Berlin, Germany: Springer, 2008, pp. 308–324,

[5] L. Atzori, A. Iera, and G. Morabito, "SIoT: Giving a social structure to the Internet of Things," *IEEE Commun. Lett.*, vol. 15, no. 11, pp. 1193–1195, Nov. 2011.

[6] J. An, X. Gui, W. Zhang, J. Jiang, and J. Yang, "Research on social relations cognitive model of mobile nodes in Internet of Things," *J. Netw. Comput. Appl.*, vol. 36, no. 2, pp. 799–810, Mar. 2013.

[7] A. M. Ortiz, D. Hussein, S. Park, S. N. Han, and N. Crespi, "The cluster between Internet of Things and social networks: Review and research challenges," *IEEE Internet Things J.*, vol. 1, no. 3, pp. 206–215, Jun. 2014.

[8] H. Ning and Z. Wang, "Future Internet of Things architecture: Like mankind neural system or social organization framework?" *IEEE Commun. Lett.*, vol. 15, no. 4, pp. 461–463, Apr. 2011.

[9] H. Lee and J. Kwon, "Survey and analysis of information sharing in social IoT," in *Proc. 8th Int. Conf. Disaster Recovery Bus. Continuity (DRBC)*, Jeju, South Korea, Nov. 2015, pp. 15–18.

[10] S.-M. Pi, C.-H. Chou, and H.-L. Liao, "A study of Facebook Groups members' knowledge sharing," *Comput. Hum. Behav.*, vol. 29, no. 5, pp. 1971–1979, Sep. 2013.

[11] M.-J.-J. Lin, S.-W. Hung, and C.-J. Chen, "Fostering the determinants of knowledge sharing in professional virtual communities," *Comput. Hum. Behav.*, vol. 25, no. 4, pp. 929–939, Jul. 2009.

[12] G. R. Milne and M. J. Culnan, "Strategies for reducing online privacy risks: Why consumers read (or don't read) online privacy notices," *J. Interact. Marketing*, vol. 18, no. 3, pp. 15–29, Jan. 2004.

[13] I. Y. L. Chen, "The factors influencing members' continuance intentions in professional virtual communities—A longitudinal study," *J. Inf. Sci.*, vol. 33, no. 4, pp. 451–467, Aug. 2007.

[14] K. W. Kang and S. K. Shin, "A model of virtual community knowledge exchange intentions: Perceived network structure, self-efficacy and individual motivations," in *Proc. 39th Decis. Sci. Inst. (DSI) Annu. Meeting*, Baltimore, MD, USA, 2008, pp. 2571–2576.

[15] R. S. Lazarus, *Emotion and adaptation (Emotion and adaptation)*. New York, NY, USA: Oxford Univ. Press, 1991, p. 557.

[16] C. Lemée, G. Fleury-Bahi, and O. Navarro, "Impact of place identity, self-efficacy and anxiety state on the relationship between coastal flooding risk perception and the willingness to cope," *Frontiers Psychol.*, vol. 10, p. 499, Mar. 2019.

[17] M.-F. Chen, "Self-efficacy or collective efficacy within the cognitive theory of stress model: Which more effectively explains people's self-reported proenvironmental behavior?" *J. Environ. Psychol.*, vol. 42, pp. 66–75, Jun. 2015.

[18] L. Atzori, A. Iera, G. Morabito, and M. Nitti, "The Social Internet of Things (SIoT)–When social networks meet the Internet of Things: Concept, architecture and network characterization," *Comput. Netw.*, vol. 56, no. 16, pp. 3594–3608, Nov. 2012.

[19] F. Bao, I.-R. Chen, M. Chang, and J.-H. Cho, "Hierarchical trust management for wireless sensor networks and its applications to trust-based routing and intrusion detection," *IEEE Trans. Netw. Service Manage.*, vol. 9, no. 2, pp. 169–183, Jun. 2012.

[20] R. S. Lazarus and S. Folkman, *Stress, Appraisal, and Coping*. New York, NY, USA: Springer, 1984.

[21] A. Baum, "Toxins, technology, and natural disasters," in *Stress and Coping: An Anthology*, A. Monat R. S. Lazarus, Eds. 3rd ed. New York, NY, USA: Columbia Univ. Press, 1991, pp. 97–139.

[22] H. W. Krohne, "Stress and coping theories," *Int. Encyclopedia Social Behav. Sci.*, vol. 22, pp. 15163–15170, 2002.

[23] S. E. Taylor and A. L. Stanton, "Coping resources, coping processes, and mental health," *Annu. Rev. Clin. Psychol.*, vol. 3, no. 1, pp. 377–401, Apr. 2007.

[24] R. S. Lazarus, *Psychological Stress and the Coping Process* (Psychological Stress and the Coping Process). New York, NY, USA: McGraw-Hill, 1966.

[25] A. Homburg and A. Stolberg, "Explaining pro-environmental behavior with a cognitive theory of stress," *J. Environ. Psychol.*, vol. 26, no. 1, pp. 1–14, Mar. 2006.

[26] A. Mathews and C. MacLeod, "Selective processing of threat cues in anxiety states," *Behav. Res. Therapy*, vol. 23, no. 5, pp. 563–569, 1985.

[27] D. Q. Chen and H. Liang, "Wishful thinking and IT threat avoidance: An extension to the technology threat avoidance theory," *IEEE Trans. Eng. Manag.*, vol. 66, no. 4, pp. 552–567, Nov. 2019.

[28] R. S. Lazarus, *Stress and Emotion: A New Synthesis*. New York, NY, USA: Springer, 1999.

[29] R. E. Dunlap, "Public opinion in the 1980s clear consensus, ambiguous commitment," *Environ., Sci. Policy Sustain. Develop.*, vol. 33, no. 8, pp. 10–37, Jul. 2010.

[30] C.-L.-J. Lai, A. Brennan, H.-M. Chan, and J. Tao, "Disposition toward environmental hazards in hong kong chinese: Validation of a chinese version of the environmental appraisal inventory (EAI-C)," *J. Environ. Psychol.*, vol. 23, no. 4, pp. 369–384, Dec. 2003.

[31] C. Sedikides and M. D. Alicke, "The five pillars of self-enhancement and self-protection," in *The Oxford Handbook of Human Motivation*, R. M. Ryan, Ed. New York, NY, USA: Oxford Univ. Press, 2019.

[32] A. Bandura,"Self-efficacy: Toward a unifying theory of behavioral change," *Adv. Behav. Res. Therapy*, vol. 1, no. 4, pp. 139–161, Jan. 1978.

[33] F. P. I. Hayward, C. J. Knight, and S. D. Mellalieu, "A longitudinal examination of stressors, appraisals, and coping in youth swimming," *Psychol. Sport Exerc.*, vol. 29, pp. 56–68, Mar. 2017.

[34] E. C. Burns and A. J. Martin, "Motivational issues in gifted education: Understanding the role of students' attribution and control beliefs, self-worth protection, and growth orientation," in *Handbook of Giftedness and Talent Development in the Asia–Pacific*, S. R. Smith, Ed. Singapore: Springer, 2019.

[35] Q. Huang, R. M. Davison, and J. Gu, "Impact of personal and cultural factors on knowledge sharing in china," *Asia Pacific J. Manage.*, vol. 25, no. 3, pp. 451–471, Mar. 2008.

[36] F.-Y. Kuo and M.-L. Young, "Predicting knowledge sharing practices through intention: A test of competing models," *Comput. Hum. Behav.*, vol. 24, no. 6, pp. 2697–2722, Sep. 2008.

[37] S. M. Furnell, P. Bryant, and A. D. Phippen, "Assessing the security perceptions of personal Internet users," *Comput. Secur.*, vol. 26, no. 5, pp. 410–417, Aug. 2007.

[38] V. H. Sweetin, L. L. Knowles, J. H. Summey, and K. S. McQueen, "Willingness-to-punish the corporate brand for corporate social irresponsibility," *J. Bus. Res.*, vol. 66, no. 10, pp. 1822–1830, Oct. 2013.

[39] K. M. Carlsmith, "On justifying punishment: The discrepancy between words and actions," *Social Justice Res.*, vol. 21, no. 2, pp. 119–137, May 2008.

[40] D. Y. Lee, "The role of attachment style in building social capital from a social networking site: The interplay of anxiety and avoidance," *Comput. Hum. Behav.*, vol. 29, no. 4, pp. 1499–1509, Jul. 2013.

[41] J. Henseler, G. Hubona, and P. A. Ray, "Using PLS path modeling in new technology research: Updated guidelines," *Ind. Manage. Data Syst.*, vol. 116, no. 1, pp. 2–20, Feb. 2016.

[42] L.-T. Hu and P. M. Bentler, "Fit indices in covariance structure modeling: Sensitivity to underparameterized model misspecification.," *Psychol. Methods*, vol. 3, no. 4, pp. 424–453, 1998.

[43] R. P. Bagozzi and Y. Yi, "On the evaluation of structural equation models," *J. Acad. Marketing Sci.*, vol. 16, no. 1, pp. 74–94, 1988.

[44] L. Hu and P. M. Bentler, "Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives," *Struct. Equation Model., A Multidisciplinary J.*, vol. 6, no. 1, pp. 1–55, Jan. 1999.

[45] R. P. McDonald and M.-H. R. Ho, "Principles and practice in reporting structural equation analyses," *Psychol. methods*, vol. 7, no. 1, pp. 64–82, 2002.

[46] J. F. Hair, C. M. Ringle, and M. Sarstedt, "PLS-SEM: Indeed a silver bullet," *J. Marketing Theory Pract.*, vol. 19, no. 2, pp. 139–152, Dec. 2014.

[47] C. Fornell and D. F. Larcker, "Evaluating structural equation models with unobservable variables and measurement error," *J. Marketing Res.*, vol. 18, no. 1, p. 39, Feb. 1981.

[48] J. Henseler, C. M. Ringle, and M. Sarstedt, "A new criterion for assessing discriminant validity in variance-based structural equation modeling," *J. Acad. Marketing Sci.*, vol. 43, no. 1, pp. 115–135, Aug. 2014.

[49] J. F. Hair, Jr, G. T. M. Hult, C. M. Ringle, and M. Sarstedt, *A primer on Partial Least Squares Structural Equation Modeling (PLS-SEM)*, 2nd ed. Newbury Park, CA, USA: Sage,, 2016.

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