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A Socio-Technical System Perspective Of Psychological Ownership Toward Sharing IoT Data In Supply Chains

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ABSTRACT

Internet of Things can expedite information-sharing between supply chain partners. However, efficient operations within the supply chain may undermine partners' psychological ownership of shared data. The behavior driven by the feel of ownership may be constrained by social, technical, and environmental factors. This study investigates whether ownership of data may affect willingness to share from the perspective of a socio-technical system. We look into (1) whether the efficiency and adaptability of a supply chain is affected by the possession of data when organizations share IoT data, and (2) whether social and technical systems impact psychological ownership. 302 questionnaires from senior managers of manufactures were collected for analysis. The results show that psychological ownership is positively associated with the efficiency and adaptability of a supply chain and that both social and technical factors enforce it. We also find that social preference can improve the association between a social system and psychological ownership but that technical preference decreases the association between technical system and psychological ownership.

Keywords: psychological ownership, socio-technical system, Internet of Things, supply chain, information-sharing

INTRODUCTION

Internet of Things (IoT) conceptualizes how things are connected through IP. Here, things can be any smart objects, such as vehicles, refrigerators, or living things. Through their connections, things not only have unique identifying characteristics, but also share information in real-time. This new phenomenon raises issues about (1) Internet technologies that connect smart objects, (2) advanced devices that capture and share information, and (3) applications that leverage new business models or platforms. From a system level, those features support device heterogeneity, scalability, ubiquitous data exchange, energy-optimized solutions, location and tracking capabilities, self-organization capabilities, semantic interoperability, and data management. Thus, embedded security and privacy mechanisms are expected [15]. The short to medium term will see the development of applications relating to transportation and logistics, healthcare, smart environments, personal and social aspects, and futuristic domains; in contrast, standardization, addressing and network issues, and security and privacy are open research issues [43]. Such developments synergize the fields of telecommunications, informatics, electronics, and social sciences, but at the same time create greater concerns about data confidentiality, privacy, and trust [15].

This new phenomenon offers opportunities for supply chain management. The automatically-activated sharing of IoT data can provide a high degree of efficiency to supply chain collaboration. With the proper design of decision models, the adaptability of collaboration can be more dynamic. However, this study argues that the ownership of data may pose a concern to both the efficiency and adaptation of supply chain collaboration. In an organization, ownership of data is about possession. Sharing IoT data may challenge the psychology of possession. The psychology of possession is about seeing an object, entity, or idea as "mine" or "ours." It generally holds that the feeling of possession is equal to the feeling of ownership [33] [44]. In holding ownership, one might consider data as one's own. The employee consequently develops possessive feelings towards the data and feels more responsible for their quality. However, will feelings of ownership affect the efficiency and adaptability of a supply chain?

This study adopts socio-technical systems (STS) theory, which can be used to explain inter-organizational phenomena [5] [27] [32] [69]. Specifically, the theory looks into behavioral constraints with respect to social, technical, and environmental factors. The concept was developed to measure the interrelationship between humans and machines that constitute the technical and social conditions of work [25]. As employee behavior and work design are interrelated, technical issues cannot be completely understood without involving both social and technical factors [21] [51]. Kull et al. [69] suggest that because supply chain productivity involves both people and organizations, an STS theory describing how organizational outcomes are affected by people in terms of social and technical systems provides a useful perspective. Furthermore, we look into how preference interacts with social and technical systems to influence psychological ownership. We conduct an empirical study on manufacturing firms and their partners. In this study, we focus on the sharing of IoT data between supply chain partners.

BEHAVIORAL SUPPLY CHAIN IN SHARING IOT DATA

A behavioral supply chain seeks to observe human tendencies and influences, such as behavioral biases, cognitive limitations, and individual preferences [42]. It considers how human behavior, which is influenced by cognitive biases, social preferences, and cultural norms, affects performance [8]. Behavior can affect managerial judgment and cause decision-making biases that impact the design, management, and improvement of supply chains [29] [55]. Research has studied the efficiency and adaptability of behavioral supply chains by utilizing, for example, behavioral decision theory, psychological ownership theory, and

socio-technical systems theory.

Behavioral decision theory shows that human preferences are neither stable nor complete [11]. Preference construction is a psychological process. Namely, an individual establishes preferences when making a judgment or decision [11]. Preference is hidden in the emotions. It is non-intuitive and is caused by emotional, rather than rational, factors. Preferences may change over time depending on past behavior and experiences [23] [26]. Preferences can notably modify the decision-making process, for example by changing choices [38] [70], even unconsciously [22]. The idea that decision-making is altered by preferences has a considerable influence on cognitive dissonance theory [70]. Thus, preference is an essential factor to consider when examining the efficiency and adaptability of supply chains via IoT.

Psychological ownership refers to feelings of ownership wherein one considers a target or a piece of a target as belonging to oneself. It reflects a state wherein an object (tangible or intangible) is experienced as a part of the extended self [34]. Psychological ownership involves a number of important organizational behavior types, such as feelings of responsibility, stewardship, the assumption of personal risk, organizational citizenship, personal sacrifice, the promotion of and resistance to change, and performance [46]. Each of these behavior types can change the efficiency and adaptability of sharing data in supply chains. It has been found that the psychological ownership has a positive effect on extra-role behavior and is mediated by organizational commitment [17], which is a significant predictor of job satisfaction and turnover intentions [36].

Socio-technical systems (STS) theory provides a framework to analyze interactive processes and relationships between organizations [5] [27] [32]. Socio-technical systems consider an organization to be an open system interacting with the environment. It incorporates consideration of both social and technical systems. A social system includes factors that transcend organizational boundaries to explain partnering behavior types such as beliefs, social networks, norms, and behavior [2] [59]. Vijayasarathy [45] emphasized that social factors such as trust, interdependence, long-term orientation, and information-sharing are crucial factors for an inter-organizational information system. In contrast, a technical system comprises the equipment, methods, and knowledge used by organization to obtain inputs, transform inputs into outputs, and offer outputs or services to customers [72]. Bringing these two types of systems together, socio-technical systems theory was created to analyze how interrelated components affect inter-organizational outcomes in the context of the external environment [69]. STS theory has been applied to many related study domains that involve both human and machines, such as information technology [49], knowledge management [40] [62], manufacturing [71], logistics [16], total quality management [7], organizational development [61], and others. Kull et al. [69] and Vijayasarathy [45] argued that creating superior social and technical systems is fundamental to a firm's efficiency and adaptability, which in turn is important to the long-term survival and success of supply chains. Moreover, Kull et al. [69] extended STS theory from an individual context to an inter-organizational context.

THEORY DEVELOPMENT

In this study, we focus on possession of data, i.e. psychological ownership, rather than commitment to organization and satisfaction, i.e. organizational ownership. It is worth noting that organizational ownership emphasizes qualities of organization-based self-esteem and organizational citizenship [46]. Psychological ownership is contrastingly concerned with an individual's possession and control of resources [35]. Psychological ownership is shaped by self-identity, efficacy, and having a place to dwell [33]). These are the reasons one experiences the feelings of ownership. Thus, psychological ownership is relevant to the process of sharing information with supply chain members via IoT objects. It is expected that successful sharing requires high levels of organizational commitment [4] [6] [18] [48] [57].

VandeWalle et al. [17] observed a positive relationship between psychological ownership and the frequency with which the members of a firm engaged in extra-role behavior. Millward & Parker [56] studied the importance of competition versus psychological ownership in determining public and private efficiency. Hartley et al. [41] found that changing efficiency reflects the effects of both changes in organizational status and alterations in the market environment.

The primary objective of high efficiency and adaptability is to enhance the performance of supply chains [24] and speed up services to customers [3]. Both are important to respond to the challenges of the environment. Lichocik and Sadowski [24] argued that the measurement of efficiency of activities is the most important element of supply chain management. Similarly, Makris et al. [64] emphasized that adaptability is a key requirement for manufacturing highly reconfigurable products. Thus, the research question is: can the ownership of IoT data affect both the efficiency and adaptability of supply chains?

As both efficiency and adaptability are key measurements of supply chains' success, we hypothesize that when supply chain partners feel a positive relationship between psychological ownership and identity or commitment, the efficiency and adaptability are enhanced.

H1: Psychological ownership is positively related to efficiency.
H2: Psychological ownership is positively related to adaptability.

As mentioned, socio-technical systems are designed to ensure flexibility by providing employees with a wide range of skills that

enable high performance in any given situation [21] [66] . A social system can influence firms' behavior in either formal or informal ways [10]. There are four features of a social system, namely social positions, social values, social associations, and social experiences. Lawler [18] found that a social system supports psychological ownership and long-term commitment. It also provides positive variance and flexibility assurance. If a partner has an excellent social system, psychological ownership intensifies. As such, we hypothesize:

H3: A social system is positively related to psychological ownership.

Similarly, a technical system is about processes, tasks, and technology that are needed for transforming inputs into outputs. There are four features of a technical system, namely technical centralities, technical requisites, technical proximities, and technical flows. In a supply chain, supplier integration is concerned with the partial unification of different organizations' technical systems [1] [45]. To improve competitive advantage, an integrated IoT system might consolidate the four technical features and provide high-quality technical system integration between supply partners. Ensuing confidence can enhance psychological ownership of employees. Thus, wehypothesize:

H4: A technical system is positively related to psychological ownership.

Preference construction is a psychological process. Preferences are calculated when making judgments and decisions [11]. One's decisions can be highly sensitive to situational factors that may be unrelated to the actual utility of the course of action. Thus, preferences are not necessarily stable. In fact, preferences are normally hidden and are non-intuitive. They are affected by emotional, rather than rational, factors. Also, preferences are highly influenced by goals, which themselves may change over time. The weights of preference for different performance attributes can vary significantly from member to member [37]. Social preferences refer to the welfare and reciprocation of partners within a supply chain. It focuses on the intrinsic concerns of the other party [9]. Preferences can mediate how the psychological ownership of supply chain members is affected by the social system. Accordingly, wehypothesize:

H5: Social preferences increase the positive effect of a social system on psychological ownership.

Pasmore [72] noted that successful socio-technical systems require adaptation and consideration of human conditions. After learning new information regarding likely outcomes, a firm may change its preferences about actions [20]. When a new partner enters a cooperative relationship, they will be affected by the firm's status and its relationship with its partners. This is especially the case when using IoT to enhance efficiency by integrating systems. The partners may have different statuses, and they may be unfamiliar with the system and insist on using an outdated system. These technical preferences may undermine psychological ownership. Thus, wehypothesize:

H6: Technical preference decreases the positive effect of a technical system on psychological ownership.

RESEARCH METHOD

To develop a survey instrument, a pool of items for measuring the constructs of the research model was identified from the literature. Given that sharing information via IoT to supply chain partners is a new approach for most firms, we revised the terms used in the literature to communicate effectively with our respondents. The items and sources are listed in Table 1.

Content Validity

As our respondents preferred to answer questions in Chinese, we translated the items from English and then retranslated into English. The retranslated English version was checked against the original version to ensure accuracy. The items were measured on a seven-point Likert scale, ranging from 'strongly disagree' (1) to 'strongly agree' (7).

A pre-test was performed on a sample comprising four academic researchers and four Ph.D. students. Then, several large manufacturing firms were contacted for the pilot-test. The respondents were asked to complete the questionnaire and provide comments on the wording, clarity, and overall appearance and content of the instrument. The responses suggested that all statements could be retained and that only minor cosmetic changes were needed. After further review by two other academic researchers, the instrument was ready to be sent to a large sample to gather data.

Table 1. Constructs and measures of the research items relating to adoption of IoT.

Construct		Source
Social System		
SS1	My firm shares information with supply chain partners.	[68]
SS2	We'll help each other to complete our tasks.	
SS3	We'll timely explain our goals	
Technical System		

Construct		Source
TS1	We'll ensure flexibility in our processes to meet customer's needs.	[67]
TS2	We'll plan our processes and technical activities needed.	
TS3	We'll achieve the necessary technical requirements in the organization by rewards.	
Social Preferences		
SPR1	You would treat fairly to your supply chain partners.	
SPR2	We will abide by the norms of each other.	
SPR3	We will care for each other.	[49]
Technical Preferences		
TPR1	We can provide highly respected products and services.	
TPR2	We will continue to look for new ways to improve work efficiency.	
TPR3	We will adapt quickly to new work requirements.	
Psychological Ownership		
PO1	You and your supply chain partners consider that this is your supply chain.	[46]
PO2	You and your supply chain partners sense that this is your supply chain.	
PO3	You and your supply chain partners are very easy to image that this relationships are own for yourself.	
Efficiency		
EF1	We are able to maintain a certain growth rate of sales	[47] [50]
EF2	We consider that our return on investment is improved.	
EF3	We consider that our ratio of outputs on inputs is improved.	
Adaptability		
AD1	We consider that our new products can improve the percentage of sales.	
AD2	We consider that we able to solving problems creatively.	[13] [14] [50]
AD3	We consider that the ability of learning new tasks, technologies, and procedures is improved.	

Data Collection

This study sought to select respondents with the greatest knowledge about the operation and management of the cooperative relationships between their manufacturing firm and its suppliers or subcontractors. Based on the literature and recommendations from practitioners, it was decided to select functional managers who are on the senior management team and are involved in maintaining and developing cooperative relationships with suppliers or subcontractors of the firm. We reached out to the top 2500 manufacturers listed in the directories of the China Credit Information Service. In an effort to maximize the response rate, a modified version of Dillman's [12] total design method was followed. A survey package including (1) a cover letter explaining the research objectives, (2) the questionnaire, and (3) a stamped, return-addressed envelope, was sent to managers of each firm. To make the process as convenient as possible, participants were offered options to return the questionnaire by either mail or fax. In the first two weeks, we called corporate executives to ask whether they would participate. After the telephone calls, 1326 questionnaires were sent out. Two weeks after the initial mailing, personalized reminder e-mails were sent to all potential participants. Those who did not respond to the initial mailing received a reminder telephone call three to four weeks later. A total of 302 usable responses from function managers or other managers in the senior management team were received. This resulted in a sample size of 302 for a response rate of 22.8%. A Chi-square analysis of the industry distribution of the respondents showed no difference in industry distribution of the firms used in the survey.

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