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Time-temperature transparency in the cold chain

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ABSTRACT

A study concerning time-temperature information sharing behavior in the one-step forward chilled and frozen food supply chains was conducted. We mailed 1774 questionnaires to food manufacturing companies in Taiwan with a response rate of 7.0%. We showed that obtaining raw materials time-temperature information from suppliers was more difficult than obtaining processed food product information from food manufacturers. The determinant factors considered were also different. For sharing time-temperature information on raw materials during distribution from suppliers to food manufacturers, the relative power of food manufacturers, business strategy, and raw material quality uncertainty were important. However, for sharing information on processed product during distribution from food manufacturers to buyers, only business strategy and processed product quality uncertainty were important. This implies that requesting information from suppliers requires more effort. In addition, when zooming in, we found that the time-temperature sharing strategies of companies differ in the subsectors. For instance, the chilled food sector has higher willingness to share time-temperature information than the frozen food sector.

1. Introduction

Temperature management in the cold chain has begun receiving more attention because unexpected temperature loss can lead to food safety problem and loss of consumer confidence (Chen, Zhang, & Delaurentis, 2014; Derens-Bertheau, Osswald, Laguerre, & Alvarez, 2015; Knowles, 2002; Nychas, Skandamis, Tassou, & Koutsoumanis, 2008; Röhr, Lüddecke, Drusch, Müller, & Alvensleben, 2005). However, it is difficult to control and maintain the temperature all along the cold chain; some steps are especially weak, such as loading and unloading, transport, and display cabinet (Derens-Bertheau et al., 2015). This makes cold chain management challenge (Bogataj, Bogataj, & Vodopivec, 2005; Bruckner, Albrecht, Petersen, & Kreyenschmidt, 2012).

To solve this problem, a growing number of researchers have initiated cold chain-related projects on food safety and quality. Studies include, for example, identifying temperature abuses through surveys of time-temperature monitoring (Derens-Bertheau et al., 2015; Koutsoumanis, Pavlis, Nychas, & Xanthiakos, 2010; Montanari, 2008), establishing a time-temperature database through the cold chain (Gogou, Katsaros, Derens, Alvarez, & Taoukis, 2015), and food quality evaluation of time-temperature data (Giannakourou, Koutsoumanis, Nychas, & Taoukis, 2001; Olafsdóttir et al., 1997). Such studies exemplify the trend in time-temperature information developing chain-wide in the food and agribusiness (Abad et al., 2009; Bogataj et al., 2005; Giannakourou et al., 2001; Giannakourou & Taoukis, 2003; Montanari, 2008; Raab, Petersen, & Kreyenschmidt, 2011; J. Zhang, Liu, Mu, Moga, & Zhang, 2009).

The food chain that demands logistics traceability and qualitative traceability is the cold supply chain, in which food items are perishable and very sensitive to environmental conditions such as temperature, humidity, and light. Logistics traceability refers to only the physical movement of the product and treats food as a commodity while qualitative traceability refers to additional information relating to product quality and consumer safety, such as storage and distribution conditions (Folinas, Manikas, & Manos, 2006). Having time-temperature information exchange in the whole supply chain would not only improve food safety and quality, but would also enhance logistical and process optimization (Giannakourou et al., 2001). Literature research has conceptually proved that information sharing has a positive impact on the on-time delivery rate and cost in a supply chain (Hall & Saygin, 2012). In addition, rich empirical evidence has underlined the importance of information exchange on the characteristics of products, processes, and resources between stakeholders in a food

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supply chain, particularly when meeting end-customer demands in agri-food chains (Raynaud, Sauvee, & Valceschini, 2005; Wever, Wognum, Trienekens, & Omta, 2010). Having a transparent supply chain on time-temperature information could also help government to clarify responsibility and identify which who are responsible for temperature loss. Although growing numbers of researchers have considered the positive potential of developing temperature information, very little attention has been given specifically to exchange information between supply chain partners. Raab et al. (2011) point out that lack of exchange of temperature data between companies is one of challenges currently remaining in temperature tracking. Therefore, the main research questions in this paper are (1) to what extent can time-temperature information be shared during distribution? (2) What factors do food companies consider when sharing time-temperature information with buyers? We discuss the one-step-forward supply chain (Ackerley, Sertkaya, & Lange, 2010; Bosona & Gebresenbet, 2013), and in particular the time-temperature information during distribution (see Fig. 1).

2. Theoretical background and research framework

The transparency of a supply chain is the extent to which all its stakeholders have a shared understanding of and access to the product-related information that they request without loss, noise, delay or distortion (Beulens, Broens, Folstar, & Hofstede, 2005; Hofstede, 2003). Transparency implies openness and communication. However, transparency also includes risks related to visibility in the sharing of information in business relationships (Aung & Chang, 2014; Bosona & Gebresenbet, 2013). In this section, we extend previous arguments to time-temperature information sharing and build our theoretical framework. Fig. 2 shows the relationships between the direct effects of power on time-temperature information sharing. Earlier studies have shown that business strategies (Hsiao, v. d. Vorst, Kemp, & Omta, 2010; Milgate, 2001; Rao & Young, 1994) and supply chain complexity (Robertson & Gatignon, 1998) are firm characteristics that are important in analyzing differences in supply chain decisions. Thus, we include these factors as predictors in our research model.

2.1. Definition of time-temperature information sharing

To maintain effective cold chain management, recording and tracking the temperature of food through the supply chain is an important step (Bogataj et al., 2005; Montanari, 2008). In this study, we distinguish four levels of time-temperature information sharing, namely, none; temperature at departure or receiving point; whole transport temperature information; and real-time temperature information. Temperature and time data are important during storage and transportation in food supply chains (Folinas et al., 2006; Trienekens, Wognum, Beulens, & van der Vorst, 2012). Monitoring time-temperature and having real-time information is useful because immediate decisions on quality or safety can be made based on the temperature profile of the supply chain (Giannakourou & Taoukis, 2003; Wilson & Clarke, 1998; J. Zhang et al., 2009). Some common examples of existing temperature-monitoring tools include contact thermometer, infrared thermometer, RFID (radio frequency identification) and data loggers (Abad et al., 2009; McFarlane, 1995; Raab et al., 2011; Rogers, 1997). Other advantages from temperature tracking include the reduction of costs for logistical operations, minimization of food waste, increased strategic marketing opportunities, and improved communication with intolerant consumers (Aung & Chang, 2014; Bastian & Zentes, 2013; Moe, 1998).

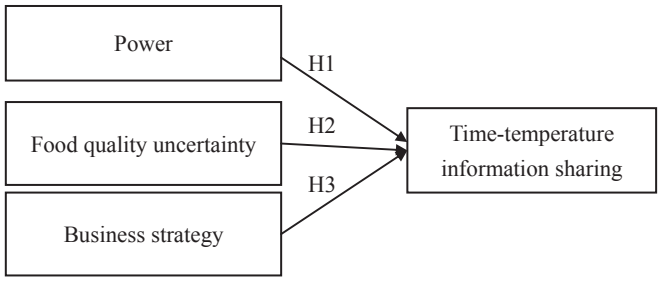

Fig. 2. Research framework: relationship between factors and time-temperature information sharing decisions.

2.2. Power

Data traceability, including collecting, keeping and sharing information, is one of key issues in the management of the food supply chain (Aung & Chang, 2014; Beulens et al., 2005). Transparency in food supply chains could be affected by power (Hingley, 2005). Power refers to one channel member's ability to influence the behavior and decisions of other members (Beier & Stern, 1969). If a focal organization is highly dependent upon another organization for an important resource (e.g., an input to its manufacturing process), that other organization will have power over the focal organization (Crook & Combs, 2007; Pfeffer & Salancik, 2003).

Power is the potential of one person to have an effect on the attitudes, perceptions, and/or behavior of another (French & Raven, 1959). Influence is the result of the successful application of that power. Five kinds of social power can be identified: expert power, referent power, legitimate power, reward power, and coercive (punishment) power (French & Raven, 1959). Studies in the literature have found that expert power and referent power of customers are important in improving suppliers' normative relationship commitment (Dapiran & Hogarth-Scott, 2003; Yeung, Selen, Zhang, & Huo, 2009; Zhuang, Xi, & Tsang, 2010). Meanwhile, reward power and coercive power enhance instrumental relationship commitment, which is based on compliance where one party accepts the influence of another in the hopes of receiving favorable reactions from another party (Gaski, 1984). Supply chain actors could exercise any of these five powers to influence the other actors (Hingley, 2005; Yeung et al., 2009). Furthermore, power could influence supply chain transparency (Beulens et al., 2005). Thus, we propose following hypothesis.

H1. *The lower power the food firm has, the higher the level of time-temperature information sharing between the firm and its downstream partners.*

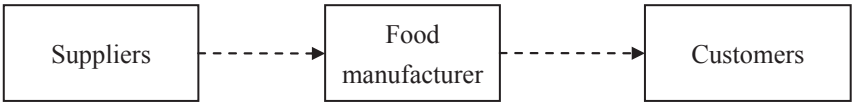

Figure 1. Chilled and frozen food supply chain: one-step forward information sharing during distribution.