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Exploring Latent Factors Influencing the Adoption of a Processed Food Traceability System in South Korea

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ABSTRACT

Several recalls of dietary supplements and infant formula not only caused direct economic loss to processors but also created distrust of food traceability systems(FTSs) initiated by government. In Korea, mandatory FTS regulations on infant formula and dietary supplements were enacted at the end of 2014, allowing the government to collect electronic traceability data to cope with food outbreaks. The aim of this study is to examine the influence and process of latent factors by developing a theoretical model and testing empirical data from the Korean processed food sector. The particular value of this study is to identify the latent factors influencing the diffusion of an electronic FTS. Three external factors (organizational adaptability, validity and awareness of FTS) were incorporated into a technology acceptance model (TAM) based on previous studies, and structural equation modeling (SEM) was used as a tool for confirmatory analysis. The validity of FTSs has a prominent effect on attitudes toward FTSs and compliance intentions. Contrary to the findings of previous studies, organizational adaptability does not influence a positive effect on attitudes toward FTS. Furthermore, subgroup analysis showed that retailers reacted significantly to the different influences than manufacturers. The findings of this paper have implications for both policy makers and regulatory authorities. The results of this theoretical and practical study contribute to establishing a conceptual framework and motivate additional researches on FTS adoption and diffusion in processed food sectors.

Keywords: food traceability systems; technology acceptance model; diffusion and adoption of FTS; structural equation model; processed food sector

1 Introduction

Free trade agreements have reduced trade barriers and allowed food enterprises to trade food products at historically high levels. The quantity of food products in worldwide trade is increasing at such a rapid rate that customers are increasingly exposed to the dangers of hazardous food recalls. Many nationwide food outbreaks are associated with commercially distributed food products (Hassini *et al*., 2012). In the event of a food outbreak, food traceability is useful for identifying the origin of products and investigating problems across the farm-to-fork supply chain. Traceability is an effective tool for risk management in order to support a mandatory or voluntary recall system (Charlebois *et al*., 2014).

High customer expectations have spurred the Korean government to improve safety in the processed food sector since 2003. Many international food scandals have increased public awareness of the legislative requirements for food traceability (Carriquiry and Babcock, 2007). Statutory traceability regulations for electronic recordkeeping were enacted to improve food traceability in Korea on December 1, 2014, and this legislation applied to only infant formula and dietary supplements. According to the United Nations 2018 e-Government Survey (UN, 2018), Korea is ranked third on the e-government index and development of ICTs in the world. As an e-government leader of the top 10 countries, Korea is driving innovation by tackling complex tasks to adopt electronic labels with barcode and information sharing among supply chain actors. Most interdisciplinary academic research has focused on the traceability of beef, agricultural products, and fish in many nations. Considering large-scale hazardous potential of the processed foods, it is necessary to improve the traceability across whole supply chain from farm to table.

This paper introduces the current FTS in Korea and reviews the relevant literatures to develop a confirmatory model incorporated into a technology acceptance model (TAM) (Davis, 1989) with empirical analysis by means of a structural equation model (SEM). The originality of this study is its examination of several critical factors using unique industry data and its analysis of their effects on the FTS process initiated by the government. The paper is organized as follows. A food traceability overview is provided and the current FTS in Korea are reviewed in Section 1. In Section 2, we review the literature, addressing food traceability and the theoretical background for our proposed model. We develop a research framework that explains the process of FTS adoption as confirmatory analysis. Section 3 presents the results of a survey of 301 industry samples. We use SEM to test our conceptual framework and describe the practical implications, including suggestions for future research, in Section 4.

1.1 Food traceability overview

ISO 9000 standards (ISO, 2005) define traceability as the ability to trace the history, application, or location of the product under consideration. The Codex Alimentarius (Commission, 2004) defines traceability as the ability to follow the movement of food through specified stage(s) of production, processing, and distribution. Food traceability has been employed in many countries not only as a tool to manage food quality and safety (Charlebois *et al*., 2014; Forås *et al*., 2015) but also to inspect and certify. European Union regulation 178/2002 narrowly defines traceability as the ability to trace and follow a food, feed, food-producing animal, or substance intended or expected to be incorporated into a food or feed through all stages of production, processing, and distribution. In Europe, EC General Food Law Regulation 178/2002 (Law, 2002) requires the establishment of a traceability system for all food products and has been modified to address specific matters, such as GMOs, allergens. In the US, food traceability was first introduced and became a legislative imperative in response to bioterrorism. Traceability improvements in the food sector was intensified with implementation of the FSMA (Food Safety Modernization Act). The FSMA introduced a system of preventive controls, inspections, and compliance authorities in response to violations in both domestic and imported foods in the US.

Many publications have discussed various analytic studies on food traceability in the past two decades. Food traceability is an interdisciplinary field, but no common framework has emerged to explain the definition or implementation of food traceability (Karlsen *et al*., 2013). Given the complexity of the global food system, improving traceability practices across the entire food sector is a challenge. Information connectivity and supply chain visibility have been a focal area in recent decades, and food traceability should be considered an integral part of logistics management (Bosona and Gebresenbet, 2013). Moreover, to be truly effective, an FTS should be conceived and implemented at the entire supply chain level (Dabbene *et al*., 2014), going beyond the basic principle of one-step-back and one-step-forward traceability in EC Regulation 178/2002. The new technological advancements like RFID, NFC, DNA barcoding provide promising tools for improving the efficiency and compatibility of the present FTS (Badia-Melis *et al.,* 2015). The IoT devices exchanging GS1 message standards has enabled stakeholders to create a distributed ledger to share data to trace, which improve the transparency and accuracy of information by integrating Block chain and IoT (Kim *et al*., 2018). Food traceability is a cornerstone of the increasingly complex, industrialized, and global food system. Therefore, the food product should be tracked and identified as the units in which the recording of the joining and splitting across the supply chain (Olsen and Borit, 2018).

1.2 The current status of the FTS in Korea

Food traceability began with an opt-in pilot project to minimize the risks of microbial agricultural food hazards in accordance with Good Agricultural Practices (GAP) in Korea. On December 21, 2006, an agricultural products traceability act was enacted (www.farm2table.kr) by the MAFRA (Ministry of Agriculture, Food and Rural Affairs), and seafood traceability (www.fishtrace.go.kr) was enforced by the MOF (Ministry of Oceans and Fisheries) on January 26, 2007, on a voluntarily basis and was applicable to specific domestic fishes. On December 21, 2007, Korea's Cattle and Beef Traceability Act was implemented to improve the domestic livestock sector and protect consumers by efficiently preventing epidemics and ensuring meat safety. The producers, including all trading partners, must record and transmit the identification number for tracing on the national platform (www.mtrace.go.kr). On November 22, 2010, the Cattle and Beef Traceability Act was amended and applied to imported beef, with the unique number assigned at the time of customs clearance (www.meatwatch.go.kr).

A Chinese milk scandal in 2008 involved domestic dairy products, infant formula, and other suspicious food products that were contaminated with melamine. The Ministry of Food and Drug Safety (MFDS) issued a compulsory recall to identify and withdraw all relevant foodstuffs that were imported, processed, or distributed in internal markets. However, the recall measure failed to identify business operators or collect foods at the expected level of food safety due to the lack of shared traceable data across the food supply chain. Therefore, a processed food traceability system was introduced voluntarily and legally went into effect in September 2008. Several recalls of dietary supplements caused not only direct economic loss to manufacturers but also created distrust of government-initiated FTSs. Mandatory FTSs were applied to infant formula and dietary supplements at the end of 2014, allowing all stakeholders to share electronic traceability data to cope with food outbreaks. Under regulations, the unique traceable number should be assigned to food products with GTIN-13 and a batch or lot number.

FTS provides more useful information to consumers through web site (http://www.tfood.go.kr) as well as mobile application. The traceability information requested by the government includes a standardized traceable number, product information, processed food manufacturer's (importer's) profile name, quantity and unit of measure, buyer profile, and dispatching date. Retailers also have mandatory recordkeeping obligations that include the standardized traceable number, supplier's name, receipt-selling date, quantity, and unit of measure. The aim of this study was to describe the influence and process of latent factors by developing a theoretical model and testing empirical data from the Korean processed food sector. The following literature review extracted three external factors, namely, organizational adaptability, validity and awareness of FTSs. We incorporated these external factors into TAM and proposed our research framework to conduct confirmatory analysis using SEM.

2 Literature review

2.1 Technology acceptance model (TAM) and its applicability

Food regulations in Korea have driven the technological evolution of an electronic FTS. The FTS involves the delivery of technology information service via IoT to improve product traceability. TAM (Davis, 1989) is the most parsimonious and powerful theory for explaining technology acceptance. TAM is well established and has been applied to various research fields as a strong confirmatory framework that predicts user acceptance. Recently, an extended TAM has been developed to test citizen engagement in online e-government services (Cegarra *et al*., 2014; Venkatesh *et al*., 2012). Another study (Lee *et al*., 2011) also proposed an extended TAM that combined innovation diffusion theory with TAM. Although many scholars have employed and studied TAM in various domains, such as healthcare and policy innovation (Chan *et al*., 2012; Ward, 2013), few studies related to FTSs have been conducted in the processed food sector. This paper incorporated major external factors influencing FTSs into TAM to carry out confirmatory statistical analysis of our research model.

2.2 Research model and hypotheses with related theories

2.2.1 Organizational adaptability

It is noteworthy to consider the diffusion of an electronic FTS as a technology-based service, such as e-government. Organizations sometimes fail to adopt a new technology or technology-driven service because they fail to make necessary organizational adaptations (Chatterjee *et al*., 2002). Organizational adaptation depends on a certain level of organizational competency that makes necessary organizational changes by redesigning processes and acquiring new expertise (Tung-Wen Sun *et al*., 2013). In the context of FTSs, technology integration is also a major part of organizational adaptability, representing the degree of inter-connectivity between an organization's back-end information system and the supply chain partners' systems (Zhu *et al*., 2006). Therefore, our research posits that organizational adaptability has a significant influence on the level of an electronic FTS. This factor could play an important role in determining whether a supply chain actor adopts an FTS or not, depending on its competence. Organizational adaptability has varying effects on attitudes toward FTSs (Venkatesh *et al*., 2012). Thus, we formed the following hypotheses:

H1. Organizational adaptability has an effect on the intention to comply.

H2. Organizational adaptability has a positive effect on attitudes toward an FTS.

2.2.2 Validity of FTSs

The FTS is a process innovation to change adoption behavior and achieve a certain end-state desired by the government. When processed food manufacturers and retailers do not have any prior experience in adopting a mandatory FTS service, their perceptions of the FTS service can be generated by bilateral trust with the government. The perceived trust can be defined as a cognitive state affecting users' intentions to accept vulnerability based on the positive anticipation of an intention or behavior by another (Camerer, 1998). Prior research posits that perceived trust plays an important role in users' intentions to adopt specific services (Montijn-Dorgelo and Midden, 2008). A large number of previous studies have found that users' trust significantly affects attitudes toward a service in the areas of consumer behavior, commercial transactions, and other areas in an internet-based environment (Bart *et al*., 2005; Wu *et al*., 2011). Trust between the government and food business operators is therefore based on the validity of policies and regulations enacted by the government. Therefore, on the basis of prior studies, we hypothesized that the perceived validity of an FTS affects users' attitudes toward it.

H3. The perceived validity of an FTS has a positive effect on attitudes toward it.

2.2.3 Awareness of FTSs

Some supply chain actors are reluctant to participate in an FTS because they do not completely understand the incentives and benefits given by the government (Van der Vorst and Bremmers, 2004). The food traceability program initiated by the Taiwanese government in 2004 failed mainly because most farmers lacked awareness of the program (Liao *et al*., 2011). Thus, effective training and education programs are required to increase levels of business operators' awareness. According to Bosona and Gebresenbet (2013), some supply chain actors are initially resistant to mandatory adoption of FTS because they consider an electronic FTS to be a heavy bureaucratic load. This finding implies that adopting an FTS will be more difficult when users are less aware of FTSs. Therefore, on the basis of the validated connections provided by prior research, we hypothesized the following:

H4. Awareness has a positive effect on attitudes toward FTSs.

2.2.4 Attitude and compliance intention

A strong positive attitude toward FTSs must positively affect the intent to comply with the FTS, based on the TAM and its extended theories. Therefore, we hypothesized the following:

H5. Perceived attitudes toward FTSs have a positive effect on the intent to comply by adopting food traceability regulations.

2.2.5 Moderating variables

We formulated and validated two subgroup analyses: processed food manufacturers (n = 106) and retailers (n = 195). In the proposed research model, we also analyzed and validated differences in adoption behaviors among those that adopted FTSs in different years.

2.2.6 Research model

The research model (Fig. 1) was examined to validate the proposed hypotheses.

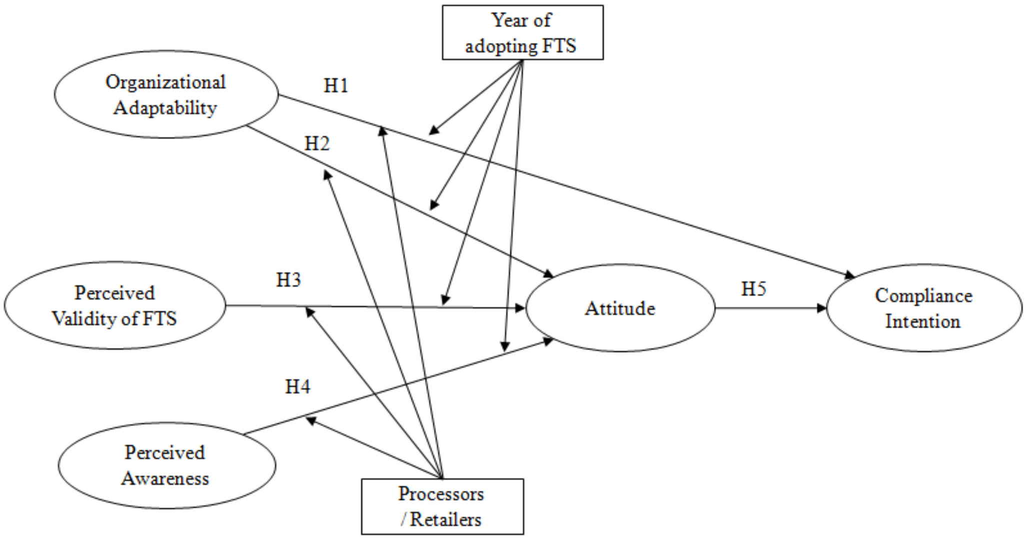

Figure 1. The proposed research model.

3 Research methodology

3.1 Research design

We used the same questionnaire, putting considerable effort into context, response format, measurement scale, and clarity of instructions. The questionnaire items were reviewed and modified by an expert group with three professors in the areas of food engineering, industrial engineering and statistics; one communication researcher; and three representatives of the food sector, two from processed food manufacturers and one from retailers. The role of the expert group was to derive influential factors for FTS implementation and to design a research methodology. Then, we conducted three testing rounds with a pre-survey. Factors and their reflective items were contextualized from prior research are shown in Table 1. The survey participants responded to each item on the questionnaire using a 7-point Likert scale from "strongly agree" to "strongly disagree." Table 1 includes an overview of the measurements with definitions. From the results of the pre-test, we used 23 of the initial items and excluded 8 items. The final structured items on the questionnaire are described in Table 1.

Table 1.
The structured items of the survey instruments.

Constructs	Items	Descriptions
Organizational Adaptability	OA 1 OA 2 OA 3	I really feel my organization has a great deal of traceable data requested by MFDS. I am happy that the top management fulfills the commitment to implement FTS I would be very happy to utilize the human resource, IT infra, etc. of my organization
Validity of FTS	VF 1 VF 2 VF 3	I think my company has an enough resources like IT infra, human power to implement. I think FTS is more trustworthy than other food safety system. I feel that FTS is highly reliable than other food safety and quality system
Awareness of FTS	PA 1 PA 2 PA 3	Adopting FTS give us social benefit relating to food safety. Overall, I feel that introducing and implementing FTS is beneficial for our society Overall, I feel that adopting FTS give us more economic benefits.
Compliance Intention	CI 1 CI 2 CI 3	I intend to use the FTS system for performing my job as often as needed. To the extent possible, I would frequently use FTS in my job. I would rather use FTS than other food safety applications or services in my job.
Attitude toward FTS	AT 1 AT 2 AT 3	I would have positive feelings toward FTS in general. It is better for me to use FTS in the event of food hazardous accidents. I would have positive feelings toward FTS in general.

3.2 Data collection

FTS regulation forces all enterprises to designate a single representative for an FTS who can access the MFDS's centralized information system. The representative is required to record and send the traceable data requested by the government. After the prior approval of representatives, 323 staff members provided informed consent to participate in the questionnaire. We used an online survey method to collect industry data at the level of individual units. We analyzed the filtered data from 301 respondents who had a high level of knowledge about FTS services (Table 2). The processed food manufacturers were responsible for generating traceability data and transmitting data to government, whereas the retailers were responsible for identifying and sending data to the MFDS. The mandatory year of adopting an FTS varied by the annual sales of the processed food manufacturer and the areas of the retailers. Processed food manufacturers with more than 4.5 million USD and retailers with more than 1,000m^2 had to adopt an FTS by the end of 2014. Processed food manufacturers with annual sales from 4.5 million to 1 million USD had to adopt an FTS by the end of 2015. Retailers with areas from 1,000m^2 to 500m^2 had to adopt an FTS by the end of 2015. Table 2 shows that the number of processed food manufacturers is 106 (35.2%); the rest are retailers. Small and medium-sized companies with less than 50 employees accounted for 64.8%, and companies with more than 50 employees accounted for 47.2%. Table 2 shows that 52.9% of the respondents had already adopted an FTS in 2014, whereas 47.2% adopted an FTS in 2015, which implies that FTS obligations are applied to firms on an annual basis.

Table 2.
Respondent characteristics.

Respondents profile	Frequency	Percent (%)	Cumulative (%)
Type of firm			
Processors	106	35.2	35.2
Retailers	195	64.8	100.0
Size of revenue			
≥ 4,200,000 USD	196	65.1	65.1
≥ 830,000 USD, < 4,200,000 USD	68	22.6	87.7
< 830,000 USD	37	12.3	100.0
Number of employee			
≥ 200 personnel	30	10.0	10.0
≥ 50 personnel, < 200 personnel	82	27.2	37.2
≥ 10 personnel, < 50 personnel	83	27.6	64.8
≥ 1 personnel, < 10 personnel	106	35.2	100.0
Year of adopting FTS			
In 2014	159	52.8	52.8
In 2015	142	47.2	100.0

3.3 Data analysis and results

We used AMOS 1.8 and SPSS 18.0 for our data analysis, which we carried out using a two-step methodology (Anderson and Gerbing, 1988) to prevent possible interactions between the measurement and structural model of the SEM. The structural model describes relationships among latent factors, and the measurement model describes relationships between observed variables and latent factors.

3.3.1 Measurement model

We estimated the measurement model using confirmatory factor analysis (CFA) to test whether all factors possessed validity and reliability. The composite reliability levels and the Cronbach's alpha values of the measurements were calculated to evaluate validity and reliability. All Cronbach's alpha values were higher than 0.70, indicating internal reliability. Further analysis was conducted to assess the psychometric properties of the scales. The construct validity of the research instrument determines the extent to which the operationalization of a factor actually measures what it is designed to measure. Convergent validity was assessed using three measures, as shown in Table 3. Previous studies have shown that all factor loadings should be greater than 0.50 to ensure convergent validity. As shown in Table 3, this study met those recommendations.

Table 3.
Convergent validity test result.

Constructs	Items	Factor loading	Composite reliability	Average variance extracted
Organizational Adaptability	OA 1	0.831	0.70	0.61
	OA 2	0.796		
	OA 3	0.703		
Validity of FTS	VF 1	0.787	0.68	0.57
	VF 2	0.761		
	VF 3	0.709		
Awareness of FTS	PW 1	0.799	0.76	0.64
	PW 2	0.691		
	PW 3	0.896		
Compliance Intention	CI 1	0.893	0.78	0.74
	CI 2	0.823		
	CI 3	0.934		
Attitude	AT 1	0.812	0.80	0.78
	AT 2	0.898		
	AT 3	0.860		

It is recommended that the square root of the average variance extracted (AVE) of factors is higher than the correlation between two factors. All values in this survey satisfied this requirement (Table 4). Therefore, the measurement scales for each factor have high convergent validity.

Table 4.
Correlation and square roots of average variance extracted.

Constructs	OA	VF	AW	AT	CI
OA	0.78				
VF	0.51	0.75			
AW	0.73	0.31	0.80		
AT	0.40	0.90	0.28	0.86	
CI	0,41	0.88	0.30	0.90	0.88

3.3.2 Structural model

The structural model was examined using the cleansed measurement model. We used CFA to examine the measurement model fit using eight common model fit measures: chi-square/degree of freedom = 2.889, P < 0.0001, GFI = 0.905, AGFI = 0.857, NFI = 0.928, CFI = 0.952, RMSEA = 0.088, and RMR = 0.079. The fit of the measurement model is thus good. The fit of the structural model is also good: chi-square/degree of freedom = 2.654, P < 0.0001, GFI = .0.914, AGFI = 0.873, NFI = 0.933, CFI = 0.957, RMSEA = 0.074, and RMR = 0.215. As Table 5 shows, all the model fit indices satisfy their respective acceptance criteria suggested in the literature (Hair *et al*., 1995; Hooper *et al*., 2008). Therefore, we have shown that the hypothesized model appears to be a good fit for the data. To test structural relationships, we estimated the hypothesized causal paths. Four hypotheses were supported, and one hypothesis was rejected. The standardized AMOS path coefficients and overall fit indices are shown in Fig. 2 and table 6. Three variables (organizational adaptability, validity of FTSs and awareness) were significantly related to attitude and explained 82.6% of the variance in attitude: organizational adaptability for attitude (β = -0.151, $p < 0.05$), validity of FTSs (β = 0.953, $p < 0.001$) and awareness (β = 0.152 1, $p < 0.05$). Attitudes were significantly related to compliance intention and explained 80.2% of its variance: attitude (β = 0.954, $p < 0.001$). On the other hand, organizational adaptability was not related to compliance intention. Thus, all hypotheses were supported except for H1.

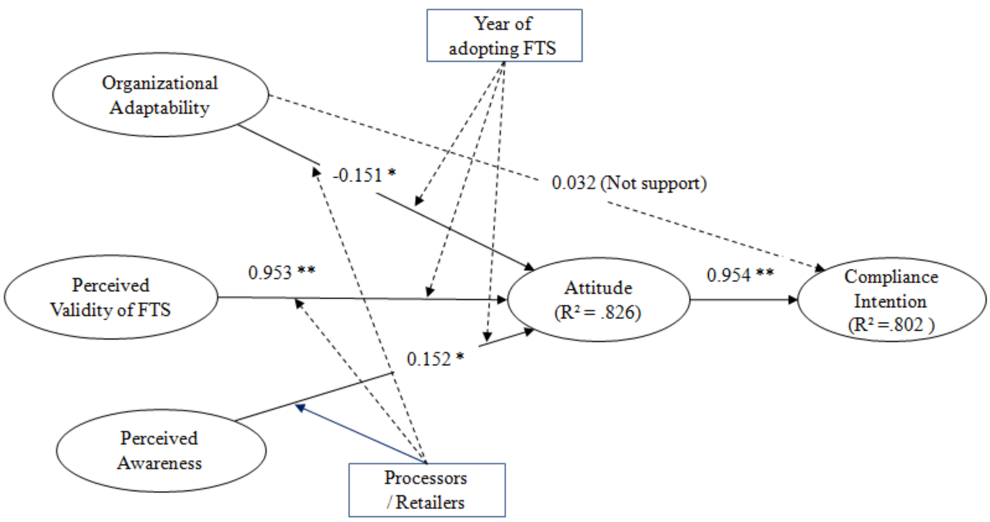

Figure 2. Research model Hypothesis test result (P** :0.001,*:0.05).

Table 5.
Fit indices for the measurement model and structural model.

Fit index	Measurement model	Structural model	Threshold value
χ2 /d.f	2.889	2.654	<5.00
GFI	0.905	0.914	>0.90
AGFI	0.857	0.873	>0.80
NFI	0.928	0.933	>0.90
CFI	0.952	0.957	>0.90
RMSEA	0.088	0.074	<0.10
RMR	0.079	0.215	<0.08

Table 6.
Summary of Hypothesis tests.

Hypothesis	Standardized Path coefficient	SE	CR	Support (P<0.05)
H1: OA → AT	- 0.151	0.121	- 2.111	Supported
H2: OA → CI	0.032	0.074	0.762	Not Supported
H3: VF → AT	0.953	0.088	12.884	Supported
H4: AW → AT	0.152	0.083	2.609	Supported
H5: AT → CI	0.954	0.061	16.434	Supported

3.4 Group analysis as a supplementary analysis

As a supplementary analysis, we performed multiple group analysis to examine whether there are different path coefficients of business types (processed food manufacturers and retailers) and different adoption years. First, we conducted additional multiple group analyses according to the business type, processed food manufacturer (n = 106), and retailer (n = 195) to determine whether the patterns of FTS adoption were consistent across these subgroups. We found that each subgroup had patterns of FTS compliance adoption similar or identical to those observed in the group as a whole. Table 7 presents the results of each subgroup's CFA for each measurement model and gives factor loadings with the composite reliability and AVE values. These values suggest that the measurement scales for each factor support the convergent validity and factor validity within each subgroup.

Table 7.
Results of confirmatory factor analysis between processor and retailer.

Constructs	Items	Manufacturer		Retailer	
		Factor loadings	CR / AVE	Factor loadings	CR / AVE
Organizational	OA 1	0.778	0.71 / 0.45	0.862	0.82 / 0.68
Adaptability	OA 2	0.686		0.845	
	OA 3	0.530		0.764	
	VF 1	0.823	0.68 / 0.57	0.778	0.64 / 0.57
Validity of FTS	VF 2	0.758		0.762	
	VF 3	0.665		0.728	
Awareness of FTS	AW 1	0.702	0.68 / 0.59	0.729	0.71 / 0.67
	AW 2	0.525		0.684	
	AW 3	0.998		0.999	
Compliance Intention	CI 1	0.944	0.84 / 0.78	0.930	0.80 / 0.78
	CI 2	0.898		0.892	
Attitude	CI 3	0.803		0.830	
	AT 1	0.939	0.81 / 0.71	0.883	0.75 / 0.75
	AT 2	0.725		0.844	
	AT 3	0.852		0.587	

Then, we estimated a free model (model 1) in which the lambdas for all factors were free across groups as shown in Table 8. Model 1, which evaluates configurable invariance, yielded $\chi2 = 376.40$ with 162 degrees of freedom. The second model (model 2) was estimated to determine whether the measurement model is the same for processed food manufacturers and retailers. To evaluate this model, we constrained the factor loadings (lambdas) across the two subgroups. The $\chi2$ difference between the two models (model 1 and model 2) showed non-significant results ($\Delta\chi2 = 392.32$, df = 172), which means that the measurement scale was equal across the subgroups. Third, we estimated model 3 to determine whether the factor co-variances were equal across subgroups. This procedure was conducted by constraining the φs to be equal to evaluate nomological validity.

Table 8.
CFA model comparison between processor and retailer.

	Δchi	df	CFI	RMSEA	Δ /df	Sig
Unconstrained	376.40	162	0.932	0.067		
γ (model 2)	392.32	172	0.930	0.065	15.92/10	No
Ø (model 3)	393.88	177	0.931	0.064	1.56/5	No
γ Ø (model 4)	412.45	187	0.929	0.063	18.57/10	Yes

Based on the discriminant validity results (model 2), we conducted additional SEM analyses according to three factors (organizational adaptability, validity of FTSs, and awareness) to determine whether the patterns of FTS adoption were consistent between processed food manufacturers and retailers. Then, to assess the differential effects of processed food manufacturers and retailers, we conducted a series of chi-square difference tests on the constraints of each hypothesis. Then, to assess the differential effects of manufactures and retailers, a series of chi-square difference tests were conducted on the constraints of each hypothesis. The results of this analysis shown in Table 9 did not show any significant differences between subgroups except for the awareness factor and attitude factor to AT ($\Delta\chi2$ = 3.90, df = 1 ≥ 3.84 threshold). Hence, the regression coefficient of awareness on FTS attitudes was significantly different between processed food manufacturers and retailers. The awareness of retailers has a significantly stronger effect on attitudes toward adopting FTSs than that of processed food manufacturers.

Table 9.
Path constrained model.

Path constraints	Λchi	Df	Λ /df	Λchi / Sign
Free model	423.02	190		
Univariate test				
Constrain OA → CI	423.12	191	0.10	No
Constrain OA → AT	423.03	191	0.01	No
Constrain PV → AT	423.11	191	0.09	No
Constrain AW → AT	426.92	191	3.90	Yes
Constrain AT → CI	423.04	191	0.02	No

Second, we again conducted multiple group analyses according to adoption year to evaluate whether the patterns of FTS adoption were consistent across these subgroups. Regarding the subgroups that adopted FTSs in different adoption years, Table 10 shows that the $\chi2$ difference between these two models (model 1 and model 2) showed significant results ($\Delta\chi2$ = 412.07, df = 172). This result means that the measurement scale is unequal across subgroups. Therefore, as a next step, we cannot statistically assess the differential effects of the two subgroups that adopted FTSs in different years (2014 versus 2015).

Table 10.
CFA model comparison between different years of adopting FTS (two subgroups).

	Δchi	df	CFI	RMSEA	Δ /df	Sig
Unconstrained	371.99	162	0.931	0.066		
Γ (model 2)	412.07	172	0.921	0.068	40.08/10	Yes
Ø (model 3)	394.45	177	0.928	0.064	17.63/5	Yes
γ Ø (model 4)	468.29	187	0.907	0.071	73.84/10	Yes

4 Discussion and conclusions

FTS can be improved when it is coordinated with the processed food and produce sectors, which provide ingredients into the processed food. While much attention has been focused on the traceability in produce sectors, a little research has aimed at analyzing FTSs in the processed food sectors. The model expressed a theoretical rationale to explain that the intention to comply with a mandatory FTS was influenced by three external factors (organizational adaptability, validity, and awareness of the FTS).

We found that compliance intention in adopting FTS was indirectly affected by organizational adaptability, validity and awareness of FTSs. The empirical findings indicate that main positive effects toward FTSs are the validity of FTSs and awareness of FTSs, while the negative effect is organizational adaptability. The validity of FTSs has the strongest positive effects on attitudes toward FTSs. The three variables (external factors) were significantly related to attitude and explained 82.6% of the variance in attitudes toward FTSs. Organizational adaptability has a negative effect on attitudes toward FTSs but no significant effects on compliance intention. This result shows that organizational adaptability did not play significant factor, which is inconsistent with previous research (Schwägele, 2005). A possible explanation is that large processed food manufacturers have a well-established internal food safety system, so they are unlikely to change their business practices and information systems as requested by the government. Similarly, small and medium-sized processed food manufacturers also tend to be less reluctant to change their business practices and not willing to accept an electronic FTS. This paper reveals that critical success factors such as government laws and regulations, consumer knowledge and top management is critical to the implementation of FTS, which is in line with the findings by Duan et al., (2017).

This paper shows that the type of firm plays a moderating role that affects the path between awareness and attitudes toward FTSs. Retailers and manufacturers have different influences on their awareness and attitudes toward FTSs. A possible explanation is that retailers are more resistant to adopting FTSs because of difficult identification of the expanded barcode at the time of receipt. However, the adoption year of an FTS was not associated with an influential impact on attitudes toward the FTS and its three antecedent factors.

This study can greatly contribute to the understanding, diffusion and adoption of an FTS, which may highlights several implications for policy makers. The noteworthy contribution is to establish a substantive research framework to investigate industry behavior under the government initiated FTS. The government initiated FTS regulation is the most important critical success factor with highest drive-power (Shankar *et al.,* 2018). Thus, understanding and exploring FTS diffusion can provide insights into the dynamics of government-led innovation.

This study has some limitations regarding the generalized interpretation of its findings. First, the causal mechanism of each factor could only be inferred based on the research framework and the cross-sectional nature of this analysis. Since the FTS diffusion plan in Korea has been phased in since the end of 2014, a possible future research avenue might be investigating the longitudinal nature to a larger degree, and satisfaction rate could be considered as a dependent variable. Second, this study was conducted with a simplified model by intentionally excluding other latent factors. It is reasonable to infer that other factors, such as cost, benefits, experience, and satisfaction toward FTSs, could be incorporated into a future research model. Future studies investigating other latent factors not included here will extend our findings by addressing our study's limitations.

Despite its limitations, our derived research models and empirical results also provide valuable indicators for future research and may guide the development of a theorized common framework for FTSs. This study performed the first confirmatory analysis of latent factors and their mechanisms involved in FTS diffusion. Since the external factors of our research model is critical for successful FTS diffusion, government should give much more attention on laws, regulations, and its support to the food enterprises.

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