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Critical factors affecting the adoption of container security service: The shippers' perspective

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A B S T R A C T

After September 11, 2001, a so-called container security service (CSS) composed of auto-detection and radio frequency identification (RFID) technologies has been introduced and commercialized. The objective of this study is to identify the factors affecting intention to adopt the CSS. A novel research model was developed based on the technology acceptance model. Eight hypotheses derived from this model were empirically validated using a questionnaire survey of current users of container transportation and structural equation modeling (SEM). The results suggest that security (SE) strongly effects on the perceived ease of use, attitude and behavioral intention (BI) to adopt the CSS. This implies that system operators should further enhance data security to increase the intention to adopt the CSS.

1. Introduction

With the ability to offer door-to-door service, containers have become the predominant mode for transporting cargo and play an important role in global supply chain management. However, to enjoy this convenience, the security (SE) of containers must be ensured. Notably, containers, especially ocean-going containers, usually take several days or even weeks to reach their destinations. During a journey, containers carrying commodities are temporarily outside the physical control of their owners, and are instead handled by truckers, terminal operators, shipping companies and in some cases railroad operators. In the field of logistics, auxiliary tools, such as barcodes and radio frequency identification (RFID) tags, have been widely adopted to enhance cargo tracking (Tzeng et al., 2008; Lee et al., 2008). When a box, carton or pallet passes specific locations, their codes are scanned or read via these tools into a backup system. As the number of times a code is read during a journey increases, the preciseness of cargo tracking increases, which is helpful in reducing the risk of cargo loss.

Some pilot tests have been conducted in which container ID codes are read automatically as a substitute for manual operation. The most common technologies adopted are RFID and optical characteristic recognition (OCR). Although both can automatically read container numbers accurately, thereby reducing the possibility of errors generated while manually inputting codes, these technologies provide limited functions in enhancing container SE. Therefore, the so-called container security service (CSS) has been introduced into the container transportation industries. In the CSS, an electronic device, a conveyance security device (CSD), is affixed to a container that automatically detects and records events a container undergoes during its journey. Once a container passes through fixed readers setup at gates and on gantry cranes in terminals, the container number and all records are read remotely and transmitted to a backend system. The entire CSS process can be divided into three stages (see Fig. 1).

In the preparation stage, a CSD with a unique ID code and an empty container are picked up by a shipper. After

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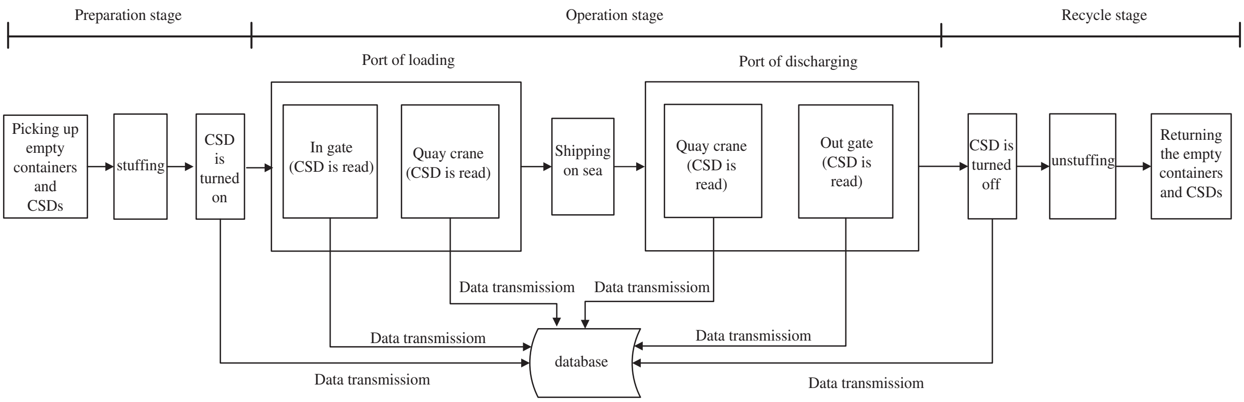


Fig. 1. A typical operation process of CSS.

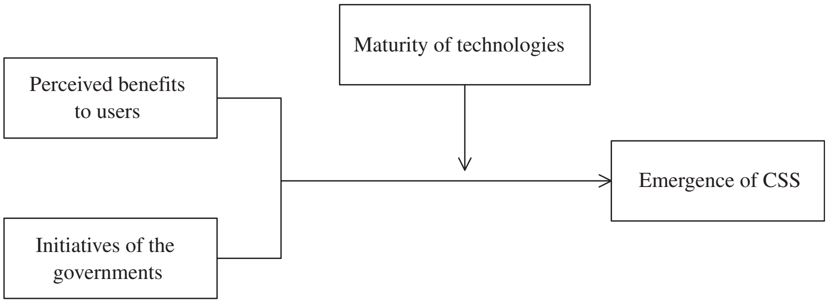


Fig. 2. The driving factors of CSS.

stuffing the container, a CSD is affixed to the container and the container door is closed.[1] The CSD is then turned on and starts detecting and recording events. Additional information, such as container number, seal number, manifest number and trip status, are input into the CSD when the container is headed for the US. The operational stage begins when the CSD is turned on. In practice, containers are trucked to terminals before being loaded onto ships. When a container passes through a terminal gate, the information on the CSD is transmitted remotely to a fixed reader. If a container has been tampered with on route between a shipper's premises and gate, an alert code is sent to the system database and then relayed to shippers or consignees instantly. Similarly, when containers are lifted onto a vessel, the data in their CSDs are automatically read again to check their SE status, and record that these containers are now on a vessel. When the container arrives at the destination terminal, its CSD is read at the gantry and gate. Finally, when a container arrives at the consignee's premises, its CSD is read again and turned off before its doors are opened, which is the start of the recycle stage. During this stage, CSDs are collected and sent back to carriers.

After September 11, 2001, the SE and efficiency of the global supply chain, which concerns both physical and information flows from an origin to customers (Banomyong, 2005), has become an important issue in global transportation. The CSS may be considered an innovative service added to the conventional container transportation service. Users (mostly meaning shippers) can decide to use the CSS as long as they agree to pay surcharges for its use. Two direct factors and one indirect factor drive the emergence of the CSS (see Fig. 2). The perceived benefit to users is the first factor driving emergence of the CSS; that is, the CSS enhances SE during container transportation. In practice, a seal and an equipment interchange report (EIR) have been used to ensure container SE during a journey. A seal still undamaged at a destination with its original number proves that a container had not been opened during its journey. However, as inspections are performed by public sector employees, such as customs or quarantine officials, seals in some cases must be cut for inspection purposes. After inspection, a new seal is affixed to the container; this practice has engendered debate regarding the trustworthiness of seals. Conversely, the EIR only records container status when a container is transferred between parties during a journey, such as between shippers and truck drivers, and trucker drivers and terminals; thus, EIR has limited SE function. Both seals and EIRs are used to identify responsibility when incidents occur or claims are made. They are lack of abilities to prevent illegal activities.

[1] Most CSDs are designed to be easily embedded in the doors of containers to monitor events. Thus, a CSD should be installed on the door before it is closed. The CSD is then turned on.

For shippers concerned about global supply chain management or move high-value cargo, reliable ways of increasing container SE are needed. Currently, two strategies are typically adopted to increase container SE; namely, enhancing cargo protection, and precisely tracking containers. To enhance cargo protection, some shippers carefully check the roof, floor and walls of empty containers while picking them up because a secure container provides good protection for cargo. In addition to the seals provided by carriers, some shippers use their own seals on the container doors to reduce the likelihood of a container being tampered with. To precisely track a container, container-tracking data is provided by most carriers on their websites; however, the quality of data from the perspectives of timeliness and accuracy can be improved. Because data are updated and transmitted from hundreds of parties worldwide, including ports, terminals, rail ramps and inland depots, data quality is not uniform. Some data are precise and transmitted in a timely manner, while other data are poor and delayed. Consequently, many accounts prefer to setup direct EDI connections with liners rather than tracking their containers on a liner's website.

The issue of SE is not only a concern of users of container transportation, it is also a problem of national SE in many countries, especially in the US after September 11, 2001. As container content cannot be seen and identified from the outside, containers are sometimes used by opportunists to smuggle goods and people. In addition to consumer goods, such as agricultural products, alcohol and cigarettes, drugs and weapons, which can cause serious social problems, are also commonly smuggled in containers. Therefore, most countries have focused on enhancing anti-smuggling activities at seaports and airports. Consequently, checking container SE is an important task of customs or homeland security departments in most countries. Some countries are developing technologies to assist officials in checking container SE, which also drives the emergence of the CSS.

With new remote-communication technologies, the issue of upgrading container SE is now being considered and discussed again. For instance, various kinds of electronic seals (e-seals) that can send signals automatically have been developed and tested. Once an e-seal is broken, or a container deviates from its preplanned route while being moving by trucks, a control center will immediately be notified. Notably, such a mechanism has a blind spot for detecting incidents in which a container is tampered with without breaking its seal. For example, digging holes in walls or taking off the entire door of a container are common smuggling methods. This study presents a novel analytical framework for identifying the critical factors that affect customer behavioral intention (BI) to adopt the CSS. The rest of this paper is organized as follows. Section 2 presents the theoretical background and hypotheses. Research methodologies, including sampling, data collection and construct measurements, are described in detail in Section 3. Section 4 discusses empirical results of a questionnaire survey. Finally, conclusions and suggestions are summarized and presented in Section 5.

2. Theoretical background and hypotheses

The CSS is an innovative service composed of auto-detection, auto-identification and remote-communication technologies. Therefore, the technology acceptance model (TAM) is used as the basis for the main research framework. This section first reviews the theoretical background of TAM. Research hypotheses are then presented in accordance with these theories and characteristics of the CSS.

2.1. Theoretical background

The theory of reasoned action (TRA), which has been widely applied to explain the relationship between attitude and behavior, was developed by Ajzen and Fishbein in 1980. The TRA assumes that personal behavior is controlled by BI, meaning that the most direct factor influencing personal behavior is BI. Other factors that may influence personal behavior are mostly indirect influences. In a TRA framework, attitude and subjective norm (SN) are the two principal factors that are positively related to BI. That is, when attitude and SN values are high, BI is high. Although the TRA has been widely applied in many studies, it is limited by its basic assumptions, assuming that behavior is voluntarily; that a person can decide without constraints whether he or she wants to execute a behavior (Ajzen and Fishbein, 1980). However, if some resources such as time, money, technology or cooperation are needed to perform certain behaviors, then performance will be beyond a persons self-control (Ajzen and Madden, 1986). To compensate for this limitation, the theory of planned behavioral (TPB) was developed by Ajzen in 1985. This theory considers factors that influence behavioral control. In addition to attitude and SN, which are constructs in the TRA, another construct, perceived behavioral control (PBC), has been added to the TPB framework. Thus, opportunity and resources needed to execute a behavior, and capability to execute a behavior both influence BI. Moreover, in the TPB framework, a behavior is influenced by BI, which is based on attitude, SN and PBC. Notably, PBC is based on the resources and opportunities needed to execute a behavior and their importance to that behavior.

The TAM model, which is a special example of applying TRA to explain information technology (IT), was developed by Davis in 1989 to explain the behavior in adopting IT. In addition to the relationship between attitude and BI, and BI and behavior, three constructs, perceived usefulness (PU), perceived ease of use (PE) and external variables, were included in this model as factors that influence attitude. The PU means that a technology is perceived useful by a potential user. As PU increases, the positiveness of a user's attitude increases. The PE represents how ease is perceived by a potential user to learn a technology. PE is positively related to adoption attitude. Additionally in the TAM, PE positively impacts PU. Furthermore, a potential user may have a negative attitude toward adopting a technology he or she is asked to use. However, because a technology may increase work efficiency, potential users may still have positive BI to use the technology. The external variables are other factors that may influence user adoption of a technology, such as design characteristics and training.

2.2. Research hypotheses

To identify the critical factors that influence user BI to adopt the CSS, this study proposes a novel research framework mainly based on the TAM. Additionally, in considering the characteristics of the CSS, some other constructs are incorporated into the framework. Fig. 3 shows the research framework. The constructs and their relationships are described in detail as follows.

The PE has been tested and shown to be a significant predictor of attitude in many studies focusing on the new technology. For instance, Taylor and Todd (1995), Gurran and Meuter (2005) and Vijayasarathy (2004) proposed that PE positively impacts attitude. Furthermore, Moon and Kim (2001) indicated that PE significantly influences attitude toward use. In terms of the CSS, a shipper must install a CSD on a container and turn it on to monitor a container during its journey. Moreover, some software setup must be done by shippers to receive container status data during its journey. Therefore, if the processes in CSD installation or software setup are too complex, the attitude toward adoption of the CSS may be negatively influenced. Hence, we propose the following hypothesis:

H_1. Perceived ease of use has a positive effect on a user's attitude to adopt the container security service.

In regard to the factors associated with PE and PU, which were originally integrated into the TAM, some studies have demonstrated that PE positively impacts PU (Taylor and Todd, 1995; Venkatesh and Davis, 2000; Lu et al., 2007). For the CSS, ease of use has been clearly defined by the US Customs and Border Protection (CBP), which ensures that most CSD products are designed to be installed easily on containers doors to simplify usage and enhance the efficiency in monitoring intrusion events. Additionally, users can easily check the status of a CSD via the Internet or receive warning messages on a PDA or mobile phone. These characteristics of the CSS may positively influence a user's PU. Therefore, we propose the following hypothesis.

H_2. Perceived ease of use has a positive effect on a user's perceived usefulness of the container security service.

Attitude is comprised of feelings favoring or against using a new IT (Taylor and Todd, 1995). In the TAM, PU has been tested and shown to be a significant predictor of attitude. Some empirical studies demonstrated that PU positively impacts a user's attitude toward using a new technology (Taylor and Todd, 1995; Vijayasarathy, 2004; Moon and Kim, 2001; Gurran and Meuter, 2005). For the CSS, according to interviews the practitioners, the PU is rooted in two factors. One is enhancing container SE and tracking efficiency; the other is the incentive provided by the US CBP to shorten container inspection time at US ports. The degrees of PU depend on the situations of potential users. Based on related literature and practices, we expect that PU significantly impacts attitude toward adopting the CSS. Therefore, we propose the following hypothesis.

H_3. Perceived usefulness has a positive effect on attitude toward behavioral intention to adopt the container security service.

When using new technologies, especially when data transmission is involved; SE is always a concern. Lu et al. (2007) studied the intention of shippers to use Internet services in the liner shipping industry, and suggested that SE significantly influences PU. Gurran and Meuter (2005), who analyzed three technologies for self-service, found that risk negatively impacts user attitude toward telephone banking. Moreover, perceived risk has a direct or indirect negative impact on user adoption of e-commerce services (Eastin, 2002) or intention to continue using an e-service (Hsu and Chiu, 2004). To monitor containers, a CSD must move with a container and its corresponding

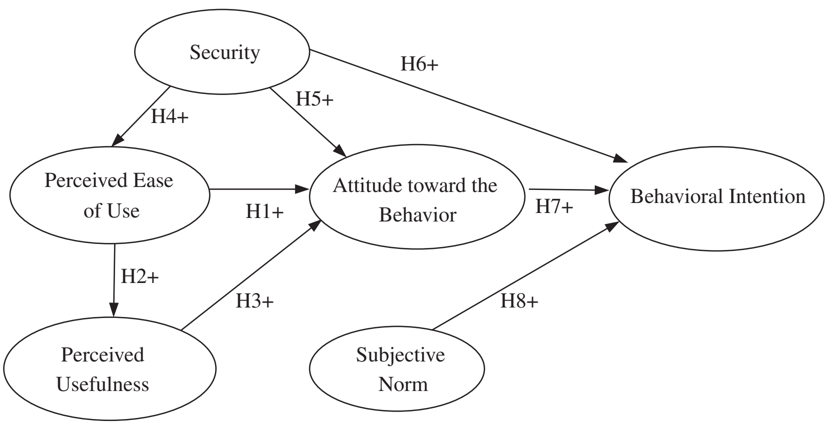


Fig. 3. Research model for the adoption of CSS.

data should be read or written remotely. Many shippers are concerned that data in a CSD will be disclosed from the database of system providers. Notably, the US CBP has recommended that each CSD store container ID number, seal number, manifest number, and trip and status related information. These data are highly confidential; therefore, each time a container is loaded and closed, a shipper must turn on the CSD and then input these data using a secure handheld reader (SHHR). If a CSD and readers are perceived safe enough to protect the data, shippers may feel that the whole CSS is easy to use and not worry about that confidential information will be disclosed. Similarly, the perceived degree of safety of the CSS is positively related to intention to adopt the CSS. Thus, we propose the following hypotheses:

H_4. Security has a positive effect on a user's perceived ease of use for the container security service.

H_5. Security has a positive effect on a user's attitude toward behavioral intention to adopt the container security service.

H_6. Security has a positive effect on a user's behavioral intention to adopt the container security service.

Last, this study is interesting in how BI is influenced by user attitudes and the SN. Some studies have demonstrated that a user attitude is a positive predictor of BI (Vijayasarathy, 2004; Moon and Kim, 2001; Gurran and Meuter, 2005). Thus, if a potential user has a positive attitude, then he or she may have increased intention to use or adopt it. However, unlike other new free IT services, such as on-line booking or tracking, use of the CSS has a surcharge. For shippers who have regular containers to ship, the accumulated surcharge for using the CSS is substantial. Therefore, users must make trade-offs between costs and benefits when deciding whether to use the CSS. However, the benefits of using the CSS could not be easily quantified at present. For instance, the benefits are precise tracking of containers in a timely manner, monitoring and recording events throughout a journey, and reducing the time containers spend at US ports. Although these intangible benefits cause potential users to hesitate to pay for the CSS, another important factor influencing potential users to adopt the CSS is SN, which is a user's perception that most important parties think he or she should or should not perform a behavior. Venkatesh and Davis (2000) proposed that SN positively impacts user intention. In practice, not only shippers are concerned with the costs or issues associated with container SE, those related to shipments, such as consignees, banks related to the bills of lading, and some forwarders and logistics companies, are also concerned. Therefore, adoption of the CSS by shippers may be influenced by these external factors or parties. Thus, we propose the following two hypotheses:

H_7. Attitude has a positive effect on a user's behavioral intention to adopt the container security service.

H_8. Subjective norm has a positive effect on a user's behavioral intention to adopt the container security service.

3. Methodology

3.1. Sampling and data collection

The study population was users of liner shipping via terminals A and B in Taiwan. These two terminals were chosen because they are equipped with fixed readers and a wireless local area network (WLAN), which the CSS requires. Although these two terminals are long-term leased by a shipping company for its owned fleet and customers, a few vessels and customers (shippers and consignees) of other liner companies are also served to increase terminal utilization. The Chinese questionnaires were sent to shippers who have used the CSS or had high monthly transportation volume. A cover letter explaining the study purpose and the detailed operational procedure of the CSS was attached to help subjects answer the questionnaires.

In total, 161 of 268 questionnaires were returned. The effective return rate was 60%. Table 1 lists the characteristics of the sample population. Several industrial sectors

Table 1
Respondents' characteristics.

	Frequency	%
Working experience		
Less than 5 years	12	7.5
6–10 years	23	14.3
11–15 years	30	18.6
16–20 years	28	17.4
More than 20 years	68	42.2
Company industry		
Freight forwarders	32	19.9
Logistics operators	16	9.9
Communication and electronics	13	8.1
Plastics	12	7.5
Computer	12	7.5
Metallic production	12	7.5
Furniture and wooden production	11	6.8
Machine	11	6.8
Petroleum material and chemical	10	6.2
Other	10	6.2
Steel	7	4.3
Automobile	7	4.3
Textile	5	3.1
Food processing	3	1.9
Company size		
Less than 100 employees	83	51.6
101–400 employees	38	23.6
401–700 employees	15	9.3
701–1000 employees	4	2.5
More than 1000 employees	21	13.0
Monthly transportation volume		
Less than 10 TEU	42	26.1
11–20 TEU	23	14.3
21–30 TEU	22	13.7
31–40 TEU	11	6.8
More than 40 TEU	63	39.1

were included in the sample. Respondents were distributed in the following industries: freight forwarders and logistics operators, 29.8%; communication and electronics, 8.1%; plastics, computers, and metal production, 7.5%; furniture and wood products, 6.8%; machinery, 6.8%; petroleum and chemicals, 6.2%; steel, 4.3%; automobiles, 4.3%; textiles, 3.1%; and food processing, 1.9%. In terms of company size, 51.5% of responding companies had less than 100 employees, 23.6% had 101 to 400 employees, 9.3% had 401 to 700 employees, 2.5% had 701 to 1000 employees, and 13% had more than 1000 employees. Most responding companies were frequent users of liner shipping as only 26.1% moved less than 10 TEUs monthly. Roughly 42.2% of respondents had related work experience of more than 20 years.

3.2. Construct measures

To examine the study constructs and hypothesized relationships, the questionnaire for the CSS was utilized for data collection. The items for PU were adapted from those developed by Davis (1989). Items for PE and attitude toward adopting the CSS were originally created by Davis (1989). Items for attitude to adopt the CSS were originally created by Ajzen and Fishbein (1980) for testing TRA. These measurement items have been widely accepted in literature and used by other studies (e.g., Vijayasarathy, 2004; Brown et al., 2003; Lu et al., 2007). Slight modifications were made to fit items to the study context. SN was measured using modified variables developed by Venkatesh and Davis (2000). Items for SE, which is an important factor associated with Internet use, were adapted from the work by Lu et al. (2007). All constructs in the research model were validated using items mostly used in previous studies. A few items were developed by this study according to the characteristics of the CSS. Items were grouped under each construct in the questionnaire to ensure that respondents followed the logical flow of ideas. According to Venkatesh and Davis (2000), such a grouped format is best for predicting and explaining user behavior. The measurement factors and indicators are shown in Appendix. All responses were measured on Likert-type, multiple-item scales, ranging from 1 for "strongly disagree" to 5 for "strongly agree." Scale selection was based on previous studies relating to conceptual construct operationalization (e.g., Agarwal and Prasad, 1999).

3.3. Statistical analysis

The AMOS 7.0 software was used as the primary statistical tool for testing the research model (see Fig. 3). In this study, a two-stage model building process was adopted to apply structural equation modeling, in which the measurement model was tested first and then the structural model was tested. The measurement model describes how constructs were measured by observed variables (items). After an acceptable measurement model was obtained, a structural model was constructed and the hypothesized causal paths among constructs were tested by applying a simultaneous test. This test helped determine whether the proposed conceptual framework had an acceptable fit to empirical data.

4. Results

4.1. The measurement model

The constructs were tested for two psychometric properties, validity and reliability, to ensure that the measurement model was accurate and sound. Validity assesses the degree to which items measure theoretical constructs; reliability assesses the stability of the scale based on an assessment of the internal consistency of items measuring the construct (Churchill, 1979). Validity was assessed through content, convergent and discriminant validity. An instrument has content validity if its items representatively sample the intended domain of the concept it is intended to measure (Ahire et al., 1996). Convergent validity determines whether all items measuring a construct cluster form a single construct. Discriminant validity measures the degree to which a concept differs from other concepts, and is indicated by a measure weakly correlated with other measures from which it should theoretically differ (Churchill, 1979).

The confirmatory factor analysis (CFA) was applied to examine the reliability and validity of the measurement model containing 26 items describing six latent constructs: PU, PE, attitude toward a behavior (AT), SN, SE and BI. Table 2 shows the CFA results. First, the reliability of each latent construct was evaluated by examining its construct reliability and average variance extracted (AVE). Construct reliability means that a set of latent indicators of constructs are consistent in their measurement (Lu et al., 2007). Table 2 shows the computations of each construct. The construct reliabilities were as follows: PU, 0.929; PE, 0.935; AT, 0.944; SN, 0.923; SE, 0.909; and BI, 0.928. All exceeded the recommended level of 0.70 (Hair et al., 1998). The AVE measures the amount of variance in the specified indicators accounted for by the latent construct. It is a complementary measure for the construct reliability value (Koufteros, 1999). Table 2 shows the AVE results for each construct. All exceeded the recommended level of 0.50 (Bagozzi and Yi, 1988).

Second, the validity of the measurement model was evaluated. To establish content validity, all constructs and most items were sourced from relevant literature. Furthermore, a pilot test was conducted in October 2007 to assess questionnaire validity, completeness, readability and understandability. During the pilot test, three professors, two doctoral students in the shipping transportation management field and four practitioners from shipping companies were invited to review the questionnaire items. The constructs measures were refined according to their comments. Convergent validity was assessed by examining the factor loadings of each item according to a common rule; that is, the loading value must exceed 0.50 for acceptability (Kline, 1998). The desired convergent validity of constructs was achieved as all factor loadings (see Table 2) exceeded the threshold.

Table 2
The factor loading, stand errors, mean, standard deviation, construct reliability and average variance extracted.

Measures	Factor loading	SE[a]	Mean	SD[b]	Construct reliability[c]	AVE[d]
Perceived usefulness			3.88	0.66	0.929	0.592
PU1	0.71	0.30	3.89	0.77		
PU2	0.75	0.27	3.84	0.80		
PU3	0.75	0.26	4.08	0.78		
PU4	0.70	0.40	3.80	0.89		
PU5	0.79	0.27	3.83	0.85		
PU6	0.90	0.11	3.84	0.76		
Perceived ease of use			3.63	0.64	0.935	0.713
PE1	0.73	0.23	3.75	0.70		
PE2	0.85	0.14	3.52	0.72		
PE3	0.94	0.07	3.63	0.74		
Attitude toward the behavior			3.55	0.62	0.944	0.719
AT1	0.84	0.12	3.55	0.66		
AT2	0.79	0.18	3.60	0.70		
AT3	0.91	0.08	3.52	0.71		
Subjective norm			3.88	0.62	0.923	0.583
SN1	0.57	0.39	3.61	0.75		
SN2	0.83	0.18	3.78	0.77		
SN3	0.79	0.23	3.99	0.79		
SN4	0.82	0.20	3.93	0.79		
SN5	0.78	0.20	4.10	0.72		
Security			3.36	0.67	0.909	0.589
SE1	0.76	0.29	3.47	0.83		
SE2	0.76	0.32	3.23	0.87		
SE3	0.84	0.16	3.57	0.71		
SE4	0.79	0.25	3.46	0.80		
SE5	0.68	0.44	3.06	0.90		
Behavioral intention			3.19	0.67	0.928	0.638
BI1	0.76	0.20	3.42	0.74		
BI2	0.83	0.17	3.01	0.77		
BI3	0.86	0.15	3.16	0.78		
BI4	0.74	0.27	3.19	0.80		

[a] SE is an estimate of the standard error of the covariance.
[b] SD signifies standard deviation.
[c] Construct reliability = (sum of factor loadings)^2/[(sum of factor loadings)^2+(sum of error variances)].
[d] AVE signifies average variance extracted.

As for the mean of items, all of them were above three (higher than 2.5), which means that most subjects had a positive attitude toward the question items. The values of 4.10 and 4.08 for SN5 and PU3 are obviously higher than others, meaning that the facilitation formality provided by customs was concerned by the subjects. Conversely, item SE5, BI2 and BI3 had lower values of mean, indicating that most subjects had a relatively conservative attitude toward the data transmission and intention of usage of the CSS. The main reason may be that the CSS has not been popular in the industry yet.

The test of discriminant validity is an important analysis (Koufteros, 1999). Discriminant validity exists if items share more common variance with their respective construct than any variance a construct shares with other constructs (Fornell and Larcker, 1981; Koufteros, 1999). In this study, the χ^2-test was also applied to examine discriminant validity. According to Anderson and Gerbing (1988), the χ^2-test should be performed for one pair of factors at a time, rather than as a simultaneous test of all pairs. As the research model contained six constructs, 15 χ^2 tests were performed for examining the discriminant validity of each construct pair. For each test, the differences in χ^2 values and degree of freedom between two models were calculated. In the first model, the estimated correlation parameter between the two constructs was fixed at 1.0. In the second model, the correlation was estimated freely. Discriminant validity existed between any construct pairs as computations (see Table 3) were all significant.

As for overall fit of the model, AMOS provides absolute goodness-of-fit (see Table 4). The *p*-value of the χ^2 ($\chi^2 = 461.636$, df = 284) was 0.00. However, since sample size in this study was more than 100, the χ^2 value and related *p*-value are neglected as they are overly sensitive to sample size (Jöreskog and Sörbom, 1993). The normed χ^2 (χ^2/df) was used to examine goodness-of-fit, and should not exceed the acceptable threshold of three. The measurement model had a normed χ^2 value of 1.63, which was acceptable. Additionally, five common measures were calculated to assess the goodness-of-fit. The comparative fit index (CFI) was 0.937, which exceeded the recommended level (see Table 4). The goodness-of-fit index (GFI), adjusted GFI (AGFI) and normed fit index (NFI) did

Table 3
Results of the χ^2 difference tests between the latent construct pairs.

Construct pair		Unconstrained model[a]		Constrained model[b]		$\Delta\chi^2$
		χ^2	df	χ^2	df	
Perceived usefulness	Perceived ease of use	68.708	26	283.258	27	214.550***
Perceived usefulness	Attitude toward the behavior	78.847	26	249.735	27	170.888***
Perceived usefulness	Subjective norm	87.478	43	339.810	44	252.332***
Perceived usefulness	Security	107.130	43	415.509	44	308.379***
Perceived usefulness	Behavioral intention	70.281	34	309.539	35	239.258***
Perceived ease of use	Attitude toward the behavior	7.327	8	218.775	9	211.448***
Perceived ease of use	Subjective norm	37.302	19	218.109	20	180.807***
Perceived ease of use	Security	22.071	19	227.162	20	205.091***
Perceived ease of use	Behavioral intention	11.714	13	197.973	14	186.259***
Attitude toward the behavior	Subjective norm	60.131	19	267.661	20	207.530***
Attitude toward the behavior	Security	21.296	19	171.016	20	149.720***
Attitude toward the behavior	Behavioral intention	18.895	13	86.034	14	67.139***
Subjective norm	Security	78.555	34	322.167	35	243.612***
Subjective norm	Behavioral intention	81.404	26	299.670	27	218.266***
Security	Behavioral intention	33.702	26	133.060	27	99.358***

*** Significant at the $p<0.001$ level.
[a] Unconstrained model means that the correlation between the construct pair was freely estimated.
[b] Constrained model means that the correlation between the construct pair was fixed to one.

Table 4
Goodness-of-fit measures of the CFA.

Goodness-of-fit measure	Recommended value	Value of this study
χ^2/degree of freedom	$\leq$3.00	1.625
Goodness-of-fit index (GFI)	$\geq$0.90	0.819[a]
Adjusted goodness-of-fit index (AGFI)	$\geq$0.80	0.777[a]
Normed fit index (NFI)	$\geq$0.90	0.853[a]
Comparative fit index (CFI)	$\geq$0.90	0.937
Root mean square error of approximation (RMSEA)	$\leq$0.08	0.063

[a] Close to but not exceeding the commonly recommended threshold.

Table 5
Goodness-of-fit measures of the structural model.

Goodness-of-fit measure	Recommended value	Value of this study
χ^2/degree of freedom	$\leq$3.00	1.487
Goodness-of-fit index (GFI)	$\geq$0.90	0.844[a]
Adjusted goodness-of-fit index (AGFI)	$\geq$0.80	0.802
Normed fit index (NFI)	$\geq$0.90	0.869[a]
Comparative fit index (CFI)	$\geq$0.90	0.952
Root mean square error of approximation (RMSEA)	$\leq$0.08	0.055

[a] Close to but not exceeding the commonly recommended threshold.

not achieve the threshold with values of 0.819, 0.777 and 0.853, respectively. However, they were partially acceptable as they were close to the commonly recommended level. The root mean square error of approximation (RMSEA) was 0.063, which was acceptable. In sum, the overall goodness-of-fit for the model indicates that the measurement model exhibited a sound fit with data.

4.2. The structural model

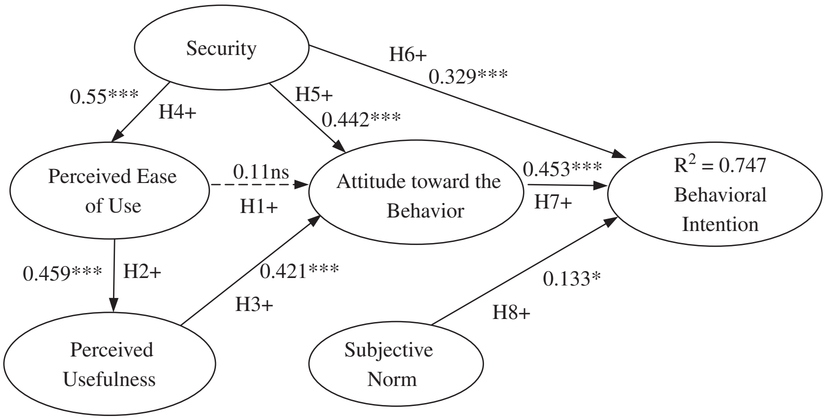
The structural model used to verify the hypothesized relationships among studied constructs was examined. The common model goodness-of-fit measures (see Table 5) were estimated by AMOS 7.0. The *p*-value of the chi-square ($\chi^2 = 410.554$, df $= 276$) was 0.00. However, since the χ^2 value and related *p*-value are overly sensitivity to sample size, the normed χ^2 (χ^2/df) was used to examine goodness-of-fit, and should not exceed the acceptable threshold of three. The structural model had a normed χ^2 value of 1.487, which was acceptable. Except for the GFI and NFI, all other indices achieved the commonly recommended thresholds. However, the values of 0.844 and 0.869 for GFI and NFI were close to the commonly recommended threshold of 0.9; thus, these two indices were marginally acceptable. In sum, the indices shown in Table 5 demonstrated that the model exhibited a moderate fit with data.

The hypotheses in the research model were tested. Table 6 presents test results for hypotheses. The critical ratio (CR) is a *t*-value obtained by dividing the estimate of covariance by its standard error. A value exceeding 1.96 indicates statistical significance at the 0.05 level. All CR values (see Table 6) were higher than the threshold except for 1.518, meaning that the effect of PE on AT was insignificant. This analytical result indicates that hypotheses H_2–H_8 were supported, and H_1 was not supported (see Fig. 4). The R^2, which is the squared multiple correlations, is used to measure the amount of variance in an observed construct for which other constructs account. The R^2 has a range of 0–1. A high R^2 value means that other constructs accounted well for a given construct. The R^2 of BI was 0.747, indicating that was well accounted for by SE, AT and SN (see Fig. 4). Among the factors influencing BI, AT was the most important determinant as its path coefficient was highest.

Table 6
Results of the structural equation modeling.

Variables	Estimates	SE[a]	CR[b]
Perceived ease of use → attitude toward the behavior	0.110[c]	0.073	1.518
Perceived ease of use → perceived usefulness	0.459	0.081	5.646
Perceived usefulness → attitude toward the behavior	0.421	0.066	6.403
Security → perceived usefulness	0.550	0.094	5.874
Security → attitude toward the behavior	0.442	0.080	5.551
Security → behavioral intention	0.329	0.068	4.851
Attitude toward the behavior → behavioral intention	0.453	0.068	6.658
Subjective norm → behavioral intention	0.133	0.066	2.028

[a] SE is an estimate of the standard error of the covariance.
[b] CR is the critical ratio obtained by dividing the covariance estimate by its standard error.
[c] Underlined value is the critical ratio that did not exceed 1.96, at the 0.05 level of significance.



*significant at p <0.05, **significant at p <0.01, *** significant at p <0.001, ns: p>0.05 not significant R2 = (sum of squares due to regression) / (total sum of squares)

Fig. 4. Results of path analysis.

4.3. Discussion

The proposed research model was largely supported by the empirical data collected. Path analysis results provide strong support for all hypotheses, except H_1, which was expressed as a broken line (see Fig. 4). The first hypothesis, H_1, arguing that PE positively impacts AT, was not supported. The reason may be that the CSS is a new IT service in the liner shipping industry, and many shippers in this sample used the CSS with the assistance of system operators, while some other shippers knew about the CSS but had not used it. Hence, judging whether the CSS was easy to use was difficult for some respondents; thus, the impact of PE on AT was insignificant. Notably, H_8, which stated that SN positively impacts BI, was supported, but not as strongly as other hypotheses. The main reason was the CSS is not yet widely used in the shipping or global trade industries. Moreover, although the US CBP will require each container to carry a CSD when entering a US port, this law has not yet been implemented; thus, the influence of SN is not significant.

5. Conclusions

The CSS, which has advantages such as auto-detection, auto-identification and wireless communication, is a new service for ocean-going containers. The CSS records any intrusion events on containers during their journey, and updates shippers and carriers of the status of containers. Driven by anti-terrorism policy, the US CBP requires timely and precise container tracking. Some mega shippers now use the CSS to increase the security of their containers. Since the target market for the CSS is a very conventional industry, studying the introduction process for this new technology and factors affecting shipper intention to adopt CSS is important. This study identified the critical factors influencing user BI to adopt the CSS. Conclusions and implications for future studies are as follows:

1. Analytical results indicate that SE strongly impacts the PE, AT and BI to adopt the CSS. As container data is stored in the CSD carried by a container, the risk of data

disclosure has increased. In particular, joint ventures and alliances are common strategies in the liner shipping industry; thus, containers are sometimes handled by partners. If the CSS is not sufficiently secured, shippers and liners will be concerned about the data security. This implies that system operators should further enhance data security to increase the intention of adopt the CSS.

2. Although the path coefficient of H_8 is significant in this study, its value is not as large as others, meaning that the influence of SN on a user BI is not strong. The main reason is that the CSS is not well known in international trade and liner shipping industries. Therefore, at present, shippers have not been required by cargo buyers, banks or other related parties to use the CSS while moving container cargo. However, since anti-terrorism measures have become important in the shipping industry, many incentives and regulations will be introduced by public sector in the near future. We expect that these external factors will affect BI to adopt the CSS. This is an issue for further study.
3. Systems like the CSS or RFID will generate considerable external effect as long as those involved in shipping containers adopt the same data format and protocol. For example, if shippers, truckers, terminals, ocean-going liners and customs adopt the same standard for a system, data for container movement status can be updated, transmitted or shared in a timely and accurate manner, thereby increasing the efficiency of the entire container transportation chain. However, terminals and truckers have their own systems. We suggest that container shippers watch for global prevailing standards and adopt a compatible system as containers move among global ports rather than in a closed system. Following the prevailing standard will favor the existing common infrastructure, and prove helpful in developing new applications.

Appendix

The measurement factors and indicators which are dependent variables are shown in Table A1.

Table A1

Constructs	Description	Sources
Perceived usefulness (six items)	PU1: Using CSS could enhance the efficiency of tracking containers, which is useful to company. PU2: CSS could render container's latest movement status, which is useful to our company. PU3: Using CSS could facilitate the custom formality, which is useful to our company. PU4: CSS could help preventing stealing or smuggling incidents, which is useful to our company. PU5: CSS could monitor the containers' security status, which is useful for our company. PU6: In general CSS is useful to our company.	Developed in this study (items 1–5) Davis (1989) (item 6)
Perceived ease of use (three items)	PE1: I could easily understand the procedures of manipulating the CSS. PE2: Learning how to use CSS is easy for me. PE3: In general CSS is easy to use.	Developed in this study (item 1) Davis (1989) (items 2 and 3)
Attitude toward the behavior (three items)	AT1: I think our company uses CSS is a correct decision. AT2: The evaluation of using CSS for our company is positive. AT3: I advocate our company using CSS.	Taylor and Todd (1995) (items 1 and 3) Moon and Kim (2001) (item 2)
Subjective norm (five items)	SN1: I think our customer or other partner will expect us to use CSS. SN2: I think the universality of using the CSS of our competitors will enhance our company's intention to use it. SN3: I think the subsidy of CSS from the government will enhance our company's intention to use it. SN4: I think a standard of the CSS established by the government will enhance our company's intention to use it. SN5: The facilitation formality provided by customs will enhance our company's intention to use it.	Venkatesh and Davis (2000) (item 1) Hwang (1993) (items 2–4) Developed in this study (item 5)
Security (five items)	SE1: While using CSS, I feel free to let the system operator control the data related to our containers. SE2: I believe the data stored in the CSD will not be leaked out. SE3: I trust the ability of CSS to monitor our company's container in the whole journey. SE4: I think CSS could effectively protect our company's container. SE5: I don't worry about the transmission of data will be interfered with rain, fog or other unexpected factors.	Curran and Meuter (2005) (items 1 and 4) Lu et al. (2007) (items 2 and 3) Developed in this study (item 5)
Behavioral intention (four items)	BI1: I think our company will use the CSS in the future. BI2: I think our company will use the CSS actively. BI3: I think our company will use the CSS frequently in the future. BI4: I think our company will require our business partners to use the CSS.	Lu et al. (2007) (item 1) Moon and Kim (2001) (items 2–4)

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