# An e-Seal in Container Security Program: How to maximize the benefits of e-Seal in the battle against terrorism

by

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## Declaration

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# Abstract

Preventing unauthorized access to ocean transportation is one of the most important tasks in anti-terrorism activities in border protection. The e-Seal technology is expected to play an important role in this task. This technology can record a tampering attempt in real-time and notify authorities remotely. Because this technology has also great value for improving business effectiveness, it is expected that pilot programs in the private sector will lead adoption. Although research indicates that many possible bottlenecks such as the price and reliability of e-Seals have been resolved, pilot programs in the private sector are very inactive. This research is intended to find the cause of this sluggish initiation of pilot programs.

The problem selected in this thesis is the relationship between the private sector's confidence in its ability to proactively learn of e-Seal requirements and its incentive to carry out a pilot program. This issue has not been discussed in depth yet. The hypothesis examined in this research is that if a company has more confidence in its ability to learn e-Seal requirements proactively, it has greater incentive to conduct pilot programs.

Two approaches are employed in this research. One is a survey of industry professionals. This survey consists of twenty Likert-scale questions and the result is evaluated statistically. The other and auxiliary method is a mathematical model. The model expresses the relationship between resource amount and the result in detection of unauthorized access. The survey also asks participants about their understanding of behaviors in the model.

The survey rejects the hypothesis; the correlation between the confidence and the incentive is small and not significant. Because there are significant correlations between the participants' confidence and understanding of behaviors in the model, it is suggested that the problem is in how the private sector perceives its incentive. The survey results suggest that this is because the private sector believes it has little chance to change the e-Seal requirements, even if it learns the requirement proactively.

# Glossary and Abbreviation

| | |
|---|---|
| CBP | U.S. Customs and Border Protection |
| C-TPAT | Customs-Trade Partnership Against Terrorism. |
| CSI | Container Security Initiative |
| DoD | U.S. Department of Defense. |
| DHS | U.S. Department of Homeland Security |
| RFID | Radio Frequency IDentifier |

# Chapter 1 Introduction

## 1.1. Overview

This thesis investigates the reason for the delay of e-Seal adoption in ocean container transportation, which is important to the fight against terrorism. At the moment there is no good explanation for this delay. This research examines the hypothesis that private sector pilot programs, which are required for e-Seal adoption, are not carried out because the private sector does not think they will bring benefit. To verify this hypothesis, this research employs both a survey and a mathematical model. The results suggest that the private sector does not believe it has enough change to change e-Seal requirements by conducting a pilot program, despite the fact that the feasibility of amendment is thought to be the major incentive for the private sector.

An e-Seal is a special kind of seal which can report its identification number as well as other useful information over the radio waves. The e-Seal technology is expected to enhance both the efficiency of U.S. Customs and Border Protection (CBP) activities and the business value achieved in private transportation sector. At the moment, the e-Seal technology seems to be mature and its price is approaching industry's expectation. However, the adoption of e-Seal is still very slow. The purpose of this research is to investigate why the adoption of e-Seal lags behind industry expectations.

Existing discussions are examined in both commercial and academic sources. Although there are few articles on this subject in academic sources, in commercial journals there are many articles discussing reasons for the delay in the e-Seal adoption. The reasons found through the literature survey are as follows:

- The general slow adoption of RFID technology
- Lack of an e-Seal standard
- Possible security flaws in e-Seal
- Lack of business cases
- Delay in introduction of incentive programs

The literature survey for this thesis concludes that the above possible reasons do not adequately explain the delay in adoption of e-Seal because these factors do not impede the adoption of e-Seal-related technologies or products in other applications and industries.

Based on the above result, the author decides to examine a hypothesis which has not been sufficiently discussed, in order to add new information to the existing knowledge body.

First, the problem in this study is defined formally. Judging from the ongoing status of e-Seal-like technologies in other industries, the expected level of e-Seal adoption is defined as pilot trials for business cases by leading transportation companies in the private sector. Therefore, the formal problem definition is given as follows:

**Why do transportation companies ~~not have enough~~lack incentives to carry out a pilot trial of an e-Seal application with a business scenario, assuming e-Seal adoption is integrated into the C-TPAT program?**

Then the primary hypothesis is generated from this problem definition. Among the possible factors which may affect the adoption of e-Seal, the author selects the issue of communication between CBP and the private sector. This is because this factor is important in explaining unique characteristics of the e-Seal adoption but is not discussed in the industry. For more detail, this factor is defined as the confidence in the private sector that it properly and proactively understands the intentions of CBP. As a result, the primary hypothesis examined in this study is defined as below:

**As ~~confidence in~~ the private sector becomes confident that it properly and proactively understands the intention of CBP ~~increases~~, the incentive for~~in~~ the private sector to carry out a trial of an e-Seal application anticipating probable amendment of the C-TPAT program also increases correspondingly.**

In addition, additional hypotheses are discussed in this study. These hypotheses are related to an independent variable: agreement on the mathematical model explaining how e-Seals increase the benefit of CBP. This study introduces a mathematical model which explains how e-Seals work in CBP’s activities against terrorism and improve its results. Investigation agreement on this model helps to examine the details of the primary hypothesis.

The mathematical model attempts to explain the correspondence between CBP’s resource assignment and expected results, as well as how use of an e-Seal system changes that relationship. This model generates the following hypotheses for investigation:

- The break-even point of e-Seal adoption can be determined using only data regarding the containers to which e-Seals are applied, if resources are properly assigned to maximize detection of smugglings.
- The criteria determining what kind of containers should be equipped with an e-Seal can be assigned to maximize detection of smugglings.
- The more criteria-satisfying containers attach an e-Seal, the more smuggling will be detected.
- E-Seals with rich functions increase the detection rate while keeping costs on CBP’s side constant.
- Employing an additional group of containers for e-Seal inspection increases detection of smuggling.

In order to verify the above hypotheses, a survey is employed. This survey is a quantitative questionnaire survey on the industry professionals working for U.S. import trade. It is designed to evaluate the absolute level of reliance on CBP's policy and willingness to take initiatives in the private sector. Correlation of those factors is also examined.

There are 20 questions in the survey excluding respondents' profile. These questions are asked with a five-point Likert scale. Because the Likert scale is a kind of interval scale, descriptive statistics applicable to an interval scale can be calculated, such as mean, variance, standard deviation and coefficient of variation. As for inferential statistics, Pearson correlation is used to calculate the intercorrelations among variables.

The questionnaire was sent to 89 industry professionals and 22 responses were returned. All responses have answers to all questions. Data reliability of the survey is proven as good through Cronbach's alpha reliability test.

The correlation between the confidence in CBP's intention and the incentive to conduct a pilot program is not only non-significant but also very low. On the other hand, the correlations between the confidence in CBP's intention and the respondents' agreements on assumption of the mathematical model are shown almost significant. Therefore it is expected that there are problems in recognizing incentives. Evaluation of other variables suggests that the lack of incentive stems from the respondents' doubt whether

CBP will accept feedback from the results of pilot trials.

# Chapter 2 Literature Review

## 2.1. Container Seals

A seal is a device which attaches to a door and provides security by having to be broken to allow access to the contents. The difference between a seal and a lock is that a lock can be opened and closed by a corresponding key but a seal cannot be opened without breaking it. This is the reason seals are widely used in international transportation. International transportation is monitored by more official agencies, such as customs and border protection offices, than is domestic transportation. These agencies take a discrepancy between documented and actual contents more seriously, since they have to prevent undesirable activities such as tax evasion and/or smuggling. A lock does not provide strong enough evidence to those authorities that its container has not been opened during transportation.

There are two major categories of seals – indicative seals and barrier seals (Wolfe, 2002).

Indicative seals are made of relatively fragile materials such as plastic or thin wire/sheet metal. They can be easily severed by common tools and therefore do not provide any physical protection. The purpose of indicative seals is to reflect tampering. These seals are tied through a hasp or around a lock/handle; when the door is opened, the seal is broken. Indicative seals have a unique identification number, which is an alpha-numeric number of up to ten digits, on their surface. If any unauthorized person breaks a seal and attaches another seal after accessing the contents, this tampering can be detected by comparing the identification number between the original documents and the attached seal.

Barrier seals also have an identifying number but provide additional physical protection. Physical characteristics of barrier seals vary, from metal bars to thick wire made of a special alloy. The strength of a barrier seal is determined by what sort of tampering the seals must be protected from. In some cases a seal can resist only casual tools such as sharp knifes and in other cases it should withstand industrial bolt cutters. There is an industrial standard of high-security barrier seals, called ISO/PAS 17712. The high-security seals compliant to this standard have become popular, as usage of those seals is required for a voluntary container security program in the U.S. (C-TPAT, described in detail later). ISO/PAS 17712 compliant seals are required to withstand at least 2,200 pounds of pulling force. Barrier seals are slightly more expensive than indicative seals: ordinary barrier seals cost from 50 cents per unit, while the price of regular indicative seals start from 25 cents each (Field, 2005). However, barrier seals require dedicated tools to be opened and the operation of these tools is difficult and dangerous. Therefore the total cost to employ barrier seals becomes more expensive than the difference in tag prices.

From the viewpoint of customs and border protection, there are three major purposes for using seals in internal container trade.

The first purpose is to detect tampering. If a seal is found to be broken or the identifier is different from the one on the cargo document, it is obvious that the container was opened by an unauthorized person at some point in the transportation route.

A second purpose is protection from containers tampering, which barrier seals can provide. As explained above, barrier seals cannot be broken by usual tools. This means attackers with limited tools and time cannot access the contents of a container.

The last purpose is to provide tracking information. Ideally, it is expected that a seal's identifier value will be recorded at each handoff in the chain of custody (Wolfe, 2002). These tracking records provide information about when and where the container is handed over and the status of the container at that time. That information gives clues in case of inspection into unauthorized accesses. Actually, however, these tracking records are hardly kept at the moment. This is because it is difficult to read ten-digit seal numbers and write them down for all containers at all handovers.

The above protections do not work well unless business practices are properly controlled. For example, in the cases below, smuggling cannot be detected even though seal tracking does not record any problems.

- If a container loading facility (e.g. a factory or a warehouse) is not guarded properly, a terrorist or collaborator can easily sneak into the facility and place an item in a container before it is sealed.
- In some regions and/or companies, there are business practices in which containers are not sealed by the proper personnel, who have the authority to determine that the container was not accessed by any unauthorized persons before shipment. Instead, seals are passed to cargo workers (usually truck drivers). Those workers are ordered to seal the container when all cargoes are loaded. In this case, if these workers are forced or bribed to overlook contraband, they will not seal a container until smuggling items are placed in the container.
- At the loading and transit ports, authorities such as the customs or border protections have authority to open a container for inspection, even if the container has a high-security seal. In this case, the container is sealed again and this operation is recorded after inspection. As the original seal is broken after inspection, a new seal is used and the original one is stored just inside the door. If an officer in those authorities cooperates with terrorists, contraband may be concealed during this inspection process.

There are still chances that skillful criminals and/or terrorists will succeed in smuggling, even if all business practices with seals work well.

First of all, a seal can be counterfeited. During transportation, a container seal is only discriminated by its identification number. Therefore, the seal can be forged if a terrorist group includes a skillful forger and the group knows the ID number in advance. Even if the appearance of the forged seal is different from the original, there is very little chance that someone will notice that difference.

It is a common tactic among smugglers to create a small and inconspicuous chamber which can be accessed without opening the container door, such as in a post. If involved parties do not inspect containers carefully, this secret chamber can be a safe place for small but valuable smuggled items such as drugs for criminals, and dangerous biochemical materials for terrorists.

Another measure to bypass a seal is to tamper with the five sides other than the one with a door. If a criminal/terrorist's group is so skillful that it can make holes in the side, top or bottom of a container and then repair those holes after concealing smugglings, the group can successfully smuggle the contraband goods without interference from a seal. This attack takes time, requires special tools such as a steel cutter, and makes loud sounds. However, it is still possible if the attacker group can work where there is no surveillance.

## 2.2. E-Seal

E-Seals are a special kind of seal which has the capability to provide its identification number via an electronic measure. There are many methods capable of electronic readability, such as infrared, terminal contact or radio (Wolfe, 2002). Among those methods, radio transmission is regarded as most feasible and close to practical use. Therefore, in this research "e-Seal" refers to seals with remote readability via radio. In general, the technology to access the identity information of a device via radio is called RFID (abbreviation of Radio Frequency IDentification). From a technical viewpoint, e-Seals are regarded as one application in RFID technology. The e-Seal and similar technology can also be used for logistics devices other than ocean containers, such as air freight containers, or trucks between America and Canada/Mexico. However, in this research, only usages and adoption in ocean transportation are covered because of space limitations.

There are several kinds of e-Seals grouped by behaviors and functions – passive e-Seals, active e-Seals and smart containers.

Passive e-Seals are seals which have only a small antenna and a chip, without a battery. This kind of e-Seal only works when it is "read" by e-Seal readers. The seal becomes active when it receives radio waves from a reader. The chip activates itself with the power it receives from the radio wave and then it sends its identifier back to the reader. Merits of passive e-Seals come from their simplicity. Passive e-Seals are inexpensive. Wal-Mart employs RFID labels which use an identical technology and the price of those labels is closing to 10 cents per unit (Collins, 2006). Also, passive e-Seals are easy to maintain; battery replacement is never required. The shortcomings of passive e-Seals come from the fact that these seals do not have batteries. The range of readability is short (up to 30 feet) because they need to work with the power provided via radio waves. Also, when these seals are not powered by a reader, they cannot take any actions against tampering attempts, such as sending an alert or recording a tampering timestamp.

Active e-Seals are very similar to popular radio devices such as walkie-talkie or EZ-pass transponders widely used in the northeastern U.S. These seals have their own batteries and can send and receive information at any time. They have a far longer read range than passive e-Seals (up to 300 feet) (Lahiri, 2005), and can not only respond to a reader but also send beacons periodically to broadcast their status and allow locating. Also, these seals are always active and when tampered with they can record the time of attack. The most significant drawback of active e-Seals is their price. At the moment, the price of e-Seals is estimated to be 10 to 20 dollars per unit after mass production (Tirschwell, 2006).

An active e-Seal can be combined with sensors. These sensors can be tampering monitors on five sides other than the door, radioactivity, chemical and/or virus/germ monitors. In addition to security surveillance, sensors can monitor conditions important to business cases, such as humidity or temperature. Communication devices can also be combined with active e-Seals. Combined with GPS, an active e-Seal can determine its location in real-time and record the exact address of tampering attempts.

A cellular/satellite phone attachment enables an e-Seal to report its state in real-time to a remote security server over a wireless network.

Smart containers are a special kind of containers with e-Seal, communication and/or sensor functionalities. As such multifunctional devices would be too expensive to be discarded after a single use or too big to be implemented in a seal form, a major part of such a device is embedded in a container and its external sensor is used as a seal. Strictly speaking, smart containers are not seals. However, in the industry smart containers are regarded as an alternative technology with e-Seals, so in this research smart containers are regarded as a kind of e-Seal. At the moment, the cost of a smart container is roughly expected to be the same as active e-Seals - 10 to 20 dollars per use per unit. (Wolfe, 2002).

From the viewpoint of customs and border protection, there are many advantages in using e-Seals. Some of these advantages apply to all e-Seals and others are only for particular types. Those advantages are as follows:

- An identification number in e-Seals can be protected by electronic encryption and authentication. This means that only proper seal readers can read an e-Seal identification number and forged seals can be easily detected because they will not be authenticated. The strength of this protection depends on the kind of e-Seal. An active e-Seal has stronger protection than a passive e-Seal because it can use power from its battery and drive a more complicated circuit.

- E-Seal improves the accuracy of reading and reduces workloads. As described above, reading and writing identification numbers of seals are not feasible if these operations are carried out manually. However, if the task is automated, it becomes realistic that all handoff activities can be recorded along with identification numbers.
- An active e-Seal, which can send information without being accessed from a reader, is able to not only record tampering attempts but also report these attempts to monitoring systems in real-time. This means immediate actions can be taken after an attack. In addition, active e-Seals can be combined with a cell/satellite phone unit and/or GPS unit. With this combination, an active e-Seal can send its location periodically to a security server and send tampering alerts in real-time. Also, it can report and track its movement. If the movement record indicates that a container stayed off the regular route for a long time, it will be suspected that something wrong may have been done with the container.
- A smart container can report any suspicious container status beyond tampering at the container door, such as radiation from a hidden chamber or tampering at five sides other than the door.

From the viewpoint of the private sector, there are benefits to using e-Seals other than increased security. Those benefits come from the fact that the ocean transportation industry is facing the necessity to use RFID technology for improvement of business efficiency. As e-Seal is an application of RFID technology, e-Seals are expected to be used for these purposes.

One of the possible applications of e-Seals is remote readability of a container number. At the moment there is no working standard of remote readability of container numbers. There is an industrial standard of RFID container plate (ISO 10374) but it is hardly used in the industry at the moment. Some container operators use optical character readers (OCR) to read a container number but most operators still depend on eyeballs to read them. E-Seals provide an opportunity to increase productivity and accuracy in reading container numbers.

Another promising usage is real-time locating of containers. The technologies used for active e-Seals are indeed identical with the ones used for real-time locating system (RTLS). RTLS is indispensable to container operators because container yards and van pools are so vast and store so many containers that, without the support of locating systems, workers cannot find a container. Active e-Seals can be used in RTLS.

## 2.3. Threat of Terrorist Attack over Ocean Container

The reason e-Seal technology attracts attention widely within the industry is the terrorist attacks of September 11th, 2001. Before those attacks, risks to the ocean transportation system were not well recognized in the industry. Instead, unauthorized access to ocean containers and consequent crimes, such as thefts and/or smugglings, were generally considered annoying but inherent in the ocean transportation business, as shoplifting in the retail business (Scalet, 2003). However, after September 11th, the vulnerability of ocean transportation becomes widely acknowledged.

The results of possible terrorist attacks are regarded differently in research. Gordon et al. estimate the damage of a terrorist attack can be up to $45 billion, if containers laden with bombs explode in the container wharf area in Los Angeles and reconstruction takes one year (2006). On the other hand, Leamer and Thornberg argue that the impact is far smaller than that estimation by comparison with natural disasters and social events (such as labor-related port closure in California for 10 days) (2006). The reason they conclude that the damage would be relatively small is that the supply chain can detour Los Angeles and its wharf area. It is difficult to evaluate the reality of these estimates because each study employs a different method of estimation based on different sources.

Despite such concern in the industry, the capability to prevent terrorist attacks is very limited at the moment.

First, the size of an ocean container is huge compared with its freight. The current ocean transportation system can carry a significant amount of cargo at fairly low prices. The freight of a forty foot container from an Asian port to an American west coast port is around four thousand dollars. On the other hand, a standard forty foot ocean container can carry cargoes of up to 67 cubic meters (2,366 cubic feet) and 27,000 kilograms (59,525 lbs.).

Also, the capacity for investigation in American ports is limited. Only five percent of containers are actually investigated. This is not only because of the shortage of man power. There are also physical limitations. For example, it takes five hours by three inspectors to fully examine one forty foot ocean container - to discharge all contents, inspect them and put them back into the container (Flynn, 2003). If this investigation were required for every incoming container, it would require an unrealistic area for operation.

Therefore, measures to increase the efficiency of terrorist attack detection are highly required.

## 2.4. Present Expectation for e-Seal

Since the terrorist attacks, CBP has vigorously introduced multiple anti-terrorism programs in ocean container transportation which have different scopes and involve different participants. Those programs are as below (Downey, 2006):

- C-TPAT (Customs-Trade Partnership Against Terrorism) – this is a voluntary program for U.S. import shipments involving shipping companies, forwarders and importers. C-TPAT requests its participants to employ good security practices and provides some preferential treatments in return.

- CSI (Container Security Initiative) – this is a program between CBP and its foreign counterparts. With the CSI program, CBP can exchange suspicious cargo information and even station its inspectors in foreign ports. This program allows CBP to take actions against suspicious containers before they arrive at American ports.
- ATDI (Advanced Trade Data Initiative) – this program obligates foreign shippers to submit the shipping documents to the U.S. 24 hours before the shipment is on board. The information gathered by this program is used to identify suspicious shipments before they are laden on a vessel. This rule is called "24-Hour Advance Vessel Manifest Rule".
- Smart Box Program – this is a program to support technology development which enhances container securities.

Among the above programs, C-TPAT is most closely related to the e-Seal adoption. The reasons are as below:

- Both the C-TPAT program and the e-Seal adoption are driven by the private sector in U.S. import supply chain. Procurement, implementation and operations are carried out by the private sector.

- C-TPAT is a voluntary program pursuing win-win results between security and business case improvement, while e-Seal is dual-use technology which can be used both for security and business.

- The C-TPAT program is in effect and e-Seal is mature enough in technology. The Smart Box Program is another program related to the e-Seal technology but the program is now focused on very high-level concepts and does not have direct relevance to e-Seal adoption at the moment.

As a result, both CBP and the private sector expect the e-Seal adoption to be managed under the C-TPAT program. For example, the C-TPAT program is planned to include preferential treatment called "Green Lane" and an e-Seal is regarded as a future requirement of Green Lane. Green Lane is a treatment that allows higher priority to containers which satisfy security requirements. This treatment is attractive to many importers in the U.S., as their business is very sensitive to transit time but U.S. customs are always congested.

Based on the above situation, this research assumes that CBP's intervention in the e-Seal adoption is basically done through the C-TPAT program.

## 2.5. E-Seal Adoption Status and Discussions

At the moment, the e-Seal technology seems to be ready for adoption. Some reports insist that investment on an e-Seal system can be returned within three years (Cuthbert, 2006). And the price of an e-Seal is becoming close to the break-even points assumed in these reports. In other aspects e-Seals are also regarded as already mature and do not require any technical breakthrough before widespread adoption.

However, the expanded use of e-Seals has been very slow. None of the major shipping companies have carried out meaningful field trials or pilots. CBP has not been able even to decide the standard of e-Seals. There is no fixed outlook about the widespread adoption of e-Seals.

As described already, there is a consensus that the e-Seal technology has a potential for improvement in security, efficiency and business value. Therefore, if the adoption of the e-Seal technology is stalled by reasons other than immature technology, those reasons and responsible parties should be detected for necessary correction.

## 2.6. Discussion of delay of adoption

At the moment, there is no decisive hypothesis which explains well why the adoption of e-Seal is slow. Also, no hypothesis provides a sufficient clue as to what elements should be changed in the e-Seal adoption programs. There are several possible explanations for the fact that the adoption of e-Seal is slower than the expectations in the industry.

Some of these explanations regard the delay as a result of problems in RFID technology, which is used in e-Seals.

It is said in the RFID industry that the RFID technology may have lost momentum compared with the enthusiasm of two years ago, which lead to adoption plans by Wal-Mart and the Department of Defense (Roberti, 2005). At present there are no new major adoption plans for the RFID technology by large organizations. In addition, existing plans are behind schedule. The delayed adoption of e-Seals is sometimes explained as a part of the delay of the overall RFID adoption.

E-Seal specific problems are also discussed. At the moment, the e-Seal specification is not standardized. The e-Seal standard is discussed in the industry workgroup as ISO 18185 but it has not been finalized yet. In the market there are two e-Seal products from two vendors – Savi and WhereNet. Both products employ active technology and are already used in purposes other than e-Seals. Those products have clear-cut pros and cons and it is said that the industry cannot decide which technology to adopt as the standard (Tirschwell, 2006; Edmonson, 2006; O'Connor, 2005; Barlas, 2005).

Security is another concern in adopting e-Seals. Some articles express the fear that the e-Seal system may be subject to risks of being spoofed or "hacked" because of the lack of security (Collins, 2005; Barlas, 2005; Hoffman, 2006).

There are other explanations of delay from the viewpoint of business.

One of those explanations focuses on the fact that the business model has changed from original expectations. An e-Seal was once assumed to store a good deal of information useful through the supply chain, such as cargo manifest and other shipping documents. However, during the discussion of how to meet CBP's criteria, the e-Seal unit is decided to hold only an ID number. Under this constraint, some people (such as Tirschwell (2006)) say that no ROI is possible.

Other reports point out the lack of any incentive system to promote e-Seal use. As explained previously, CBP plans to introduce the "Green Lane" concept, which guarantees preferential handling of containers at import customs. The private sector expected that e-Seals would soon become a requirement of Green Lane. However, due to budget shortages and continuing congestion in ports, CBP has not committed any fixed plan to realize Green Lane yet. Therefore, at the moment, shippers have no incentive to use e-Seals, other than their reputation to support CBP's effort, according to Downey (2006).

## 2.7. E-Seal adoption process and expected achievement.

Before evaluating the hypotheses presented in the last section, it is necessary to clarify the stages through which the e-Seal adoption process will pass, and what stage is expected to be achieved at present.

In order to discuss the stages of the e-Seal adoption, the factors driving the e-Seal adoption should be confirmed. As explained previously, both CBP and the private sector expect that the e-Seal adoption will occur as a part of C-TPAT compliance and will be driven by incentives in the private sector. However, it is also possible to assume that the e-Seal adoption will be driven by law enforcement, as CBP has authority to obligate importers to use e-Seals.

These two models for the e-Seal adoption are defined as below:

- CBP led model: CBP decides the specification of e-Seals to maximize national security and obligate the private sector to use that specification. The private sector will use e-Seals for its business purposes as far as they are allowed by the specification.
- Private sector led model: E-Seal vendors and user companies (mostly shipping companies) try to develop and test e-Seals which may enhance both national security and business value. CBP will adopt one or multiple e-Seal specifications which are widely accepted in the industry.

Under ordinary circumstances, the private sector led model is more desirable. One reason is that CBP has limited resources (budgets and personnel) for overall anti-terrorism activities in ocean container transportation and prefers the private sector to bear R&D costs. Another reason is that the e-Seal technology is still emerging and obligations of particular specification may obstruct further innovation. As a result, CBP declares that it expects the initiative for the e-Seal adoption to come from the private sector (Downey, 2006).

On the other hand, the private sector is afraid that CBP may switch to a CBP led model under strong political pressure. For example, "24-Hour Advance Vessel Manifest Rule" explained in section 2.4 was introduced in spite of industry's and foreign countries' opposition after the September 11th terrorist attacks.

Therefore, this research assumes that all concerned parties expect the private sector led model but are aware of the risk that the model may be switched.

Under the private sector led model, the stages in e-Seal adoption are as below:

- Technical demonstration by e-Seal vendors
- Pilot adoptions by leading transportation companies
- Limited rollout for small ports by CBP
- Full-scale introduction

Compared with the other e-Seal related technologies, the research expects that "Pilot adoptions by leading transportation companies" should have been achieved at the moment.

## 2.8. Evaluation of hypotheses about RFID technology

This section ~~will~~ discusses the hypotheses suggesting that delayed adoption is caused by problems in RFID technology.

The first hypothesis examined here is that the delay in the e-Seal adoption is a part of slow adoption of the overall RFID technology. This hypothesis is motivated by two major cases: retail supply chain and pharmaceutical distribution.

In retail industry, almost all large retailers started pilot programs two years ago; these programs use RFID technology in backyard operations and deliveries by applying RFID tags to cases and pallets. However, at the moment only Wal-Mart continues its RFID program, while other retailers have suspended their RFID pilot and other active research programs (Roberti, 2005).

For pharmaceutical distribution, the impetus for the RFID adoption comes from a governmental mandate. In this industry there is a great concern about the underground market in which counterfeit or stolen drugs are traded. RFID labels are thought helpful for anti-counterfeit measures and to maintain chain-of-custody for drugs with appropriate documents, called “e-Pedigree”, throughout the distribution system. The government has strongly supported the adoption of RFID in this field and there are many pilot programs carried out by drug makers and RFID system vendors. In spite of that support, the adoption is much slower than government expectations and the government office issued a report declaring that the delay of adoption is regrettable (Whiting, 2006).

However, analogous explanations are not possible in the e-Seal adoption.

First of all, the overall adoption of RFID has not stagnated. According to a survey by IDTechEX in 2006, the adoption of RFID is rapidly increasing (Harrop, 2006). The impression that expansion of RFID usage has slowed down only comes from the above two industries.

Secondly, the technologies used by various industries are different. In retail supply chain and pharmaceutical distribution, passive RFID technology is assumed to be used. This technology is not mature enough and does not satisfy expectations from the industry; price does not meet the industries’ requirement, the inferior goods rate is still high and mass production is not ready at vendors’ factories. On the other hand, the active e-Seal technology, which is acknowledged as a standard e-Seal candidate, is already widely used and sufficiently mature.

Lastly, even in retail supply chain and pharmaceutical distribution, the adoption level has already reached “Pilot adoptions by leading transportation companies”, which is expected in the e-Seal adoption. In retail supply chain, Wal-Mart is working vigorously and other retailers are waiting to observe the experience of Wal-Mart. As for pharmaceutical distribution, drug makers and distributors are conducting pilots of e-Pedigree. It is very natural that companies try to conduct pilot programs of an emerging technology in order to enhance (or not to lose) their competitive power. Also, these pilots are very important for the widespread adoption. Some research, such as Bhuptani's (2005:141-156), shows that those initiatives work as business catalysts for full-scale and industry-wide introduction. If no companies initiate pilot programs, it would be assumed there are problems other than the technology itself.

The second hypothesis examined in this section is the lack of an e-Seal standard. At the moment, there are multiple *de jure* and *de facto* standard candidates in the market.

The e-Seal product which is regarded as most close to the standard is that of Savi. This product uses active technologies operating in the 433 MHz frequency range. The greatest advantage of Savi’s product is that it is already employed by U.S. Department of Defense and NATO armies for military purposes. For civilian applications, Savi offers the SaviTrak platform which provides data exchange capability and container visibility to the users of its e-Seals. Also, this technology itself is standardized as ISO 18000-7 and has been discussed as one of the e-Seal standards in ISO 18185. The drawback of Savi's product was that 433 MHz frequency range has not been allowed for use in some countries other than the U.S. However, by the end of 2006, China and Japan, which are the last major countries which do not allow using 433 MHz frequency range, will amend regulation to allow use of that frequency range and Savi's product can be used in almost all the industrialized countries.

Another e-Seal product on the market and regarded as a strong candidate is the one from WhereNet. WhereNet products use active technologies operating in the 2.4 GHz frequency range and are widely used for RTLS in many industries, including container yards. Also, WhereNet devices are used for the identification of container trailers and trucks in the Los Angeles and Long Beach area. The greatest advantage of WhereNet is that its capabilities for both identification and RTLS are already proven in the market. Also, its 2.4 GHz frequency range is allowed for use in most countries. The shortcoming of WhereNet technology is that this technology has become a candidate for the e-Seal standard only very recently. It was not among the original technologies discussed for ISO 18185.

In ISO 18185, passive e-Seals in the 850 to 950 MHz frequency range are discussed as a standard. However, at the moment this specification is not backed by influential vendors.

Obviously, this lack of a standard has strong negative effects on e-Seal adoption. Many articles, such as Roberti (2005) and Barlas (2005), insist that without a standard no user companies will start to support e-Seals.

However, the slow standardization process may not be a cause but a result. Progress in the standardization process and demand for a technology are interdependent; if there were strong demand for standardization, a compromise would be made to meet that demand, whether the compromise is on the standard or product side. For example, EPC Gen 2, a passive RFID standard used in retail supply chain, obligates that compliant tags should allow multiple modulation to support both speed-conscious environments and high interference environments. As for pharmaceutical distribution application, two frequency ranges (13.56MHz and 902 to 928 MHz) are regarded as candidates for the standard. In order to meet a demand in pharmaceutical distribution, some vendors are going to support multi-frequency RFID readers supporting both frequency ranges (O'Connor, 2006). The reason such compromises are not made in e-Seal industry is simply because the demand is weak.

The last hypothesis related to technology problems is a concern of data security. Data security issues in general RFID technology are widely discussed by the media (Consumer Report, 2006; Albrecht, 2005). As for e-Seals, it is reported within the ISO technical committee that there are disagreements among vendors whether or not the current draft of e-Seal provides enough data security features (Roberti, 2005; Barlas, 2005).

Actually, the data security issue in e-Seal is exaggerated and not an obstacle to adoption. The active e-Seal technology has been verified by and used in U.S. military service for a long time. The e-Seal is read-only and has little meaningful information. The only information it carries is an identification number, which is also printed on the surface of the seal. Any other useful information such as shipper's name or cargo description can be available only after an attacker has successfully infiltrated the IT systems of a shipper or carrier, which are rigidly protected.

## 2.9. Evaluation of hypotheses about business cases

Some articles hypothesize that lack of business cases is the cause of delay in e-Seal adoption.

The first business related hypothesis is that the changes in expectation of e-Seal role caused a decrease of business value and consequent delay of adoption. Originally, an e-Seal was expected to store not only an identification number but also other useful information such as a cargo manifest. An active e-Seal has plenty of memory and it is not difficult to hold such information. As many operational tasks in container transportation occur out of office, it is very helpful if workers can access necessary information directly from the container they are working on. Later, this concept was abandoned because of security concerns. If an e-Seal has to contain valuable business information, the seal should support writing data onto it. Read-write e-Seals inevitably have security flaws compared to read-only e-Seals. Also, authentication and encryption for business information should be more strict and complex than those for an identification number. It is concluded that the above increase of complexity would spoil the business value of e-Seals.

However, judging from other applications of RFID, there are not good grounds to claim that removing business information from e-Seals seriously decreases business values. In retail supply chain, an RFID tag stores only an identification number. All business related information is expected to be exchanged over the EPC network, which provides the ability to look up activities linked to a tag identification number over IT systems of companies involved in the supply chain of that product. Clauss (2006) reports a proof-of-concept trial which uses only identification numbers but provides visibility and real-time locating of ocean containers by using the EPC network.

Another business related hypothesis is that the delay of Green Lane introduction has a great impact on the business value of the e-Seal adoption. Green Lane would reduce transportation costs significantly. Container Security Inc., a security and tracking systems vendor for international container transportation, estimates that if a noninvasive inspection can be avoided because of Green Lane, the total cost reduction is 300 dollars per container, which consists of faster cargo delivery and less work in documentation and cargo handling. If avoided inspection is invasive, the cost reduction increases to $1,000 (Downey, 2006).

However, even without Green Lane, e-Seal brings still vast improvement of business value by means of efficient operation and improved visibility. From the shipper's perspective, improved visibility enabled by automated container tracking will cause 1,150 dollars of cost reduction per container by allowing lowered inventories and out-of-stocks and operational improvement such as less lead-time variance and downtime in manufacturing (Downey, 2006). From the carrier's viewpoint, improvement of operations by container auto-identification is so great that the payback period is just a single year if a company uses e-Seals to improve its internal operations, according to Cuthbert (2006).

Also, if the private sector expects that Green Lane adoption will be behind schedule, it will postpone full-scale rollout but still continue the pilot adoptions, as long as Green Lane is expected to be introduced in future. As explained above, the obligation of RFID adoption in "e-Pedigree" is heavily delayed from industry's expectation, yet drugmakers and distributors continue pilot programs.

# CHAPTER 3 Problem definition, theoretical framework and research design

## 3.1. Specific problem definition

As seen in the literature survey, the major interest of this study is the slow adoption of an e-Seal system. At the outset of research, the specific problem under investigation must be defined.

At the moment, e-Seal adoption remains at an early stage. There are some technical demonstrations by e-Seal vendors. However, at the moment no pilot adoptions by leading transportation companies are being carried out. Judging from the adoption process of other e-Seal related technologies, it should be natural that the e-Seal adoption would have reached that stage.

On the other hand, many existing circumstances seem to support e-Seal adoption strongly, as explained in the last chapter. Existing research indicates that an e-Seal system would be useful for national security activities against terrorism. These articles also claim that container carriers can collect their investment on an e-Seal system within a few years from improved efficiency in their internal operations (even without considering preferential treatments). As CBP has declared it will respect the decision of the private sector, leading companies can take the lead in the adoption without awaiting CBP's final decision. The price and functionality of e-Seals are approaching the level expected in the above studies.

Based upon the above circumstances, the problem examined in this study is why the adoption of an e-Seal system is slow. As there is no decisive explanation for the delay at the moment, a new explanation should be considered rather than examining an existing reason in detail.

## 3.2. Formal problem definition

In order to make the survey clearer, the problem described above should be defined more precisely.

First, it is expected that the private sector will lead the adoption. This reason for this expectation is explained in Section 2.7; a private sector led model suits e-Seal circumstances and both CBP and the private sector agree on this model. Also, the e-Seal adoption is voluntary and included in the C-TPAT program.

The second assumption is that the expected level of the e-Seal adoption is that leading transportation companies conduct pilot trials, as discussed in Section 2.7. The reasons are as below:

- The e-Seal technology is mature enough to allow and encourage business case pilot trials; hardware prices, performance and stability of product supply will not obstruct e-Seal adoption.
- Business level pilot trials have a critical roll in voluntary and exploratory approaches required for e-Seal specification development.
- Other major RFID applications have already reached this stage.

From the above two assumptions, it is concluded that the leading transportation companies should have incentives to carry out pilot trials. Because a pilot trial itself does not yield a profit, other incentives are required by commercial companies. Such incentives may vary, including customer reputation. However, taking initiative in the industry is the most important incentive. In an e-Seal adoption process, the results of pilot trials will eventually be reflected in C-TPAT specifications. Therefore the incentive of pilot trials is to influence C-TPAT specifications unless any additional incentive for pilot trials is explicitly provided by CBP.

Based on the above, the problem investigated in this research is formally defined as follows:

**Why do transportation companies ~~not have enough~~lack incentives to carry out a pilot trial of an e-Seal application with a business scenario, assuming e-Seal adoption is integrated into the C-TPAT program?**

## 3.3. Theoretical Framework

The next step in the research is to define a theoretical framework which explains the cause of the above question.

From the above formal problem definition, it is natural that the dependent variable in this research is **incentive ~~in~~ for the private sector to carry out a trial of an e-Seal application under probable enforcement of the C-TPAT program**.

Some candidates of the independent variable are examined through the literature survey in the previous chapter. However it was concluded that most of them do not seem to explain the root cause of the delay well. Among these candidates, the slow standardization process can be the root cause, but it is not decisive. Therefore, the author decides to discuss an independent variable not discussed yet in order to contribute original information to the existing body of knowledge on this issue.

This research selects a communication issue between CBP and the private sector as the principal independent variable. The candidates of independent variables examined in the literature survey are in the technology and business cases of the private sector. Among the issues not discussed yet, this communication issue seems to provide an important and plausible explanation. However, existing articles discussing this issue are very few.

In e-Seal applications, the result of pilot trials can take effect only after the results are included in C-TPAT specification. This is the difference from RFID applications in other industries; the result of pilot trials for these applications becomes effective directly through influence of the pilot program itself (e.g. superiority of the program) or the company (e.g. dominant market share).

Therefore, if CBP imposes any constraints for the private sector to conduct e-Seal pilot trials, or it declares it will not accept some kind of trial results, it will reduce incentive for pilot trials. However, that is not the case. CBP says it is open to all pilot trials and to accepting the result of e-Seal pilot trials in the private sector.

On the other hand, unreliable communication in the planning phase may decrease the incentive for e-Seal pilot trials. The e-Seal applications in C-TPAT pursue dual-purposes and each purpose is sought by a different party (i.e. national security by CBP and business case improvement by the private sector). Also, the requirements of CBP are hidden before the pilot trial; these requirements should be found and clarified through the trial. If results in a pilot trial do not fit corresponding CBP requirements, the trial becomes useless. Therefore, a company's confidence in CBP's hidden requirements has a strong impact on the incentive to carry out a pilot trial.

Based on the above understanding, an independent variable examined in this study is defined as follows: **confidence in the private sector that it properly and proactively understands the intentions of CBP**.

Another variable is discussed in this theoretical framework: **agreement on the mathematical model explaining how e-Seals increase the benefit of CBP**. This thesis introduces a mathematical model which explains how e-Seals work in CBP's activities against terrorism and improve its results. If the private sector agrees on the model, it will be more confident that it can understand CBP's intention in advance, as the model helps the private sector to anticipate CBP's possible action. Also, this agreement will increases the incentive to conduct pilot trials not by way of a growth of confidence in the private sector; for example, the private sector can design a pilot trial more easily by referring to the mathematical model.

In this theoretical framework, agreement on the mathematical model is treated as an independent variable. It is not an intervening variable because it does not surface between two other variables. Also, handling this variable as a moderating variable is not suitable for this study; in this study, the effect of this variable should be examined as a subordinate parameter to explain the relationship between the dependent variable and the major independent variable, not as a contingent one.

Based on the above discussion, the five features of the theoretical framework are defined as below:

(1) The variables considered relevant to the study

The variables used in this study are as below:

- Dependent variable: Incentive in the private sector to carry out trials of an e-Seal application anticipating probable amendment of the C-TPAT program
- Independent variable: Confidence in the private sector that it properly and proactively understands the intentions of CBP
- Independent variable: Agreement on the mathematical model explaining how e-Seals increase the benefit of CBP.

(2) Relationships between/among the variables.

The relationships expected in this theoretical framework are as below:

- As confidence in the private sector becomes confident that it properly and proactively understands the intention of CBP increases, the incentive forin the private sector to carry out trials of an e-Seal application anticipating probable amendment of the C-TPAT program also increases correspondingly.
- As agreement on the mathematical model explaining how e-Seals increase the

benefit of CBP, incentive in the private sector to carry out trials of an e-Seal application anticipating probable amendment of the C-TPAT program also increases correspondingly.

- As agreement on the mathematical model explaining how e-Seals increase the benefit of CBP, confidence in the private sector that it properly and proactively understands the intention of CBP also increases correspondingly.

(3) Discussion of the nature and direction of the relationships in previous research

This feature is not applicable to this research, as no previous research refers~~red~~ to these relationships.

(4) Logical explanations of relationships

The explanations of the above relationships are as below:

- Assuming the same outlook on the potential business value, if a company is more confident that it understands the intentions of CBP in advance, the company will think its e-Seal pilot trial has less risk that the results will be negated by hidden requirements of CBP. This consequently results in more incentive to carry out e-Seal trials.
- If the private sector regards the mathematical model explaining how e-Seals

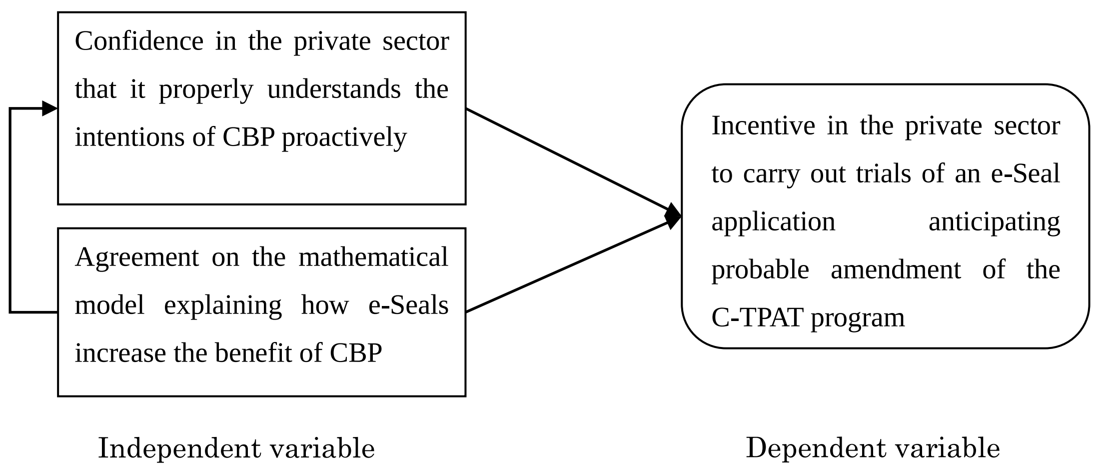
increase the benefit of CBP as reasonable, it will consider that CBP will also act based on the model. Therefore it becomes more confident in understanding CBP's intention in advance.

- The agreement on the mathematical model will increases the incentive to conduct pilot trials by reducing the cost to conduct a pilot trial by utilizing the mathematical model.

(5) Schematic diagram

The schematic diagram for the theoretical framework in this study is as below:

*Figure.3.1.* Schematic diagram for the theoretical framework




## 3.4. Hypothesis

In this study, the primary hypothesis is defined for the relationship between the independent variable and the major dependent variable. This is because the agreement on the mathematical model is introduced to support the investigation into this relationship. Therefore the primary hypothesis examined in this research is as below:

**As ~~confidence in~~ the private sector becomes confident that it properly understands the intention of CBP ~~increases~~, the incentive for~~in~~ the private sector to carry out trials of an e-Seal application anticipating probable amendment of the C-TPAT program also increases correspondingly.**

Two other hypotheses related to the subordinate independent variable are as below:

- As agreement on the mathematical model explaining how e-Seals increase the benefit of CBP, the incentive for~~in~~ the private sector to carry out trials of an e-Seal application anticipating probable amendment of the C-TPAT program also increases correspondingly.
- As agreement on the mathematical model explaining how e-Seals increase the benefit of CBP, ~~confidence in~~ the private sector becomes confident that it properly understands the intention of CBP ~~also increases~~ correspondingly.

All of these hypotheses are directional because a direction of the relationship between the variables is indicated. Also, they are alternate hypotheses because they expect positive correlation.

## 3.4. Research methodology

In order to examine the hypothesis presented in the last chapter, this study employs a survey as a primary research method.

The basic characteristics of the survey are as below:

- The type of investigation in this research is a correlation study. The dependent variable in this study is the incentive for investment in e-Seal in the private sector. However, this incentive can also be affected by environmental issues other than the dependent variables, such as e-Seal prices. Therefore this research can identify association only.

- The extent of researcher interference is minimal in this study. This is because the researcher cannot interfere with the activities in the industry other than sending a questionnaire to industry professionals.

- The study setting is non-contrived because the researcher cannot interfere with the activities in the industry other than sending a questionnaire.

- The unit of analysis in this report is individual. The survey is carried out with professionals in the ocean transportation and related industries. These participants are requested to respond to questions in the questionnaire based on their personal perceptions, not from the standpoint of an organization to which they belong.

- The time horizon of this study is cross-sectional: a survey is carried out only once and data are gathered at the same time. Longitudinal surveys are not expected in this study.

In addition to a survey, this study employs a mathematical model analysis in order to give more detailed results to the primary hypothesis, as explained in Section 3.3,

The mathematical model expresses the relationship between the amount of resources CBP can assign to anti-terrorism activities and the number of detected smugglings. Then, an effect of the e-Seal adoption under the voluntary program is introduced into the model. As a result, the model explains how e-Seals increase the detected smugglings under the same assigned resources.

The model is developed logically from some basic concepts and does not depend on quantitative findings from the literature review. Also, this model is original and does not refer to any existing research. Therefore it is probable that the mathematical model is not valid.

## 3.5. Details of the survey

The survey was conducted in November 2006. The participants of this survey were industry professionals with various backgrounds; though all of them have knowledge about U.S. import business, they work in and out of the U.S. as well as have different jobs such as shipping, logistics or container operations. Responses were solicited by targeted e-mail lists and select professional groups. All communications were carried out via e-mail. The methods employed in this survey are fully compliant with UCAIHS requirements and approved by NYU in advance. No individual responses are analyzed, but rather all responses are consolidated.

Other than questions about respondent profiles, there are 20 questions included in the survey. These questions investigate respondent perceptions of both independent and dependent variables in the hypothesis as well as related issues so that verification from multiple viewpoints can be possible.

The survey refers to e-Seals only in the introduction and each question does not use the word “e-Seal”. There are two reasons for this. First, e-Seal issues are discussed in the industry but few of these discussions give good insight into the relationship between e-Seal adoption and the communication issue. Therefore, if the word “e-Seal” is used in questions, it may mislead participants into answering based upon perceptions of issues other than communication between CBP and the private sector (e.g. progress in standardization or e-Seal prices). Secondly, in order to secure enough responses for statistical analysis, it is necessary to ask for participation from people who understand the C-TPAT program well but are lacking in knowledge of e-Seals. The author concludes that the hypothesis in this thesis can be examined by questions which do not include the word “e-Seal” explicitly.

All questions other than profiles are asked with a five-point Likert scale. Because the Likert scale is a kind of interval scale, measures applicable to an interval scale are calculated. These measures are mean, variance, standard deviation and coefficient of variation. Also, since these questions are designed to hang together as a set, the internal consistency can be tested by Cronbach’s alpha.

Pearson correlation is used to calculate intercorrelations among variables.

The questionnaire document is attached at the end of this research paper.

# CHAPTER 4 Mathematical Model Analysis

This chapter describes a mathematical model of CBP's benefits from an e-Seal program. This model is original and does not refer to any existing research.

## 4.1. Basic Model of Detection and Resources

First, the target to be pursued in this model should be defined along with an approach to the target. In this model, the target is to increase the detection of contraband. This is measured by the quantity of detected smuggling. To achieve the goal, CBP can assign resources to various measures of cargo inspection. There are various kinds of resources CBP can utilize such as budget or trained personnel. However, in this model these resources are expressed in an abstract value, "resources".

The volume of detection is a product of the number of containers which CBP must inspect and the detection ratio of smuggling. As CBP cannot control the volume of containers it must inspect, the tactic CBP can employ is to improve the detection ratio of smuggling.

In this model, CBP cannot control the probability that a container contains smuggling. Instead, CBP can modify the efficiency of inspection by adjusting resource assignment. If CBP does not assign any resources, it cannot detect any smuggling. As CBP assigns more resources, the detection ratio increases and approaches the frequency of smuggling. These resources can be used in various inspection methods such as:

- Documentary inspection (e.g. comparing involved companies with black lists, examining documents for inconsistencies)
- Non-invasive physical inspection (e.g. X-ray or gamma-ray inspection)
- Invasive physical inspection (e.g. manual inspection through opening of containers)

Also, these inspections are conducted not for all containers but for sampled ones. The sampling rates vary.

In this model CBP is assumed to be able to decide the most suitable combination of those inspection methods and sampling rates corresponding to the value of inspection resources per container. This means that CBP employs only the most effective methods when it has limited resources and increases the employment of possible inspection methods. Also, sampling rates of containers increase along with assigned resources. Therefore, as the assignment of resources per container increases, the detection ratio increases sharply at first then becomes slowly asymptotic to the possible smuggling rate.

In this model, fixed costs are not considered. This is because multiple inspection methods are employed and each employs different sampling rates; this means that the fixed costs of each method are averaged and can be treated as variable costs.

The relationship between the detection ratio and resources per container is defined as a function *f(x)*. Based on the above definitions, the value of *f(x)* increases monotonously and the marginal utility of resources (i.e. differential coefficient of *f(x)*) becomes asymptotic to zero.

This relationship can be expressed by the following equation:

$$(4.1.) \ldots \quad \frac{DS}{CV} = f\left(\frac{R}{CV}\right)$$

Where:

*DS*: Detected smugglings

*CV*: Container volume (numbers of containers)

*R*: inspection Resources

*f*: Relationship between detection ratio and resources per container

Equation (4.1.) can be transformed as below:

$$(4.2.) \ldots \quad DS = f\left(\frac{R}{CV}\right) \times CV$$

Characteristics of *f(x)* are determined by the reliability of containers to be inspected. If containers are shipped by a reliable organization and carried through a reliable route, the possible smuggling rate becomes lower. Also, priority among inspection methods is also different among container groups with different reliability.

## 4.2. E-Seal Efficacy on Inspection

The next step is to introduce a concept to represent the efficacy of e-Seals into the above model. Though e-Seals are one of the methods that CBP can employ for contraband inspection, their effects and costs are treated in different ways from other methods in this model.

In this model, e-Seals work to increase detected smugglings (*DS*) and do not change the possible smuggling rate (i.e. terrorists attempt smuggling whether a container is sealed by an e-Seal or not). With regard to the relation between e-Seals and other inspection methods, e-Seals are assumed to increase the efficiency of other inspection methods. This is because e-Seals provide tracking information. With that information CBP can carry out inspections more quickly (e.g. with fewer resources) and effectively (e.g. by selecting more appropriate samples for detailed inspection).

To express the above concept in a mathematical way, a new variable “e-Seal multiplier” is introduced. This variable explains the extent to which the e-Seal adoption increases the efficiency of resources.

This amended model can be expressed in an equation as below:

$$(4.3.)\ \ldots\quad DS = f\left(m \times \frac{R}{CV}\right) \times CV$$

Where:

*m*: e-Seal Multiplier

Characteristics of e-Seal multiplier *m* are determined by the reliability of a target group. When an e-Seal is used in an unreliable environment, the tracing information created by the e-Seal is less useful and therefore the value of assigned resources increases less, as some inadequate practices (e.g. discussed in Section 2.1) negate the value of e-Seals.

Also, *m* is assumed to be determined by the least reliable container in the target group. This is because the value of *m* reflects how the operation can be simplified by utilizing e-Seal information: the risk of applying inadequately simple inspection is greater than the inefficiency of applying excessively complicated inspection.

The cost of an e-Seal system to CBP is assumed to be fixed in this model. This is because the dominant part of e-Seal cost to CBP is assumed to be computer system costs. E-Seals are purchased by shippers. Most infrastructure costs are shared among transportation companies (shipping companies, container yards and truckers). On the other hand, computer systems handling e-Seal information, which is developed and operated by CBP, should be very powerful and therefore expensive, as the expected data volume is very huge and this data should be processed in almost real-time.

In this model, the amount of resources necessary to implement an e-Seal system is referred to as $R_{system}$.

## 4.3. Break-even point of e-Seal adoption

The next step of model analysis is to examine the impact of an e-Seal system adoption. Modeling all conditions would be very complex; to simplify, the break-even point is investigated: under what conditions will adoption of e-Seal result in the same amount of smugglings under the same available resources?

In deciding e-Seal adoption tactics, it is assumed that CBP determines the acceptable reliability of containers covered by the e-Seal adoption. As explained already, less reliable containers have a smaller e-Seal multiplier and it may be pointless to attach an e-Seal to these containers. In this model, containers are separated into two groups based on whether e-Seal can be applied – “sealable” and “non-sealable”.

Because sealable and non-sealable containers have different reliabilities, these groups have different relationships $f(x)$. Therefore, the detected smuggling value before e-Seal adoption is expressed in the equation below:

$$(4.4.)\ \ldots\ DS_{total} = f_{sealable}\left(\frac{R_{sealable}}{CV_{sealable}}\right) \times CV_{sealable} + f_{nonsealable}\left(\frac{R_{nonsealable}}{CV_{nonsealable}}\right) \times CV_{nonsealable}$$

Where

$DS = DS_{total}$

$R = R_{sealable} + R_{nonsealable}$

$CV = CV_{sealable} + CV_{nonsealable}$

In this model, it is assumed that CBP can allocate resources properly to maximize total smuggling detection. Under this assumption, additional resource assignment to either the sealable group or the non-sealable group causes the same amount of smuggling detection; if one group is more effective, the total detection can be increased by moving resources from the less effective group to the other.

To express this condition in a mathematical way, the marginal utility of $R$ is the same both in the sealable group and the non-sealable group. This can be expressed in the equation as below:

$$\begin{aligned} & \frac{d}{dR}\left( f_{sealable}\left(\frac{R_{sealable}}{CV_{sealable}}\right) \times CV_{sealable}\right) \\ (4.5.)\ \ldots\ & = \frac{d}{dR}\left( f_{nonsealable}\left(\frac{R_{nonsealable}}{CV_{nonsealable}}\right) \times CV_{nonsealable}\right) \\ & = \frac{d}{dR}\left( f_{total}\left(\frac{R_{total}}{CV_{total}}\right) \times CV_{total}\right) \end{aligned}$$

In this model not all sealable containers are assumed to be sealed. This is because some container shippers believe that the benefit of the e-Seal adoption is not enough to cover e-Seal costs or because CBP cannot afford to introduce e-Seal systems to all ports at the same time.

Under this condition, sealable containers are again separated, now into "sealed" and "unsealed" groups. The relationship *f(x)* is the same with sealed and unsealed containers, as the reliability of these groups is the same.

This condition can be expressed in an equation as below:

(4.6.) …

$$DS_{total} = f_{sealable}\left(\frac{R_{sealed}}{CV_{sealed}}\right) \times CV_{sealed} + f_{sealable}\left(\frac{R_{unsealed}}{CV_{unsealed}}\right) \times CV_{unsealed} + f_{nonsealable}\left(\frac{R_{nonsealable}}{CV_{nonsealable}}\right) \times CV_{nonsealable}$$

Where:

$$R_{sealable} = R_{sealed} + R_{unsealed}$$

$$CV_{sealable} = CV_{sealed} + CV_{unsealed}$$

$$\frac{R_{sealable}}{CV_{sealable}} = \frac{R_{sealed}}{CV_{sealed}} = \frac{R_{unsealed}}{CV_{unsealed}}$$

Equation (4.6.) changes after an e-Seal system is launched.

$$DS_{total\_launched} = f_{sealable}\left( m \times \frac{R_{sealed\_launched}}{CV_{sealed}} \right) \times CV_{sealed}$$

(4.7.) … $$+ f_{sealable}\left( \frac{R_{unsealed\_launched}}{CV_{unsealed}} \right) \times CV_{unsealed}$$

$$+ f_{nonsealable}\left( \frac{R_{nonsealable\_launched}}{CV_{nonsealable}} \right) \times CV_{nonsealable}$$

As described above, this model assumes that the available resources remain unchanged before and after the e-Seal system launch. As a result, the following equation is produced:

(4.8.) … $$R_{sealed\_launched} + R_{unsealed\_launched} + R_{nonsealable\_launched} + R_{system} = R_{sealed} + R_{unsealed} + R_{nonsealable}$$

At the break-even point of e-Seal adoption, $DS_{total}$ and $DS_{total\_launched}$ become the same. Therefore, the marginal utility for non-sealable and unsealed container groups should be the same before and after the e-Seal system launch, as the container volume and detected smuggling in these groups are the same before and after the e-Seal system launch.

(4.9.) … $$\frac{d}{dR}\left( f_{nonsealable}\left( \frac{R_{nonsealable}}{CV_{nonsealable}} \right) \times CV_{nonsealable} \right) = \frac{d}{dR}\left( f_{nonsealable}\left( \frac{R_{nonsealable\_launched}}{CV_{nonsealable}} \right) \times CV_{nonsealable} \right)$$

(4.10.) … $$\frac{d}{dR}\left( f_{sealable}\left( \frac{R_{unsealed}}{CV_{unsealed}} \right) \times CV_{unsealed} \right) = \frac{d}{dR}\left( f_{sealable}\left( \frac{R_{unsealed\_launched}}{CV_{unsealed}} \right) \times CV_{unsealed} \right)$$

As a result, the assigned resources for non-sealable and unsealed container groups are not changed before and after the e-Seal system launch (e.g. $R_{sealable}$=$R_{sealable\_launch}$, $R_{nonsealeble}$=$R_{nonsealable\_launch}$). With this result, equation (4.8.) can be rewritten as below:

$$(4.11.) \ldots R_{sealed\_launched} + R_{unsealed} + R_{nonsealable} + R_{system} = R_{sealed} + R_{unsealed} + R_{nonsealable}$$

By transforming this equation, the relation below is generated:

$$(4.12.) \ldots \quad R_{sealed\_launched} = R_{sealed} - R_{system}$$

Based on the above information, the relationship at the break-even point is expressed as follows:

$$(4.13.) \ldots \quad \begin{aligned} & DS_{total\_launched} = DS_{total} \\ &= f_{sealable}\left( m \times \frac{\left(R_{sealed} - R_{system}\right)}{CV_{sealed}} \right) \times CV_{sealed} \\ &+ f_{sealable}\left( \frac{R_{unsealed}}{CV_{unsealed}} \right) \times CV_{unsealed} \\ &+ f_{nonsealable}\left( \frac{R_{nonsealable}}{CV_{nonsealable}} \right) \times CV_{nonsealable} \end{aligned}$$

Comparing equation (4.6.) and (4.13.) and deducting the common entries, the above equation can be modified as below:

$$(4.14.)\ \ldots\quad f_{sealable}\left(\frac{R_{sealed}}{CV_{sealed}}\right)\times CV_{sealed}=f_{sealable}\left(m\times\frac{(R_{sealed}-R_{system})}{CV_{sealed}}\right)\times CV_{sealed}$$

Equation (4.14.) can be further simplified as below:

$$(4.15.)\ \ldots\quad R_{sealed}=m\times(R_{sealed}-R_{system})$$

This is the condition at which the rate of detected smugglings is the same before and after the adoption of e-Seal system. If the right side is greater than the left side, it means that the adoption of an e-Seal system increases the detection of smugglings.

## 4.4. Analysis on break-even point

On equation (4.15.) there are three ways to make the right side larger than the left side. Those methods are as below:

- Increase e-Seal multiplier $m$
- Increase the inspection resources for e-Seal: $R_{sealed}$
- Decrease the resources for e-Seal system adoption/implementation: $R_{system}$

There are two methods to increase e-Seal multiplier $m$.

One approach is to use the e-Seal system for more reliable containers. As described above, in this model *m* is assumed to be determined by the least reliable container in the target group. However, when the e-Seal system covers more reliable containers, the number of covered containers decreases. This consequently results in lower $R_{sealed}$ value. If too few containers are covered by the e-Seal system and the value of $R_{sealed}$ becomes smaller than that of $R_{system}$, the right side of equation (4.15.) becomes smaller than the left side. On the other hand, if too many containers are covered and the *m* value approaches 1, the right side of the equation also becomes smaller. Therefore there is a most suitable coverage of the e-Seal system over containers which can maximize the detection of smugglings.

Another approach to increasing *m* is to use a more efficient e-Seal system. From the viewpoint of CBP, there are two ways to increase the efficiency of an e-Seal system: to assign more resources to an e-Seal system internally and to obligate the private sector to use more powerful e-Seals. The former approach means assigning more data analysts or adding more functions to an e-Seal application. This tactic is indirect and it is difficult to estimate its effectiveness. In addition, CBP is responsible for funding that enhancement. The latter approach is to use more functional e-Seals, such as smart containers instead of active e-Seals, adding more sensors or GPS modules. These can provide information and directly increase the efficiency of inspection. In addition, the cost of e-Seals is shared by the private sector. Therefore, CBP has a strong incentive to introduce complex and expensive e-Seals.

Regarding the value of $R_{system}$, on one hand, when $R_{system}$ is greater than $R_{sealed}$, an e-Seal system has no value. As $R_{sealed}$ value is proportional to $CV_{sealed}$, it is preferable that a greater number of containers is covered by the e-Seal program. On the other hand, when the value of $m$ approaches 1, the e-Seal system also loses its economic value. As discussed above, the value of $m$ declines as less reliable containers are covered. Therefore, there is a point between zero and coverage of all containers, at which the value of an e-Seal system is maximized.

The value of $R_{sealed}$ can be changed without modifying $m$. In this model, it is assumed that not all the containers satisfying the criteria for e-Seal attachment actually employ e-Seals ("unsealed" container group). If "unsealed" containers become "sealed", the value of $m$ remains unchanged because those container groups have the same reliability. However, the $R_{sealed}$ value increases because it is proportional to $CV_{sealed.}$. This means that once CBP decides the criteria of an e-Seal system it has incentive to apply e-Seals to all containers which satisfy the criteria.

The value of $R_{system}$ also can be changed without modifying $m$. As described above, CBP can transfer the cost of an e-Seal system partly to the private sector.

## 4.5. Small enhancement of the model – multiple e-Seal utilization

The above model may be slightly altered in order to evaluate an additional feature.

Assume that CBP employs the other forms of e-Seal inspection. The original e-Seal inspection group remains the same. In addition, some containers in the “non-sealable” group are regarded as sealed. That is, the original “non-sealable” container group is divided into two groups “now sealable” and “still non-sealable”.

This container group has e-Seal multiplier *m*, which is smaller than the original *m* but greater than 1. This new *m* value is referred to as $m_2$. Also, the amount of resources to enhance an e-Seal system for this change is referred to as $R_{system\_new}$.

Before applying second level e-Seal inspection, the amount of detected smuggling remains unchanged. Therefore, the equation below applies:

$$f_{non\_sealable}\left(\frac{R_{non\_sealable}}{CV_{non\_sealable}}\right)\times CV_{non\_sealable}$$

$$\text{(4.16.)} \ldots \quad = f_{now\_sealable}\left(\frac{R_{now\_sealable}}{CV_{now\_sealable}}\right)\times CV_{now\_sealable} + f_{still\_nonsealable}\left(\frac{R_{still\_nonsealable}}{CV_{still\_nonsealable}}\right)\times CV_{still\_nonsealable}$$

After second-level e-Seal inspection is adopted, equation (4.16.) is changed as below:

$$f_{non\_sealable}\left(\frac{R_{non\_sealable}}{CV_{non\_sealable}}\right)\times CV_{non\_sealable}$$

$$(4.17.)\ \ldots \quad = f_{now\_sealable}\left(m_2\times\frac{(R_{now\_sealable}-R_{system\_new})}{CV_{now\_sealable}}\right)\times CV_{now\_sealable}$$

$$+\ f_{still\_nonsealable}\left(\frac{R_{still\_nonsealable}}{CV_{still\_nonsealable}}\right)\times CV_{still\_nonsealable}$$

It can be assumed that $R_{system\_new}$ is very small and may be negligible, as it can use the same infrastructure of the original e-Seal system. Therefore, as far as $m_2$ is smaller than 1, the second level e-Seal adoption is always beneficial.

This approach (dividing containers into groups to get greater *m* value) can be applied to even smaller groups. Therefore, CBP has an incentive to employ multiple container groups based on their reliabilities.

## 4.6. Assumptions on behaviors of CBP

Based on the above mathematical model and consequent considerations, there are some points which affect CBP's considerations as below:

- The break-even point of e-Seal adoption can be determined using only data regarding the containers to which e-Seals are applied, if resources are properly assigned to maximize detection of smugglings.,
- The criteria determining what kind of containers should be equipped with an e-Seal

can be assigned to maximize detection of smugglings.

- The more criteria-satisfying containers attach an e-Seal, the more smuggling will be detected.
- E-Seals with rich functions increase the detection rate while keeping costs on CBP's side constant.
- Employing an additional group of containers for e-Seal inspection increases detection of smuggling.

In the following chapters, the prevalence of the findings in the industry will be examined.

# Chapter 5 Results and Discussion

## 5.1. Survey Overview

The survey was conducted in November 2006, through targeted e-mail lists and select professional groups. The questionnaire was sent to 89 industry professionals via e-Mail and 22 questionnaires were returned (response rate = 25%). All questions in the questionnaire were answered in all responses (i.e. there were no questions left blank).

## 5.2. Profile of Respondents

The profiles of respondents are as below:

*Table 5.1.* Frequency Distribution of Employers

| Employer | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Shipping Company | 13 | 59.1 | 59.1 |
| Container Terminal | 0 | 0.0 | 59.1 |
| Forwarder / 3PL | 9 | 40.9 | 100.0 |
| Total | 22 | 100.0 | |

*Table 5.2.* Frequency Distribution of Positions

| Position | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| Senior Manager | 8 | 36.4 | 36.4 |
| Junior Manager | 5 | 22.7 | 59.1 |
| Clerk | 6 | 27.3 | 86.4 |
| Analyst / Researcher | 3 | 13.6 | 100.0 |

| Total | 22 | 100.0 | |
|---|---|---|---|

*Table 5.3.* Frequency Distribution of Regions

| Region | Frequency | Percent | Cumulative Percent |
|---|---|---|---|
| North America | 5 | 22.7 | 22.7 |
| Latin America | 1 | 4.5 | 27.2 |
| Europe | 3 | 13.6 | 40.8 |
| Asia/Oceania | 13 | 59.2 | 100.0 |
| Middle East/Africa | 0 | 0.0 | 100.0 |
| Total | 22 | 100 | |

Because the total number of responses is small and investigation on each category will not elicit statistically meaningful results, the research takes all responses as a whole and does not carry out investigation for each category.

## 5.3. Data Reliability

Cronbach's alpha is used to examine the reliability of the survey results. The value of Cronbach's alpha reliability coefficients in this survey is 0.84. In general, reliabilities over 0.80 are considered good (Davidson, 2006). Consequently, the internal consistency and reliability of the measures in this survey can be considered good.

## 5.4. Descriptive Statistics

The descriptive statistics for each question are as below:

*Table 5.4.* Descriptive Statistics.

| Variable | Mean | Variance | Std. Deviation | Coefficient Of Variation |
|---|---|---|---|---|
| Q1: The current C-TPAT program has enough appeal for most U.S. importers to participate. | 3.36 | 1.00 | 1.00 | 0.30 |
| Q2: In the near future (within three years) the C-TPAT program will have enough appeal for most U.S. importers to participate. | 3.45 | 0.83 | 0.91 | 0.26 |
| Q3: Taking the lead in pilot tests for a new requirement in the C-TPAT program is beneficial to leading and enterprising companies. | 3.50 | 0.83 | 0.91 | 0.26 |
| Q4: Receiving preferential treatment (such as Green Lane) is an important reason for a company to participate in the C-TPAT program. | 4.05 | 0.62 | 0.79 | 0.19 |
| Q5: Performing in a socially responsible way and consequent reputation are an important reason for a company to participate in the C-TPAT program. | 3.82 | 0.63 | 0.80 | 0.21 |
| Q6: Increasing internal management effectiveness (such as forensic/traceability) is an important reason for a company to participate in the C-TPAT program. | 3.55 | 0.64 | 0.80 | 0.23 |
| Q7: In general, it is better to employ a single practice or technology for both public security compliance and private benefits than to use different ones for each respectively. | 3.77 | 1.33 | 1.15 | 0.31 |
| Q8: Under the C-TPAT program, a single practice or technology can fulfill the requirements of both security compliance and private benefits in the near future (within three years). | 3.18 | 0.82 | 0.91 | 0.19 |
| Q9: The benefits of standardization in C-TPAT outweigh the drawbacks. | 3.45 | 1.12 | 1.06 | 0.31 |
| Q10: If a dual-use technology or practice is | 3.82 | 0.44 | 0.66 | 0.17 |

| | | | | |
|---|---|---|---|---|
| introduced into C-TPAT as a requirement, the majority of C-TPAT participants can benefit from it. | | | | |
| Q11: During discussion to determine whether a new requirement will be introduced into C-TPAT, the private sector can understand the intention of CBP behind the requirement. | 3.23 | 0.47 | 0.69 | 0.21 |
| Q12: Before a new possible requirement is proposed as an agenda from CBP, the private sector can learn of the requirement and act proactively. | 3.14 | 0.89 | 0.94 | 0.30 |
| Q13: If a company carries out a trial and finds that a technology and/or practice is useful for anti-terrorism activity, the company has a chance to amend the C-TPAT program by appealing the trial result. | 3.41 | 0.44 | 0.67 | 0.20 |
| Q14: If CBP declares its intention to introduce a new requirement into the C-TPAT program and the private sector finds that the practice is not practical, the private sector has a chance to prevent adoption of the requirement. | 3.05 | 1.19 | 1.09 | 0.36 |
| Q15: If a dual-use security practice is adopted in the private sector and becomes a de facto standard, CBP will accept it even if there are other similar practices and these are better from CBP’s viewpoint. | 3.27 | 0.78 | 0.88 | 0.27 |
| Q16: CBP can detect the optimum requirement in C-TPAT which maximizes the profit of CBP. | 3.00 | 0.76 | 0.87 | 0.29 |
| Q17: Once requirements are determined, CBP will receive the maximum profit when all importers satisfying the requirements participate in C-TPAT. | 3.55 | 0.55 | 0.74 | 0.21 |
| Q18: If a security measure can be taken by either | 2.95 | 1.09 | 1.05 | 0.35 |

| | | | | |
|---|---|---|---|---|
| CBP or the private sector with the same effects, CBP prefers that the measure is handles in the private sector. | | | | |
| Q19: Benefits from a security practice become bigger as more resources are assigned to anti-terrorism activities. | 3.18 | 1.01 | 1.01 | 0.32 |
| Q20: If CBP can introduce multiple levels of requirements, its benefit will increase compared with introduction of only one level. | 3.45 | 0.64 | 0.80 | 0.23 |

## 5.5. Inferential Statistics

The table below is a Pearson correlation matrix obtained from the results of this survey. As the number of samples is 22, all figures above 0.43 are significant at p = 0.05 and those above 0.54 are significant at p = 0.01.

*Table 5.5.* Correlations among the Variables

| | Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 | Q9 | Q10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Q1 | 1.0 | | | | | | | | | |
| Q2 | 0.80 | 1.0 | | | | | | | | |
| Q3 | 0.42 | 0.46 | 1.0 | | | | | | | |
| Q4 | 0.04 | 0.10 | 0.43 | 1.0 | | | | | | |
| Q5 | -0.09 | -0.01 | 0.00 | 0.09 | 1.0 | | | | | |
| Q6 | 0.33 | 0.43 | 0.33 | 0.11 | 0.39 | 1.0 | | | | |
| Q7 | 0.45 | 0.19 | -0.25 | -0.09 | -0.10 | 0.19 | 1.0 | | | |
| Q8 | 0.45 | 0.41 | 0.17 | 0.12 | 0.44 | 0.71 | 0.50 | 1.0 | | |
| Q9 | 0.29 | 0.52 | 0.39 | 0.15 | 0.05 | 0.37 | 0.09 | 0.36 | 1.0 | |
| Q10 | 0.46 | 0.22 | 0.08 | 0.11 | -0.34 | -0.07 | 0.63 | 0.22 | 0.33 | 1.0 |
| Q11 | 0.40 | 0.06 | 0.11 | 0.33 | 0.25 | 0.02 | 0.01 | 0.31 | 0.11 | -0.01 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Q12 | 0.40 | 0.42 | 0.08 | -0.14 | 0.42 | 0.34 | 0.38 | 0.64 | 0.51 | 0.27 |
| Q13 | 0.12 | 0.07 | -0.43 | -0.40 | 0.06 | -0.08 | 0.50 | 0.03 | 0.13 | 0.28 |
| Q14 | 0.38 | 0.12 | 0.17 | 0.00 | 0.12 | 0.24 | 0.39 | 0.52 | 0.27 | 0.54 |
| Q15 | 0.26 | 0.08 | 0.12 | -0.22 | -0.20 | -0.09 | 0.16 | -0.24 | -0.50 | 0.01 |
| Q16 | 0.54 | 0.54 | 0.00 | -0.14 | 0.14 | 0.27 | 0.52 | 0.60 | 0.31 | 0.33 |
| Q17 | 0.30 | 0.60 | 0.42 | 0.20 | 0.10 | 0.28 | -0.18 | 0.27 | 0.40 | 0.02 |
| Q18 | 0.11 | 0.37 | 0.07 | 0.00 | 0.22 | 0.20 | 0.19 | 0.36 | 0.49 | -0.08 |
| Q19 | 0.50 | 0.53 | 0.16 | -0.31 | 0.22 | 0.23 | 0.20 | 0.33 | 0.05 | -0.02 |
| Q20 | 0.32 | 0.42 | -0.13 | -0.34 | 0.14 | 0.11 | 0.32 | 0.27 | 0.19 | 0.07 |

| | Q11 | Q12 | Q13 | Q14 | Q15 | Q16 | Q17 | Q18 | Q19 | Q20 |
|---|---|---|---|---|---|---|---|---|---|---|
| Q11 | 1.0 | | | | | | | | | |
| Q12 | 0.39 | 1.0 | | | | | | | | |
| Q13 | 0.10 | 0.36 | 1.0 | | | | | | | |
| Q14 | 0.11 | 0.41 | 0.17 | 1.0 | | | | | | |
| Q15 | -0.26 | -0.22 | -0.04 | -0.26 | 1.0 | | | | | |
| Q16 | 0.32 | 0.70 | 0.49 | 0.40 | -0.06 | 1.0 | | | | |
| Q17 | 0.50 | 0.37 | 0.01 | -0.09 | -0.17 | 0.37 | 1.0 | | | |
| Q18 | 0.35 | 0.35 | 0.44 | 0.13 | -0.35 | 0.57 | 0.28 | 1.0 | | |
| Q19 | 0.14 | 0.37 | 0.17 | -0.05 | 0.37 | 0.38 | 0.31 | 0.19 | 1.0 | |
| Q20 | 0.24 | 0.55 | 0.62 | -0.25 | 0.09 | 0.75 | 0.29 | 0.54 | 0.42 | 1.0 |

## 5.6. Hypothesis Testing

In this survey, the primary dependent variable “incentive in the private sector to carry out a trial of an e-Seal application under enforcement of the C-TPAT program” is measured by Question 3. The primary independent variable “confidence in the private sector that it properly and proactively understands the intentions of CBP” is measured by Question 12.

The Pearson correlation between these two variables is 0.08. This means that these two variables do not have significant correlation at $p = 0.05$. As a result, the primary hypothesis is rejected.

The other hypotheses in this research are related to another independent variable: the respondents' agreement on the mathematical model. Variables related to such agreement are measured by Question 16 to Question 20. None of these variables have correlation with Question 3 significant at $p = 0.05$. Correlation between Question 13 and Question 16/20 are significant at $p = 0.01$ (0.70 and 0.55 respectively). Correlations between Question 13 and Question 17/18/19 are 0.35 and 0.36 and tend to have a moderate relationship. Consequently, it is concluded that there is correlation between confidence of understanding and agreement on the best practices.

## 5.7. Interpretation of results and their significance

As shown in the last section, the primary hypothesis in this research is rejected; there is no significant correlation between confidence in the private sector that it properly understands CBP's intention and perception of incentive to carry out an e-Seal pilot trial. Actually, the value 0.08 as Pearson correlation is too small to find any meaningful relationship, apart from that it does not make statistical significance.

As a result, the results of the survey invite investigation of why the correlation is very small.

Evaluation on secondary hypotheses provides some additional insights. These insights are as below:

- Among the agreement on the best practices expected from the mathematical model, Question 16, 18 and 20 have strong and significant (at p = 0.01) correlations with each other (0.57 between Q.16 and Q.18, 0.75 between Q.16 and Q.20, 0.54 between Q.18 and Q.20). As these questions are independent and not causal to one another, it is suggested that these three results share a common explanation (hereafter these three items are referred to as "core model properties"). This result supports a hypothesis that the respondents' attitudes conform to the assumptions of the mathematical model and how it works.

- As for relationships between the confidence in understanding CBP's intention (Question 12) and the above core model properties, two of these have significant correlation at p = 0.01 (0.70 between Q.12 and Q.16, 0.59 between Q.12 and Q.20). The other tends to have moderate correlation (0.35 between Q.12 and Q.18).

- On the other hand, correlations between the core model properties and the perception of incentive to carry out a trial (Question 3) are very small and not considered as meaningful (0.00 between Q.3 and Q.16, 0.07 between Q.3 and Q.18,

-0.13 between Q.3 and Q.20).

The above results indicate that the mathematical model used in this research is substantial to a major extent and related to the participants' confidence in understanding CBP's intentions. This means that the participants in this survey regard CBP’s recognition of incentives in the same way as the research expects. However, the participants do not believe these confidences are related to the incentive to carry out a trial.

In order to investigate the above results in greater detail, other results of the research are examined.

The results related to Question 12 are investigated first. This question asks whether a company can understand CBP's intention after CBP decides upon a change and explains it to the private sector.

There are no significant correlations between Question 12 and the core model properties (0.32 between Q.12 and Q.16, 0.35 between Q.12 and Q.16, 0.24 between Q.12 and Q.20). This result is natural; once a company obtains official explanation of CBP's intentions, the company’s confidence in understanding CBP's intentions has no relationship to agreement on results of the mathematical model.

The correlation between Question 3 and Question 12 is 0.11. This is too small to find any meaningful relationship.

From the above inspection, it is concluded that there are no helpful insights from investigation on the results related to Question 12.

Inspection on Question 13 may provide some clue. This question asks whether a company can change the C-TPAT requirements if the company discovers a useful practice through a trial. Differences in results between Q.12 and Q.13 may provide helpful insights if the small correlation in the primary hypothesis is related to whether the confidence in the private sector comes in advance of or after CBP's public explanation.

This question has significant correlation with the core model properties: with Q.16 and Q.18 at $p = 0.05$ (0.49 and 0.44 respectively), with Q.20 at $p = 0.01$ (0.62). This means that the confidence of changing the C-TPAT requirements through a trial corresponds to the agreement on the mathematical model.

On the other hand, there is a significant negative correlation between Question 3 and Question 13 at $p = 0.05$ (-0.43). This correlation means that if a respondent thinks a company has less chance to amend the C-TPAT program through a trial, the company perceives a benefit to carrying out a trial.

This negative relationship seems to be inconsistent. However, it can be explained by an assumption that the private sector considers the purpose of an e-Seal trial as confirming CBP's requirements and does not believe it can change these requirements by giving feedback regarding trial results. Under this assumption, respondents who are not involved in e-Seal or other C-TPAT compliance issues are neutral to these issues. As they become involved in these issues more deeply, they develop more clear attitudes – negative to the feasibility of changing CBP's intention but positive to the necessity of trial programs.

The above assumption is supported by some results in the survey.

First, evidence exists in questions about the benefit of the dual-use technology. There are three questions (Question 7, 8 and 10) examining the perceived benefit from different viewpoints: Q.7 asks whether the dual-use technology can be beneficial in general, Q.10 asks the same under the C-TPAT program, and Q.8 asks whether a workable dual-use requirement can be implemented in the C-TPAT program within three years. The mean of Question 8 (3.18) is significantly lower than that of Question 7 (3.77, 95% confidence by t-Test) and Question 10 (3.82, 99% confidence by t-Test). This result indicates that respondents believe that the dual-use technology is useful both in general and for the C-TPAT program but do not have the same level of confidence that the dual-use technology can be introduced into the C-TPAT program within three years.

Another explanation is in questions about the kinds of benefits to program participation in this survey: Question 4 for preferential treatment, Question 5 for social responsibility and Question 6 for internal management efficiency. The means of those questions are similar (4.05, 3.82 and 3.55 respectively). However, the correlations between Question 4 and others are very low (0.09 and 0.11 respectively), while the correlation between Question 5 and 6 is 0.39 and tends to have some meaning. These results indicate that the respondents consider the benefit from preferential treatment totally different from others.

## 5.8. Relation of results to previous knowledge or the framework

The suggestion in the above section is a denial of this assumption: the private sector does not believe it is feasible that feedback on e-Seal trial results will change CBP's requirements. The framework used to formulate the hypotheses assumes that the private sector leads the e-Seal adoption by planning and carrying out pilot projects. If the private sector does not believe it is useful to find hidden requirements of an e-Seal system in the C-TPAT program and give feedback to CBP, the private sector led model does not work well.

This result is also an addition to existing knowledge. Through the literature survey on the RFID technology, many articles are found that refer to the pilot trials in other RFID application such as pharmaceutical distribution. However, these articles explain that companies carrying out pilot trials believe that success in their trial will result in their own benefit through their initiative in adoption of the technology. Some articles on national security in international transportation focus on the difficulty of employing a technology standard which can be used both for national security and commercial benefit, such as Stowsky (2004). But none of these articles found in the literature survey refer to difficulties in the pilot trials.

Two approaches are suggested to mitigate difficulties in this new finding. As discussed in the last chapters, it is not realistic to employ a CBP led model in e-Seal pilot trials. Therefore other measures should be taken to increase benefit and/or reduce risk to carry out trials under the current framework for e-Seal adoption.

One method to decrease risk is for companies to form a working group and the group to take responsibility for carrying out trials. This approach reduces both risk and benefit; failure is shared among the participants but a company can include only a part of its aims into the trial plan. In other industries such as pharmaceutical distribution, the working group approach is widely taken. However, the ocean transportation industry is very slow to employ this approach. The reason has not been discussed yet and needs to be investigated. Generally, it is possible for CBP to encourage the working group approach by admitting the authority of that working group and committing to adopt the decisions of that group.

Another method is to divide the e-Seal adoption process into stages. By dividing stages the private sector can focus on what it has interest in without considering risks in a whole adoption. For example, leading ocean transportation companies and standard bodies may start to carry out pilot tests of RFID container plates (Sullivan, 2006; Swedberg, 2006) without considering migration with e-Seal, while other companies are still taking a wait-and-see approach. The reason these companies hesitate is the risk that they will have to support both RFID container plates and e-Seals. If CBP decides to split the e-Seal adoption plan and in the first stage only the hardware specification is decided, it will both accelerate adoption of RFID container plates and encourage e-Seal pilot trials.

Finally, CBP can refine its requirements for e-Seal pilot trials in the private sector. Its requirements are still vague but a part of them may be clarified by CBP itself without waiting for the results of pilot trials. If these requirements are clarified before e-Seal pilot trials, the private sector will have more incentives to carry out trials because its risk is reduced.

# Chapter 6 Conclusion

## 6.1. Conclusions

The most important conclusion in this study is that the private sector does not believe that the private sector led adoption model for e-Seal will work properly; the survey results show that there is small and non-significant correlation between the confidence of understanding CBP's intention proactively and the incentive to conduct a trial in the private sector. This result is contrary to the assumption in this study; if the framework employed in this research is valid, there should be significant correlation between these two variables.

This small correlation comes not from a belief in the private sector that it cannot understand CBP's intention properly, but from the perception that it has little chance to change CBP's plan of e-Seal adoption, according to inspection on the remainder of the survey.

Another major conclusion in this research is that the mathematical model proposed in this study seems to produce results similar to the industry perceptions. The survey results indicate that the respondents' agreement on three of five of the model's features have strong correlation with each other.

These features are concluded from the model but are each independent from other viewpoints. Therefore, this outcome suggests that the mathematical model is substantial to a major extent and reflects common understanding among the industry, at least concerning these three features with strong intercorrelations.

## 6.2. Recommendations

The conclusion that the private sector does not believe that the private sector led adoption model for e-Seal will work well means CBP should reconsider the ongoing approach. On the other hand, the results of the literature review suggest that to abandon the private sector led model will produce many harmful side effects and is not recommendable.

Instead of surrendering the private sector led model, this study makes recommendations for CBP to mitigate the difficulties in the private sector under the private sector led model. These three recommendations are discussed in Section 5.7. and can be summarized as below:

- CBP should encourage companies to form a working group to take responsibility for carrying out trials; it will help companies to share the risk of a pilot program.
- CBP should divide the e-Seal adoption process into multiple stages; narrowing the

scope of a trial reduces risk of unexpected (e.g. political) intervention and a company has to less reason to fear such intervention.

- CBP should refine its requirements for e-Seal pilot trials in the private sector; it will help a company to learn which specifications can be changed through a pilot trial and which cannot.

The fact that the survey generally proves the mathematical model encourages attempts to inspect the model in greater detail and make necessary modifications to it. At the moment, many studies and articles on e-Seal adoption lack analysis based on a mathematical approach. Applying this model (or an enhanced version) will help researchers to increase the value of their work. This model also provides a baseline to compare the results of their models and studies each other.

In addition to e-Seal adoption, the mathematical model in this study can be enhanced to be applied to other security and/or anti-terrorism programs, as this model depends only on some basic concepts and can be applied to many security programs with minimal changes. The potential applications of this model vary from similar programs (e.g. other international transportation security programs via land or air) to ones in totally different industries (e.g. a pre-registration program at airport inspection gates).

## 6.3. Summary

This thesis investigates the reason for the delay of e-Seal adoption in ocean container transportation. Adoption of e-Seals (or similar technology) is widely expected as an essential element of anti-terrorism activities. Therefore, this subject is worth investigatation.

The literature review demonstrates that there are many existing articles on this issue and many reasons are discussed in these articles. However, the review also suggests that at the moment there is no decisive reason which explains the delay adequately. Therefore, the author chose to investigate an undiscussed but feasible reason.

At the beginning of the study, the adoption level assumed to have been achieved is set at: pilot adoptions by leading transportation companies. Then, to explain delay of adoption at this level, this study selects a communication issue between CBP and the private sector as the reason investigated: inadequate communication between these two parties decreases the private sector's expectation to amend CBP's requirements, which is the most important incentive to conduct a pilot trial.

After constructing a theoretical framework, the primary hypothesis is defined: As confidence in the private sector that it properly understands the intention of CBP increases, incentive in the private sector to carry out trials of an e-Seal application anticipating probable amendment of the C-TPAT program also increases correspondingly.

In order to verify this primary hypothesis, this research conducts a survey of industry professionals about their perception. In addition, this study introduces a mathematical model which expresses the relationship between resource amount and the benefit of CBP. Agreement on this model is also questioned in the survey. This model is mainly used to examine the primary hypothesis more in detail in case the hypothesis is rejected by the survey. The model helps to determine at what stage the hypothesis is wrong. In addition, the model itself is worth examined because at the moment there are no mathematical models to explain costs and benefits in policy making about anti-terrorism activities.

The results of the survey suggest that the private sector does not believe it has enough chance to change CBP's e-Seal requirements by conducting a pilot program, despite the fact that the feasibility of amendment is thought to be the major incentive for the private sector. Therefore, this thesis recommends that CBP should take actions to reduce the risks of the private sector in conducting pilot trials, such as when a company discovers a meaningful result through a pilot trial but the result is ignored by CBP.

The mathematical model seems to be proven to a major extent by the results of the survey. This means that the further improvement and enhancement of this model will help not only the adoption of e-Seals but also other anti-terrorism programs. Therefore the thesis recommends developing the mathematical model both for the e-Seal adoption more in detail and examining the feasibility of usage in other applications.

## 6.4. Originality

The mathematical model about the relationship between assigned resources and detection of terrorists' activity is the major point of originality in this thesis. Within the literature survey for this research, there are no commercial articles or academic papers which employ a mathematical model to evaluate cost-effectiveness of anti-terrorism measures.

A mathematical model provides a baseline to compare results of studies. It is very important to discuss issues of anti-terrorism activities and other national security openly and in public. However, when a discussion comes to qualitative evaluation, it becomes very difficult to compare arguments using different approaches. For example, in the literature survey of this research, two articles estimating the monetary damage of possible terrorist attacks on Los Angeles/Long Beach Terminal Island conclude totally different amounts.

Although this mathematical model is simple and depends only upon some basic concepts, it leads to an interesting conclusion: if resources are already assigned properly and in the optimal conditions, the breakeven point of an additional measure can be calculated only for the group in which the measure is applied. This model may be useful in evaluating other voluntary security measures than C-TPAT, such as a pre-registration program at airport inspection gates.

Another point of originality in this research is discussion on adoption problems unique to dual-use technology aiming at both national security and commercial benefit. As the technology becomes more complicated and expensive, anti-terrorism activities require more spontaneous and positive participation from the private sector. However, existing articles on either international transportation or national security do not refer to this point.

Finally, this study discusses the importance of communication between the public and private sector regarding voluntary anti-terrorism measures, to which few existing articles refer. This viewpoint is necessary for constructive discussion, because in voluntary programs the incentive of possible participants has a vital role and proper communication can increase this incentive.

## 6.5. Contribution to Body of Knowledge

This research constitutes valuable contributions to the existing body of knowledge as follows:

- Enhancing the existing body of discussion over the e-Seal adoption by expanding the literature survey.

- Proposing a framework for adoption of dual-use technology used both for anti-terrorism activity and commercial benefits.
- Introducing a mathematical model to explain the relationship between assigned resources and detection of terrorists' activity.
- Confirming that the e-Seal adoption model assumed at the moment may not work properly.

First, prior to this research, there were no well-organized lists of discussions about the e-Seal adoption in the industry; each discussion appeared in separate articles and their contexts vary. By referring to the literature survey in this research, researchers and other persons concerned can grasp the structure of the e-Seal adoption problem as a whole more easily and precisely.

Secondly, this research proposes a new and unique framework to investigate adoption of dual-use technology. The adoption of dual-use technology consists of mandate by the public sector and initiatives in the private sector. However, existing articles focus on only one or the other. With the framework used in this research, communication issues between CBP and the private sector are taken up in order to explain the relationship between mandate by the public sector and initiatives in the private sector.

Thirdly, the mathematical model about the relationship between assigned resources and detection of terrorists' activity is original. This will help further discussion about not only e-Seal adoption or the C-TPAT program, but also voluntary anti-terrorism programs in general.

Finally, the results of the survey suggest that the adoption model assumed by CBP is not working properly at the moment. The adoption plan requires some amendment or mitigations for current problems.

## 6.6. Limitation of Study

The mathematical model in this study depends on some intuitive assumptions to draw an elegant and useful conclusion, such as different treatment between an e-Seal system and other inspection methods. Although this simplification is necessary to conclude a meaningful result from the model within the limited resources of this thesis, there is space for further research to examine whether these intuitive assumptions undermine the model as a whole.

Also, the model is not validated in its qualitative aspect. In this research the model is built and inspected only from mathematical manipulations. However, validity of resource assignment should be investigated also by quantitative factors such as budgets and number of personnel CBP assigns to each inspection method, as well as number of smuggling detected by each inspection method.

The survey in this research is too focused to verify the relationship between the confidence on CBP in the private sector and the intention for investment. This approach makes it impossible to evaluate the relative importance of this factor compared with others such as e-Seal prices and lack of a standard.

Another limitation of the survey is that the number of respondents is too small to allow analysis based upon the subcategories (i.e. employers, positions and regions). If further analyses on subcategories would be possible, they may reveal facts which do not appear in this study.

In addition, all respondents in the survey belong to vendor-side companies and no business people in user companies (i.e. shippers and/or consignees) participated in the survey. This presents a risk that the results of this survey are skewed; the user companies are also important players in voluntary anti-terrorism activities but may have different incentives than do vendor companies.

## 6.7. Scope for Future Research

The author, a member of the ocean transportation industry, intends to conduct a more comprehensive survey. That survey should cover all possible causes of the delayed adoption. Also, the survey should have participant numerous enough to allow statistical analyses on subcategories such as positions, regions and employers including shippers and consignees. A survey satisfying the above criteria will be a very large-scale one and beyond the capacity of an independent researcher. Therefore the author considers asking for support from a trade paper which understands the importance of this issue and approves of the survey.

It would be helpful to carry out some orientation studies such as focus group interviews before conducting a survey again. At the moment, problems in e-Seal adoption are not discussed in an academic way and it is difficult to estimate the validity of questions in the survey.

It is expected that researchers with experiences in handling mathematical models will take an interest in this research and work to examine and expand the mathematical model. The ability of the author to handle a mathematical model is very limited and there is much room for improvement.

Examinations of assumptions in the mathematical model are required. They may reveal inconsistency of the model or potentialities for use in other anti-terrorism security applications.

Another scope for future research on the mathematical model is qualitative examination such as comparison to the budget of CBP. This examination would be also useful for application of this model to other voluntary anti-terrorism activities, such as pre-registration programs at airport inspection gates.

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# Appendix 1 - Project Summary Statement

**NEW YORK UNIVERSITY**
*A private university in the public service*

**School of Continuing and Professional Studies**
Graduate Programs in Management & Systems

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**Project Summary Statement**

You are invited to take part in a research study about the development and use of best practices and information technologies in businesses. The study deals specifically with the effect of e-Seal on an anti-terrorism program. The study is being conducted by Koichiro Hayashi, at New York University, School of Continuing and Professional Studies, Management and Systems Graduate Program as part of the requirements for the Masters degree. The faculty sponsors for this study are Mr. Bruce Baulch, Adjunct Assistant Professor, and Prof. Anthony Davidson, both of the Division of Graduate Programs in Business, SCPS, NYU.

If you agree to participate in the study, you will be asked to take part in a survey about the perception of the private sector toward an anti-terrorism program that will take no longer than 10 minutes to complete. The survey will be conducted via email exchange as is attached hereto.

There is no risk to participation in this study beyond that of everyday life. Although you will receive no direct benefits, your participation may help the investigator and industry better understand the effect of e-Seal on an anti-terrorism program. Your participation in the study is voluntary and by returning this survey you are indicating your consent to participate; you may choose not to participate or withdraw from participation at any time without penalty. You may also decide not to answer any questions you prefer not to answer.

Confidentiality of your research record will be strictly maintained by assigning a code to each response and not recording any identifying information. Your name will not be mentioned in any reporting, publication or presentation without your express, written consent.

If there is anything about the study or your participation that is unclear or that you do not understand, if you have questions or wish to report a research related problem, you may contact Koichiro Hayashi, 212-253-5525 kh588@nyu.edu or the faculty sponsor, Bruce Baulch, 212-263-7188, brb4@nyu.edu. For questions about your rights as a research subject, you may contact the New York University Committee on Activities Involving Human Subjects, 15 Washington Place, #1A, New York, NY 10003, (tel) 212-998-4808 or human.subjects@nyu.edu.

Please indicate your consent to the above by return email. If you wish to give the investigator permission to quote your name and/or corporation in his/her thesis, presentations or publications please include that in your response.

Please print out this document to keep for your records.

# Appendix 2 - Questionnaire Form

Dear Participants,

My name is Koichiro Hayashi and I am a graduate student at New York University (NYU). I am presently working towards a Masters of Science in Management and Systems. A key requirement for attaining such a degree is the development and presentation of a thesis paper. The title of my thesis paper is “An e-Seal in Container Security Program: How to maximize the benefit of e-Seal in battle against terrorism”.

My thesis paper attempts to understand what the factors both in CBP and the private sector maximize the benefit of C-TPAT, an anti-terrorism program for U.S. import containers.

C-TPAT is a voluntary program and importers determine whether they participate in the program based on the expected costs and benefits.

Some requirements in C-TPAT are being discussed but not introduced yet. Among these requirements, some will improve not only security against terrorism but also business values on the private sector, such as increased visibility. One of the most discussed examples is e-Seal technology. CBP expects that enterprising companies will take the lead in adoption of those requirements.

I ask that you please take around ten minutes to answer the following survey questions. These questions request that you attempt to weigh the factors necessary to investigate how the private sector understands the intentions of CBP and prepares for these.

**The following questions are about your profile:**

Q. What is your employer?

- Shipping company
- Container terminal

- Forwarder / 3PL

Q. What is your position?

- Senior manager
- Junior manager
- Clerk
- Analyst / Researcher

Q. What region are you working in?

- North America
- Latin America
- Europe
- Asia/Oceania
- Middle East/Africa

**All of the following questions ask your perception on a scale of 1 to :**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

You are kindly requested to answer with your own opinions as an industry professional, not those of your company or customers.

**The following questions are about your general perception of the C-TPAT program.**

Q.1: The current C-TPAT program has enough appeal for most U.S. importers to participate.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly | Disagree | Neither | Agree | Strongly |

| | | | | |
|---|---|---|---|---|
| Disagree | | Agree nor Disagree | | Agree |

Q.2: In the near future (within three years) the C-TPAT program will have enough appeal for most U.S. importers to participate.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.3: Taking the lead in pilot tests for a new requirement in the C-TPAT program is beneficial to leading and enterprising companies.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.4: Receiving preferential treatment (such as Green Lane) is an important reason for a company to participate in the C-TPAT program.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.5: Performing in a socially responsible way and consequent reputation are an important reason for a company to participate in the C-TPAT program.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.6: Increasing internal management effectiveness (such as forensic/traceability) is an important reason for a company to participate in the C-TPAT program.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

**The following questions are about your general perception of dual-use requirements in the C-TPAT program.**

Q.7: In general, it is better to employ a single practice or technology for both public security compliance and private benefits than to use different ones for each respectively.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.8: Under the C-TPAT program, a single practice or technology can fulfill the requirements of both security compliance and private benefits in the near future (within three years).

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor | Agree | Strongly Agree |

| | | | | |
|---|---|---|---|---|
| | | Disagree | | |

Q.9: The benefits of standardization in C-TPAT outweigh the drawbacks.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.10: If a dual-use technology or practice is introduced into C-TPAT as a requirement, the majority of C-TPAT participants can benefit from it.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

**The following questions are about your general perception of communication between CBP and the private sector.**

Q.11: During discussion to determine whether a new requirement will be introduced into C-TPAT, the private sector can understand the intention of CBP behind the requirement.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.12: Before a new possible requirement is proposed as an agenda from CBP, the private sector can learn of the requirement and act proactively.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.13: If a company carries out a trial and finds that a technology and/or practice is useful for anti-terrorism activity, the company has a chance to amend the C-TPAT program by appealing the trial result.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.14: If CBP declares its intention to introduce a new requirement into the C-TPAT program and the private sector finds that the practice is not practical, the private sector has a chance to prevent adoption of the requirement.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.15: If a dual-use security practice is adopted in the private sector and becomes a de facto standard, CBP will accept it even if there are other similar practices and these are better from CBP's viewpoint.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

**The following questions are about your general perception of the detailed relationship between requirements and CBP's benefits.**

Q.16: CBP can detect the optimum requirement in C-TPAT which maximizes the profit of CBP.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.17: Once requirements are determined, CBP will receive the maximum profit when all importers satisfying the requirements participate in C-TPAT.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.18: If a security measure can be taken by either CBP or the private sector with the same effects, CBP prefers that the measure is handles in the private sector.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.19: Benefits from a security practice become bigger as more resources are assigned to anti-terrorism activities.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |

Q.20: If CBP can introduce multiple levels of requirements, its benefit will increase compared with introduction of only one level.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Strongly Disagree | Disagree | Neither Agree nor Disagree | Agree | Strongly Agree |