POSSIBLE IMPACTS OF SUPPLY CHAIN SECURITY ON EFFICIENCY

A SURVEY STUDY ABOUT THE POSSIBLE IMPACTS OF AEO SECURITY CERTIFICATIONS ON SUPPLY CHAIN EFFICIENCY

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ABSTRACT

Purpose of this paper
A new topic that during the last years has come to the attention of researchers is supply chain security. Stakeholders are progressively realizing the importance to join the authority regulations issued by governments (e.g. AEO) to reduce transport delays at Customs or other business certifications (e.g. TAPA) to reduce theft. However the impacts of these certifications on security and efficiency are not always well understood. Hence, the purpose of this paper is to shed the light on the relationship between these two constructs.

Design/methodology/approach
The research design is based on a literature search and a survey with the European members of the TAPA EMEA association. By means of Structural Equation Modeling the impact of security on efficiency is evaluated.

Findings
The findings put in evidence that whenever security is enacted, efficiency may be improved.

Research limitations/implications
The analysis focuses on the Authorized Economic Operator (AEO). In addition the study is limited to the members of the TAPA EMEA association.

Practical implications
The analysis proposed in this paper may support logistics and supply chain managers in enhancing understanding about the possible impacts of security certifications on supply chain efficiency.

Originality/value
Previous researchers, by means of normative approaches, claim that security certifications can improve both security and efficiency. This paper indicates that this conclusion is supported by the data.

Keywords: Supply Chain Security Programs, Transport Security, AEO certification, TAPA EMEA, supply chain efficiency.
1. INTRODUCTION

Security in supply chains is a topic that has got more and more attention from researchers and practitioners during the last years. Criminal activities, as for instance theft and counterfeiting of cargo, show worrying signals of vulnerabilities in supply chains. The European Parliament has reported theft of lorries and cargo in Europe for a value of about €8.2 billion yearly (European Parliament, 2007a). Likewise, the Federal Bureau of Investigation (FBI) in US has reported cargo theft in the range between $10 and $30 billion per year (Anderson, 2007). Other statistical reports show that in Europe counterfeited and pirated items amounted to $176 billion in 2007 (Rodwell et al., 2007). According to another report from the European Commission, in 2006, almost 3 millions of pharmaceutical products were found to be counterfeits (EU Commission, 2008). These figures may be higher, since logistics operators have a tendency to hide the problem to their customers (Ekwall and Lumsden, 2007).

In Europe, supply chain actors interested in preventing and mitigating the consequences of security incidents have the possibility to join voluntary certification programs, business certifications, or authority certifications issued by governments around the world. The most known voluntary security certification in Europe is the Transported Asset Protection Association (TAPA EMEA, 2008). At the same time, diverse authority certification programs have been issued by governments to prevent terror threats and ensure the security and safety of our communities (European Parliament, 2005; European Parliament, 2007b). The main motivation of authority certification programs is that supply chains could be the next target of terrorists (Burke, 2005; Johnston and Nath, 2004; Sheffi, 2001). For instance, the intentional counterfeiting or contamination of food or pharmaceutical products could kill or seriously injure hundred thousands of people. Similarly, global supply chains could be exploited to smuggle nuclear weapons or terrorists into a country (Sheffi, 2001). In Europe, the Authorized Economic Operator (AEO) is a supply chain security certification that has the scope of stimulating operators to increase security while offering expedite Customs procedures (CP3 Group 2006).

The new challenge faced by managers is to make decisions about what security certifications to choose and more specifically to evaluate the impact of the certifications on efficiency. Previous research presents diverging opinions on this issue. Some researchers claim that security certifications are merely an additional burden for operators. It is well known that companies have to face new costs in form of security investments, but also in form of human and time resources, since the security routines have to be built on top of existing duties of terminal and transport operators (Stevenson, 2005; McNaught, 2005; Mazaheri and Ekwall, 2009). Loss of efficiency could stake a competitive advantage on the marketplace and result in consistent economic losses. In addition, too restrictive of security measures could make transport chains less flexible and reliable, implying the loss of their capability to quickly respond to demand volatility. Other authors, by means of normative approaches, sustain that security improvements bring higher efficiency (Rice and Spayd, 2005; Sheffi, 2001; Willys and Ortiz, 2004; Powanga, 2006). However, none of the known literature examines in details, with the support of empirical data, how security certifications affect the security and efficiency of logistics and transport organizations. Hence, the question concerning the impact of security certifications on the efficiency of supply chains haven’t been fully answered yet.

By means of a survey performed with the members of the TAPA EMEA organization, the purpose of this paper is to enhance the understanding of the possible impacts of the AEO certification on supply chain efficiency. Finally, this paper discusses needs for future research
as well as it provides recommendations for managers about how to determine whether this certification could be convenient for them or not. The research design is based on a literature search and a survey.

This paper is structured in six sections. After the introduction, the literature review and the formulation of hypotheses are presented. Next, the methodology is illustrated. Next, the results from the survey are outlined in form of descriptive statistics and test of the hypotheses. Finally, the implications for researchers as well as managers and decision makers are discussed.

2. LITERATURE REVIEW AND RESEARCH HYPOTHESIS

The Authorized Economic Operator (AEO) is a concept integrated in the SAFE framework of standards designed by the World Customs Organization (WCO) to disseminate around the world the security requirements issued in US and finally to facilitate global trade (CP3 Group 2006). Hence, the scope of the AEO initiative is to detect high-risk cargo as early as possible in the supply chain and in a resource-efficient way (CP3 Group 2006). The AEO program is only applicable for organizations, with activities regulated by customs law, within EU 27 and also Norway, Switzerland and Liechtenstein. The certification is assessed by each country’s Customs authority. AEO is structured with two different sides (AEO-C and AEO-S) which together are called AEO full.

Table 1. Summary of requirements and benefits of AEO certifications (EU Commission, 2007).

<table>
<thead>
<tr>
<th></th>
<th>Customs Compliance</th>
<th>Record Keeping</th>
<th>Financial Solvency</th>
<th>Safety and Security</th>
<th>Customs Simplifications</th>
<th>Fewer inspections</th>
<th>Priority Treatment</th>
<th>Choose place for control</th>
<th>Prior Notification</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEO-C</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>AEO-S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AEO-F</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

These are:

- **AEO-C (Customs Simplifications).** This certificate is given to operators that fulfil the criteria of customs compliance, appropriate record-keeping and financial solvency. The benefits of this certificate are easier admittance to customs simplifications, fewer physical and document controls, priority treatment and possibility to choose the place for control (Table 1).

- **AEO-S (Security and Safety).** This certificate is given to operators that are able to maintain appropriate safety and security standards. Benefits of this certification include prior notifications of inspections, reduced data set for summary declarations, fewer physical and document based controls, possibility to request a specific place for the control (Table 1).

- **AEO-F (Customs Simplifications/ Security and Safety).** This certificate is given to operators that fulfil the demands for both AEO-C and AEO-S. The benefits will be all
those related to AEO customs simplification and AEO security and safety certifications (Table 1).

Examining previous research it is claimed that enhancement of security determine improvements in efficiency (Rice and Spayd, 2005; Sheffi, 2001; Closs and McGarrell, 2004). The turning point occurred with the aftermath to the terrorism attack against the World Trade Centre in 2001, which entailed that the threat from terrorism needed to be handled. Therefore different supply chain security programs were launched and the most of scientific articles have been oriented to understand the effects of these programs both on security and efficiency (Fletcher, 2007; Gutiérrez et al., 2007; Grainger, 2007; Hameri and Hintsa, 2009). Lee and Whang (2005), in accordance to the Total Quality Management (TQM) doctrine, show how the implementation of RFID based technologies can speed up Customs’ inspections and provide operators with time and costs savings. Rice and Spayd (2005) and Sheffi (2001) state that complying with authority certifications can also bring “collateral benefits” as trade facilitation, asset visibility and tracking, faster standard development etc. Haughton (2007) demonstrates the economical and competitive advantages for large and small shippers becoming FAST-approved (Free And Secure Trade, a security certification related to trade driven between Canada, US and Mexico). Powanga (2006) adds that only large firms may have the possibility to trade-off the security costs with benefits related to supply chain transparency. Willys and Ortiz (2004) emphasize that efficiency and security in supply chains are closely interrelated, since higher security may reduce Customs delays so as the higher transparency of information of goods flows may reduce shipping costs and time.

![Figure 1. Research hypothesis H1.](image)

**Figure 1. Research hypothesis H1**.

Hence, the following hypothesis may be formulated:

**H1. Higher security brings higher supply chain efficiency.**

The theoretical hypothesis is thereafter tested by measuring possible impacts on security and efficiency of four security certifications. Hence, the following sub-hypotheses will be tested:

**H1a. The implementation of the AEO-C security certification brings higher supply chain efficiency.**

**H1b. The implementation of the AEO-S security certification brings higher supply chain efficiency.**

### 3. Method

The research in this paper follows the tradition in logistics of using a system approach to answer research questions (Aastrup et al., 2008; Gammelgaard, 2004). The main idea of system theory is to illuminate holistic thinking; it is based on the assumption that a whole system is different from the sum of its components. As part of the system we consider two elements: the AEO-C and the AEO-S certifications. For each of these elements we develop, with support of a literature review, the constructs of security and efficiency. The literature
review was performed by searching in Elsevier and Emerald databases as well as in google scholar. In particular the following keywords have been used: “supply chain security”, “supply chain efficiency”, “transport security” and “transport efficiency”. The formulation of the hypothesis can be described as a cyclic abductive approach that by means of literature search aimed to understand the business itself, the supply chain security programs and the interaction between the logistics business and these programs (Dubois and Gadde, 2002; Kovacs and Spens, 2005).

3.1. Survey Study

A survey research design was used to collect the data. Once the hypotheses were formulated, a first draft of the survey to be sent to practitioners was outlined by the authors and reviewed by three academics experts for clarity, readability, specificity, representativeness, content validity, and face validity (Czaja and Blair, 2005). Afterwards, the questionnaire was tested and reviewed by 10 security managers. At the end of each of the processes, some items were rewritten, some eliminated or others added. The questionnaire was published on a survey website and the members of the TAPA EMEA association (310 logistics security professionals in Europe) were invited to join via email. Since many companies in EU are not AEO certified, the TAPA database could increase the possibility to find 1. AEO certified companies or 2) individuals with optimum knowledge of the certifications and security topics. For confidentiality issues, the emails of the TAPA EMEA members could not be disclosed and therefore a member of the TAPA EMEA board acted as an intermediary and took the responsibility to send out the email. The email contained a short summary of the purpose of the study as well as instructions to access the online questionnaire. An email address and a telephone number for respondents who needed support were included in the email. To increase the rate of responses the introductory email ensured the confidentiality of the answers. In addition, an executive summary of the final results was offered as an incentive to answer. The cover letter was addressed to risk, quality, supply chain or security managers. The first email was sent in the beginning of the last week of January 2010 and the deadline was set to the 10th February 2010. After this first period, only 42 companies had filled in the online questionnaire, corresponding to a response rate of about 14%. Hence, a reminder email, specifying the scope of the study and the importance to answer the survey, was sent in the middle of February 2010. This increased the response rate to 20.6% (N=62).

3.2. Instrument

The questionnaire sent to the TAPA EMEA members was made of 4 blocks of questions:

- **Block 1 - Generic questions.** This first block was made of questions concerning the demographic characteristics of the industries that joined the investigation. Hence, type of company, position in the company of the respondent, annual sales, number of employees and type of products moved.

- **Block 2 - AEO Certification.** The second block contained generic questions about the AEO certification (including the three variants AEO-C, AEO-S and AEO-F). Questions included membership of the organization, type of certification, and what factors related to the certification, the respondent believed could influence security and performance of the organization.

- **Block 3: AEO-C possible impact on security and efficiency.** This block of question aims to measure the impact of the AEO-C on both security and efficiency. Security is measured by means of a scale made of 2 items measured on a 5 point Likert scale (from 1, Very Bad, to 5, Very Good). Likewise, efficiency is measured by means of a scale
made of 6 items measured on a 5 point Likert scale (from 1, Very Bad to 5, Very Good).

- **Block 4: AEO-S possible impact on security and efficiency.** This part of the questionnaire is similar to the previous however the focus is on the AEO-S certification.

### 3.3. Security measures

Scales to measure security and efficiency were deducted from existing literature. Supply chain security is the combination of preventive and recovery measures in form of human and material resources intended to protect transport infrastructure, vehicles, systems and workers against intentional unlawful acts (EU, 2003). Supply chains become progressively more complex, so does the mission to secure them (Anderson, 2007). Supply chain security consists of the combination of routines, technologies and managerial strategies to enhance the protection of assets and operations against voluntary attacks (Urciuoli, 2010). Security threats are not merely confined to theft in supply chains, but also to international terrorism, and other criminal actions as drug contraband, human trafficking etc. security attacks to supply chains trigger disruptions with consequential losses for businesses but also safety risks for our communities (Rice and Spayd, 2005; Sheffi, 2001). In this context, managerial strategies assume a special role to ensure security prevention but also supply chain resiliency (Sheffi, 2001). A supply chain is proactive if it has the ability to put into place actions to prevent an incident. At the same time, it is resilient if measures are in place to ensure that the supply chain can bounce back to stable conditions after the incident (Closs and McGarrell, 2004). Supply chain security is also a term that is used by customs to indicate the capability to protect supply chains while facilitating the movement of people and goods across borders. As a consequence, the variables used to measure the security of the certifications are meant to measure the reduction and prevention of security threats, as well as the recovery capability of the organization (Figure 2).

![Figure 2. Dimensions in supply chain security scale.](image)

### 3.4. Efficiency measures

Supply chains’ strain for efficiency is reflected in the actual design of physical transportation systems as well as in the planning of operations. Previous research has shown that there are plenty of variables that could be used to measure efficiency in supply chains. However, in this study we have chosen to use those items that have been mentioned in papers discussing the possible impact of security on efficiency. Hence, the following items have been identified (Figure 3):

- Supply chain visibility.
- Competitive advantage.
- On-time deliveries.
- Transportation costs.
One of the most mentioned benefits of supply chain security is the enhanced visibility of the assets transported. Improving security by enabling the capability of tracking cargo in warehouses or moved in transport conveyances will directly allow supply chain companies to access the location and status of a product in real time. This implies that delivery uncertainties may be reduced and managers may forecast with higher precision when the products will arrive to the final destination (Rice and Spayd, 2005). Competitive advantage is an important topic for supply chains, as experts believe that in the future competition will not take place between single companies but between supply chains (Christopher, 1992). In particular, within the security context, Haughton (2007) illustrates the importance of competitive advantage of those supply chains that actively secure their operations and assets. Likewise Rice and Spayd (2005) affirm that firms may gain competitive advantage if security investments are well allocated. Supply chain security means also improved process efficiency and monitoring of companies’ administrative procedure, including paperwork. Typical examples are tracking and tracing systems but also automated systems to share information, monitor inventory levels or access of authorized personnel in facilities. Hence, we may affirm that labour efficiency is improved and administrative operations may become less time-consuming. The importance of technical systems may also be claimed in relation to the improvement of other efficiency factors. Technology may reduce inventory costs (Rice and Spayd, 2005; Lee and Whang, 2005; Willys and Ortiz, 2004). Enhanced capabilities to locate cargo in real time may also be exploited to reduce safety stocks as well as ordered quantities to be shipped (Zuidwijk et al., 2011). Likewise, on time deliveries are strongly related to visibility capabilities as transport uncertainty will be reduced and possible disruption may become easier to predict and detect (Lee and Whang, 2005). A main consequence of the above implications is that the overall costs required to transport goods may decrease, determining consistent savings for all operators involved in the supply chain (Gunasekaran et al., 2004).

### 3.5. Respondents Profile

The group of firms that joined this investigation is in large part constituted by medium (16%) and large enterprises (69%), even though small firms are fairly represented (about 15%)
(Table 2). The type of companies that answered the survey is prevalently constituted by logistics service providers, 3PL, 4PL, Forwarders and warehouse owners (51%), followed by manufacturing firms (11%), physical transport carriers (8%) and wholesaler/distributor (3%) (Table 2). Other type of companies (26%) includes insurers, underwriters, airline companies, law enforcement, security service providers and mail distributors.

Table 2. Demographic data of respondents (type of company and number of employees, N=62).

<table>
<thead>
<tr>
<th>Type of Company</th>
<th>No. of Employees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other</td>
<td>2 3 12 17</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>1 0 6 7</td>
</tr>
<tr>
<td>Wholesaler/Distributor</td>
<td>1 0 1 2</td>
</tr>
<tr>
<td>Forwarder/3PL/4PL/warehouse/Logistics Service Provider</td>
<td>3 6 22 31</td>
</tr>
<tr>
<td>Physical Transport Carrier</td>
<td>2 1 2 5</td>
</tr>
<tr>
<td>Responses</td>
<td>9 10 43 62</td>
</tr>
</tbody>
</table>

The annual sales of 44.7% of these companies are greater than €100 million. 19.1% of the firms have annual sales between €10 and €50 million and 17% between €2 and €10 million (19.1% of the respondents preferred not to answer to this question). The most of the individuals that answered the questionnaire are in order security managers (53.2%) and risk and quality managers (12.8%). These were followed by operations (10.6%) and logistics manager (8.5%) and other profiles as CEOs and managing directors (14.9%). Finally, the companies transports electronic equipment (80%), followed by automotive components (43%), pharmaceuticals (41%), apparel (35%), clothes (29%) and food (24%). Other main products moved by the companies, which were specified in the questionnaire by the respondents, include theft critical cargo as tobacco, flash memory chips, industrial machinery, semi-conductors, footwear/sport equipment, non-food retail products and letters and parcels of all kind.

3.6. Data Analysis

The analysis of the collected data consists of the following phases:

**Descriptive statistics.** This phase concerns the analysis of missing values, means, and standard deviations. In addition, to provide more details about the shape of the variables’ distributions, Kolmogorov-Smirnov tests, Z-scores of the skewness and kurtosis are reported. More specifically, the Kolmogorov-Smirnov test tells whether the variables are normally distributed and the Z-scores of the skewness and kurtosis are exploited to verify whether the distributions 1) are concentrated within low or high scores, 2) are heavy tailed or 3) flat.

**Confirmatory Factor analysis.** Scales have been built by performing CFA upon the items used to measure the constructs related to the possible impacts on security and efficiency of respectively the AEO-C and AEO-S certifications. Before running these analyses it was ensured the absence of common method bias by performing an un-rotated factor analysis with Kaiser Criterion (Eigen value > 1). This analysis revealed the existence of three distinct factors that accounted for 59.7% of the variance. In particular, it was noticed that the first
factor accounted for only 30.6% of the variance. Hence, the absence of common method bias may be assumed (Paulray et al., 2008). A Confirmatory Factor Analysis (CFA) has been run to determine how well the measured variables represented the constructs (Hair et al., 2009). The analysis of the model fit indices was exploited to establish construct validity and unidimensionality. Convergent validity was assessed by examining the value of standardized coefficients and t-values for the individual paths (Hair et al., 2009). Discriminant validity was estimated by examining differences of the $\chi^2$ values for the fixed and free solutions (Hair et al., 2009).

3.7. Test of Hypotheses

The structural equation model illustrated in Figure 4 was tested by using LISREL 8.80 and for each of the two AEO certifications analysed: AEO Customs simplification and AEO Safety and Security. The model used the supply chain security construct as the exogenous variable and the efficiency one as the exogenous. The model parameters were estimated using the method of maximum likelihood, which is set as default in the software (Joreskog and Sorbom, 1999). Within this stage the values of model fit indices were checked to validate whether the model fits the data and significance was determined by examining the t-Test values at least at $p<0.05$ level.

![Figure 4. Structural Equation Model tested for both the certifications (AEO-C, AEO-S).](image)

3.8. Validity and Reliability

The validity of the questionnaire has been ensured by pre-testing the questionnaire first with academics and thereafter with professional experts. This process enhanced wording, format, comprehension and therefore the overall accuracy of the survey (Groves et al., 2004). The survey was sent to supply chain, risk, quality and security managers of members of the TAPA EMEA association. This ensured that the respondents had the necessary knowledge to answer the questions. Reliability of the survey has been assessed by measuring internal consistency, and by verifying the absence of non-response bias between early and late respondents (Armstrong and Overton, 1977).
4. ANALYSIS

4.1. Descriptive Statistics

The AEO-F certification appears to be the most popular among TAPA EMEA members. Today, many respondents are AEO-F certified (about 26%), followed by the AEO-C (8%) and AEO-S (3%). Finally, about 34% of the respondents are not AEO certified. Among those that are not certified, about 24% is planning to comply with AEO-F in the future while only 3% and 1% respectively with AEO-C and AEO-S. Almost 17% stated that is not going to certify with AEO in the nearest future. Diverse factors may affect the impact of the AEO certification on security and efficiency (Table 3). The factors that affect security are in order the best practices (43%), the procedures related to the specification of security requirements in standard agreements (45%) as well as to the risk auditing and assessment process (41%). Security technologies are indicated by only 14% of the individuals. Finally, 6% of the respondents chose crime expertise and 14% couldn’t answer the question. The factor related to Customs delays as well as the best practices are believed to influence the efficiency of an organization by the most of the respondents (37% each). Other factors that influence performance are security requirements in the standard agreements (35%) and the process to audit and assess risks (31%). The influence on performance of security technologies and crime expertise are pointed out by respectively 10% and 2% of the respondents. Finally, 14% of the respondents couldn’t answer the question (Table 3).

Table 3. Possible impact of AEO and TAPA on security and performance (N=62, NA=Not Applicable).

<table>
<thead>
<tr>
<th>AEO</th>
<th>Security</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best Practices</td>
<td>43%</td>
<td>37%</td>
</tr>
<tr>
<td>Security Technologies</td>
<td>14%</td>
<td>10%</td>
</tr>
<tr>
<td>Risk Auditing and Assessment</td>
<td>41%</td>
<td>31%</td>
</tr>
<tr>
<td>Security Requirements in standard agreements</td>
<td>45%</td>
<td>35%</td>
</tr>
<tr>
<td>Crime Expertise</td>
<td>6%</td>
<td>2%</td>
</tr>
<tr>
<td>Customs Delays</td>
<td>NA</td>
<td>37%</td>
</tr>
<tr>
<td>Don’t Know</td>
<td>14%</td>
<td>14%</td>
</tr>
</tbody>
</table>

Table 4 reports in order the possible impacts on security of the AEO-C and AEO-S certifications as they are measured by the items used in this investigation. The first variable, AEO-C Threat reduction, measuring the overall possible impact of the AEO-C certification on the reduction of security threats, is the only one that is between 1 (Very Bad) and 2 (Bad) (M=1.52, SD=0.68).

Table 4. Possible impact of AEO-C and AEO-S on security (N=62).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Statistic</th>
<th>df</th>
<th>Sig.</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEO-C Threat Reduction</td>
<td>1.52</td>
<td>0.68</td>
<td>0.36</td>
<td>47</td>
<td>0.00</td>
<td>2.83</td>
<td>-0.36</td>
</tr>
<tr>
<td>AEO-C Threat Recovery</td>
<td>2.10</td>
<td>0.75</td>
<td>0.23</td>
<td>47</td>
<td>0.00</td>
<td>2.11</td>
<td>-0.51</td>
</tr>
<tr>
<td>AEO-S Threat Reduction</td>
<td>3.40</td>
<td>0.88</td>
<td>0.26</td>
<td>40</td>
<td>0.00</td>
<td>-2.11</td>
<td>1.24</td>
</tr>
<tr>
<td>AEO-S Threat Recovery</td>
<td>3.28</td>
<td>0.96</td>
<td>0.23</td>
<td>40</td>
<td>0.00</td>
<td>-2.19</td>
<td>0.49</td>
</tr>
</tbody>
</table>
In addition, we may observe that the AEO-S has a stronger impact on threat reduction and recovery, as both the average scores are above 3 and the AEO-C has scores between 1.5 and 2.1 only. By performing the K-S test it was found that all the variables were significantly non-normal \((p<0.01)\). The positive skewness of the distribution of this variable indicates a significant concentration of low scores \((p<0.01)\). Almost all of the remaining variables’ distributions are significantly light tailed (Z-scores of skewness and kurtosis lower than zero, \(p<0.05\)). Hence, it is possible to state that among respondents there has been a general consensus when judging the generic impact on security of the AEO-C as low.

Table 5. AEO-C possible impacts on efficiency \((N=62)\).

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Stat.</th>
<th>df</th>
<th>Sig.</th>
<th>Skewness</th>
<th>Kurtosis</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEO-C Labour Efficiency</td>
<td>2.18</td>
<td>0.80</td>
<td>0.28</td>
<td>46</td>
<td>0.00</td>
<td>-1.02</td>
<td>-1.35</td>
</tr>
<tr>
<td>AEO-C On Time Deliveries</td>
<td>3.56</td>
<td>0.88</td>
<td>0.24</td>
<td>46</td>
<td>0.00</td>
<td>-1.38</td>
<td>0.39</td>
</tr>
<tr>
<td>AEO-C Competitive Advantage</td>
<td>3.92</td>
<td>0.63</td>
<td>0.32</td>
<td>46</td>
<td>0.00</td>
<td>0.19</td>
<td>-0.41</td>
</tr>
<tr>
<td>AEO-C Visibility</td>
<td>3.37</td>
<td>0.93</td>
<td>0.25</td>
<td>46</td>
<td>0.00</td>
<td>-2.40</td>
<td>0.92</td>
</tr>
<tr>
<td>AEO-C-Transport Costs</td>
<td>2.48</td>
<td>0.68</td>
<td>0.37</td>
<td>46</td>
<td>0.00</td>
<td>-2.83</td>
<td>-0.24</td>
</tr>
<tr>
<td>AEO-C Inventory Costs</td>
<td>2.50</td>
<td>0.71</td>
<td>0.37</td>
<td>46</td>
<td>0.00</td>
<td>-3.22</td>
<td>-0.14</td>
</tr>
<tr>
<td>AEO-S-Labour Efficiency</td>
<td>2.83</td>
<td>0.82</td>
<td>0.34</td>
<td>36</td>
<td>0.00</td>
<td>-1.87</td>
<td>0.27</td>
</tr>
<tr>
<td>AEO-S-On Time Deliveries</td>
<td>2.69</td>
<td>0.92</td>
<td>0.23</td>
<td>36</td>
<td>0.00</td>
<td>0.46</td>
<td>-0.25</td>
</tr>
<tr>
<td>AEO-S Competitive Advantage</td>
<td>2.89</td>
<td>1.03</td>
<td>0.20</td>
<td>36</td>
<td>0.00</td>
<td>-0.09</td>
<td>-0.59</td>
</tr>
<tr>
<td>AEO-S Visibility</td>
<td>2.63</td>
<td>0.97</td>
<td>0.20</td>
<td>36</td>
<td>0.00</td>
<td>-0.11</td>
<td>-0.98</td>
</tr>
<tr>
<td>AEO-S-Transport Costs</td>
<td>2.33</td>
<td>0.88</td>
<td>0.24</td>
<td>36</td>
<td>0.00</td>
<td>0.22</td>
<td>-0.67</td>
</tr>
<tr>
<td>AEO-S Inventory Costs</td>
<td>2.18</td>
<td>0.86</td>
<td>0.22</td>
<td>36</td>
<td>0.00</td>
<td>0.12</td>
<td>-0.89</td>
</tr>
</tbody>
</table>

Table 5 report the possible impact on efficiency of the AEO-C and AEO-S certifications. The K-S test for all the variables indicates that the distributions are all significantly non-normal \((p<0.001)\). Generally the impact of the AEO-C on the 6 efficiency items range between 2 \((Bad)\) and 4 \((Good)\). The variable with the highest scores concerns the impact on competitive advantage \((M=3.92, SD=0.62)\), on time deliveries \((M=3.56, SD=0.88)\), and visibility \((M=3.37, SD=0.93)\). The variables that score worst are instead labour efficiency \((M=2.18, SD=0.80)\), risk auditing and assessment \((M=2.26, SD=0.75)\) and best practices \((M=2.31, SD=0.74)\). This gives indication of the administrative burden caused by the AEO-C requirements. This is also noticed by examining the values of the Z-score of skewness and kurtosis of the distributions. The AEO-S impact on efficiency factors are noticeably between 2 \((Bad)\) and 3 \((Neither Bad nor Good)\), hence the impact is lower than the AEO-C. The
variable that scores worst is the impact on inventory costs (M=2.18, SD=0.86), probably because this certification is mainly oriented to the protection of terminals of distribution chains (Table 5). The variable that scores highest is the impact on labour efficiency, even though its mean value is below 3 (M=2.83, SD=0.82).

4.2. Factor Reliability analysis

For each of the AEO certifications we examined the consistency and reliability of the scales for security and efficiency. Thereafter the structural equation models were tested.

**AEO – Customs Simplification.** Confirmatory Factor Analysis (CFA) was run to further establish unidimensionality and construct validity. The values for the fit indices show that the model fits the data sufficiently well (Goodness of Fit [GFI]=0.91, adjusted goodness of fit [AGFI]=0.832, NNFI=0.84, CFI=0.89, root mean square residual [RMSR]=0.05, root mean square error of approximation [RMSEA]=0.06 and $\chi^2$/[NC]=25.7). The Cronbach’s alphas of the two factors and only for the efficiency measure it was found above 0.6 which indicates the acceptability of the reliability of the scale identified with the factor analysis.


<table>
<thead>
<tr>
<th>Measurement Model</th>
<th>AEO-C*</th>
<th>AEO-S**</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item</td>
<td>Std. Coefficient</td>
<td>t-Value</td>
</tr>
<tr>
<td>Security</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact Reduction Security Threats</td>
<td>0.24</td>
<td>1.56</td>
</tr>
<tr>
<td>Impact Capability to Quickly Recover</td>
<td>0.27</td>
<td>1.47</td>
</tr>
<tr>
<td>Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impact Labour Efficiency</td>
<td>0.25</td>
<td>2.41</td>
</tr>
<tr>
<td>Impact On-Time Deliveries</td>
<td>0.31</td>
<td>2.45</td>
</tr>
<tr>
<td>Impact Competitive Advantage</td>
<td>0.34</td>
<td>3.53</td>
</tr>
<tr>
<td>Impact Supply chain Visibility</td>
<td>0.70</td>
<td>5.76</td>
</tr>
<tr>
<td>Impact Transportation Costs</td>
<td>0.23</td>
<td>2.47</td>
</tr>
<tr>
<td>Impact Inventory Costs</td>
<td>0.40</td>
<td>4.26</td>
</tr>
</tbody>
</table>

* Goodness of Fit [GFI]=0.91, adjusted goodness of fit [AGFI]=0.832, NNFI=0.84, CFI=0.89, root mean square residual [RMSR]=0.05, root mean square error of approximation [RMSEA]=0.06 and $\chi^2$/[NC]=25.7

** Goodness of Fit [GFI]=0.80, adjusted goodness of fit [AGFI]=0.61, NNFI=0.79, CFI=0.86, root mean square residual [RMSR]=0.08, root mean square error of approximation [RMSEA]=0.19 and $\chi^2$/[NC]=62.42

To assess discriminant validity we made use of the CFA and in the particular we observed significant differences of the $\chi^2$ values for the fixed and free solutions. This testifies the distinctiveness of the two constructs, p<0.05 (Table 7). In addition, the examination of the confidence intervals that was set to be equal to plus or minus two standard errors of the correlation coefficient of the pair of constructs, don’t include the value of 1.
Table 7. Assessment of discriminant validity (AEO-C and AEO-S).

<table>
<thead>
<tr>
<th>AEO-C</th>
<th>AEO-S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>Efficiency</td>
</tr>
<tr>
<td>Security</td>
<td>-</td>
</tr>
<tr>
<td>Efficiency</td>
<td>0.02-0.90</td>
</tr>
</tbody>
</table>

*χ² differences between the fixed and free solution (significant at p<0.05 [1 df]). Second Row: confidence interval (do not include 1.00).

Table 8. Indirect and Total Effects (AEO-C and AEO-S).

<table>
<thead>
<tr>
<th>Exogenous Variable</th>
<th>AEO-C</th>
<th></th>
<th>Endogenous Variables</th>
<th>Efficiency</th>
<th>Efficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Security</td>
<td>0.00</td>
<td>0.86* (1.44)</td>
<td>Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Indirect</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>Security</td>
<td>0.00</td>
<td>0.27* (1.78)</td>
<td>Efficiency</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Indirect</td>
<td>Total</td>
<td></td>
</tr>
</tbody>
</table>

Note: *t-Values significant at p<0.01. **

AEO-Safety and Security. As for the previous case the analysis shows that the model fit sufficiently well the data (Goodness of Fit [GFI]=0.80, adjusted goodness of fit [AGFI]=0.61, NNFI=0.79, CFI=0.86, root mean square residual [RMSR]=0.08, root mean square error of approximation [RMSEA]=0.19 and χ²[NCF]=62.42) (Table 6). Discriminant validity was also verified by observing significant differences of the χ² values for the fixed and free solutions testify the distinctiveness of the two constructs, p<0.01. Also in this case the confidence intervals do not include the value of 1 (Table 7).

4.3. Hypotheses testing

AEO – Customs Simplification. The hypothesized structural model was tested with LISREL. In particular, given the satisfactory measurements results the summated scores were used to measure the model’s latent constructs. The model parameters were estimated using the method of maximum likelihood. The values for the model fit indices indicate that the model fits the data sufficiently well (Goodness of Fit [GFI]=0.91, adjusted goodness of fit [AGFI]=0.83, NNFI=0.84, CFI=0.89, root mean square residual [RMSR]=0.05, root mean square error of approximation [RMSEA]=0.06 and χ²[NCF]=25.74). t-Tests show that the hypothesized relationship was found to be significant at 0.01 level (Table 8). More specifically, the path from resource allocation to prosecution degree is statistically significant (b=0.86; t=1.44; p<0.01).

AEO-Safety and Security. By following the same procedure described in the previous section, the hypothesis related to the AEO-S certification was tested. Also in this case, we could observe that the model fits the data sufficiently well (Goodness of Fit [GFI]=0.80, adjusted goodness of fit [AGFI]=0.61, NNFI=0.79, CFI=0.86, root mean square residual [RMSR]=0.08, root mean square error of approximation [RMSEA]=0.19 and χ²[NCF]=62.42). The t-Tests values show that the hypothesized relationship was found to be significant at 0.01 level (Table 8). More specifically, the path from resource allocation to prosecution degree is statistically significant (b=0.27; t=1.78; p<0.01).
5. CONCLUSION

This paper has addressed the relationship between security and efficiency in relation to the implementation of the AEO-C and AEO-S certification programs. The relationship between security and efficiency has been discussed by several authors as a positive relationship; higher security may bring higher efficiency. However, the majority of these investigations has a normative approach and lacks empirical data. Hence, the study presented in this paper aims to analyze deeper this relationship with the support of empirical data collected with a survey. In view of the existing studies the overarching hypothesis that the implementation of security benefits efficiency was formulated and split in two sub-hypotheses aiming to test this relationship for the two supply chain security certifications.

Findings unveil that AEO-C may have a negative impact on security and almost neutral effect on efficiency. If compared to AEO-S we discover that AEO-S may provide better security but lower efficiency impacts. The constructs, developed to measure security and efficiency for both the certifications, are demonstrated to be both sufficiently valid and reliable. Finally, both the sub-hypotheses concerning the positive impact of security on efficiency are supported by the data and therefore considered to be tenable.

The contribution of this study is to bring to light a broader array of variables in order to capture the complexity between efficiency and security in logistics operations of two major European supply chain security programs. Hence, efficiency covers many more areas than just customs inspections, i.e. labor efficiency, inventory costs, transportation costs etc. if these factors are considered in addition to the customs simplification then we discover that the enhanced protection of supply chains may positively affect efficiency and duplicate the benefits of the customs simplifications. The practical implication of the findings is that managers, facing the dilemma of choosing security certifications, will have the possibility to enhance their comprehension of AEO-C and AEO-S as well as to acquire clarifications about the impacts of the certifications on security and supply chain efficiency. One interesting finding of this research is that the AEO-C seems to provide less security but still good efficiency advantages; while the AEO-S, beyond the efficiency gains, provides also enhanced protection. Hence, we recommend joining the AEO to take advantage of the benefits addressed in this paper. In addition, managers interested in acquiring support about how to physically protect their assets are recommended to join the AEO-S. The companies that cannot afford the investment in expensive technical systems can merely join the AEO-C.

The limitations of this investigation concern the size of the sample as well as the formulation of the factors to measure efficiency and security. Thus, future research should be addressed to perform the same survey on a larger database of European companies. Another limitation is the limited amount of respondents AEO certified; only 37% (AEO-F 26%, AEO-C 8% and AEO-S 3%). Likewise, the survey does not allow us to see how the AEO-F certification was achieved, i.e. if companies directly applied for it or if they applied in steps (AEO-C then AEO-F or AEO-S then AEO-F). This issue brings a consistent degree of uncertainty in the results as the respondents may have had difficulties in perceiving and discriminating the impacts of the AEO certifications on supply chain efficiency. Finally, more research is required to deeply investigate what factors should be considered to measure security and efficiency of certifications.
REFERENCES


