I+D Revista de Investigaciones
ISSN 2256-1676 / ISSN en línea 2539-519X
Volumen 19 Número 2 julio-diciembre de 2024 pp. 49-62

Identification of the need for a merchandise traceability system in Mexico's customs warehouses[1]

Sistema de rastreabilidad de mercancías en los almacenes aduanales en México

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Article received 1 September 2023; accepted 10 January 2024

Abstract

This research aimed to identify the need for a merchandise traceability system in bonded warehouses in Mexico for seized and abandoned goods. This system would indicate their location in real-time and eliminate missing goods to improve resource management within the bonded warehouse. To gain a detailed understanding of the current situation, a qualitative descriptive research study was conducted as a case study in the customs bonded warehouse of Nuevo Laredo, Tamaulipas. Interviews with personnel were used as the primary instrument, and the information was analyzed using a data matrix. This analysis revealed several issues: an optimal warehouse management system, more electronic systems in warehouse processes, and a technological solution to enable goods traceability. In this context, RFID (Radio Frequency Identification) technology emerges as a promising implementation option.

Keywords: information technology, foreign trade, public administration, monitoring.

Resumen

Esta investigación tuvo como objetivo identificar la necesidad de contar con un sistema de rastreo de mercancías en los almacenes fiscales de México para mercancías incautadas y abandonadas. Este sistema indicaría su ubicación en tiempo real y eliminaría las mercancías perdidas para mejorar la gestión de recursos dentro del almacén fiscal. Para conocer a detalle la situación actual, se realizó una investigación cualitativa descriptiva como estudio de caso en el depósito fiscal de Nuevo Laredo, Tamaulipas. Como instrumento principal se utilizaron entrevistas con el personal y la información se analizó mediante una matriz de datos. Este análisis reveló varias cuestiones: un sistema óptimo de gestión del almacén, más sistemas electrónicos en los procesos del almacén y una solución tecnológica que permita la

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trazabilidad de las mercancías. En este contexto, la tecnología RFID (identificación por radiofrecuencia) se perfila como una opción de aplicación prometedora.

Palabras clave: tecnologías de la información, comercio exterior, administración pública, seguimiento.

Introduction

Under the procedures and controls with which the customs authorities currently operate, the Asset Administration and Disposal Service (SAE) carried out 64 auctions in 2016, from which it obtained approximately 260,000,000 dollars of proceeds from the disposal of furniture (seized and abandoned goods). These proceeds are entered into the fiscal precincts in Mexico (Secretaria de Hacienda y Crédito Publico [SHCP]], 2023).

However, because there are inconsistencies in the amounts of secured goods, they can be modified monthly or eliminated due to duplicity of correction. Therefore, as of June 2018, the Attorney General's Office of the Republic (PGR), now called Attorney General's Office (FGR), through the official letter PGR/UTAG/DG/003707/2018. It requested to treat the information of the secured assets as confidential, that is, that they will not be published. This is under the General Law of Transparency and Access to Public Information (LGTAIP)).

In addition to preliminary research (now research files) by the Public Prosecutor's Office (MP), there is a need for a more efficient control of the process of safekeeping and custody of the goods. Therefore, when the merchandise arrives at the Service of Administration and Disposal of Goods (SAE) or is returned to the exporter or importer, accurate traceability in time, with a technology system in the fiscal or bonded warehouses, is necessary.

In this sense, the main purpose of this article is to identify the need of a traceability system. With the use of technologies for seized or abandoned goods arriving at the Tax Administration Service (SAT) fiscal or bonded warehouses, to have real-time information to eliminate missing goods, through a control of the introduction, extraction, handling, storage or custody.

Currently, there are several technological developments focused on supporting product traceability, according to Moreno et al. (2015) there is a successful traceability by proposing the technology of a barcode, attached to the goods. Likewise, Ramírez and Castro (2014) considered RFID (radio frequency identification) technology, a wireless technology that can be used to identify targets through the communication between the reader and a tag.

Mexico has 49 customs offices authorized to enter and exit goods throughout the country (Servicio de Administración Tributaria [SAT], 2014). Nuevo Laredo, Tamaulipas customs office is the one with the largest crossing of cargo vehicles in the country for both imports and exports. The Administración General de Aduanas (2019), reported that, in the Mexican Republic, the Nuevo Laredo customs had the highest number of operations, in total, 23,565 operations were registered (23.25%). Therefore, this research was carried out in the Nuevo Laredo customs office, which has the highest percentage in import and export operations. The highest flow of goods generates greater complexity in the tracking of the safeguarded inputs, and thus becomes the ideal object of study.

Context of customs in Mexico

The General Customs Administration (AGA) is an entity under the SAT which regulates: systems, methods and procedures to which customs must align, likewise, it is deconcentrated from the Ministry of Finance and Public Credit (SHCP). According to Article 10 of Ley Aduanera (LA, 2018), customs regulates the entry and exit of goods to Mexican territory, whether legal or illegal, with external and internal logistics, to give a specific authorized place.

The Universidad Nacional Autónoma de México (UNAM, 2002) considers the importer as the one who submits a foreign merchandise to tax regulation and control so that it can be freely promoted to the country for consumption or production. The exporter is the one who sends national merchandise for consumption or use to foreign countries, considering that both incoming and outgoing merchandise must be subject to a customs process.

The merchandise that wants to enter or leave the country legally, must be inspected by customs personnel, called: Foreign Trade Officers (OCE). The operation consists of the entry of the merchandise into the fiscal or bonded premises. According to Article 14 of LA (2018) fiscal precincts are places where customs operations perform the handling of foreign trade goods, which include custody, loading and unloading. Castro (2014), mentions that there are two main warehouses, which are defined as follows:

- General bonded warehouse: stores and safeguards a customer's main merchandise.
- Bonded warehouse: facility recognized by the customs authorities, used to store goods according to established conditions and for an unlimited period of time, it also has the same functions as a warehouse.

According to Article 23 of the LA (2018), the goods that are presented to customs, must be registered in an official

document called pedimento. According to Méndez (2015), the pedimento is the format composed of different sections that performs the customs operation. The pedimento demonstrates whether they have paid the contributions to the SAT for entry or exit of foreign trade goods and also checks if they are in a legal way.

The goods that are in a bonded warehouse before customs, will be assigned a customs regime according to their requests of the exporter or importer, sometimes the goods can be abandoned or seized. The Diario Oficial de la Federación (DOF, 2018) establishes that they will cause in favor of the Federal Treasury the goods, in the terms assigned in Article 29 of the LA. So, the abandonment of goods can be in two ways, according to Article 90 of the LA (2018):

a) Expressed, the interested party makes it in writing.

b) Tacit, they are not withdrawn in accordance with the established deadlines:

- Three months: goods for export.

- Three days: explosive goods, perishable goods and live animals.

- Two months: goods that are seized by customs authorities for administrative or judicial processing, and that are not removed from the bonded warehouse.

Table 1 presents the procedure for the abandonment of goods, according to the Customs Operation Manual (MOA) to legally perform and be processed to the Service of Administration and Disposal of Goods (SAE) to give a final destination to the goods (Secretaría de Hacienda y Crédito Público [SHCP], 2021).

Table 1
Abandonment of goods procedure

Step	Activity
1	The merchandise will be registered the following day when it enters customs, to the fiscal or fiscalized precinct.
2	Notify the interested party by certified mail, not exceeding 5 working days.
3	People from CERYS capture information to SICOBI.
4	Notify them with the address of the future, to the owners that they have 15 working days to withdraw them.
5	If they ignore the deadlines mentioned, they become property of the Federal Treasury.
6	The goods are transferred to the Asset Administration and Disposal Service (SAE) to give them a final destination.
7	60 calendar days to go to reception with a delivery request to pick it up.
8	If the merchandise is not removed within 10 working days, customs may destroy or donate it.

Source: Secretaría de Hacienda y Crédito Público (SHCP, 2021).

According to Article 151 of LA (2018), the precautionary seizure shall be:

- When the import or export merchandise is prohibited according to regulations and non-tariff restrictions, or issue payment of compensatory quotas.
- Do not accredit the necessary customs documentation and introduce the undeclared merchandise.
- Exceed by more than 10% of the total value declared in the customs documentation that covers the merchandise.
- Introduction into the fiscal precinct, cargo vehicles with merchandise for import without a customs declaration.
- Name, domicile of the supplier abroad, fiscal domicile of the importer, or company name, is false or non-existent.
- When the value declared in the customs declaration is 50% or more lower than the transaction value of identical merchandise.

Table 2 shows the steps detected by the customs authority in the seizure of goods.

Table 2
Procedure of the precautionary seizure

No.	Process
1	Customs examination
2	Second examination
3	Verification of goods in transport
4	Document review during clearance
5	Verification
6	Customs broker will give a record of the facts to the importer or exporter

Source: (SHCP, 2021).

To provide a solution to the irregularities of the seizure, according to MOA (SHCP, 2021), it calls the Administrative Procedure in Customs Matters (PAMA). This is to provide an absolute resolution of the review of foreign merchandise in Mexican territory or outgoing merchandise with incidents detected by the customs authority.

Abandoned and seized goods, when not removed within the terms established in the customs law and by the importers or exporters, are part of the federal treasury and

are transferred to the Asset Administration and Disposal Service (SAE).

The Secretaría de Hacienda y Crédito Público (SHCP, 2016),mentions that the SAE began its operations on June 17, 2003, and is responsible for allocating assets for the state, to support the Rule of Law, Public Finances, and the Mexican Financial System, with the corresponding responsibility or commitment. Table 3 shows the functions provided by the SAE: disposal, donation, destruction, and assignment of assets, with its different functions, which are regulated by: Federal Law for the Administration and Disposal of Public Sector Assets (LFAEBSP), Regulations of the Federal Law for the Administration and Disposal of Public Sector Assets (RLFAEBSP).

Table 3
Functions of Property Management and Disposal Services

Asset Administration and Disposal Service (SAE)		
Services	**Functions**	**Articule**
Disposal	1. Public bidding 2. Auction (online or in-person) 3. Auction 4. Direct award	Articules 44 to 51 - Articules 41 to 50 Articules 52 to 54 - Articule 51 Articules 55 to 67 and 39 - Articules 53 and 54 Articule 68 - Articule 55
Donation	Federal Public Administration Governments of the Federal Entities and Municipalities. Local public services	Articules 34 and 35 - Articules 56 to 60
Destruction	Goods are unaffordable even for sale	Articules 69 to 75 - Articules 61 and 62
Assignment of goods	SAT asset assignment and donation system	Non-transferable foreign trade goods that become property of the Federal Treasury

Source: Federal Public Administration Accountability Report 2006–2012.

Recovery of abandoned merchandise in favor of the Federal Tax Authorities

According to LA (2018) articles 29, 30 and 32, as legal basis and the General Foreign Trade Rules of 2017: 1.2.2.2.and 2.2.4, as well as its Annexes 10 and 28, the merchandise that has become property of the federal treasury may be imported definitively by those who were its owners, as long as they obtain authorization from the customs office in question. Such authorization will be granted for only one occasion and provided that there is no debt with the bonded warehouse or bonded warehouse. In addition, it must prove compliance with the non-tariff regulations and restrictions, as well as the payment of the contributions, if any, of the corresponding countervailing duties. The interested party (importer or exporter) to withdraw the merchandise from the bonded warehouse, must present the following information and be accompanied by the documentation indicated:

- Description and quantity of the merchandise in accordance with the consigned in the shipping document and presenting a copy of the same.
- Customs office of the fiscal or fiscalized precinct.
- Date on which the merchandise was abandoned, submitting, if applicable, a copy of the official notice by which it was notified by customs.
- Tariff fraction of the merchandise.

They will have a period of one month to remove the goods from the fiscal or bonded premises. In which case the customs office must partially or totally cancel the transfer documents and the goods must be physically located in the fiscal premises. Provided that the interested party submits a declaration under oath stating that the goods are high-risk goods in terms of animal, plant and public health, instead of the definitive importation, the return of the goods may proceed.

Theoretical framework

Zhuangzhuang (2020) considered traceability as the process of product circulation, which is useful for maintaining brand image and improving stakeholder confidence. Hui and Kexin (2023) commented that the traceability system can identify the key indexes of each process and thus can track and manage specific information. Also, the stakeholder knows that their products can be traceable and effectively protect their rights and interests. Tagarakis et al. (2021) stated that traceability is the ability to access information about a

product and its movement, which has become a key to the quality of the goods and their safety.

The implementation of technologies for the timely tracking of goods is supported by a wide variety of definitions of traceability. According to Burganova et al. (2021) current warehouse technology has been able to grow impressively, with an evolution that had not been seen until today. The most impactful proposal is by ISO 9000 (2015), which mentions that traceability is the ability to follow historical data, application, or location of everything that is available to operate.

It is of utmost importance to provide timely tracking of the goods in detail, where the merchandise comes from and its final destination, for the claim by the interested parties. Dopico (2015) indicates that traceability allows tracking a product throughout the production, processing, distribution, and marketing process. Likewise, he refers to the operational part of the value chain, the importance of internal and external logistics, what really matters is to track the customs operational part. And finally, Ramírez and Castro (2014), mentioned that the lack of traceability generates losses, so it is necessary to have a follow-up and control of entry, storage, and distribution. Technology allows control and monitoring to obtain assurance in processes with high variability. According to Lydia & Murugan (2022) a good warehouse can reduce losses if they implement a monitoring system that tracks and controls.

The implementation of traceability within the processes, is a powerful tool to combat crime. It strengthens the customs operation, which prevents the introduction of illicit goods into the country, and thus have the timely tracking of goods from their introduction into the fiscal precincts or warehouses. It is necessary to have a successful planning for the system and to have knowledge of the types of tracking that exist. According to Purwandoko et al. (2023), to have a record of all activities within a warehouse, a traceability system is necessary to verify inputs and outputs, obtaining the collection and analysis of information related to traceability in a database system.

VINSSA (2016) established that traceability is composed of three different traceability processes: the first is upward (backward) to identify the raw material that arrives, the type of supplier, etc.; the second is internal or processes (within the company) and the third is downward (forward) where the distribution is defined in detail, including its destinations.

Singh and Kumar (2021) mentioned that the quality within a warehouse is based on the data information obtained within the warehouse.

The Customs Authority must consider what is applicable to carry out the tracking of goods, within the procedure of abandonment of goods, in accordance with the provisions of the Second Unit, section C, of the Customs Operation Manual (MOA). For its part, the Ley Aduanera de mercancía (LA, 2018), also states in Article 29, Eighth Unit, item B of the MOA, and in "El procedimiento para el tratamiento de bienes de Comercio Exterior, Faltantes, y sobrantes en recintos fiscalizados" (The procedure for the treatment of Foreign Trade goods, shortages, and surpluses in bonded warehouses).

Studies applying traceability

Zhang and Shao (2022) mentioned that technology serves to have real-time control, security, and monitoring of things in warehouses to ensure traceability. Through evolution, technology has proposed several solutions for its traceability challenges and improved the existing ones. According to the studies that have been conducted for traceability, these have been applied in: warehouses, warehouses, customs, distribution center (CEDIS), food companies and exporters. Mbakop et al. (2023) also considered that traceability can trace all aspects, as established in 1987 by ISO 8402, which defined traceability as: “the ability to retrieve the history, use or location of an entity by means of recorded identifications". In addition, it has an economic value in increasing the traceability of the product's origin, as well as allowing consumers to better judge the quality of the product they buy. Table 4 shows a summary of some studies where traceability has been implemented, including the different research methodologies and technological systems employed.

Table 4
State of the art of traceability

Reference	Country	Methods	Technological system	Results
Sales (2016)	Esmeraldas-Ecuador	Cause - Effect Diagram, ABC Analysis, Pareto theory.	Acces	A control method is needed to monitor the goods with traceability.
Marcelo (2014)	Perú	Cost-Benefit Analysis. ABC Classification	WMS- bar code	Easy coordination of information and distribution within the warehouse: decrease shrinkage and inventory levels and coordinate space.

Reference	Country	Methods	Technological system	Results
Herrera et al. (2018)	México	ABC methodology	Master plan	Classify products, handle them properly and eliminate existing inventory.
Núñez (2014)	Bogotá, Colombia	Rational and systematic procedure	RFID - WMS	Reducing costs and improving the flow of information through the application of ICTs
Rodríguez (2016)	Bogotá, Colombia	Process Flow Diagram	Barcode	Improve customer service, reduce error rates and operating cost overruns, obtain real-time information and control of merchandise to help reduce potential operational errors.
Achachagua e Hipólito (2017)	Perú	Pareto analysis - case stu	RFID	Localization and inventory control, achieving a 46.2% reduction in localization time. With operations and logistics cost reduction.
Salazar et al. (2016)	Ecuador	Cause - Effect Diagram	Barcode	Guaranteeing product traceability is an opportunity that generates benefits, favoring international trade.
Ramírez y Castro (2014)	Colombia	Causal analysis. Conceptual model, Linea programming, Delphi model, Genetic algorithms, simulation, Mixed integer linear programming.	Barcode and RFID	Implementation of traceability in the fruit supply chain and its relationship with investment capacity and product quality.
Milić et al. (2017)	Croacia	Business Model	RFID	Efficiency and optimization of the supply chain with management and maintaining a high level of product quality
Moreno et al. (2015)	España	Business Model	RFID and 2D barcode	Guarantee access to medicines, without affecting quality and with adequate protection.
Kubáč (2018)	Praga	Optimization model	RFID - Blockchain	Increase transparency by preventing counterfeiting in the supply chain and achieving customer satisfaction.
Mukhina et al. (2015)	Suecia	Cryptographic methods / Encryption method	Barcode	Improvement in a cross-information evaluation system and internal staff development.
Solanki y Brewster (2014)	Reino Unido	Framework Apache Storm	EPCIS, SPARQL y SPIN	Real-time supply chain traceability from manufacturer to final destination.

Reference	Country	Methods	Technological system	Results
Liukkonen y Tsai (2016)	Reino Unido	Business Model	Auto-ID	Identification of the most common objects for determination in production.
Arévalo (2015)	Guatemala	Deming cicle- SWOF	Electronic cards and personal codes	Continuous improvement in internal procedures.

Technology for traceability

Technology is adaptable to traceability and plays an important role in meeting the need to provide an effective response to stakeholders regarding seized or abandoned goods. Gonzalez et al. (2021) established that traceability is significant to know and identify strengths and weaknesses in this relationship and to know what are the weaknesses of the consumer-customer.

Figure 1

Most commonly used technologies for traceability

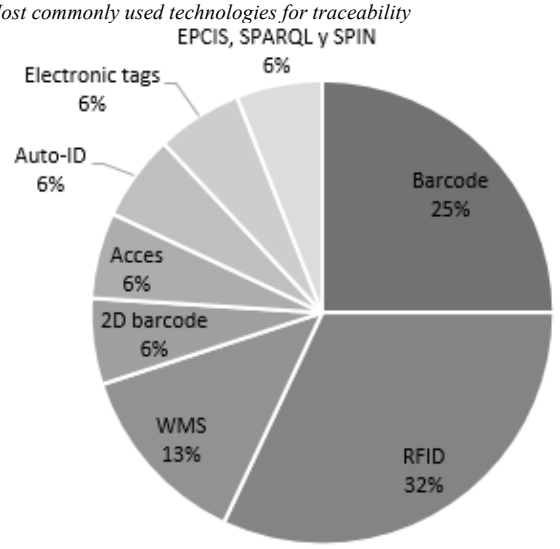

Figure 1 shows that the most frequently applied technology in traceability studies is RFID (Radio Frequency Identification), with 32% of the total number of traceability studies conducted. León-Duarte et al. (2020) mentioned that traceability refers to tracking and tracing products until they reach the interested party at the end. This is to know the location and trajectory, to be able to trace the product quickly, and to reduce labor costs. The authors also proposed 6 types of traceability: product, process, inputs, conditions, genetics, and measurements. In the study by Bargui and Ben-Abdallah (2021), traceability resulted in a set of storage rules for data from the specification of requirements to obtain an up-to-the-minute improvement.

The technology, which follows in second place of use, is bar coding with 25% and WMS (Warehouse Management System), which stands for Warehouse Management System, is in third place, obtaining 13%. According to Tufano et al. (2022) Warehouse Management Systems (WMS) perform the task of tracking storage and picking operations through data tracking. Beyond the simple purpose of traceability and according to Tong et al. (2023), WMS is fundamental in warehouse management. It uses software to perform warehouse check-in/check-out to perform warehouse allocation, inventory, disassembly/assembly review to be able to ensure safety, integrity, and entry.

The three most popular technologies are detailed to show their basic operation and characteristics that influence their use. Likewise, a brief description of its components with advantages and disadvantages is made, achieving information for traceability quickly, accurately, and efficiently. It is a tool of supreme help to control and facilitate the location, optimize inventories to measure the performance of operations, and decrease errors, counterfeit goods, lost, and protection with increased security.

Affia and Aamer (2023) suggest that technologies have facilitated the process within the warehouse. By applying the best and innovative ones, it is possible to have traceability, such as radio frequency (RFID), which is the integrated connection between physical elements (sensors or devices), to have real-time visibility, obtaining the exchange of information, and access to data.

Banerjee et al. (2020) considered that it is important to develop a traceability system within the warehouse, to allow and have the monitoring of the data of their products updated and at a low cost.

Similarly, Singh and Jenamani (2021), mentioned that traceability is based on RFID technology, indicating in real time and generating data. Moreover, it is characterized by the facilities it has such as adapting to different environments, with a powerful tool within the processes of different industries or warehouses, allowing to improve traceability, with accuracy, efficiency, and speed to protect the goods.

Finally, Walaszczyk and Szymonik (2021) recognized that good traceability management is the special stage of a warehouse.

According to Ramirez and Castro (2014), ten important characteristics of RFID tags are presented in Table 5.

Table 5

RFID tag characteristics

No.	Characteristics	Description

1	Storage	Large amount of data storage.
2	Automatic	Automates processes to maintain traceability, reducing human error.
3	Security	Labels (passive) can be hidden on the goods, preventing their visibility in case of theft.
4	Link	Stores data without direct contact with tags.
5	Robustness	Ensures operation in case of adverse conditions (dirt, humidity, temperatures, etc.).
6	Costs	Reduces operating costs.
7	Handling	Ease of removal.
8	Access Read/Write	Rewrite to add and delete information as many times as desired (read/write tag).
9	Identification	Identifies the products.
10	Updating	Information stored in the tag in case it is read/write.

Source: Vázquez (2017).

Zhang and Shao (2022) mentioned that accurate information is now required for traceability and visibility of goods. Today, it is vital for any stakeholder to provide complete and truthful information about the history of each commodity. To know at all times the: What?, When?, Where? And Why? Of any good in the fiscal or bonded warehouse.

Mabeya (2022) established that RFID technology is efficient and effective to locate and manage the flow of goods, from which the current location, status, and history of what will be stored is obtained. This generates better traceability in real time, so it is recommended that human intervention is minimal to avoid errors.

According to Nosenko et al. (2021), controlled technological operations are the key factor to improve the efficiency of the organization and scheduling of production. They consider two technologies: QR coding and RFID technology, with which all merchandise identification can be tracked.

RFID technology applied to traceability (Ramirez and Castro, 2014) leads to safety and quality. Only a few studies have focused their efforts on exploring optimization for traceability procedures, such as transfer times and the steps it has followed until reaching the interested party, or in this case, the SAE.

Garde (2016), identified that barcodes may have certain disadvantages such as the limited amount of data information that can be stored, since they cannot be reprogrammed. According to León and De La Re-Iñiguez (2020), barcode technology is a monitoring system that allows to obtain traceability of products, due to the identification and recording of information. Therefore, it facilitates control and the origin can be identified so that reliable results are obtained with minimal errors. Being mandatory a direct line of sight between the reader and the code, so its application is limited according to the distances, as well as being able to perform readings in a second.

On the other hand, Quisberth (2021) mentioned the possibilities that RFID technology offers, such as the remote reading of the information contained with the help of a tag without the need for physical contact. The ability to perform multiple simultaneous readings (and in some cases, writing)). According to Novelo et al. (2015) RFID technology is the door to a wide set of applications in various areas. To be able to provide traceability solutions, to have greater inventory control in a warehouse for localization and to be able to provide tracking and identification of objects and people, to obtain access control security.

Shahbazi and Byun (2020) considered that the development of technology in areas related to the traceability system is based on low-cost implementation. Georgise and Mindaye (2020) identified that warehouse management relies heavily on manpower, so they recommended improving traceability for distribution with the support of technologies such as RFID cards.

Methodology

Study type

The approach of this research is qualitative of descriptive type, in a case study, since the information obtained is analyzed to describe the phenomena in detail (Cauas, 2015). Thus, the research is non-experimental (Hernández et al., 2014), with a cross-sectional design, with the purpose of describing the variables and analyzing the changes in the variables, such as the procedures of the goods, analyzing the bonded warehouse. That way, it can collect data with the advantages and consequences of the technology for a diagnosis of a traceability system. The study was developed in three phases: interview, analysis of the information and generation of conclusions.

Participants

The Procuraduría General de la República (PGR, 2018) established that the information recorded in the systems used by the General Directorate of Control and Registration of Ministerial Securitization is not provided in a timely or accurate manner. This also applies to the data shared with institutional areas. Therefore, as part of

the data collection process was through an interview and as the information handled in customs is confidential, this limited the number of people interviewed, as well as the type of information requested.

This is why the sample is non-probabilistic (Hernández et al., 2014 citing Creswell, 2013), since non-probabilistic samples are used in qualitative studies. The sample used is by convenience, since the information to which there is access is limited, which is composed of: two Foreign Trade Officers (FTO) representing operational profiles and a department head representing a managerial profile. All participants belong to the Nuevo Laredo, Tamaulipas customs office, so the sample is adaptable and acceptable.

Materials and instruments

The interview was conducted following the methodologies outlined by Ruales (2017) and Sales (2016), as shown in Table 6. The interviews developed by these authors share significant similarities and are more closely aligned with the study variables.

Table 6
Interview

AUTHOR	QUESTIONS	VARIABLE	INTERVIEW TYPE
Sales (2016)	Do you consider that the operations carried out in the bonded warehouses are managed under an optimal warehouse management system? What is it?	Warehouse	**SENIOR MANAGEMENT INTERVIEW**
	Are there defined policies in the warehouses that guide the activities?	Warehouse	
	Are electronic systems used in any of the warehouse processes? Which ones?	Traceability	
	What indicators does management use to measure the efficiency of the bonded warehouse processes?	Warehouse	
	On average, how long do goods remain in a bonded warehouse?	Traceability	**OPERATIONAL STAFF INTERVIEW**
	Are the tools and equipment used in accordance with the operations carried out there?	Warehouse	
	Is the physical space adequate to the needs of the goods (allocation of spaces and areas) and are physical inventories carried out periodically (how long is it done)?	Warehouse	
	Is the inventory of goods coded?	Traceability	
	Briefly explain the processes of the goods within the warehouse / bonded warehouse.	Warehouse	
Ruales (2017)	Is there a technological system in place that allows the traceability of the goods?	Traceability	
	If inventory information is entered manually, where is this information recorded?	Traceability	
	Is there an updated record of the location of the goods?	Traceability	

Procedure

In the second phase of the process, a data matrix was employed to analyze the information obtained from the interviews conducted by Sáenz and Tamez (2014). This matrix identifies the dimensions evaluated and their significance in relation to the objects of study. Following Monje (2011), a table was created with interviewees' responses recorded in the columns, while the themes or categories emerging from the interviews were placed in

the rows. The last column contains a "conclusive summary," which highlights the different opinions of each interviewee.

In the third phase, based on the analysis from the matrix, an opinion, or conclusion is proposed for each subcategory. This aims to identify areas of opportunity for recommending the most effective traceability system for the fiscal precinct.

Results

The interview was conducted with individuals in a complex, sensitive, and confidential environment, making it challenging to obtain information and personnel for the interviews. To encourage openness, interviewees were offered the option to have their responses treated anonymously, which they chose to accept. After collecting the interviews, a tabulation was created to relate the answers and analyze them.

Based on the information gathered, various scenarios regarding the operations of Nuevo Laredo Customs were analyzed. It became evident that the results obtained were quite contradictory, particularly between the responses of the head of the Customs department and those of the foreign trade officers (operational personnel).

This contradictory information reveals a significant divergence in perspectives: the Department Head believes that there is an optimal warehouse management system in place for operations within the bonded warehouse. In contrast, the operational staff contend that there is inadequate control of merchandise and a lack of designated areas for proper storage due to disorganization.

To address this, a discussion is conducted that juxtaposes these conflicting viewpoints with the relevant literature. This analysis begins with the examination of the contradictory information, followed by a discussion of the points on which both parties agree.

Discussion

In the Theoretical Framework, Flamerique (2018) and Ganivet (2017) emphasize the importance of warehouse management, which facilitates the control and proper location of products, indicating how and where goods should be stored. This reduces handling operations and minimizes errors. An effective management system accelerates the processing of goods, reduces turnaround times, and increases satisfaction for stakeholders involved with seized or abandoned goods, thereby improving quality and lowering costs. It is essential to develop an optimal warehouse management system to ensure that all goods are stored according to their nature.

Karimi and Namusonge (2014) note that warehouse management systems (WMS) offer basic storage location functionality. Similarly, Marcelo (2014) highlights the main advantages of WMS, including data efficiency and reliable readability. These systems can be standalone or integrated into an Enterprise Resource Planning (ERP) system and may utilize advanced technologies such as radio frequency identification (RFID).

Regarding performance measurement, the department head mentioned that the administration applies indicators to evaluate the effectiveness of the fiscal precinct's processes. However, the operational personnel indicated that they are unaware of these indicators, underscoring the need for improved training and communication to ensure that workers are informed and engaged. Silva et al. (2015) stress the importance of training, as operational weaknesses can lead to poor performance in internal processes and potential legal issues.

The operatives also reported a lack of understanding of the processes related to goods within the warehouse or bonded warehouse, as their role is limited to handing over seized or abandoned goods to the warehouse manager. In contrast, the department head stated that only registration occurs for goods leaving the premises, with no detailed procedures for managing goods within the bonded warehouse. Therefore, there is a pressing need to enhance the manual of operations (MOA) for managing abandoned goods and seizures to improve overall control. Roca and García (2016) suggest that developing a procedures manual involves establishing control points, management indicators, creating process flowcharts, and identifying policies, roles, and activities. This approach ensures clarity regarding what, how, when, and where tasks should be performed, as well as the necessary resources and requirements.

Both management and operational areas acknowledged the absence of a technological system for tracking goods until they become part of the Sistema de Administración de Enajenación (SAE). The department head indicated that the facility's role is limited to receiving, storing, and delivering goods, stating that tracking is not cost-effective nor within its mandate. However, to deliver requested goods reliably and account for them to the SAE, a technology system for traceability is essential. Núñez (2014) identifies RFID as a promising technological innovation that, when implemented in warehousing, can reduce inventory losses, enhance process efficiency, and improve information accuracy. Although the initial investment for RFID may be higher than that for other technologies, such as barcodes, its coverage range is significantly greater. Achachagua and Hipólito (2017) report that RFID can reduce product location time by 46.2%.

Despite the operatives noting that inventory information is manually recorded in control books and filing cabinets, the department head denies the existence of such manual records and does not clarify how inventory management

is conducted. According to Fan et al. (2014), accurate inventory management can minimize effort, prevent fraud, and resolve discrepancies—outcomes that RFID can help achieve.

The department head asserts that there is an updated record of asset locations, while the operational staff claim there is none. This contradiction is noteworthy, as the department head earlier denied having a manual inventory register and did not specify how inventory management is executed, suggesting a lack of awareness regarding operational processes. It is critical to mention that, although there may be an updated system for tracking goods, its specifics are not disclosed, and the operatives are unaware of its existence, indicating a gap in traceability technology.

In the second part of this article, we discuss the areas of agreement among interviewees. Both management and operational staff concur that policies exist in the warehouses to guide activities. Castro (2014) highlights the need to coordinate all warehouse operations to ensure that merchandise is stored according to its nature and that adequate facilities are in place for proper handling and information systems.

Regarding how long merchandise typically remains in a bonded warehouse, the department head noted that this duration depends on pending procedures. The operational staff corroborated this, stating that items can remain for months or even years, depending on the length of legal processing. Castro (2014) asserts that bonded warehouses can store goods indefinitely.

The department head indicated that the tools and equipment used are contingent on the type of facility, a point the operational staff confirmed due to the variety of equipment available. Castro (2014) recommends coordinating four factors: merchandise, facilities, storage systems, and personnel.

The department head stated that the physical space meets the needs of the goods, including the allocation of specific areas, a sentiment echoed by the operatives. Ganivet (2017) notes that physical warehouse space should be divided into zones to optimize operations, such as reception, storage, picking, verification, and office areas.

Both the management and operational personnel agreed that goods are identified using barcodes, aligning with Rodriguez's (2016) proposal for using barcodes as part of an internal traceability system. Table 7 presents a summary of the issues identified at the inspected sites.

Table 7
Existing problems in bonded warehouses

No.	Problems
1	Lack of optimal warehouse management system
2	Lack of electronic systems in warehouse processes
3	Lack of equipment
4	Lack of a technological system that allows the traceability of goods

Conclusions

After discussing the results of this research for the development of a traceability system in bonded warehouses in Mexico, the analysis of various authors highlights the importance of technologies such as RFID, barcodes, and WMS. Each of these technologies offers advantages in inventory management, primarily by improving the control procedures for the entry, registration, identification, control, and withdrawal of goods. Therefore, in the case of bonded warehouses in Mexico, where there is no technology for the traceability of secured goods, it is crucial to adopt these technologies. Poor management generates losses for the SAT and frustration for owners who cannot recover their merchandise.

The analysis and discussion of the interview results reveal a clear need for asset control, leading to the establishment of the following recommendations.

Recommendations and future work

1.- RFID technology is recommended for the traceability of goods in bonded warehouses from their entry to their exit, to share the information generated by the system. It is a system that does not require direct scanning for its identification.

2.- A quality department is recommended, which can be supervising the real and correct information with the help of the traceability technology, delivered by the operatives.

3.- With the implementation of the technology, there will be a significant elimination of paper records.

It is recommended that bonded warehouses implement an internal exit order for goods that are withdrawn for the SAE or returned to the interested party. A document indicating the detailed information of each good is required to have internal control.

5. It is recommended that personnel be trained to use the goods traceability control system optimally.

Finally, as future work, it is suggested to review the procedures established in the MOA for a better management of seized goods, as well as to create a portal where users can track their merchandise within the bonded warehouses in order to expedite their recovery. Or, if necessary, the SAT can dispose of them

immediately to clear the space occupied within the premises.

Acknowledgments

We appreciate the support of the participants for the information provided.

Conflicts of interest

The authors declare that there is no conflict of interest in this study.

References

Achachagua, Y., & Hipólito, Y. (2017). *Diseño e implementación de un sistema de localización y control de inventarios en un almacén de aduanas, utilizando tecnología RFID*.

Administración General de Aduanas. (2019). *Ventanilla única*. https://ventanillaunica.gob.mx/vucem/cifras.html

Affia, I., & Aamer, A. M. (2023, April). A framework for designing IoT-based smart warehouse infrastructures. In *AIP Conference Proceedings* (Vol. 2646, No. 1). AIP Publishing.

Arévalo, V. M. R. (2015). *Habilitación de la agencia de aduana consultores Rivera como operador económico autorizado para la facilitación del comercio exterior*.

Banerjee, S., Saini, A. K., Nigam, H., & Vijay, V. (2020, January). IoT instrumented food and grain warehouse traceability system for farmers. In *2020 International Conference on Artificial Intelligence and Signal Processing (AISP)* (pp. 1-4). IEEE.

Bargui, F., & Ben-Abdallah, H. (2021). An ontology-based approach for automatic goal requirements engineering in data warehouse design. *International Journal of Information and Decision Sciences, 13*(2), 143-165.

Burganova, N., Grznar, P., Gregor, M., & Mozol, Š. (2021). Optimalisation of internal logistics transport time through warehouse management: Case study. *Transportation Research Procedia, 55*, 553-560.

Castro, G. E. (2014). *Operaciones auxiliares de almacenaje: Organización de los almacenes y análisis de documentación, riesgos, proceso y mantenimiento* (1st ed.). Ideas Propias Editorial.

Cauas, D. (2015). Definición de las variables, enfoque y tipo de investigación. *Biblioteca electrónica de la Universidad Nacional de Colombia, 2*, 1-11.

Creswell, J. W. (2013). Steps in conducting a scholarly mixed methods study.

Diario Oficial de la Federación. (2018). https://dof.gob.mx/nota_detalle.php?codigo=5528958&fecha=25/06/2018

Dopico, D. C. (2015). Implantación de la trazabilidad y su relación con la calidad: Marco conceptual y retos estratégicos. Aplicación al sector pesquero. *Economía Agraria y Recursos Naturales, 15*(1), 79-98.

Fan, T. J., Chang, X. Y., Gu, C. H., Yi, J. J., & Deng, S. (2014). Benefits of RFID technology for reducing inventory shrinkage. *International Journal of Production Economics, 147*, 659-665.

Flamerique, S. (2018). *Gestión de existencias en el almacén*. Marge Books.

Garde, P. P. (2016). Estudio de implantación de sistema de trazabilidad RFID en el proceso productivo de Tasubinsa.

Ganivet, S. J. (2017). *UF0926 - Diseño y organización del almacén*. Elearning.

Georgise, F. B., & Mindaye, A. T. (2020). Technologies for storage & warehouse management of coffee beans in Ethiopia. *TRKU, 62*(9), 5375-5393.

González, F. D. J. G., Covarrubias, I. E. L., & Cruz, J. L. L. (2021). Trazabilidad hacia atrás en la MIPyME de la Ciudad de Aguascalientes, México. *Conciencia Tecnológica, (62)*, 5.

Hernández, R., Fernández, C., & Baptista, P. (2014). *Metodología de la Investigación* (6th ed.). McGraw Hill.

Herrera-García, R. A., Juárez, C. G., Chiw-Gramillo, E. D., & AM, L. C. A. (2018). Implementación de la metodología ABC en un centro de distribución.

Hui, X., & Kexin, Z. (2023). Dynamic evaluation of a post-pandemic agricultural traceability system based on the HFLTS-DEMATEL method. *International Journal of Quality & Reliability Management*, (ahead-of-print).

ISO 9000. (2015). Trazabilidad en calidad. http://gestion-calidad.com/trazabilidad-en-calidad

Karimi, K., & Namusonge, G. S. (2014). Role of information technology on warehouse management in Kenya: A case study of Jomo Kenyatta University of Agriculture and Technology. *International Journal of*

Academic Research in Business and Social Sciences, 4(11), 2222-6990.

Kubáč, L. (2018). RFID technology and blockchain in supply chain.

Ley Aduanera. (2018). *Diario Oficial de la Federación*. http://www.dof.gob.mx/nota_detalle.php?codigo=5389356&fecha=20/04/2015

León-Duarte, J. A., Re-Iñiguez, B. M., & Romero-Dessens, L. F. (2020). Ventajas del uso de sistemas de trazabilidad electrónica en procesos de manufactura. *Información Tecnológica, 31*(1), 237-244.

León-Duarte, J. A., & De La Re-Iñiguez, B. M. (2020). Review of traceability system applications: Case study of the wiring harness industry. *Estudios de Administración, 27*(2), 96-112.

Liukkonen, M., & Tsai, T. N. (2016). Toward decentralized intelligence in manufacturing: Recent trends in automatic identification of things. *The International Journal of Advanced Manufacturing Technology, 87*, 2509-2531.

Lydia, J., Monisha, R., & Murugan, R. (2022). Automated food grain monitoring system for warehouse using IoT. *Measurement: Sensors, 24*, 100472.

Mabeya, F. (2022). Improved warehouse for SMT material management using modern technology retrieval system and better traceability (Doctoral dissertation, Minnesota State University, Mankato).

Marcelo, L. F. (2014). Análisis y propuestas de mejora de sistema de gestión de almacenes de un operador logístico. Pontificia Universidad Catolica del Peru.

Mbakop, L., Jenkins, G. P., Leung, L., & Sertoglu, K. (2023). Traceability, value, and trust in the coffee market: A natural experiment in Ethiopia. *Agriculture, 13*(2), 368.

Méndez, C. R. (2015). *Pedimento Aduanal: Manuel práctico para su elaboración*. Tax Editores Unidos S.A. https://www.tagusbooks.com/leer?isbn=9786074408157&idsource=3001&li=1

Milić, D. C., Martinović, M., & Šimović, V. (2017). Pallet tracking and cost optimization of the flow of goods in logistics operations by serial shipping container code. *World Academy of Science, Engineering and Technology International Journal of Computer and Information Engineering*.

Moreno, A., Angulo, I., Landaluce, H., & Perallos, A. (2015). Easy to deploy solution for pharmaceutical drugs traceability in distribution warehouses. In *IEEE International Conference on Intelligent Transportation Systems (ITSC)*.

Monje, A. C. A. (2011). *Metodología de la investigación cuantitativa y cualitativa: Guía didáctica*. Universidad Sur Colombiana.

Mukhina, M., Chah, K., & Wang, T. (2015). Improving the processes in a warehouse: A case study.

Nosenko, V., Silaev, A., & Grednikov, S. (2021). Information model of the automated system of assembling plant identification and traceability. In *Proceedings of the 6th International Conference on Industrial Engineering (ICIE 2020) Volume II* (pp. 596-605). Springer International Publishing.

Novelo, M. A. C., Kauil, A. D. R. U., & Uc, J. A. Y. (2015). Control y trazabilidad de hatos ganaderos mediante la implementación de sistema web-móvil con tecnología RFID.

Núñez, Q. M. J. (2014). *Gestión de almacenamiento: Vinculación y utilización de los sistemas de almacenamiento en la cadena de abastecimiento*.

Procuraduría General de la República. (2018). Gobierno de México. https://datos.gob.mx/busca/dataset/centro-nacional-de-control-de-bienes-asegurados-cenacba-mensual

Purwandoko, P. B., Seminar, K. B., Litaay, C., Triyono, A., & Mayasti, N. K. I. (2023, April). Analysis and design of internal traceability system for rice processing industry. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1168, No. 1, p. 012050). IOP Publishing.

Quisberth Colque, E. E. (2021). Implementación de un sistema de cobro de productos con tarjetas RFID y lector de código de barras mediante PIC18F2550 para supermercados (Doctoral dissertation).

Ramírez, M. M. H., & Castro, J. A. O. (2014). Perspectiva de trazabilidad en la cadena de suministros de frutas: Un enfoque desde la dinámica de sistemas. *Ingeniería, 19*(2), 63-84.

Roca, A. F., & García, C. M. Q. (2016). Importancia de los manuales de procedimientos para la mejora de los procesos operativos en las agencias de aduanas. *Revista Caribeña de Ciencias Sociales*.

Rodríguez, C. F. E. (2016). Diseño de un sistema de trazabilidad interno para el control de mercancía en un centro de distribución del sector farmacéutico.

Ruales, A. D. M. (2017). Implementación de un sistema de código de barras para mejorar la trazabilidad de los materiales en un warehouse de una empresa de servicios de mantenimiento de turbinas.

Sáenz, L. K., & Tamez, G. G. (2014). Métodos y técnicas cualitativas y cuantitativas aplicables a la investigación en ciencias sociales. Ed. Tirant Humanidades México.

Salazar, G. M. D., Soledispa, V. B. S., & Clark, T. M. (2016). Estrategias de trazabilidad para la exportación de cacao. *Revista Publicando, 3*(8), 375-389.

Sales, R. H. (2016). Gestión de almacén de las mercancías en abandono del SENAE Distrito Esmeraldas (Doctoral dissertation, Ecuador-PUCESE-Maestría en Administración de Empresas mención Planeación).

Servicio de Administración Tributaria. (2014). *Directorio de Aduanas*. http://omawww.sat.gob.mx/contacto/contactenos/Paginas/dir_adu.aspx

Silva, P. P. B., Castro, M. R., & Mendoza, H. M. B. (2015). Modelo de capacitación sobre logística integral de almacenamiento para autoservicios de retail. *Scientia et Technica, 20*(1), 32-41.

Secretaría de Hacienda y Crédito Público. (2016). ¿Qué es y de qué se encarga el SAE? https://www.gob.mx/shcp/articulos/que-es-y-de-que-se-encarga-el-sae?idiom=es

Secretaría de Hacienda y Crédito Público. (2021, December 21). *Manual de operación aduanera - MOA*. https://anam.gob.mx/moa/

Secretaría de Hacienda y Crédito Público. (2023). Comunicado conjunto SHCP - SAE No. 196. https://www.gob.mx/shcp/prensa/comunicado-194-sae-logra-ventas-por-4-5-mil-millones-de-pesos

Shahbazi, Z., & Byun, Y. C. (2020). A procedure for tracing supply chains for perishable food based on blockchain, machine learning, and fuzzy logic. *Electronics, 10*(1), 41.

Singh, T., & Kumar, M. (2021). Empirical study to predict the understandability of requirements schemas of data warehouse using requirements metrics. *International Journal of Intelligent Engineering Informatics, 9*(4), 329-354.

Singh, S. K., & Jenamani, M. (2021). Cassandra-based data repository design for food supply chain traceability. *VINE Journal of Information and Knowledge Management Systems, 51*(2), 193-217.

Solanki, M., & Brewster, C. (2014, November). A knowledge-driven approach towards the validation of externally acquired traceability datasets in supply chain business processes. In *International Conference on Knowledge Engineering and Knowledge Management* (pp. 503-518). Springer International Publishing.

Tagarakis, A. C., Benos, L., Kateris, D., Tsotsolas, N., & Bochtis, D. (2021). Bridging the gaps in traceability systems for fresh produce supply chains: Overview and development of an integrated IoT-based system. *Applied Sciences, 11*(16), 7596.

Tong, Q., Ming, X., & Zhang, X. (2023). Construction of sustainable digital factory for automated warehouse based on integration of ERP and WMS. *Sustainability, 15*(2), 1022.

Tufano, A., Accorsi, R., & Manzini, R. (2022). A machine learning approach for predictive warehouse design. *The International Journal of Advanced Manufacturing Technology, 119*(3-4), 2369-2392.

Universidad Nacional Autónoma de México. (2002). *Importación y exportación de México*. Instituto de Investigación Jurídica. https://archivos.juridicas.unam.mx/www/bjv/libros/6/2951/10.pdf

VINSSA. (2016). Rastreabilidad o trazabilidad de la industria. https://vinssa.com/news/rastreabilidad-o-trazabilidad-de-la-industria134117

Vázquez Mouzo, J. (2017). Control automático de temperatura para cadena de frío mediante tecnología RFID.

Walaszczyk, A., & Szymonik, A. (2021). Model of food traceability process in the context of warehouse management. In Galińska, B. (Ed.), *Wieloaspektowość współczesnej logistyki – transport, miasto, konsumenci* (pp. 1-12). Wydawnictwo Politechniki Łódzkiej. doi:10.34658/9788366741218

Zhang, X., & Shao, P. (2022). Logistics information traceability mechanism of fresh e-commerce based on image recognition technology. *Applied Bionics and Biomechanics, 2022*.

Zhuangzhuang, L. (2020). Study on the construction of traceability system of cold-chain agricultural products

based on blockchain: A case study of Ningxia cabbage. In *2020 International Conference on Big Data & Artificial Intelligence & Software Engineering (ICBASE)* (pp. 270-274). IEEE.