

# Information Exchange in Global Logistics Chains: an application for Model-based Auditing

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**Abstract.** An integrated data pipeline has been proposed to meet requirements for visibility, supervision and control in global supply chains. How can data integration be used for risk assessment, monitoring and control in global supply chains? We argue that concepts from model-based auditing can be used to model the ‘ideal’ flow of money and goods, and by identifying deficiencies, to determine possible risks concerning safety and regulatory compliance. In particular, we propose to use the ‘value-cycle model’ for describing economic transactions, and connect the expected economic status transitions to the physical flow of goods. The model will be illustrated by a case study of the trade lane of a retail organization trading between China and United Kingdom.

**Keywords:** global logistics, supply chain visibility, computational auditing

## 1 Introduction

International trade is an important pillar for our global economy. Trade is as old as the world itself. The international trade system, with a legal structure encased in international conventions, is centuries old. Complex networks have since developed, based on extensive specialization in representation, fronting and performing activities on behalf of others. This has streamlined trade, but also creates a lack of transparency. The complex system for international trade, logistics and transport has come under scrutiny after 9/11, when additional informational requirements were imposed: ISPS, CTPAT, CSI, and later, in Europe, AEO and the ECS/ICS European advanced manifest rule. Much of these regulations have made international trade more complicated and have added costs to the international supply chain [1].

Trade facilitation in relation to international logistics is beginning to gain attention. Recently, the World Bank has initiated the Trade Facilitation and Logistics initiative<sup>1</sup>. Many practical initiatives are labeled under the heading e-freight: initiatives to enhance visibility, digitize documentation, automate declaration processes, and so on. Consider, for example, projects such as Discwise, e-freight, Euridice, Smart\_CM, INTEGRITY, I-Cargo and COMCIS. These projects should lead to a new

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<sup>1</sup> See <http://web.worldbank.org/>

standardized system for electronic communication in international transportation of goods, which should eventually proliferate in the common software used in international trade: ERP systems, warehouse management systems, transport management systems and customs declaration systems.

At the same time, also regulatory innovations are only cautiously explored. Consider initiatives such as system-based control, coordinated border management, standardization in government data exchange, and the development of a ‘single window’ for all administrative activities related to the crossing of borders [2].

Many risks can be reduced to a lack of transparency in parts of the supply chain. As Hesketh and Heijmann have argued [3], questions such as “Is this your luggage? Did you pack this yourself? Do you know what it contains? Did the shipment leave your sight?”, which are common in air traffic, often remain unanswered in container trade. One explanation may be the drive for efficiency resulting in large volumes, which lead to advantages of scale. At the same time, this drive for efficiency also leads to a lack of transparency and a loss of control at the container level.

A potential solution could be a standardized information exchange for international trade, logistics and transport: *data pipeline* (van Stijn et al. 2011). Such developments are explored in EU funded projects such as CASSANDRA. A central question in these projects is: could customs officials use this trade data for system-based control. How could that reduce risks? That leads to the following research question:

How can trade data, collected along the supply chain, be used to enhance regulatory compliance and control?

Data visibility offers opportunities for real-time monitoring of risks. However, what constitutes a risk? At what level of detail should we analyze a supply chain? These questions can only be solved by a theoretical approach for the analysis of the flow of goods, that explores the relationship with the data taken from commercial trade documents.

In this paper we will therefore explore the usefulness of concepts from model-based auditing [5, 6] for improving regulatory compliance and control over the supply chain. Model-based auditing uses a normative meta-model of the movement of money and goods, as is customary in the Dutch owner-ordered audit tradition [7]. We refer to Blokdijsk et al [8] for an exposition in English.

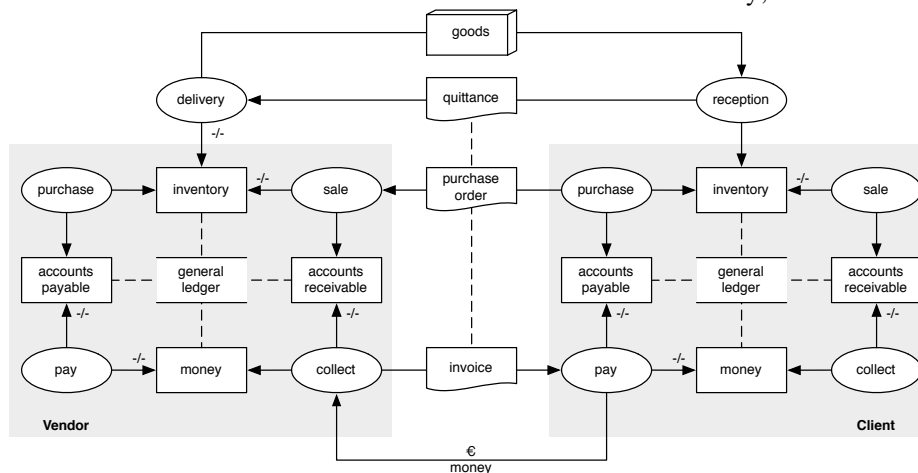
Adequacy and usefulness of the approach is illustrated through a case study of a trade lane for a retail company in the United Kingdom, that sources much of its products from China .

The remainder of the paper is organized as follows. In Section 2 we explain the basics of model-based auditing. Section 3 explains the use of quittance and seals. In Section 4 we present the case study. The paper concludes with recommendations.

## **2 Model-based Auditing**

Business reality can be modeled as a value cycle: an interrelated system of flows of money and goods [7]. The value cycle of a trading company for example contains two types of transactions: purchasing and selling goods. The flow of money exactly mirrors the flow of goods, albeit in reverse. Figure 1 shows an example of the value

cycle for two trading companies, connected by trade documents (quittance, invoice, purchase order). We use the following notation. Decisions (authorizations) are shown as a round shape: an event or change of state. Rectangles are the recordings of a state of a certain value to the company, such as inventory or accounts payable. Records of states, i.e. accounts, are related through *reconciliation relationships*, indicated by dashed lines, which come together in the general ledger. The direction of the arrow indicates the influence of events. The sign ‘-/-’ indicates decrement of the corresponding account. Thus, a purchase leads to an increment of the accounts payable, while the purchased goods are added to the inventory. A sale leads to an increment of the accounts receivable and a decrement of the inventory, etc.



**Fig. 1.** Value cycle models of two trading companies, linked by trade documents.

Depending on the type of business, the relationship between the flow of money and the flow of goods is stronger or weaker. For manufacturing, the relationship is strong, because the resources needed to manufacture a product can be counted. In the services industry the relationship is much weaker. The stronger the relationship, the more the auditor can rely on expected proportions. In particular, to measure the completeness of revenue, the auditor can verify revenue against the number of goods sold and the sales price. This is an example of reconciliation. When there is a weak relationship, additional procedural controls are needed to ensure reliable reporting. A well-known way to strengthen the relationship is to introduce quasi-goods, such as numbered tickets or tokens, of which flow can be fully controlled. Starreveld [7] developed a typology based on the type of business, to determine the expected internal controls.

The relationship between flows of money and goods can be expressed in two ‘laws’. The first law is concerned with *transformation*. It is called the law of the rational relationship between sacrificed and acquired goods, and states that, for all events  $e$  that affect states or accounts  $S, T$  according to arrows in Fig 1,  $S \rightarrow (e) \rightarrow T$ , we have:

$$(1) \text{input}(T, e) = f \cdot \text{output}(S, e), \text{ for some normative ratio } f.$$

For example, if we look at a sales event, we have: *increase in accounts receivable = sales price • decrease in inventory*. Similarly, if we look at a purchase event, we get: *increase in inventory = increase in accounts payable \* purchase price*. Note that the difference between sales price and purchase price explains that profit is being made.

The second law is about *preservation*. For all states  $S$ , the value at the end of a period should equal the value at the beginning, with increments added and decrements subtracted. Also losses are accounted for. We assume norms for expected losses.

$$(2) S[t_1] = S[t_0] + \text{input}(S, [t_0, t_1]) - \text{output}(S, [t_0, t_1]) - \text{losses}(S, [t_0, t_1])$$

Note that some accounts are counted in monetary value, while others, like inventory, are counted in other units: kilos, hours, boxes, or containers. A special instance of the first law therefore deals with *conversion* or *aggregation*. Paul Griffioen (p.c.) argues how important units are in expressing accounting equations.

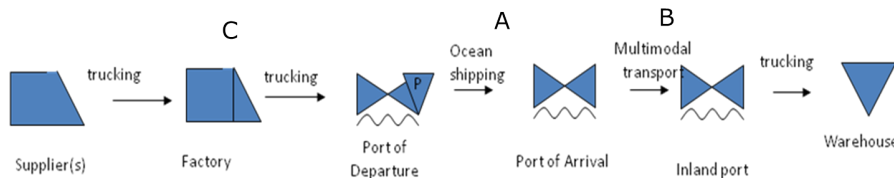
$$(1') T \text{ in unit } u = f \cdot T \text{ in unit } v, \text{ for } f \text{ a normative conversion ratio.}$$

For example, suppose that we are looking at shipments of shoes. Because of the size of a shoebox and the way shoes are stacked on pallets, suppose that on average a 20-foot container will contain 5600 pairs of shoes. So we get *Shoes* in unit *20-ft-container-load* = 5600 • *Shoes* in unit *pair*.

The general idea of model based auditing is to use such reconciliation relations to define a normative meta model of the flow of money and goods (Soll), and use it to verify actual audit samples against (Ist), if needed, continuously [9]. Deficiencies can be either exceptions or violations, and will therefore have to be explained.

**How to apply the value cycle in international trade?** The value cycle model uses variables related to the commercial transaction (inventory, purchase, sales, credit and debt). This ignores a further detailing of the cost components related to international transportation: duties, logistics costs, inventory costs, insurance, supply chain finance, etc. In practice, for each of these additional services, a transaction is established. This leads to a ‘web of transactions’, with reconciliation links that can be used for auditing. The value of the goods will appear in the purchase order and in the insurance.

Moreover, the value cycle model itself does not specify any physical relationship between resources and finished product. For each application domain, these ‘laws’ have to be found and tested in practice. Now clearly, if this value cycle approach is to be applied to international trade lanes, the set of financial equations needs to be extended with physical goods equations.



**Fig. 2.** International supply chain with status transitions.

To this end, we need a simplified model of the international supply chain. Such a model is given in Figure 2. We will now discuss the various trade documents that are

traditionally used to transfer information about economic status transitions (e.g. transfer of custody over goods; transfer of ownership rights).

Originally, in the Europe Union, the customs office is informed about the nature of the goods arriving in a European port, when the goods are at point A. This is achieved by the summary declaration filed by the ocean carrier to customs at a European port. The carrier files this declaration based on the ship manifest. Given the nature of the ship manifest, and its source data, the carrier bill of lading or sea waybill, the data in the manifest cannot be very detailed. In particular, the description of the goods is a free text field. As a result, this information is considered insufficient for risk analysis purposes<sup>2</sup>. In fact, it may be undesirable to some stakeholders that the carrier would have more detailed information about the goods. Detailed information may increase the risk of theft; moreover, when the carrier knows the value of the goods, he must insure the goods against that value. Under the current 'ignorant' practice, insurance can remain much cheaper because the carriers' liability is limited.

With the development of the ICS/ESC regulation<sup>3</sup>, customs are informed earlier, but this information is considered even less reliable, because it is essentially based on the same data, but needs to be provided earlier in the process when the exact content of the container may not even be determined yet. In most cases, accurate information follows only when a full import declaration is lodged, at point B. At this point, the goods may have already entered European territory under a transit arrangement. What would be preferable is to have insight in the information about the goods at point C in Figure 2. This is the moment the goods are stuffed in the container, and at this point an accurate description and count of the goods should be available, through the packing list, advanced shipment notification or purchase order. So ideally, the legal obligation to file the summary declaration should be transferred forward in the supply chain. However, customs do not have jurisdiction over parties outside of their territory.

What we will do here instead is to use commercially available documents and reconstruct a reliable record of the goods, based on the value-cycle approach.

**Reconciliation Relations.** Based on the value cycle approach discussed in the previous section, a large number of type-(2) preservation equations can be derived. To start with, we can formulate the preservation of the value of the cargo as reported:

$$(3) \text{ value at export} = \text{value at import.}$$

The equation can be verified by comparing the value declared to customs at export (as recorded in the commercial invoice) with the value declared to customs at import.

In addition, there are many physical preservation equations. A basic preservation equation, expressed in total volume, is:

$$(4) \text{ goods underway} = \text{goods ordered} - \text{goods delivered} - \text{goods ready for shipment} - \text{goods in manufacturing.}$$

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<sup>2</sup> See for instance extensive exchange of opinions around the Importer Security Filing and Additional Carrier Requirements (the so-called 10+2) in the US in 2008-2009, and the discussion about the quality of data of the MSC Napoli after grounding on UK shore in 2007.

<sup>3</sup> See for instance the Title VI of the Community Customs Code implementation provisions, (EEC) 2454/93

The same variable can be expressed as:

$$(5) \text{ goods underway} = \text{goods in pre-carriage} + \text{goods in terminal at origin} \\ + \text{goods at sea} + \text{goods in terminal at destination} + \text{goods in on-carriage}.$$

For each component, one can write:

- (6) goods in pre-carriage = goods arrived at terminal of origin – goods ready for shipment
- (7) goods in terminal at origin = goods in pre-carriage – goods at sea
- (8) goods at sea = total goods underway – goods at terminal in origin – goods at terminal at destination – goods in pre-carriage – goods in on-carriage
- (9) goods in terminal at destination = goods at sea – goods in on-carriage
- (10) goods in on-carriage = goods delivered – goods arrived at terminal at destination

Based on further information, other equations can be developed. The expected sailing time can for example be used to project expectations:

$$(11) \text{ goods arrived at terminal at destination } (t) = \text{goods arrived at terminal at} \\ \text{origin } (t - \text{sailing time}) - \text{goods rejected for loading } (t - \text{sailing time}).$$

Similarly, equations for pre- and on-carriage can be developed.

All these equations should clearly indicate the types of goods and the corresponding unit they are expressed in. This may result in a lot of equations, but it will help identify mismatches between cargo descriptions and actual goods movements. Furthermore, the equations can be expressed in terms of currency, individual items, unit loads (boxes, containers) or weight (tons). Griffioen (p.c.) has shown that it is crucial that such preservation equations be given a proper unit, which may in fact be a composite unit, as in the case of a recipe for a manufacturing process, or a packing list.

Note that the easiest way to fill all these equations with data is with data at the container level. The purpose of this paper, however, is to collect consignment level data (i.e. data on what is *in* the container). For this we also need to derive some type-(1) equations, that will link information on containers with information on cargo items. These equations capture aspects like packing and assembly, and unpacking and disassembly. These equations will change the basic unit for expressing and identifying goods: article; box; container; ship, etc.

For full container loads, which contain only one product in similar boxes, this is:

$$(12) \text{ Total cargo weight of the container} = \text{box count} \cdot \text{weight per box}$$

$$(13) \text{ Total number of items in the container} = \text{box count} \cdot \text{number of items per box}.$$

Equation (12) contains variables that can be independently verified: the weight of the container can be measured in the container terminal at origin or destination through weighing, and the box count can be derived from an independent tally at stuffing or stripping of the container, or from the stuffing/stripping company's invoice. Often, such companies are paid based on the number of boxes being handled, so the invoice provides a reliable independent source of evidence. The weight of the box as well as the box count are recorded on the packing list or container manifest.

With the help of these normative equations, deviations in the actual flows can be identified. Depending on the quality of the underlying information system, these deviations can point at more or less serious risks in the flow of goods. This will be further enhanced through the use of process mining [10], or even transaction or event mining [11] where the information exchange between the various levels of the logistic chain (see Figure 2) is used to impute values in the variables in the sets of equations. By mining transactions, different recordings of, for instance, weight or item numbers, for the same shipment will emerge. These differences can indicate that things went wrong during shipment. Until now, data for computational monitoring was mostly taken from the document and transaction trail, i.e. at the economic transaction level. However, data is available in the supply chain about the actual flow of goods and containers, captured by technology, such as scanners, readers and cameras. Readers at container terminals provide accurate real time information of containers arriving at or leaving the terminal. Tags on the container provide real time location information, which enable the identification, for each container, of which stage in the chain it is in. Tallying boxes during stuffing and stripping will provide an accurate and independent box count of items for each individual container. The challenge is to link these two data streams, and reconcile the unit of trade and the unit of transport.

### 3 Quittance and Seals

How can we reconcile the unit of trade and the unit of transport? And how can we link these abstract value exchanges to actual transactions on the ground? To do so, we focus on the specific activities within a logistics process, delivery and reception.

Essentially, a supply chain is a series of inventories. Links in the chain may have several functions, such as transport, assembly or distribution, but all links have an inventory function too. Crucial is that the goods are usually not owned by those who transport and store them. The goods are kept in custody. At various points in the supply chain, partners will transfer custody over the goods, aided by trade documents.

People are made responsible and personally accountable for the goods, because of the role they play in the supply chain. This may be connected to payment. Without evidence of a service being executed, it will not be paid. Therefore, we often find that parties exchanging goods and trade documents have *countervailing interests*. These strengthen the evidence being produced. For example, in equation (3) parties have an interest in reporting a high export value, in the commercial invoice to get paid, but a low import value, because otherwise they will have to pay large import duties.

We focus on the notion of quittance, as used in accounting [7] and seals, as used in trade for centuries. See [6] for an initial analysis. Consider the activities of delivering and receiving goods at a warehouse. The pre- and post-conditions are presented in Table 1 and 2. The analysis connects the update of an inventory, i.e. an equation of type (1), with conditions on the activity that constitutes the update. We expect that such an analysis can always be made for a transfer of custody.

The truck driver (deliverer) demands a quittance or receipt in return for discharging the goods; otherwise, she may be held accountable for unexplained losses. The warehouse master (receiver) is only willing to receive the goods and provide a quittance, provided that he or she has evidence that the quality and quantity of the

goods are as agreed. When the goods are packed in a box or container, they cannot be inspected. In that case, a seal on the packaging can be used as additional evidence that the goods were not tampered with since being packed. Combined with other information, e.g., matching weights, a tally, or a packing list that is undeniably linked to the box (by glue or an identification number), a seal may provide enough evidence.

**Table 1.** Pre- and postconditions of a delivery activity.

Activity	<b>Delivery of goods</b>
Primary actor	Truck driver (deliverer)
Secondary actor	Warehouse master (receiver)
Precondition	Truck load $[t_0]$ , including the goods Delivery agreement: quantity and quality of goods to be delivered by whom at what time? Quittance: declaration by warehouse master that quantity and quality of goods were delivered at time $t_1$
Postcondition	Truck load $[t_1] = \text{Truck load } [t_0] - \text{Goods}$

**Table 2.** Pre- and postconditions of a reception activity.

Activity	<b>Reception of goods</b>
Primary actor	Warehouse master (receiver)
Secondary actor	Truck driver (deliverer)
Precondition	Inventory $[t_0]$ Delivery agreement: quantity and quality of goods to be delivered by whom at what time? Some means to inspect quality and quantity of the goods and link the actual delivery to the delivery agreement.
Postcondition	Quittance. declaration by warehouse master that quantity and quality of goods were delivered at time $t_1$ Inventory $[t_1] = \text{Inventory } [t_0] + \text{Goods}$

## 4 Case Study

In this case study, we want to validate the proposed application of model-based auditing ideas to improve regulatory compliance and control in the international supply chain. In particular, we need to (i) identify transaction equations, preservation equations, and aggregation equations, and demonstrate that these are adequate (they do express the essence of that supply chain) and sufficient (no other equations are needed) for monitoring risks, in particular risks that have to do regulatory compliance and control. Here these risks are about traceability of container movement: who packed the container, what does it contain and who is responsible?

Moreover, we need to (ii) identify data elements, derived from existing trade documents, that provide sufficient evidence for making the reconciliations above. Crucial is that it is not necessary to control the whole of the supply chain, as long as we have data at specific points in the chain, to reconstruct the physical flow of goods.



**Data Collection.** Data for this case study was collected during a field trip to Yantian, China, by Inge Lucassen (TNO) and other members of the CASSANDRA project. Use of the data is gratefully acknowledged.

**Data Description.** The case study concerns a specific trade lane between China and the United Kingdom set up by a number of cooperating freight forwarding companies, for the benefit of a British retail company, here called ABC. The freight forwarding companies involved are a forwarder based in Hong Kong, a forwarder based in the UK and a container handling company in the port of Felixstowe in the UK. The two freight forwarders have recently merged, and are now one company. The container handling company remains separate, and its role is to bring containers from the container terminal and unpack the containers for storage in a warehouse in the port area. From there, the forwarder brings the goods to the distribution warehouses of ABC. About 80% of ABC's shipments go through the freight forwarder's warehouses in Yantian and Hong Kong, where the containers are stuffed by the freight forwarder. This is because there can be more control on the shipment and loading of the goods and to maintain ABC quality standards. Some full container load (FCL) shipments are still sent directly but it is expected that ABC will move to 100% warehouse shipping to have better control on the shipment quality. This means that all shipments are delivered to the freight forwarder's warehouse location in China and Hong Kong, even when this is an FCL shipment, and that the freight forwarder consolidates according to ABC's wishes. This means that it is also possible to create mixed shipments from different suppliers that are destined for a specific UK region, distribution center or store. This will simplify logistics in the UK.

Figure 3 shows a simplified diagram of the application landscape for controlling the trade lane. In principle, there is enough trade data available to trace containers, provided that parties are willing to share.

Crucial is the *purchase order* (PO), issued to both shipper, who collect the goods at various factories in the Yantian hinterland, and freight forwarder. The purchase order is the main document at the economic transaction layer. As we already observed in the introduction, often the unit of trade does not equal the unit of transport and that is particularly the case here. In fact, the PO may be shipped in a number of different shipments over a longer period of time, depending on manufacturing capacity or expected sales volumes. The forwarder therefore makes use of a *shipping order* (S/O), which is used by manufacturers to describe individual shipments and to announce the readiness for transport. Part of the job of the freight forwarder is to track of how much of a PO has already been shipped, and how much still needs to be done. This is one of the functions of the PO registration system used by the forwarder to track delivery.

$$(14) \text{ goods on PO} = \text{ goods on S/Os shipped } [t] + \text{ goods on S/Os outstanding } [t]$$

The document that describes the content of the container is called the *container manifest*. This is a document that has individual lines per type of good, containing the description of the good, the number of boxes, and the weight of a box. Based on this information, the total weight of the content of the container can be calculated. The container manifests need to match with the shipment order.

$$(15) \sum_i \text{ goods on container manifest } [i] = \sum_j \text{ goods on S/Os shipped } [j]$$

The next document is the *carrier booking*, containing details of the ship, the sailing times, destination, expected time of arrival in the UK port, etc. One shipping order may consist of several containers. However, one carrier booking may also contain containers from various shipping orders. Unfortunately, there are no trade documents at the individual container level.

$$(16) \quad \begin{aligned} & \Sigma_i \text{ goods on S/Os shipped for vessel } k[j] \\ & = \Sigma_i \text{ goods on carrier booking for vessel } k[i] \end{aligned}$$

In principle, the goods information provided to the carrier is also used for the Entry Summary Declaration lodged by the carrier, and, after the verifications as described in (14) to (16), should contain an accurate description of the goods. Given the way carriers actually record and represent the data (free text for goods description), this data is likely to be less informative than the original trade documentation.

In the period before the freight forwarder was in control of the container stuffing for ABC, manufacturers would ship goods in containers directly to the port, and the freight forwarder was informed with the container manifest to complete the carrier booking. In this situation, the match between the PO and the S/O and the actual goods shipped could not be made. As a result, the type and amount of goods that would be found in the container upon arrival in the UK was sometimes a complete surprise.

The solution was to introduce essentially an additional quittance and delivery into the chain at the port of Felixstowe, where the container handling company, who was charging ABC for its stripping activities by the box anyway, would also record product type, and make accurate entries in ABC's inventory management system directly. As a result, ABC achieved two things: (i) its inventory registration would be accurate, and (ii) it had information to discipline its suppliers for not shipping according to the PO, and withhold payment for goods not shipped.

To reinforce the last point, and to circumvent the problem that S/Os would not always directly match POs, the freight forwarders introduced the PO registration system, and ABC required all suppliers to paste the container manifest on the inside of the container door. This quittance matching process is represented as:

$$(17) \quad \begin{aligned} & \text{box count on container manifest (stuffing)} \\ & = \text{tally by container handler (unloading)} \end{aligned}$$

This quittance process and the financial penalty have been quite effective in ensuring that there is a tractable relationship between the PO, the S/O and the actual goods shipped. This has a financial impact, a logistics operations impact, but also an impact on the type of innovative logistics services that the freight forwarder and the container handling company are able to offer ABC. As a result of the greater degree of control, they are much more flexible in controlling the mix of goods in the container for different purposes, which enables them to differentiate different logistics services: from high volume shipments for sales actions to consolidate containers at individual shop level at origin. As a result of this opportunity for logistics innovation, there was an interest of ABC and its service providers to gain even more control over the process of stuffing the containers. This has led to the development to consolidate more of the goods flow at the freight forwarder's warehouses in China and Hong Kong. As part of this process, the freight forwarder itself now consolidates S/Os of individual suppliers into container manifests (see (15)). This provides the opportunity

to introduce a new quittance and delivery in the chain since the freight forwarder has introduced a tally process at origin:

(18) box count container manifest (stuffing) = tally by freight forwarder (stuffing)

Additionally, as part of the standard operating procedure for loading at the freight forwarder's warehouse, photographs are taken of the container before, during and after loading. These photographs are used for damage claims, but may also be used for additional security verification.

The tally is now made twice, which seems redundant. However, the tally in (18) is made by the freight forwarder, while the tally in (17) is made by a separate company and the countervailing interest is higher. As a result, the parties involved have been rightfully reluctant to replace the one tally by the other altogether.

The choice of the consolidation facility has introduced another quittance in the chain. The freight forwarder performs its container loading operations in China in a so-called customs supervised warehouse. This means that the warehouse has a customs office where goods are received, verified, and declared for export by an independent customs brokerage. This is part of the facilitation of the warehouse. The customs broker verifies the supplier (the driver knows who this is, because this is where he picked up the goods, and it is the party that hired him), checks the goods by sampling (the incoming driver has to present a sample of the goods in an open box upon arrival), and produces a quittance for the driver. With this quittance, the driver is then allowed to drive to the loading bay of the freight forwarder, and presents the quittance as proof of delivery. The quittance also ensures the freight forwarder that the goods are properly declared to customs for export, and it ensures the supplier that the goods were properly declared.

(19) Supplier identity, box count and product description upon arrival, by independent customs broker = goods and description on S/O for supplier *i*.

The question finally is what data could be used to better inform customs about the shipped goods in the container. This is best illustrated by focusing on data elements. Essentially, customs want to know: (1) the original shipper of the goods (i.e. the manufacturer), (2) the goods description, (3) the amount of boxes, and (4) for tax purposes, the value. The goods description and the amount of boxes follow from the container manifest, which, through equations (14), (15) and (16) can be related to the purchase order, and which are independently verified by (17) and (18). This does not provide information about the original shipper, and the value. This information is, in principle, available from the purchase order. So it is the combination of container manifest and purchase order that is required.

In the retail industry, commercial considerations often prevent the accurate recording of the exact manufacturer. On much of the documentation (PO, S/O, carrier booking) the shipper is either a commercial representative or trading company of the freight forwarder that acts as consignor. For customs this is problematic, since the original shipper is an important element in risk analysis. Not reporting this party is one thing, but actively concealing the identity of the shipper, albeit for commercial reasons, is quite another matter.

In the ABC case, however, the chain of quittance and delivery processes offers a solution. Given that the customs broker verifies the supplier, the goods description,

and the box count (19), the freight forwarder verifies the link between the S/O and the container manifest (18), and IT systems provide the link between the container manifest and the PO, customs should have relevant information on goods, and the assurance that the supplier is properly identified (but not recorded), by a representative of the customs authority at origin. The only piece of information missing is insight in the way ABC selects its suppliers, and verifies integrity, and reliability of these suppliers.

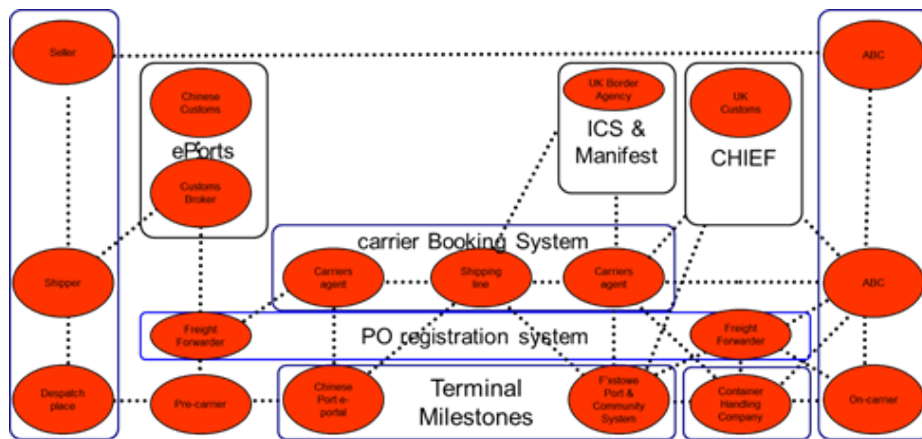


Fig. 3. Schematic application landscape for controlling the ABC trade lane.

## 4 Conclusions

In this paper we explore the possibilities of model based auditing for improving regulatory compliance and control in the international supply chain. Model-based auditing makes use of a normative model of the relationship between the flow of money and goods. In particular, the model requires (i) transaction equations, preservation equations, and aggregation equations suitable for the application domain, and (ii) trade data sufficient to reduce traceability risks. We have worked out some of the equations, in particular for the physical flows of goods. It turns out that aggregation or conversion equations are crucial: these determine the change of units (tons, boxes, etc.) in terms of which the equations are expressed.

We illustrate the approach by a case study of an international trade lane between China and the UK. The case shows that we do find enough data elements to cover essential preservation equations, which can be used as a norm to compare actual trade movements against.

We also reconfirmed the expected difference between contracts at the level of trade (purchase orders) and at the level of transport (shipping orders; carrier bookings). This difference necessitates an information system (the carrier booking system) to keep track of the amount of shipping orders done and the outstanding shipping orders.

Also the fact that ABC finds it useful to make use of an explicit tally at the receiving end, shows that the economies of scale which have improved the efficiency of the supply chain, have also reduced transparency, to such an extend, that it pays to

have transparency restored later by an additional tally service. Such a tally is an instance of a service that provides additional evidence to allow actors in the following link of the supply chain to take over custody over the goods, with sufficient confidence that what they take responsibility for what was agreed according to contract. This is only part of the story; as a matter of fact, such unpacking and tallying services also serve to simplify domestic logistics. Nevertheless, we believe that such additional tallies are 'wastage': if the information exchange would be improved, the process could be improved, and such explicit counts would no longer be necessary. So what starts from a drive to reduce regulatory compliance risks, may also have an operational benefit. The crucial step is to view the global logistics chain as a whole, not as a series of autonomous businesses.

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