Information Exchange in Global Logistics Chains: an application for Model-based Auditing[1]

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Abstract

An integrated data pipeline has been proposed to meet requirements for supply chain visibility and control. 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 specifying economic transactions, and connect the expected economic status transitions to the physical flow of goods. The usefulness of the model in practice is shown by a case study of a retail trade lane of between China and United Kingdom.

1 Introduction

The international trade has been streamlined to reduce costs, but the resulting lack of transparency has severe risks [3]. We no longer know of each container, which goods they contain. This violates customs regulations about entry declarations. Suppose we would implement a *data pipeline,* an standardized infrastructure to exchange information for international trade, logistics and transport [4]. How can we use data from such a pipeline to reduce the control risks? Consider the following research question:

How can trade data collected throughout the supply chain enhance regulatory compliance and control?

Data visibility offers opportunities for real-time risk monitoring. However, what constitutes control? At what level of detail should we analyze risks in a supply chain? These questions can only be solved by a theoretical approach to analyze the flow of goods and relate it to data. In other words, we need a model.

In this paper we explore the applicability of model-based auditing [8] for improving regulatory compliance and control over the supply chain. Model-based auditing uses a mathematically precise description of a meta-model of the movement of money and goods, as customary in the Dutch owner-ordered audit tradition [7], see [1] for an exposition in English. The approach is analogous to model-based diagnosis [2], and other model-based approaches to knowledge intensive tasks, see e.g. [6].

2 Model-based Auditing

Business reality can be modeled as a *value cycle*: an interrelated system of flows of money and goods [7]. These can be used for auditing. For instance, to verify the completeness of the stated revenues, the auditor can verify the completeness of the number of goods sold and the accuracy of the individual sales price. This is an example of a *reconciliation relation*. Depending on the type of business, the relationship between money and goods is stronger or weaker. For manufacturing, the relationship is strong, because the resources used can be counted. In the services industry the relationship is much weaker. When there is only a weak relationship, additional procedural or organizational controls are needed. Consider quasi goods such as tickets. For a given business type, the model generates invariant properties, i.e. reconciliation relations. These are then compared to actual transaction data. This can be done at design time or at run-time. Real time verification becomes like continuous control monitoring [5]. In this paper we test the feasibility of this model-based approach using a case study in international supply chains.

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3 Case Study

Data for this case study was collected during a field trip to Yantian, China, with members of the CASSANDRA project [4]. The case concerns a trade lane between China and the United Kingdom set up by freight forwarding companies for the benefit of a British retail company. Data were collected about the stakeholders, their incentives, the trading process, trade documents, and the application landscape.

In this case, as elsewhere, we observe that the unit of trade (e.g. purchases) does not equal the unit of transport (e.g. ship loads). Goods on a *purchase order* may be shipped in a number of different shipments over a longer period of time, depending on capacity or expected sales. A *shipping order* (S/O) describes individual shipments. This leads to the following example of a reconciliation relation:

goods on PO = goods on S/Os shipped [*t*] + goods on S/Os outstanding [*t*].

The need to aggregate shipments also affects the information systems needed. An application has been built to link purchase orders to shipments. Similarly, the contents of a container are listed on a *container manifest:* description of the goods, number of boxes, weight of a box, etc.

Σ_i goods on container manifest [*i*] = Σ_j goods on S/Os shipped [*j*]

The next document is the *carrier booking*, containing data about ship, the sailing times, destination, expected time of arrival in the UK port, etc. Similar aggregation relations can be specified. Together, these equations make it possible to trace the individual goods along the supply chain. Such data visibility reduces risks, both concerning customs regulations (entry declarations) and supply chain operations. Initially, the retailer was not in control. To make sure that all these separate shipments add up, an additional tallying process was introduced at the port of Felixstowe, where the container handling company also records product type, and makes entries into the retailer's inventory management system.

Another reconciliation relates export to import declarations. A trader has countervailing interests: to overstate export value (to avoid VAT) and to understate import value (to avoid import duties).

value of goods at import = value of goods at export

4 Conclusions

In this paper we explore the use of model-based auditing. We illustrate the adequacy and usefulness of the approach by a case study of an international trade lane between China and the UK. We worked out suitable reconciliation equations to model the physical flows of goods. This shows that the model can be extended to a new domain: international trade. A pilot version of the data pipeline provides access to enough data elements to cover essential reconciliations, which together show that the retailer is 'in control'. All goods can be followed along the supply chain. This restores supply chain transparency.

We reconfirm 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 additional information system (carrier booking system) to keep track of the outstanding shipping orders.

The fact that the retail company makes use of an explicit Tallyman, 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. As a matter of fact, such services also simplify logistics. So efforts to reduce compliance risks may have an operational benefit too.

References

1. Blokdijk, J.H., F. Drieënhuizen, P.H. Wallage, *Reflections on auditing theory,* 1995, Limperg Inst.
2. de Kleer, J., B.C. Williams, *Diagnosing Multiple Faults*. Artificial Intelligence, 1987. 32(1): 97-130.
3. Hesketh, D., *Weaknesses in the supply chain* World Customs Journal 2010. 4(2): p. 3-20.
4. Klievink, B., et al., *Enhancing Visibility in International Supply Chains: The Data Pipeline Concept*. International Journal of Electronic Government Research, 2012. 8(4): p. 14-33.
5. Kuhn, J.R. and S.G. Sutton, *Continuous Auditing in ERP System Environments: The Current State and Future Directions* Journal of Infomation Systems 2010. 24(1): p. 91–11.
6. Schreiber, A.T., et al., *Knowledge Engineering and Management* 2000: MIT Press.
7. Starreveld, R.W., B. de Mare, and E. Joels, *Bestuurlijke Informatieverzorging*. 1994: Samsom.
8. Weigand, H. and P. Elsas, *Model-based auditing using REA*. International Journal of Accounting Information Systems 2012. 13: p. 287–310.