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Transportation Research Procedia 00 (2017) 000–000

Transportation Research Procedia

www.elsevier.com/locate/procedia

World Conference on Transport Research - WCTR 2016 Shanghai. 10-15 July 2016

Optimal returnable transport items management

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Abstract

Reducing environmental impact, related regulations, and potential for operational benefits are the main reasons why companies share their returnable transport items (RTIs) among the different partners of a closed-loop supply chain. Face-to-face interviews with senior executives from seven companies involved in RTIs were conducted to gain a thorough understanding of how they manage the flow of RTIs as well as how they determine the number of RTIs needed in a fleet. Results indicate that RTIs managements are quite diverse, that some common beliefs about RTIs do not apply to all RTI types, and that research efforts are needed in the areas of RTI acquisition; warehouse layout, inventory routing problem; production planning and control; tracking and scheduling.

Keywords: Returnable transport item; Closed-loop supply chain; Survey; Empirical research.

1. Introduction

Nowadays, the growth model favored by economies, built on the "take, make, waste" principles, is no longer viable. Indeed, this linear model depends on the availability of abundant and inexpensive natural resources. However, a solution relies on the circular economy. This approach decouples growth from the use of scarce resources and is based on longevity, renewability, reuse, repair, upgrade, refurbishment, capacity sharing, and dematerialization (Accenture, 2014).

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Furthermore, new environmental regulations made the disposal of packaging more expensive. Regulations are extensive in European countries (Kärkkäinen et al., 2004). The European Parliament and Council, 1994/62/EC, 2004/12/EC, launched several directives in order to prevent waste production by encouraging, for instance, the reuse of packaging.

Nowadays, packaging professionals are facing an increased demand from consumers to be more sustainable, and companies are pressured to take more into account how they package the products they sell (Fitzpatrick et al., 2012). The Sustainable Packaging Coalition (2011) gives several criteria necessary to determine what is considered as sustainable packaging, one of them is "*to be effectively recovered and utilized in biological and/or industrial closed-loop cycles*". One of the challenges is, therefore, to create the infrastructure and systems needed to collect the products at their end-of-life stage and to close the loop on materials. One solution is to foster the use of shared and Returnable Transport Items (RTIs). Unlike a one-way secondary packaging such as cardboard boxes, a returnable packaging can be used more than once in the same form (Kroon and Vrijens, 1995). RTIs are reusable assets and circulate the supply chain until their end of life. The International Council for Reusable Transport Items (IC-RTI) (2003) defined RTIs as "*all means to assemble goods for transportation, storage, handling and product protection in the supply chain which are returned for further usage. It includes pallets, reusable crates, tray, boxes, roll pallets, barrels, trolleys, pallets collars, lids, etc.*" Alternate expressions used to label shared assets include Reusable Transport Items (IC-RTI, 2003), Returnable/Reusable Logistical Packaging (Rosenau et al., 1996), or Reusable Transport Packaging (Kärkkäinen et al., 2004). For consistency, the term returnable transport items (RTIs) will be used in reference to all such denominations throughout this paper.

Face-to-face interviews with senior executives from seven companies involved in RTIs are conducted. The fundamental goal of these interviews is to capture a broad view of RTIs management with the intent to determine what is happening in the field and what the main issues are. In the following sections, we review essential literature, describe the tracking systems, and present and discuss the results of the study.

2. Literature review

In their paper published in 1998, Rogers and Tibben-Lembke explain that the increasing switch to RTIs is due to environmental, regulation, and economic reasons. They discuss the success factors impacting the management of RTIs which are:

- Transportation distances: the shorter the distance is, the more transportation costs are reduced.
- Delivery frequencies: if the time between deliveries is short, fewer containers will be accumulated at either end of the circuit. Therefore, fewer containers need to be purchased, and storage requires less space. Moreover, risks of damage and losses are higher when containers spend more time at the customer.
- The number of partners: when fewer parties are involved, tracking of containers is more manageable and fewer lost containers are observed.
- The number of sizes needed: if many container sizes are used, more containers have to be purchased, handled and stored. However, it enables better cube utilization and lower transportation costs.

One could ask if these assets offer real environmental benefits when production, management of return flows, and disposal of RTIs are taken into account. These doubts have been clearing up by the Frauenhofer Institut, specialized in studies of material flows and packaging logistics. In their report, published in 1993, they compared one-way packaging and returnable containers using four criteria: energy consumption, emission to the atmosphere, water consumption and pollution, and solid waste. Their conclusion revealed that, if each container is used only a certain amount of time, returnable ones are less of a burden to the environment than one-way packaging material.

Even if it brings ecological benefits, the most important driver for companies is the fact that RTIs can also be commercially rewarding. McKerrow (1996) focusses on the benefits of using RTIs such as cost savings, better storage facilities, or ease of handling and discuss areas where RTIs systems work best. Cost evaluation models have also been developed in papers such as Flapper (1996), Dubiel (1996), Rosenau et al. (1996), Mollenkopf et al. (2005), and Twede and Clarke (2005).

Flapper (1996) considers the different aspects that have to be taken into account to determine which items to choose when companies decide to switch from one way towards returnable items. Those aspects are (1) strategic: will RTIs become a competitive advantage, how much to spend for them, etc. ; (2) functional: for which purpose RTIs are planned to be used, one or several products; (3) technical: material, weight, size,… of the RTIs; (4) environmental: government legislation; (5) logistics: collection, sorting, cleaning, maintenance,…; (6) information: will an information system be used (7) organizational: who will be responsible for the RTIs (customer, supplier, a third-party) and (8) financial: opportunity costs, losses, maintenance costs.

Mollenkopf et al. (2005) use a relative cost approach to compare Returnable and disposable items based on a case study in the automotive industry. They apply several key metrics such as container unit cost, cycle time, pack quantity, delivery distance, or daily volume. The factors taken into account for the comparison were transportation cost, labor cost, recycling revenue and disposal cost for disposable items.

Iassinovskaia et al. (2016) present a mixed-integer linear program for the pickup and delivery inventory-routing problem within time windows over a planning horizon. They consider the case of a producer that distributes its products to clients using RTIs. Clients define a time window during which the service can begin. The producer is also in charge of the collection of empty RTIs for reuse. Each partner has a storage area composed of empty and loaded RTI stock, as characterized by initial level and maximum storage capacity. This problem belongs to the family of vendor-managed inventory systems: a supplier develops a distribution strategy that minimizes the inventory holding costs and saves on distribution costs by being able to better coordinate pickups and deliveries to various customers.

Twede and Clarke (2005) also determine how logistics and packaging factors affect the cost of an RTI system. They used two case studies in the US automobile manufacturing industry and in the UK supermarket industry, to illustrate the supply chain relationships that facilitate the introduction of RTI systems. Kroon and Vrijens present, based on previous work from Lützebauer (1993), a classification enabling to differentiate between three systems:

- Switch pool systems: each participant has his allotment of containers, and each one is responsible for their storage, control, maintenance, and cleaning. Two scenarios exist depending on whether the carrier has his allotment or not.
- Systems with return logistics: a central agency owns the containers. Once they have been emptied by the recipient, who stores the containers until a certain number has been accumulated for cost-effective collection, the agency is responsible for their return. This system can differ on whether a transfer system, where the sender always uses the same containers or a deposit system (managed with a book or deposit approach) is used.
- Systems without return logistics: a central agency owns the containers and rents them to senders. These latter are responsible for maintenance, cleaning, control, storage, and return logistics.

Breen (2006) discusses the financial and operational impact caused by customers who do not send back the returning equipment to the source. The analysis was carried out over seven industry sectors and using qualitative research techniques. In this case, reverse logistics can become an expensive business undermining the competitive advantage that could have been achieved by the company.

Carrasco-Gallego et al. (2009), noticing that most of the previous literature only dealt with some subclasses of reusable items, develop a paper considering simultaneously different classes of reusable articles. They conducted ten case studies to identify the main challenges that companies face when implementing reusable articles. The latter comprises RTIs, Returnable Packaging Materials (RPM), and Reusable Products (RP). They identified five main issues: (1) the definition of the fleet size; (2) the control and prevention of the fleet shrinkage; (3) the definition of the purchase policies for new items; (4) the planning and control of reconditioning activities and (5) the balance inventory between depots if a multi-depot network is used. They finally concluded that, even if the implementation of reusable articles brought management difficulties unlike single-use items, it provides cost reduction and contributes to natural resources preservation.

In their paper written in 2010, Iassinovskaia et al. also focus on the problematic of RTIs management. They approach the different issues resulting from the implementation of such transport items, and they propose a model to test the coordination and information sharing regarding RTIs flow. The first results emphasize the importance of sharing information between the different stakeholders of the RTIs system; a reduction of 15% in the procurement of new RTIs and in the average quantity of RTIs in circulation is obtained thanks to a better coordination in the closed-loop chain.

3. Tracking systems

One of the main sources of difficulties when managing an RTI program comes from the involvement of many different actors:

- An RTI Supplier produces RTIs and sells them to the RTI Pool Owner.
- RTI Pool Owner(s) manage(s) the whole (or part of the) RTI pool and make(s) RTIs available for additional supply chain levels.
- A supplier uses RTIs to distribute his goods. Suppliers fill empty RTIs they receive from an RTI Pool Owner and hand them overfilled to Producers.
- Producers receive filled RTIs from Suppliers, using these or other RTIs to distribute their products. They make non-used RTIs available for collection.
- Retailers receive filled RTIs, making them available for collection. When final customers use the RTI, i.e., when RTIs are used as primary packaging, they have the same role as Retailers.
- Logistics service providers (LSP) collect RTIs from Producers/Retailers to RTI Pool Owners, offering additional services such as cleaning or repair.

RTIs are more often exchangeable items rather than individual assets. In the first case, one talks about “Directly Exchange RTI” where the RTI user only needs a balance of all dispatched and received items and the information about who received it. The dispatcher does not expect or want the same RTI since one of the same types is sufficient. However, in the second case, the RTI is identified thanks to a serial number, and the dispatcher expects to receive it specifically.

Regarding the high investment to purchase RTIs, it is crucial for companies to have a utilization rate as high as possible and a minimal loss rate (Kopicki et al., 1993; Maloney, 1999; Randall, 1998; Witt, 2000). Indeed, RTIs represent a significant capital expense in terms of procurement, management and maintenance. In an Aberdeen Group (2004) survey, around 50% of the respondents claim that 5% or more of revenue is consumed by logistics asset operations. However, several issues are observed, such as shrinkage due to theft, damage or customers who do not send back the empty container. Several cases have been reported by different authors (Breen 2006; Witt 2000; McKerrow 1996; LogicaCMG 2004).

A study conducted by Breen (2006), in numerous industry sectors in the UK, showed that 15% of pallets in circulation disappeared and that customers or third-parties did not return 20% of packaging. These numbers are confirmed by the survey carried out by Aberdeen Group (2004) in which 25% of the respondents affirm losing 10% or more of their RTIs fleet annually. LogicaCMG (2004) realized interviews underlining problems in the product flows such as safety stocks, delivery reliability and information flows due to the lack of cooperation in the supply chain.

An essential tool in logistics linking the information system and the physical material flow is the shipment tracking system (Stefansson and Tilanus, 2001). These systems enable good coordination of logistics flows and the detection of unexpected events in material flows that can be managed before severe problems are caused. Several solutions exist, such as barcode labels, permanent or not. However, the former is not viable since it necessitates too much manual labor to scan the labels at different points of the route, and the latter identifies the content and not the container (Vitzthum and Konsynski 2008). The most promising solution is the RFID technology enabling a fully automatable reading without line-of-sight. Regarding the financial impact of RFID technology, cost savings of about 5.5% in the asset investment and 22% in the trip fee can be obtained (Ilic et al., 2009). However, the scope chosen by the authors is quite limited, and further research should be developed for different industries and RTI types.

Melski et al. (2009) focused on the impact of RFID on inventory shrinkage by using a deterministic inventory model. The first benefit of an RFID tracking system is an increase of RTI return rates. The results also show that the procurement of new transport items is done less often and in smaller quantities. Even though the optimum maintenance lot size decreases, refurbishment is done more frequently.

Lebfevre and Yue (2012) develop a case study involving an ocean shipping company to determine, among other things, the contribution of tracking technologies to improve the management of RTIs. They found out that the main expected benefits of this system would be to enable the recovering of lost items, to know the location of each asset and the inventory in each terminal and to achieve a reduction of administrative costs. Furthermore, the authors concluded that investments in tracking technology depended on several factors: (1) the value of the Returnable Item used; (2) the improvement and additional visibility this technology would provide and (3) the real value of the investments, that is to say, comparing the total cost with the actual use of the tracking technology.

Even if high interest has been shown for its potential benefits in a study carried out by Hofmann and Bachmann (2006), few companies have implemented an RFID-based container tracking system. Furthermore, we will see in the following case studies that this solution is not applicable and adequate for all organizations.

4. Results

To gain a thorough understanding of RTIs management, face-to-face interviews with senior executives from seven companies involved in RTI systems were conducted. To ensure reliability, notes were taken, and the interviews were audio-taped. A series of forms was developed to record responses. The visited companies are:

- Company 1 (C1) is a manufacturer that produces, processes, and creates flat glass for construction, for the automotive industry and solar applications. It uses the road (70%) and overseas (30%) transport. To transport glass on road, stillages are used since the end of the 70’s, whereas for the overseas deliveries, they are used since the mid 90’s. The returnable ones, more economical, are employed with severe and high volume customers for overseas transport. It is always the case for road transport. The disposable ones are employed if the stillage has no chance to come back or if the customer asks for the order to be transported with a wood box. There are two ways for the customer to get its glass order by road. He goes to the factory where the glass was produced to collect its order or the company delivers the glass order to the customer thanks to a single haulage company that organizes all transports and subcontracts other companies when necessary.
- Company 2 (C2) is a global healthcare company that develops, manufactures, and markets products. Few returnable items are used, even though they think it is an opportunity for them.
- Company 3 (C3) is an international service, trading, and food distribution company operating on five continents. RTIs have always been used for the transport of its merchandise, and investments in new ones are realized when they start working with new customers who have specific constraints in terms of dimensions.
- Company 4 (C4) is specialized in first and last-mile delivery in city-centers with ecological vehicles created in 2012. They began to use RTIs in 2014 when deliveries to the food sector were made.
- Company 5 (C5) is a large teaching hospital that has always used rolls. In 2015, the use of other RTIs started progressively accompanied by a global communication plan to motivate intern customers.
- Company 6 (C6) is a supermarket chain that has always used RTIs.
- Company 7 (C7) is a chain specializing in discount stores and non-food distribution. It has always used RTIs and does it more and more over the years. The company tries to be simple, pragmatic and invests the right amount in them.

4.1. Reasons for using RTIs.

As shown in Table 1., the first reason for using RTIs is the economic aspect. Since one can reuse the RTI multiple times, it becomes cheaper than to buy a new one-way package every time. Moreover, in the case of first and last-mile delivery of refrigerated food, the use of polystyrene boxes enables to transport the products in a non-refrigerated vehicle. There is a trade-off to make between the costs of a refrigerated transport with carton box and an ecological transport with polystyrene boxes. The optimal solution depends on the quantity transported. The hospital also saves the cost of waste management for the one-way packaging.

The second reason is the ecological aspect; the use of RTIs enables to reduce waste. Some customers do not want to recycle the packaging received with the order. As for the economic aspect, in the case of first and last-mile delivery of refrigerated food, the use of polystyrene boxes enables to transport the products in a non-refrigerated vehicle which is 100% green.

RTI system has also been developed due to storage reasons. Indeed, some customers do not want to store RTIs in their warehouse because it is cumbersome; or some customers do not have a specific place to stock them. RTIs also facilitate efficient handling, which increases security and productivity. Furthermore, RTI systems permit to densify transportation as pallet heightener enables the transport of more items per pallet. In the food sector, the product has to be protected by using rigid containers.

Table 1. Reasons for using RTIs.

Reasons for using RTIs	Economical	Ecological	Storage	Handling	Productivity	Protection
C1	X	X	X	X		
C2	X	X				
C3			X	X		X
C4	X	X				
C5	X				X	
C6	X	X				
C7	X	X			X	

4.2. Type of RTIs.

Interviewed companies have various types of RTIs. When known, their costs are included in Table 2. The symbol "X" is used when the company uses an RTI type but the cost is unknown.

Table 2. Cost of RTIs.

Type of RTIs	Stillage	Euro-pallet	Plastic pallet	Rolls	Plastic box	Plastic tray	Pallet heightener	Polystyrene boxes
C1	€1,300							
C2		€9	€36	€150	X	X		
C3		X	X	€110		X	X	
C4								€20
C5				X	X			
C6		X		X	X			
C7		X		X	€8.5		X	

4.3. Management of RTIs.

All the companies own their RTIs; Company 4 also uses boxes from its suppliers. Company 6 rents some RTIs to EuroPoolSystem (EPS). Company 7 owns different types of returnable items: pallet heightener, plastic boxes, rolls, pallets, and roller pallets, but a certain amount of their pallets are from CHEP (a provider of RTIs) and come from their suppliers. In most of the cases, the fleet size is based on the number of orders received or on the number of deliveries. When known, the fleet size is in Table 3.

The maintenance can be done internally or by a subcontractor. Company 1 subcontracts the maintenance. A subcontractor delivers stillages that are assembled, checked, controlled, repaired, listed, and encoded in an SAP program. The maintenance cost is €170/RTI. Companies 2 and 7 use the services of a sheltered workshop for the maintenance. Company 7 does not have a regular rhythm; two or three pallets of plastic box are accumulated before sending them to the sheltered workshop. The maintenance of one box costs less than €1. The same process occurs for broken containers. The maintenance is done internally for the other companies. Company 3 stores RTIs that have to be repaired. When the number of stored RTIs is significant, a repair campaign is organized. A huge dishwasher is used to enable the continuous cleaning of the trays. In Company 4, one worker is in charge of the maintenance in the warehouse. There is no specific procedure. When 20-30 boxes are accumulated, they are washed. It costs around €0.5 per cleaning. Company 5 has a dishwasher system to wash the 50 dirtiest boxes. More boxes should be washed but they do not have the equipment for it. The cost to wash a box equals around €17. Company 6 washes between 1,000 and 1,500 pallets of boxes every day — the maintenance cost around €0.12 per box. RTIs can make 6-7 rotations before needing maintenance.

RTIs used by company 1 make between 40 and 50 rotations during their 15 years lifetime. The lifetime of a roll is a minimum of five years, during which it makes around a hundred trips per year, whereas a box makes between 70 and 80 rotations during a lifetime of around 6-8 months.

Companies do not use RFID technology. Regarding Company 3, it is too complicated to manage. There would be too many RFID readers to install due to the number of shipping docks they have, which would cause interference. Company 5 tested RFID but problems were encountered because it would cost too much to install detectors at each dock, and the risk of error is important. Company 6 has too many docks so the investment would be huge. Moreover, the technology does not permit to work with a lot of RFID close to each other because of interferences.

The last column in Table 3 shows if the company has a guarantee on RTIs.

Table 3. Management of RTIs.

	Fleet size	Maintenance cost (€/RTI)	Trace	Serial number	Inter-changeable	Guarantee €/RTI
C1	600	170	SAP-Excel	Yes	Yes	€250-350
C2	5,000 pallets 30,000 plastic boxes	unknown	EDI Transmission	Bar-codes on rolls which are not interchangeable	Yes, except for rolls	No
C3		unknown	Home-made	Yes	Yes	€100 (only for rolls)
C4	1,000	€ 0.5	Mobile application	No	Yes	No
C5		€ 17	ERP	Yes	No	No
C6	4,000 pallets	€ 0.12	Excel	Yes	Yes	€3.86 box €0.9 smaller box
C7	90,000 plastic boxes	Less than €1	No	No	Yes	No

4.4. Journey of the RTIs:

When Company 1 sends its product by road transport stillages are returned immediately with the delivery truck and go the maintenance workshop. Therefore, guarantee is not used. The company also sends orders to 30 customers for the overseas transport which represent 50% of the volume. In this case, the customer disassembles the empty stillages pieces by pieces and stores them at his company. When the customer has 10 stillages in storage, he can send them back to maintenance in the manufacturer workshops. The customer receives his credit note in which the amount of spoiled stillages has been deducted.

The distribution center of Company 2 delivers its goods using pallets. Usually, pallets are delivered in the central pharmacy of the hospital where they are stored during 2-3 weeks. When pallets are empty, they are put in a pile. When the pile is full, the driver takes it. Sometimes, the pallet is delivered directly to the customer; in this case, it has to come back immediately. For the return flows, all pallets come back to the maintenance center where they are checked. If they are not damaged they can go back to the plant; otherwise they are repaired or destroyed. The distribution center delivers pharmaceutical products to 7,000 customers in Europe.

Products of Company 3 are delivered by bi-temperature trucks. Ambient and fresh products are put together. A route includes 10 to 15 customers, 615,000 rolls and 28,000 pallets are delivered per year. They let rolls at the customer because he has to control the merchandise and put them in his inventory. The RTIs from the precedent delivery are taken back, regardless of the amount. They do not want it to be a nuisance for the customer. When they come back to the company's warehouse, an approximate count is carried out. The RTIs that do not belong to the company are sent back to suppliers or CHEP. Company 3 has 6,000 customers and delivers 1,200 customers per day.

Employees of Company 4 go to suppliers with empty boxes to fill them. From the supplier, the dispatch rider begins his tour to minimize the transit of the fresh food. At the customer's site, boxes from the precedent delivery are taken back. The company has an inventory space of around 200m² for empty boxes.

Boxes of Company 5 are brought to the customers where they are accumulated by piling them. Once a day, the boxes are taken back to the center. Company 5 delivers 750 customers whose 99% are internal.

The distribution center of Company 6 delivers by a truck the merchandise to the different warehouses and takes back the empty containers to the supplier. Some suppliers do not deliver to the distribution center but directly to the warehouse where they take back the same number of dropped off containers. From the warehouse, the same process occurs with the stores. Trucks deliver the goods and take back the empty returnable items. The returnable will be washed in the warehouse. There is an exception for vegetable market auction where the company brings its RTIs. The company always pairs the supply of goods with a return to optimize transportation. They have around a hundred customers who come every day.

The Company 7 prepares the order using plastic boxes or pallet heightener on pallets. They deliver the goods at their different stores. These latter stores the goods and unwrap them in the function of what they sell. During each delivery, the containers from the precedent delivery are taken back. The rule is that the stores can only give back 60% of what has been delivered. When the RTIs come back, they are checked and put aside if they need maintenance. When a certain amount is accumulated, they send them to a sheltered workshop. The company 7 has 82 stores.

To summarize, empty RTIs returned immediately with the delivery truck or are stored at the customers' site. In the latter case, they can be taken back after a period of time. Or, when a minimum amount is reached, they are taken back with another delivery truck or they are sent back by the customers.

4.5. Issues

The main issue encountered by companies using RTIs is a shortage. To face a shortage, Company 1 sends disposable stillages to their regular customers. Then, the executives often highlight the difficulty of managing the RTIs, such as obtaining a correct balance of RTIs with customers, to draw up the inventory, to manage the mix of RTIs specifically when it comes to guarantees. Companies 2 and 3 know that their competitors use their RTIs and Company 7 is sure that some stores use their containers for another usage. These issues and the loss of RTIs are in Table 4.

Table 4. Issues.

	Shortages	Management	Lack of storage	Mix	Lack of traceability	Quality	Loss/year
C1	X						10%
C2				X	X	X	10%
C3	X	X	X	X		X	
C4	X						1-2%
C5		X					10%
C6	X		X				
C7		X	X		X		

4.6. Discussion

RTIs management is underexploited. There is not full control of the flows and on the cost. It probably causes a significant loss of money. The maintenance cost is not visible by companies, and the conditions in which RTIs come back from customers show a lack of respect for the equipment. The evolution of the fresh product volume delivered with RTIs is more significant than the mean business evolution. Therefore, companies face a lack of space for the storage of their RTIs. Inventory space for empty RTIs should be taken into account in the architecture of the warehouse to avoid cumbersome RTIs.

Better traceability would be valuable. However, several companies do not use RFID tags because of interferences. However, some devices are in development to avoid these.

5. Conclusions

Reducing environmental impact, related regulations, and potential for operational benefits are thus the main reasons why companies have developed provisions for sharing RTIs among the different partners of a supply chain. Companies in a wide variety of industries invest substantial capital in their inventories of RTIs. Properly managed, RTIs can be a powerful tool to support efficient and sustainable supply chain practices, helping companies to free valuable capital and other resources by reducing the time and money spent to transport goods.

However, the management of RTIs is an essential component in the performance of the entire supply chain. Moreover, many difficulties arise when attempting to introduce or efficiently manage an RTI program. The first complication comes from the fact that, in most cases, RTI programs involve an important quantity of mobile items, which may be spatially scattered. Secondly, these significant RTI stocks might be managed by several actors, each of them being responsible for a different part of the process. Finally, the effective monitoring of movements among partners and the control of RTI stock levels can turn out to be particularly complicated. Several RTI owners lack insight into how large their RTI pools are, making it even harder to manage them and detect problems such as shrinkage and poor condition of the RTIs. The lack of visibility causes both RTI owners and renters difficulties in adapting to new conditions, such as new routes-to-market, new customers, or labor and time shortages.

Results indicate that RTIs managements are quite diverse, that some common beliefs about RTIs do not apply to all RTI types, and that research efforts are needed in the areas of RTI acquisition, warehouse layout, inventory routing problem; production planning and control; tracking and scheduling. That yielded information by the conducted face-to-face interviews that will be used to develop and refine items for a large-scale mail survey.

Acknowledgments

The project that leads to these results was partially funded by the Interuniversity Attraction Poles Programme initiated by the Belgian Science Policy Office (grant P7/36). This paper, however, only expresses the authors’ views.

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