

Container management strategies to deal with the East-West flows imbalance

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ABSTRACT

In this paper we look into the management of empty maritime containers by making use of reverse logistics theory. We map the reverse logistics system, identifying the drivers for recovery, the characteristics of the containers, why they are being returned, how they are being recovered and by whom. We identify that empty maritime container management has to address mainly the management of the capacity, location and reposition of the fleet of empty containers.

We review common strategies to manage the fleet of empty containers. We pay special attention to the following three strategies: balancing out trade with flows of recovered materials, using foldable containers, and exploiting modern information and communication technologies. We analyze these three strategies in more detail with respect to the direct benefits and the requirements to make them work. Furthermore we look into the inhibitors (those aspects that make their implementation more difficult), but also to opportunities and facilitators.

We conclude with directions for further research in the topic of empty container management.

Keywords: Maritime Logistics, Empty containers, Reverse logistics

1. Introduction

The last 25 years trade has been growing more than twice as fast as the world economy. This faster growth of trade relative to the economy as a whole is entirely due to the process of globalization of manufacturing and the economic opening of China (Clancy and Hoppin, 2006). Trade imbalances have always existed, but it is not surprisingly that it is currently with China that the greatest imbalances exist, for both the US and Europe. Obviously, this also has dramatic repercussions for container transport, since trade imbalances imply container transport imbalances and consequently a need to reposition empty containers.

On the transpacific trade the imbalance in 2006 was 1:2,6 in favour of eastbound traffic, with demand for 14,3 million TEU eastbound, and 5,5 million TEU westbound. Meanwhile, on the Asian-Europe trade the imbalance was 1:1,8, in favour of westbound with carryings of 7,5 million TEU and 4,1 million TEU eastbound (Robinson, 2007).

Worldwide about 20% of total container flows at sea are empty and the costs of repositioning are about \$400 per container [Drewry Shipping Consultants, 2002]. Very likely during more than 50% of the total cycle time, containers are empty (either in maintenance, repair, or in storage and transit), and the total costs per empty container including transport and handling are estimated at \$675 [Behema, 2001 and Synergie, 1996].

Although containerized cargo flows are expected to grow continuously [Drewry Shipping Consultants, 2006], the competition between shipping lines remains intense and is driven by cost efficiency. Given the fact that equipment and repositioning costs contributes on average about 20-25% in the total cost balance sheet of a container shipping line, the efficient management of empty containers is one of the competitive factors in supply chains.

In view of these circumstances the central question addressed in this paper is: what are strategies for deep-sea carriers to improve empty container management and what are the perspectives to develop these strategies?

The organization of the paper is as follows. In the next section we start with presenting a research framework to study drivers, processes and actors involved in reverse logistics. This general framework is adopted and applied to the reverse logistics of maritime containers (section 3) and as a result addresses key container management issues. In section 4 a brief overview is given of common strategies to manage empty maritime containers, followed by a more detailed discussion of what is considered as new promising strategies. These strategies are analysed in section 5 in terms of benefits, inhibitors, opportunities and facilitators. The paper ends with conclusions and an outlook on future research.

2. Reverse Logistics

Reverse Logistics is a relatively young topic within logistics research. However, during the last years the number of publications in this research field has increased rapidly.

The European Commission has financed some large scientific research projects (see [RevLog, 1998-2004], [ReLoop, 1998-2004]), In addition, the industry is also becoming aware of the importance of reverse logistics. For instance, in the U.S. there is a Reverse Logistics Executive Council [RLEC, 2006] and a Reverse Logistics Association, which publishes a quarterly magazine entirely dedicated to reverse logistics [RImagazine, 2006]. Therefore, in spite of the youth of the topic, there are already enough references to ground our understanding of reverse logistics.

In order to explain and understand reverse logistic, authors commonly pose the following questions (see e.g. [Thierry et al., 1995], [Goggin and Browne, 2000]):

- why is there recovery? (why-returning? & why-receiving?)
- what is recovered?
- how is the recovery done?
- who is doing the recovery?

These are actually the main dimensions of the framework for reverse logistics as proposed by [De Brito and Dekker, 2004]. The return reason and the characteristics of the product being returned are a sort of input to the reverse logistics system. The result (who does what, and how) also depends on the drivers for recovery (see Figure 1).

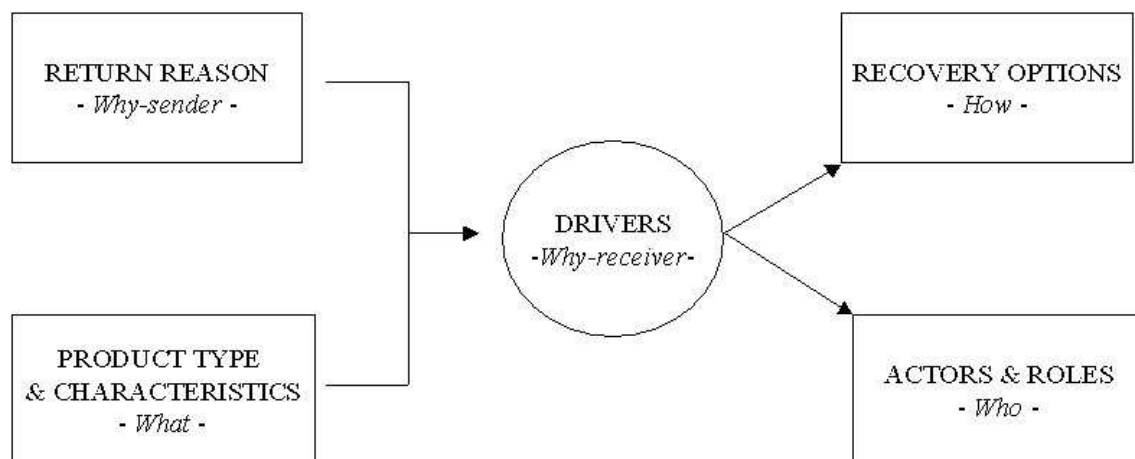


Figure 1: A framework for Reverse Logistics (Source: [De Brito, 2004]).

All together the framework can be a tool: 1) to map the reverse logistics system 2) to identify the main issues of its management. Therefore, in this paper, we apply De Brito's framework, to put the reverse logistics of maritime empty containers in perspective.

3. The reverse logistics of maritime empty containers

Return reasons

In general, products are sent back or discarded because 1) either they do not function properly or 2) because their function is no longer needed. Products that do not pass the quality control in a production line may go back for refurbishment, illustrating the first situation. Regarding the second, there are many examples, especially when the product reaches the end of its useful life, such as a Kodak's single-use photo camera.

The function of a container is to protect cargo against damage and theft, but above all to improve transport efficiency by easy transfer of goods between modes. In other words, a container functions as a multipurpose package device enabling efficient cargo transport. Containers go back and forward as part of their *function*. They can be called distribution items and in the context of reverse logistics they are named *functional returns* (see [De Brito, 2004]).

Drivers for recovery

Generally, one can say that companies get involved with Reverse Logistics, because they can either 1) profit from it (economics); 2) they are obliged to (legislation, such as in the area of the environment), or 3) out of broad responsibility (corporate citizenship). The drivers are not mutual exclusive, and very often reverse logistics takes place for a mix of reasons. Considering the price of a new standard container, which during the last five years has been in the range between \$1400 and \$3500, depending on the type and size (Foxcroft, 2007), it is profitable to re-use a container for many trips. The driver for recovery of empty containers is therefore *economics*.

Container characteristics

A container is a *distribution item*, as it is supposed to be filled with cargo, which will be subsequently distributed. A container following the International Standards Organization (ISO) is a 20-foot box, and cargo is often counted in terms of twenty-foot equivalent units (TEU's). In addition to the 20-foot box other sizes are also frequently used, especially the 40-foot container. Boxes are predominantly composed of steel.

Purchasing a container represents a substantial initial investment, but containers deteriorate slowly and are robust enough to make dozens of trips. Containers are suited for other modes of transport than just maritime, and standardization is an important facilitator of inter-modal transportation. However, transshipment terminals have to be equipped with proper cranes to handle container, which weight around 2 tonnes empty and up to 25 tonnes with cargo [Rodrigue et al., 2006].

Recovery

When empty containers are returned usually a quick visual inspection takes place. Depending on the state of the container, it is then send to repair or refurbishment (e.g. to receive protective coating), or might simply require a cleaning operation before being repositioned. Figure 2 illustrates some of the paths a container might follow in the process of recovery.

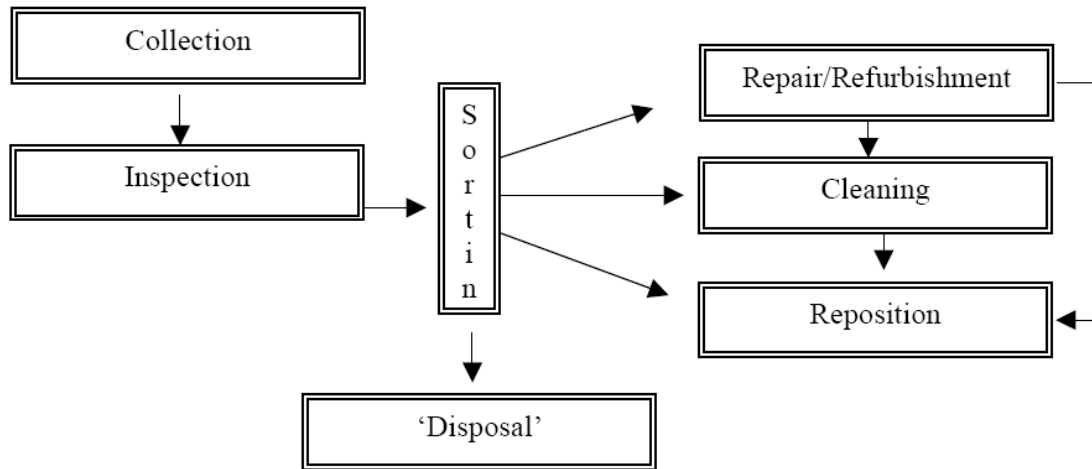


Figure 2: Recovery of maritime empty containers

Actors and roles

In the container transport chain many actors are involved to manage the cargo, documentation and information flow through the chain (see for instance www.portinfolink.com). Just focussing on the physical operations still many parties can be involved as containers are pre-eminently used in intermodal transport chains. In the maritime container transport chain the following actors can be distinguished: deep sea and short sea carriers, sea port terminal operators, inland transport operators (i.e. truck, barge and rail operators), inland terminal operators and container depot operators in the seaports and at inland destinations. For operational and commercial reasons inland container depot activities in the hinterland are usually integrated at inland terminals. Regarding the involvement of all these different actors much depends on the specific chain in which a container is transported. Figure 3 illustrates the movements of empty containers between some of the actors.

The container depot has only a role in the flow of empty containers, because its main function is the storage of empty boxes. The deep-sea carrier has the main responsibility and interest in the reverse logistics management of empty containers, because containers belong to its capital assets. Container fleet management is considered to be a critical business for the profitability of the deep-sea carriers.

In addition there is also a role for the leasing company to reposition empty containers to regions of high demand whenever a carrier leaves his leased containers in areas of container surplus. Although it is the responsibility of the leasing company to take care of these flows of empties they can be considered as the result of the reverse management strategies of the deep-sea carrier.

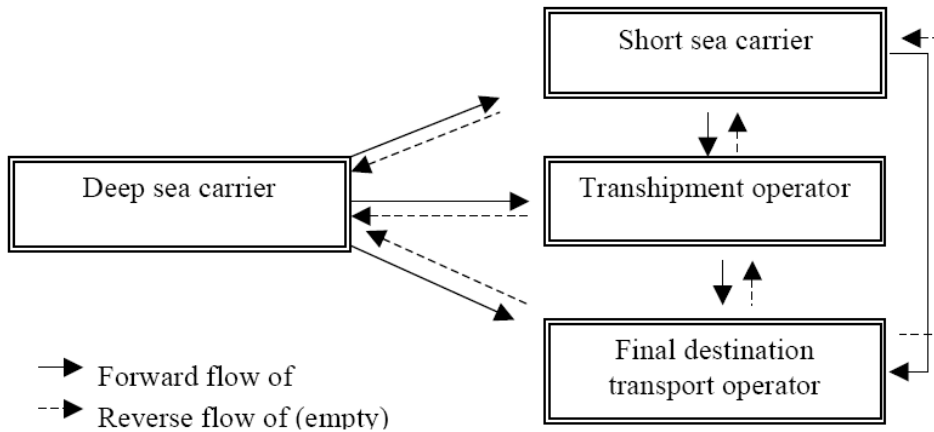


Figure 3: Actors involved in maritime container flows: an illustration

Main issues

Summarizing, containers go back in the chain because of their inherent function: being distribution items. A container can be re-distributed several times, since it was designed to be robust enough to protect product integrity in the first place. This makes reuse and re-distribution a natural and economically viable recovery option. Recovery is therefore driven by economic reasons. Since the inherent function of distribution items is to go back and forward in the chain, containers are carefully checked and cleaned, so they can be safely re-distributed. Many actors are involved, such as the shipping company, its agent and operators.

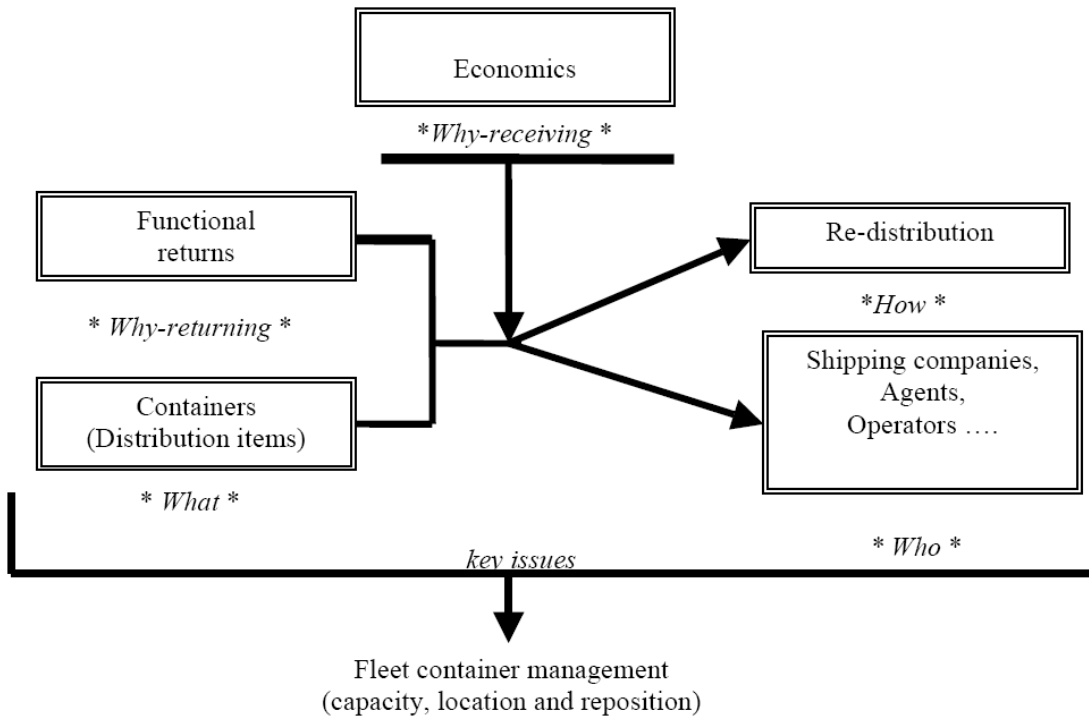


Figure 4: The reverse logistics of maritime containers

The forward distribution depends heavily on the availability of serviceable distribution items. So, one of the key-issues is to have the containers in the right place, when they are needed. Therefore, the main issue in managing the reverse logistics of maritime containers is managing the fleet of containers with respect to capacity, location and movements throughout the chain in such a way that costs are minimized.

4. Managing empty maritime containers: common strategies

For an earlier review of strategies to reduce the costs of empty transport, we refer to [Konings and Thys, 2001].

Some companies use container substitution or selective pricing as a means to deal with container fleet imbalance in certain routes, or to cover for reposition costs. As explained in [Konings and Thys, 2001], companies may offer a 40 ft container for the price of a 20 ft, or charge higher fees for crowded legs or where reposition costs are higher.

Another strategy is to participate in a pool, sharing containers with other partners. An example is the free-label containers, also known as grey-boxes, which are easily interchangeable between different organizations. Yet, container pooling does not lead necessarily to high utilization. Sea Containers Ltd., container lessor and transport operator, has consistently reported higher utilization of owned container fleet than of pooled fleet with GE capital (98% against 90% in 1st quarter of 2005) [Sea Containers News, 2004 and 2006].

Another possibility is to make use of online market places to match fleet capacity with potential freight. This sort of market places has been in use for all types of transport, but with different degrees of success. For instance cargotrans.net is a European e-marketplace for freight and vehicle in the area of road transportation. The marketplace is a means for companies to share information, which can be used to find a match between complementary needs. For instance, partial truck overcapacity on the one hand can be matched with the need of shipping a part load. Regarding sea shipping, the appearance of the e-marketplace GoCargo.com, in 1999, was thought to revolutionize business in the shipping industry. In the beginning this e-market place was relatively successful with respect to subscribers (see itcasestudies.com) but didn't survive much more than just 2 years [Kaneshige, 2001]. Other initiatives include International Asset System's Interbox, which counted more than 250 users (shipping lines, leasing companies and operators) in 2000 [Shippers Today, 2000], and Synchronet, which offers extended services on equipment, slots, and road freight in the port area.

There is also a set of advanced computational techniques available that can be used to support and optimise empty container operations. The decision-making process includes, among others:

- The network design of depots for empty containers, or simply the allocation of areas to store empty containers;
- Assigning a transportation mode (or vehicle) for reposition;
- Scheduling the reposition (when shall occur);
- Determining the reposition route, given the multiple locations to be visited (pick-ups and delivery points);

For instance, [Bourbeau et al., 2000] consider the depot location problem for a mixed-fleet of empty containers by means of a branch-and-bound technique, taking into account the costs of opening a new depot, operating costs, and costs associated with moving containers in-between depots or between a depot and a client. [Crainic et al.,1993] and [Choong et al., 2002] employ integer programming to optimise empty container operations between inland and port terminals. The latter show that a long horizon planning can stimulate the use of slower, but less expensive, modes of transportation, such as a barge.

The drawback of these advanced techniques are on the one hand its single-problem orientation, and on the other, the need of reliable data as an input. Besides this, there are many interdependencies among the different 'problems' and those should not be overlooked.

[Elera et al., 2005] show that considering simultaneously, in a single-model, routing and repositioning decisions leads to the minimization of the total costs.

5. Managing empty maritime containers: additional opportunities

Here we focus in three particular additional strategies, which may structurally improve empty container management.

Strategy A): Balancing out trade with recycling flows

One of the most important causes for the need to reposition empty containers is the existence of trade imbalances. On the one hand this is a fact of life in the shipping industry, but on the other hand opportunities emerge for carriers to seize in achieving less imbalanced cargo movements. The emergence of end-of-life reverse flows is a key development here. Let us illustrate this with the case of paper recycling.

The European's Commission packaging and packaging waste directive of 1994 was revised in 2004 doubling the recycling targets. By 2008, at least 60% of all the packaging waste (in weight) has to be recovered. Some countries such as Finland, Germany or the Netherlands are already surpassing this target, but other countries such as Portugal and Greece still have to increase their collection of paper. In the U.S. high landfill taxes and environmental awareness has also stimulated recycling targets. The American Forest Paper Association aims at a recovery rate of 55% of the domestic production by 2012 [Greve, 2005]. In 2005 paper recovery was already at 51.5%, representing 51.3 million tons.

This represents almost a 50% increase in 15 years, when compared with 27% of recovery in 1990. The potential growth is still enormous. Only in the U.S., 50% of the office paper is not recycled. There is also room for growth in the residential recycling programs, which are basically the same in number since 1992 [American Recycler, 2006]. Residential programs are often successful when economic incentives are given, as was the experience in the Portland area. Garbage collection was charged in contrast with the collection for recycling, representing up to \$170 a year of savings for the household. Also grocery and department stores are increasing their internal collection of corrugated cardboard because they can make money on it. In short, not only there is a considerable source of supply of used paper and packaging, but also there is potential to increase its volume, either in Europe or in the U.S.

On the demand side countries such as China can be said to be starving for paper. On the one hand, China has high levels of exports and a corresponding need for packaging materials, and on the other, it has to deal with a high level of deforestation. It is not surprising that America Chung Nam (ACN), a company that exports paper to China, has been the number one U.S. exporter, in volume, in 2001.

That year, ACN exported 150,000 twenty-foot equivalent units, corresponding to 2.2 million of traded paper and pulp [Taylor, 2002]. We just described the situation for paper, but a similar picture would apply to plastics or other raw materials.

Strategy B): Foldable containers

As opposed to the most common strategies to deal with empty transport, which are aimed at avoiding the movement of empty boxes by improving the match between empty containers and cargo, the concept of a foldable or collapsible container is an interesting idea, as it is focused on saving costs of the empty movements themselves.

This idea is not completely new, and the inspiration originates from many successful applications of such boxes in other areas such as the retail industry and in air transport business. For dealing with the issue of repositioning empty maritime containers also many designs for foldable and collapsible containers were launched in the past. The majority of these ideas however never passed the phase of patent granting (see Binsbergen et al.,

2000). One that has been commercially used for a while is the Six-In-One container. It is a fully dismountable 20ft container, that once dismantled, can be folded, stacked six high and interlocked to the exact dimensions of a standard container, which would make the container compatible with existing equipment and processes in the container transport industry. The Swiss based company SIO Container Company (SCC) launched it about twenty years ago. A striking characteristic of the SIO is the absence of hinges, other than the standard door hinge. The container consists of just seven separate elements with locking devices. Simple production and reduced manufacturing costs were important motives to choose for this construction based on dismountable parts. Folding a container requires a three-person team and a fork truck, and it was claimed by SCC that this process would take about 15 minutes, but in practice it took much more time. About 2000 SIO containers have been produced – of which the actual number of units still in operation (i.e. being mounted and dismounted) is unknown – but this is a too small number to speak of success (Konings and Thijs, 2001). The failure of the six-in-one foldable container has been attributed to the following facts (see Konings and Thijs, 2001): the folding process was too complicated and time-consuming and therefore was too costly, the purchase price was too high compared to a standard box, its vulnerability to damage and its high weight (in case the SIO's are interlocked). The latter would create a problem at container depots, because their existing equipment would not be suitable to handle such heavy loads. In the meantime, the idea keeps the attraction, in particular of container designers, as it has resulted recently in some new designs and registered patents for collapsible containers of which some already exist as a full-sized prototype (e.g. the Smartbox of New Logistics GmbH, the Foltainer and some other Australian designs) or in the prototype development phase (e.g. Holland Container Innovation). These designers all claim that they are able to overcome the problems as they were encountered in previous designs such as the SIO-container.

Strategy C): Information and communication technology

Maritime logistics has benefited from the use of sophisticated technology already for decades.

However, advances in modern information and communication technology (ICT) are offering further opportunities for business efficiency. Many of the ICT innovation falls under the umbrella of auto-ID systems (e.g. bar codes), smart chip cards (e.g. the GSM card), biometric technologies (e.g. iris or fingerprint identification), and other wireless technologies such as Radio Frequency Identification (RFID), and the more recent Ultra-Wideband (UWB) technology.

Some companies started forming partnerships to utilize these new technologies. After testing the RFID technology in several ports including Rotterdam, port operator Hutchison Port Holdings (HPH) formed a partnership with Savi Technology to operate a global RFID network. RFID tags will be attached to maritime containers, providing a flow of information on location, allowing clients such as shippers or logistic providers to track and trace cargo. This technology can be combined with 'motes' (small sensing devices), which can measure the temperature, humidity level and so on, accumulating additional useful information for cargo monitoring.

The potential of all the options of these technologies is driven by commercial reasons and is therefore addressed to information about the cargo itself. However, using these advanced technologies by shipping lines for operational purposes, i.e. to improve the efficiency of their empty container flows is still in its infancy.

6. Analysing the strategies: benefits, requirements and further opportunities

Strategy A): Balancing out trade with recycling flows

To make use of flows of materials for recycling diminishes the imbalance of the exports from the West to the Far East. This leverages fleet utilization and adds-value as empty containers are now being filled with cargo.

To make it work, a requirement is to do business with companies in the material reclaim business. Thus, this might require carriers to make an active search of the diversification of clients' portfolio. An inhibitor is uncertainty in shipping recovered materials to the Far East because of the growing awareness of polluting risks. China has imposed strict regulation to avoid other waste contamination in the flows of used materials coming into the country and in case of suspicion Chinese authorities may reject cargo (see [Vidal, 2004], and [Recycling International, 2005]).

There is a clear opportunity, which results directly of currently market trends. The demand for raw materials is huge in countries like China and India. This unbalance in supply-demand for recycling materials is kind of the geographically opposite to the unbalance for finished goods such as clothing, where consumption is in the West and where production is concentrated, more and more, in the Far East. Therefore, this offers a possibility to explore partnerships so empty containers might actually make their trip back to the Far East filled with recycling materials. The import of paper in China alone increased more than 150% between 2000 and 2003 [Fast Forward Magazine, 2004].

To facilitate the success, partnerships in the supply chain of recovered materials came in handy. For instance, US-based American Chang Nam, Inc. serves of broker to Nine Dragons paper mill in China. This has allowed a stable business [Taylor, 2005].

Strategy B): Foldable containers

It is evident that if empty containers can be folded or collapsed and bundled together for transport, less transport capacity is needed and so transport costs per empty unit would reduce. As a result of the possibilities to bundle folded or collapsible containers opportunities for cost savings also arise in the transshipment process (economies of scale) and the storage at depots, because less space is needed.

However, using such containers would also bring along some additional costs in the transport chain (see [Konings, 2005]). First, containers must be folded and unfolded which implies additional manpower and usually demands for ancillary equipment (e.g. a forklift). Second, the exploitation costs of a foldable or collapsible container will be higher than a standard box, because of higher building cost (resulting into higher depreciation) and higher design requirements (resulting in higher repair and maintenance costs). Third, additional transport movements may be needed to places where folding and unfolding can take place. Analyses have been carried out (see [Konings, 2005]) in which these costs and benefits of foldable or collapsible containers have been investigated for different chains and compared with the situation in which conventional standard containers are used.

This study has shown that the use of foldable containers can lead to substantial net benefits in the total chain of container transport. However, it was also found that such containers have to cope with scepticism about their technical performance, the complexity of the folding and unfolding process in particular, as well as logistical and organisational problems with using these types of boxes. The current intermodal transport system is completely designed and optimised to the physical characteristics of the standard ISO containers. This is observed at container terminals at depots and as well at all the other links in the container transport chain. If the introduction of a foldable container requires a change in logistical processes this will be something difficult to overcome. All these aspect can explain why foldable containers did not achieve a structural and wide market application yet.

However, the starting point for a serious interest in using foldable containers will be its technological design. If the technical features, in particular the possibilities to fold and unfold

can be improved this automatically will also improve its economic performance in the transport chains. Part of this design challenges is also the use of light-weight materials in the construction, as heavy weight has appeared a major shortcoming in earlier designs of foldable containers. In developing new light-weight materials (so called composites) a lot of progress is made. The R&D results in this field could facilitate the development of light-weight foldable containers. In addition, the prices of standard containers are likely to increase due to increasing costs of its materials and components, i.e. steel and floor timber. This price development will also support the competitiveness of foldable containers.

Last but not least, there is an interesting role the container lease industry could play in paving the way for using foldable containers. As argued in Konings (2005b) there are reasons to assume that container lease companies have to broaden their services beyond the traditional leasing functions of supplying equipment. The foldable container could be such an asset to enhance their services beyond its present scope. In this perspective the lease company would also get a more active role in container repositioning.

In conclusion, to make the foldable or collapsible container a promising solution for reverse logistics of empty containers it seems that there is a great challenge in both product development and marketing (see also Konings, 2005b)

Strategy C): Information and communication technology

Investing in information technology can clearly contribute to the track and tracing of containers.

Real-time information can facilitate improved allocation of space in terminals, as well as the scheduling of operations, such as the unloading and loading of containers. This information can be fed into dynamic scheduling algorithms, decreasing throughput time, increasing productivity, and increasing efficiency throughout the whole supply chain. [Kia et al.,2000] compared the port operations, with and without advanced Information and Communication Technologies (ICT). The results of the simulation show that with ICT, there are savings to be made in human resources, and on land occupancy at the terminal, among others.

There are two major inhibitors with respect to investments in these technologies: one is the issue of privacy, and the other is cost. Some fear that the technology can be abused, e.g. by collecting information without permission or by disseminating sensitive information that can be used for dubious goals. Besides, the costs are currently rather high. Fingerprint scanners are about \$2,000 and hand scanners about \$3,000, excluding maintenance and software costs. Facial recognition technology can amount to \$15, 000 (in a facility for 30,000 people), and to those should be added surveillance costs [Rosenzweig et al., 2004]. As regards RFID technology large investments are needed to create the RFID infrastructure, but the cost of RFID devices is expected to decrease rapidly in the next few years, largely due to the increase in RFID system suppliers. RFID devices including active tags are now costing between \$50 to \$100, and in case of single-use devices about \$20. The target price, enabled by production in large quantities, is \$10 (Thorby, 2007).

However, real-time and accurate information on sea and terminal operations is valuable for more than just empty container management. The potential benefits include establishing adequate contracts, billing accuracy, reducing manual effort and human error, leveraging the quality of services (by enhancing control, early detection/action in case of disruptions, coordination (e.g. for inter-modal transport networks), and security. When the benefits are considered as a whole they are likely to justify investment in ICT. For instance, the U.S. Department of Transportation (see [VOLPE, 1999]) reports that cargo thefts amount to more than \$10 billion in merchandise loss. Criminal practices include 'hijacking' trucks from ports, stealing not only the cargo but also containers, as containerized cargo theft is often carried out by transnational criminal organizations, which will carry out the distribution of the goods in other countries. Actually containerization allowed thefts to dramatically increase the value of robbed merchandise, by simply stealing full containers with valuable cargo [The Economist, 2002]. Though there are special anti-theft locks for sea containers, there are always ways to tamper them. To this, modern technology can be of use. Seals can also be

RFID-enabled to detect whether, or not containers have been illicitly opened [Knott, 2004]. A study of RAND Corporation shows that theft is practically nonexistent when a track and tracing system is in place, such as a Global Positioning System (GPS) or a Global System for Mobiles (GSM), [Van de Voort et al., 2003]. Though to have such a system in place along the whole supply chain is capital-intensive, it increases security and avoids important disruptions.

Institutional engagement will certainly play a role on the future development of ICT. The U.S. Congress passed in 2002 the Maritime Transportation Act presupposing the implementation of a worker identification credential, which has led to pilot tests with biometric technology at U.S. sea ports.

However, there seems to be some lack of prioritisation of the issue [Biometric Digest, 2006]. In Europe, Viviane Reding, the Information Society European Commissioner is requesting a more active debate on the role of modern technologies, such as RFID [Pritchard, 2006]. Institutional leadership, not necessarily from governmental bodies, could be a facilitator and actually boost modern information and communication technology in maritime logistics.

Strategy/Evaluation	A) Balancing out trade with recycling flows	B) Foldable containers	C) Information and communication technology
Direct Benefits	. Balancing load . Higher fleet utilization . Added-value	. Less space	. Real-time info. . Optimisation (resource allocation and scheduling)
Requirements	. Diversification of clients' portfolio	. Assigning human resources to the folding process	. Specialized ICT expertise
Inhibitors	. Awareness of pollution in the Far East (and subsequent regulation)	. Weight (heavier than ISO containers) . Technical challenges System dominance of ISO-containers	. Privacy issues . High costs
Opportunities	. The current unbalance between supply of used materials (in the West) and the demand for it (in the East)	. Design innovation . Rising prices standard containers	. Additional benefits, such as with respect to enhanced security (a major global priority)
Facilitators	. Partnerships in the supply chain of recovered materials	. New materials . Development of new services by lease companies	. Institutional leadership . Cost decrease for some technologies

Table 1. An analysis of strategies for the management of empty containers

Table 1 summarises the direct benefits, the requirements, the inhibitors, related opportunities and potential facilitators of the three discussed strategies.

7. Conclusions and further research

In the previous section we identified direct benefits of the all three strategies presented in Section 4. In addition, on the one hand the pre-requisites and barriers were discussed, and on the other hand advantageous circumstances and facilitators were identified. However, to mitigate threats and to incite opportunities, additional research is needed. A close dialogue with stakeholders could do this, together with estimation of the costs.

Furthermore, there are other general inhibitors for efficient empty container management not strategy-specific. For instance, the way that some contracts are established between shippers and carriers contributes largely to uncertainty with respect to fleet capacity. [Foster, 2005] sheds some light on this by examining E.I. Dupont de Nemours & Co. contract negotiations. While Dupont commits to have transported a small part of its volume by a specific carrier, say 10%, the carrier will commit to transport up to a much higher value, say 60% of the shipper's volume. This brings uncertainty with respect to empty container requirements, which may lead to higher safety stocks and under-utilization. Here lies an additional opportunity for future research.

In long term perhaps the ultimate solution for the problem of container repositioning might come through the development of a synthetic frame that will be recycled after a loaded trip to avoid a long empty return trip (Van Driel, 2007). This would shed a new light on the reverse logistics management of empty containers. The integral costs and benefits of using such a device are very obscure yet, but it would be worthwhile to explore this innovation.

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