

Foldable Containers: a New Perspective on Reducing Container-Relocation Costs

Technological, logistic and economic issues

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There is little doubt that the requirement to reposition empty containers is one of the more persistent problems in the container transport industry, and is a key factor in cutting operating costs. Empty container transport involves high costs, particularly for shipping lines, since they generally bear these container management costs. Not surprisingly, shipping lines try to reduce the costs of moving empty containers as much as they can. Most strategies are focussed on improving the instruments to match cargo with empty containers. However, due to trade imbalances transport movements of empty containers remain to some extent unavoidable. Therefore, foldable containers seem an attractive option from the point of view of saving transport costs as well as handling and storage costs. So far, however, these containers have not been introduced successfully.

In this paper we analyse why previous initiatives for foldable containers failed and discuss the conditions required for successful commercial applications.

Although the economic advantages of foldable containers seem evident, we explain that these types of boxes have to cope with scepticism about technical performance, the complexity of the folding and unfolding process in particular, as well as logistical and organisational problems with using foldable containers.

Based on past experiences it is argued that the technical characteristics of foldable containers should be improved. Technological innovations form the basic condition to enhance the economic viability of these types of boxes, as well as gaining the confidence of potential users. The logistic concept according to which foldable containers are used proves decisive to overcome logistic and organisational barriers.

The most promising market opportunities for foldable containers are in logistic chains with a limited number of links within closed loops. In this situation there are expertise, experience and scale advantages in the folding and unfolding process and low organisational costs.

1. Introduction

The enormous improvements in efficiency in the transport of goods induced by the arrival of the maritime container are well known. Influenced by changing market conditions, as well as the growing awareness of environmental values, an important downside of containerisation becomes increasingly visible. This is the fact that the place where containers are unloaded and loaded is often not the same, so that transport movements of empty containers are unavoidable. On the world scale the imbalances in container trades are a familiar and obstinate problem. Consequently there are substantial flows of empty containers. Detailed statistics about these flows are difficult to obtain since actors consider these data commercially sensitive. Table 1 gives an impression of these flows on an aggregate level. It shows the share of empty container transport moved through the port of Rotterdam. The differences between trade lanes are considerable. It also indicates that imbalances in the import and export of containers are not just a matter of concern for shipping lines, but also for the competitive position of ports¹. The position of Rotterdam as regards its share of empty containers is not too bad compared to figures for the industry as a whole.

Table 1. Movements of containers per trade lane to/from Rotterdam (x 1000 TEU), 1999

Trade lane	To Rotterdam			From Rotterdam		
	Loaded	Empty	% Empty	Loaded	Empty	% Empty
Europe	869	279	24	1109	137	11
Africa	44	33	43	93	9	9
U.S. of America	324	66	17	363	11	3
Middle + South America	168	40	19	138	18	12
Asia	1244	72	5	946	222	19
Oceania	11	2	15	46	1	2
Total	2660	492	16	2695	398	13

Source: Statistics Netherlands.

Drewry Shipping Consultants (1999) estimate the share of empty containers at sea as 21% of all containers transported. For land transport the estimates are even higher (about 40%). The total costs to the industry of this inefficiency are of course even more difficult to assess. Drewry estimate the costs of interzonal positioning (i.e. movements including a significant

¹ Butt and Ogsten (1999) address these effects clearly and argue that imbalances in container flows are a particular problem for small ports.

sea voyage) in 2000 as 9.5 million dollars, taking an average of \$ 400 per container². Including intrazonal positioning (i.e. movements overland) would add another 5.2 million dollars (Drewry Shipping Consultants, 2001).

Not surprisingly, shipping lines are very keen to minimise the costs of empty container repositioning. Current strategies however do not include the foldable container, although it seems to offer interesting possibilities.

In this paper we analyse why previous initiatives for foldable containers failed and we discuss the conditions required for successful commercial applications.

In section 2 we briefly discuss the main causes of empty transport, followed by the most important strategies used to avert empty transport (section 3). In section 4 we describe two concepts of foldable containers, which have been introduced in the market, but have not so far been commercially successful. Based on practical experiences with these concepts and an extensive market exploration, critical success conditions are formulated for foldable containers (section 5). These conditions include the characteristics of both the product and the market. In the final section 6 the most promising market opportunities are summarised.

2. Reasons for transport of empty containers

Looking at the problem of empty container transport, there are several causes for the fact that containers have to make expensive, unproductive journeys, but most of these causes have their root in the dynamics of the world economy. Transport is a derived activity and therefore trade volumes determine the demand for transport. Since trade patterns are the result of developments in the world economy, economic developments determine the size and direction of cargo flows and put their mark on the volumes of empty transport. Financial economic events may have far-reaching effects, as has been illustrated by the Asian crisis, when the demand for slots in east- and westbound trades diverged dramatically. Vessel utilisation on eastbound shipments dropped from 85% in 1997 to 55-60% in 1998, while the westbound load factor reached 100% (Lloyd's Shipping Economist, 1998). Consequently, transport of empty containers to Asia increased enormously.

Furthermore, there are trades that suffer more or less with structural imbalances, such as the trade lanes to Africa. Here containerised cargo is predominantly inbound, the outbound containerised flows are rather small.

In addition to these conjunctural and structural causes there is the phenomenon of seasons, leading to cargo flows which temporally swell in one direction.

Finally, a matter which is also relevant, is the fact that different type of goods demand for different type of equipment, either as regards the dimensions of containers (20 ft, 40 ft containers, high cube containers, pallet wide containers) or the specific application possibilities (standard containers, reefers, tank containers etc.). This can also lead to imbalances and create a need for transport of empty containers³.

² This unit cost includes the handling costs in ports, as well as land transport, storage, damage, ships time and other indirect costs. This estimation is inevitably rough, to enable an estimation of total costs to the industry. Depending on circumstances (e.g. distance or mode of land transport) the unit cost may vary considerably.

³ In this context Thalenius-Adolfsson (1989) introduces the term "operational imbalance" for imbalances in the flow of equipment, which cannot be explained by imbalances in the cargo flow.

3. Strategies to reduce the costs of empty transport

The importance for a shipping company to manage its fleet of empty containers efficiently is very well addressed by Hultén (1993; 1997). Its importance derives from the cost and revenue structure of container liner shipping, which limits shipping companies to influence their profit margins. This is particularly true for the revenue side, where freight rates are strongly determined by market forces. Due to these conditions there is a strong emphasis on cost efficiency, in which equipment management, including positioning and storing, is considered a very important part of competition. Since freight rates have tended to fall over the last decade and the costs of repositioning empty containers are high, container management has become an even more serious matter for shipping lines. To control the costs of empty transport a number of strategies are being used.

The most simple and effective method is to make use of spare ship capacity: empty slots can be filled with empty containers. At first, capacity of the own fleet will deserve consideration, but free slots of other shipping lines are also sometimes used. The possibilities for this strategy obviously strongly depend on the specific market circumstances within a trade lane, among which the number of line services of the different shipping lines is important.

The success of reducing empty transport is strongly related to the scale of operations. The larger the fleet, the larger the number of slots and services available and the larger the network (economies of density), the greater are the variety and opportunities to 'eliminate' empty containers from surplus to deficit areas (so called route triangulation). Creating carrier co-operations and alliances enhance these kind of opportunities. Deficits of one shipping line can be eliminated by the surplus of another line. Interchange of equipment and far-reaching co-operation by means of common use of equipment (the so called grey box phenomenon) fit into this strategy. For example, P&O Nedlloyd has interchange agreements with 35 shipping lines, in order to be able to have the required equipment world-wide easier, i.e. faster and cheaper (Compuship, 2000).

Another key element in reducing the costs of imbalances is pricing. Different options exist. A well-known strategy is simply to impose a freight rate surcharge on the high demand leg to compensate the repositioning costs in the other direction. Part of the repositioning costs is then shifted on to the shippers.

Sometimes, pricing policies are used to give shippers incentives to use specific types of equipment. This may vary from lower rates to encourage shippers of lightweight cargo to use a 20 ft box or for a 40 ft box to be partly filled by heavier cargo, or even 'substitution' whereby a shipper is offered a larger box for the same price of a small box (Lloyd's Shipping Economist, 1997). Such pricing strategies are used in trade between North Europe and the Far East for example. Here 20 ft containers dominate the route from Europe to the Far East, while 40 ft containers are preferred in the route from Far East to Europe. This discrepancy has to do with differences in cargo weight on these routes.

It is generally known that agreements are sometimes made with inland transport operators, who might, in exchange for free repositioning the container, use the container themselves for back haulage (container cabotage).

In addition to the scale of operation, information about cargo and containers is crucial. More sophisticated and extensive computer systems have helped enormously in bringing the scope for more potential matches. The use of in-house computer systems to match cargo and containers has become wide established. Of more recent date are computer systems, which

should bring about matches between shipping lines. The possibilities of Internet have given these systems a new dimension: virtual wide accessible auctions emerged, aimed at bringing supply and demand for containers together easier. Although first this facility suffered from much scepticism, interest is now rapidly increasing. These facilities mostly find their market at small and medium-sized shipping lines. Often the large shipping lines have better opportunities to match containers within their company. Furthermore, not participating in these auction practices avoids giving smaller competitors any commercial advantage.

One step further in applying information technology (IT) is the use of container-intelligence: satellite devices installed on containers, which enables shipping lines to track the containers accurately. Such developments, whereby satellite container tracking is used for container management purposes, is still in its infancy (Cargo Systems, 2000). Costs of satellite tracking are still a major barrier to use, but it is expected that within a couple of years containers will be equipped with IT-facilities in certain market segments (Compuship, 2000).

Another more drastic way of keeping repositioning costs down is to drop and sell the empty containers in the surplus areas and to buy containers in the deficit areas. Encouraged by the current very low purchase price of containers this is an emerging phenomenon, which might be more beneficial than repositioning. The chronic imbalance in container movements to/from China are for instance being alleviated in this way (Lloyd's Shipping Economist, 1997).

It is not only shipping lines that have interest in reducing empty transport. Container lease companies and shippers have great interest as well. Shippers and shipper organisations are sometimes very active in generating cargo flows in the 'dead leg' of an imbalanced trade, in order to mitigate rate increases in the high demand leg. Import and export groups combine their operations and book shipments in both directions in unbalanced trade lanes, helping carriers cut container repositioning costs in return for lower freight rates (Journal of Commerce, 1999).

From this brief survey we can conclude that the current strategies are mainly focussed on avoiding transport movements of empty containers. These strategies, except for utilising spare ship capacity, however do not influence the actual transport costs of empty containers. From this perspective the foldable container could be an interesting addition to the strategies used, particularly because empty transport can never be completely eliminated (see section 2).

The potential cost savings of foldable containers however extend beyond low transport costs. If empty containers can be handled as one package, the shipping lines can save terminal handling costs and, since foldable containers require less space, the storage of empty containers also provides cost savings. Nevertheless there are obviously hacks and eyes on using these containers successfully. A closer look at previous initiatives might bring us to the barriers to overcome.

4. Concepts of foldable containers: lessons from past experiences

The idea of foldable containers is not so new. In the past several designs have been proposed. The majority of these ideas however never passed the phase of patent granting (see Binsbergen et al., 2000a). Only two concepts have achieved the phase of pilot/testing and

market introduction and are currently still available⁴: the Six-In-One container and the Fallpac container.

Six-in-One container

The Six-in-One (SIO) container is a fully dismountable 20 ft dry freight box that once dismantled, can be folded, stacked six high and interlocked to the exact dimensions of a standard 20 ft x 8 ft x 8 ft 6in container. It was launched about sixteen years ago by Six-in-One Container Co (SCC), a Swiss concern with a marketing base in France. Since introduction about 2000 units have been manufactured. A shortcoming of the first series of the SIO was its maximum gross weight of 20 tonnes, while standard boxes have a gross weight of 24 tonnes. In the next generation, the carrying capacity was increased to 24 tonnes, which left only one significant difference with the standard 20 ft container: the higher tare weight, which is about 500-600 kg heavier for the SIO.

The most striking characteristic of the SIO is the absence of hinges, other than the standard door hinge. The SIO incorporates seven separate elements with locking devices. Simple production and reduced manufacturing costs were important motives to choose for this construction based on dismountable parts. Avoiding the use of hinges was believed to be a key factor for success, because of well-known problems with hinges (i.e. corrosion, frost, bending).

In figure 1 the main steps of the (un)folding procedure are shown. To fold a container a three-person team with a forklift is required. SCC claims this process takes approximately 15 minutes. To simplify and speed up the mounting/dismounting process an assembly jig was designed, enabling handling productivity to increase from four to six containers per hour.

Initially, SIO containers were only available for sale. In order to market the product more successfully, containers could also be leased from the early 1990s. In addition, the SCC company was willing to organise/operate the assembly and dismounting processes. In this way containers could be delivered erected to the shipping line user, so the customer would notice almost no difference in using a standard box or SIO container.

Although 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 - one can not speak of a great success. Their market share is far too small compared to conventional container volumes.

To find out the reasons for the lack of market penetration, several experts were interviewed, including representatives of companies that used the SIO. Practical experiences demonstrate that particularly the costs of folding and unfolding the container are a strong barrier. In practice folding and unfolding takes far more time than claimed by the manufacturer. To insert the walls and doors is a time-consuming and difficult process, particularly when parts are slightly damaged.

⁴ The Pack Flat collapsible container design of the Australian company Magnatek underwent testing in the very early 1990s (see Cargo International, 1990; 1991; 1992), but there have been no reports about manufacturing since then. Its design incorporates a unit with smooth outside walls that can be collapsed inwards through a hinge mechanism. The collapsed units can be stacked and locked together with integral twistlocks, allowing a four-unit block to be moved by common cargo-handling equipment.



Source: SCC Six-In-One containers company S.A.

Figure 1. The folding process of the Six-in-One container

Vulnerability to damage proves to be a serious concern for potential users, particularly because these kind of containers are often used in areas where containers are usually less carefully handled. In addition, theft of container parts is a serious problem in certain areas (i.e. Third World countries). According to companies, susceptibility to damage and theft make this system vulnerable.

Furthermore, companies are of the opinion that the purchase price of the SIO is too high. Compared with the standard box prices, which have dropped enormously over recent years, the SIO is about 3.5 times more expensive. However, one can debate this argument by considering the exploitation costs of the container in relation to the total costs of the container logistics (see Binsbergen et al., 2000b).

Last but not least, problems may arise regarding the integration of the SIO in the existing logistic chain. Most striking are the equipment problems existing container depots might have in handling a bundle of SIO containers, whose handling requires more time and space.

Fallpac container

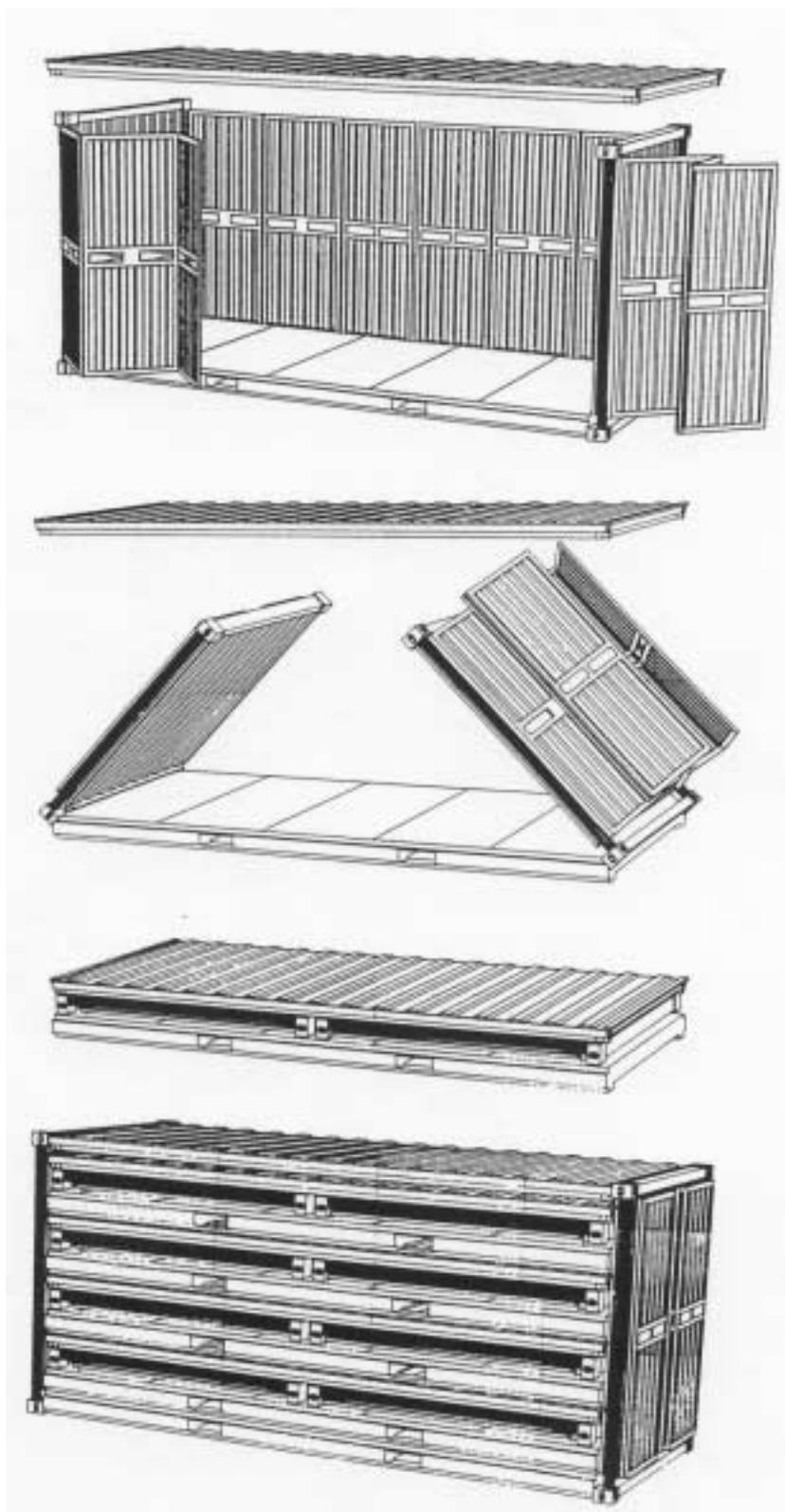
The folding technique of the Fallpac container is quite different from that of the SIO container. The Fallpac is a 20 ft dry freight box which combines dismountable and collapsible features. The roof of the container is dismountable, the remaining elements are foldable. Four folded units can be stacked inside a fifth assembled unit for empty transport (see figure 2). In this way the Fallpac container has also the same dimensions of the 20 ft standard box.

The maximum gross weight of the Fallpac container conforms to ISO standards (24 tonnes), but its tare weight is approximately 4000 kg, which is about 1700 kg heavier than the standard 20ft container.

To fold or unfold the container two people and a forklift are required. According to the Swedish manufacturer (Fallpac AB), the box can be folded within 10 minutes. Because the folding technique incorporates folding side doors, the container is suited for side loading as well as end loading. In the original design there was a problem with leakage through the side doors, but this has been solved in the more recent design.

The first Fallpac container dates from the mid eighties. Since then some design changes have been introduced. In addition to the basic design a prototype of a fully-automated version has been launched recently. For the manual version a small test series of containers have been produced and tested with customers, including Swedish Rail. These tests took place many years by now and did not result in succession. Technical problems or serious disadvantages have not been reported, except its high tare weight. Serious problems with the hinges have been reported neither. The successful flat racks might have served as a good example for the folding technique that has been chosen. However, experiences with the Fallpac have been small-scale.

The high tare weight might be an obstinate barrier itself, particular as it comes to transporting and handling a bundle of empty containers. This indicates possible problems of integrating the container in existing logistic processes: this seems not only a problem for the Fallpac, but for the SIO container too. Last but not least, it seems that the very limited application of the Fallpac can be attributed to little marketing and insufficient promotion of the distinct features of the concept.



Source: Fallpac AB

Figure 2. The folding process of the Fallpac container

5. Conditions for a successful concept of foldable containers

The conditions for the success of foldable containers are related to three aspects: the costs and quality of the product, the market orientation, that is to say, the logistic concept that is used, and the marketing of the product.

5.1 Product characteristics: costs and qualities

Low costs for folding and unfolding the containers.

Folding and unfolding containers implies additional handling (manpower) and usually demands for ancillary equipment. Cost savings elsewhere in the logistical chain should compensate these additional costs. In other words, there is a trade-off between the cost savings of using foldable containers and the additional costs they bring about in the logistical chain. The net result, and therefore the success of foldable containers, will strongly depend on the time and costs involved with folding and unfolding. This influence of the folding costs on the cost competitiveness of foldable containers is further explained in Annex A with a quantitative example.

Low manufacturing costs (purchase price).

Because of the more complex construction of a foldable container the manufacturing costs will be higher than for a standard box. It is true that these additional costs can apparently be earned back easily through substantial savings in empty transport. However, it is important to consider revenues too. The turnaround time of a standard box is much shorter than for a speciality, such as a foldable container. In other words, the revenues of a standard box might be greater than a foldable container due to higher container productivity. This can be explained by the comparative advantages of standard boxes in multi-trade operations. This means that the manufacturing costs of a foldable container should be in proportion to those of a standard container, and moreover, should be related to the life span and the costs of folding and unfolding (see Binsbergen et al., 2000b and Annex A).

Compatibility with existing equipment for intermodal transport.

In order to compete with standard containers, foldable containers should offer the same transport opportunities. To have the same system advantages as standard containers, the technical characteristics of foldable containers should conform to the norms and features of standard containers. These characteristics concern:

- *The external dimensions and gross weight* in the unfolded state;
- *The strength and stiffness*: in order to stack containers in unfolded state and to stack a bundle of foldable containers;
- *Watertightness*: to avoid cargo damage;
- *The presence of corner fittings at the bottom and top* of the container;
- *The ability to merge folded containers to a bundle with external standard dimensions* in order to achieve scale advantages in transport and transshipment;
- *The ability to lift a bundle of folded containers on top* in order to have the same possibility for handling as the standard container;

- *Simple and effective consolidation of a bundle of folded containers* in order to have a safe handling process.

Specific technical features.

In addition, there are several technical features, which are important for a technical efficient functioning of the system:

- *Robustness for damages*, particularly in terms of robustness to the folding and unfolding process. The larger the risk for damage, the more vulnerable the system is;
- *Avoiding loose parts* to prevent theft and loss;
- *Use of high-quality joint- and hinge constructions*. Moving parts bring about a higher risk for damage: corrosion, sand and frost are potential causes of damage, especially if containers are used world-wide;
- *Simple and safe bundling of a package of empties*. It should be possible to bundle empty containers quickly and easily into a package that can be handled safely. Systems using safety catches to lock containers with each other may experience problems, which are typical for moving parts;
- *Simple folding and unfolding*, assuming that a minimal level of know how is required to fold and unfold a container adequately. This reduces the risk of damage and simplifies repairs where needed. These conditions reduce the vulnerability of the system. A simple folding process is an important condition for the wider application of this container.

Finally, as regards maximum payload restrictions, *the tare weight deviation of the standard container* is important. Because of constructive requirements, a higher tare weight of the foldable container seems unavoidable. It is true that in transport the maximum volume is usually the limiting factor and not the maximum weight (see also Van Leewen, 1999), but for heavy cargo predominantly 20 ft containers are used. Therefore, to have wider application possibilities for a 20 ft foldable container minimal concessions regarding the payload should be made. This supports a need to investigate the possibilities for lightweight materials in construction.

5.2 Market orientation: the choice of the logistic concept

An important aspect affecting the performance of the foldable container is its application. This not only determines the cost-effectiveness of the container, but also makes demands on the arrangement and organisation of the logistic chain. On the basis of the number of links in the logistic chain in which containers are used in the folded state, the following logistic basic concepts can be distinguished (see also figure 3):

- I. Port-to-port concept
 - one sea trade lane: point to point transport
 - long distances
 - over sea (deep sea)
 - transport of folded containers between two seaports (container depots)

- II. Maritime worldwide concept
 - repositioning between continents: trunk routes, coarse-grained network
 - long distances
 - over sea (deep sea)
 - transport of folded containers between seaports (container depots)

- III. Maritime/continental worldwide concept
 - repositioning within and between continents: coarse-grained network
 - long and medium length distances
 - over sea (deep sea + short sea) and/or overland
 - transport of folded containers between seaports, between seaports and container depots in the hinterland, between container depots in the hinterland

- IV. Door-to-door worldwide concept
 - transport between and within continents: fine-meshed network
 - long and medium length distances
 - overland and over sea
 - transport of folded containers between customers and container depots in the hinterland, between container depots and seaports and between seaports

The simplest concept is the port-to-port concept (I). The main characteristic of this concept is that it is directed towards client specific solutions for a specific trade lane. Trades with a permanent imbalance make up the most important area of application. The foldable container ensures a more efficient return journey for the container. The containers are increasingly set on one and the same route (point to point transport), so that certain expertise can be built up in the folding and unfolding of containers. In connection with diffuse and relatively thin return flows to the shipment port, the seaport is the most suitable location for joining together the empty containers (a port-to-port concept). The utilisation area has the character of a niche market; the transport volumes are modest. The character of the trades is such that the container will usually only be used for a restricted category of products. The number of parties involved in the logistic chain of the foldable container can be quite small (e.g. one shipping company, two terminals, two seaport depots).

The maritime/worldwide concept (II) is particularly concerned with the repositioning of empty containers between continents. It is assumed that a large number of containers are used (large transport volumes) and that the containers are suitable for the transport of many sorts of products. The number of involved parties in the logistic chain of the foldable container may be quite small (e.g. shipping companies, terminals, seaport depots). The number of involved parties depends on the number of shipping companies making use of them and the number of ports used in the concept.

The maritime/continental - worldwide concept (III) is one where further optimisation of the repositioning is contemplated, because the movement of empty containers within continents is also included. As a result, the number of involved parties in the logistic chain of the foldable container becomes large (e.g. shipping companies, terminals, seaport depots, inland operators and inland depots). Such a concept also assumes that a large number of containers will be used (large transport volumes) and that the containers are suitable for the transport of many sorts of products.

The door-to-door-concept (IV) assumes that, wherever convenient, empty containers will be transported in the folded state. The containers can be assembled and disassembled anywhere and so in principle will therefore be used worldwide, even though this concept can also be used as an extension of the port-to-port concept. The number of containers in this concept need not necessarily be large, any more than the requirement of suitability for many sorts of products has to be met. The number of involved parties in the logistic chain of the foldable container is actually very large (e.g. shipping companies, terminals, seaport depots, inland operators, inland depots and shippers/receivers of goods).

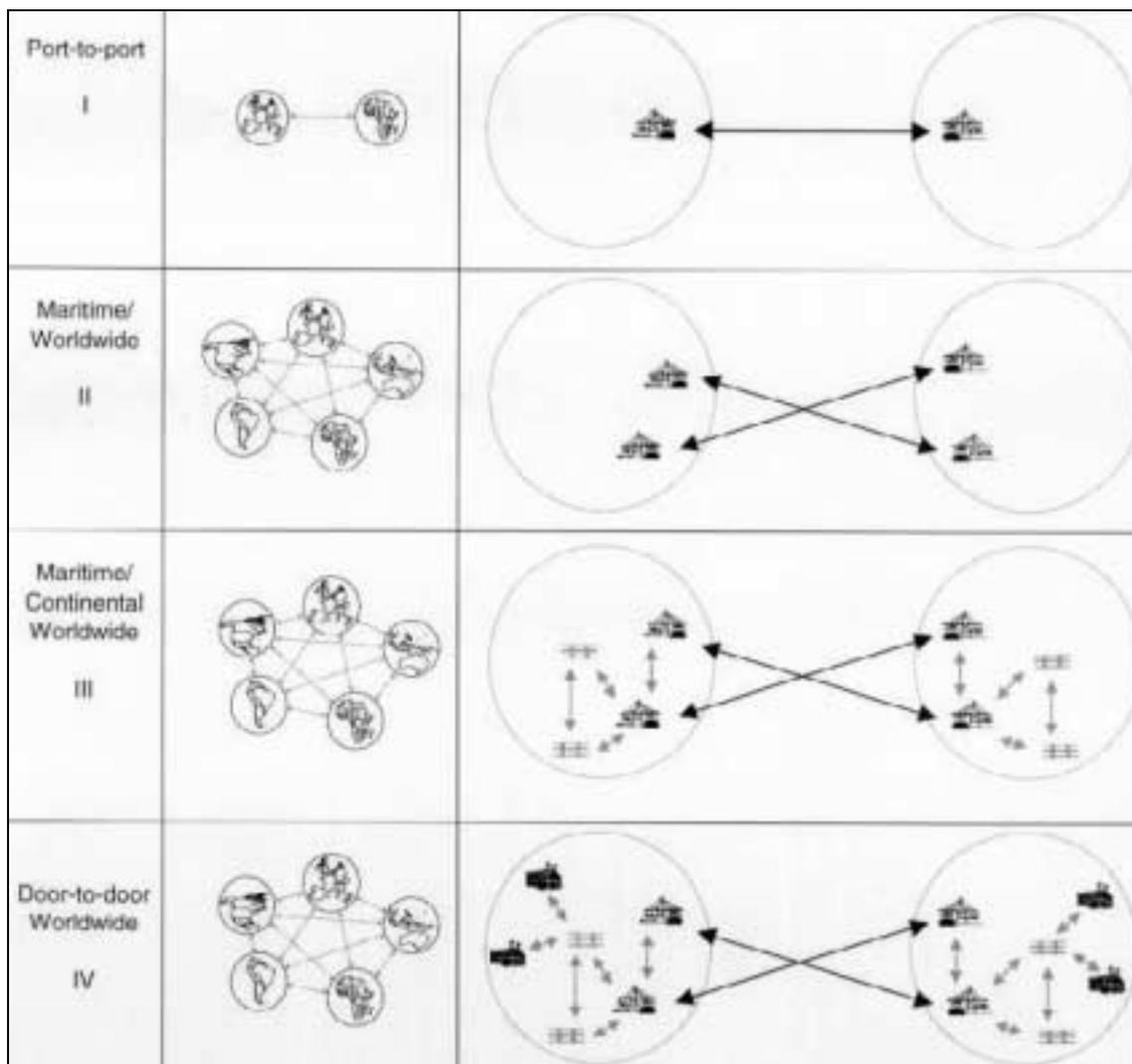


Figure 3. Logistic concepts for the application of foldable containers

The above-mentioned concepts differ on some important aspects:

- *Type of network*: ranging from point-to-point relations (concept I) to a fine-meshed network (concept IV). This implies different requirements regarding the transport volumes.

An important condition for achieving savings is for the transport volumes of empty

containers (in size and direction) to be of an order that facilitates the necessary bundling. The greater the extent to which foldable containers are used into more complex and fine-meshed networks, the more difficult is this to achieve. These conditions are most favourable in a port-to-port concept.

- *Number of places and locations where containers are folded and unfolded:* at depots in seaports, at depots in the hinterland or at the place of the shipper/consignee. These aspects are relevant for possible scale advantages in folding and unfolding and will influence the technical requirements of the containers. Scale advantages are conceivable in the concepts I, II and III in the folding and unfolding of containers, because these activities are concentrated at depots, where expertise and experience in folding containers show up very well. Initially it is important that existing equipment at depots can be used, so that the containers can be integrated relatively easily in the existing processes at a depot. Depending on transport volumes, economies of scale can be increased by investing in special equipment for folding and unfolding. Given the transport volume, such investments become economically more feasible as folding and unfolding takes place at a limited number of locations in the chain. Shippers and consignees often do not have heavy handling equipment available. Therefore in the door-to-door concept (IV) only simple equipment should be required, and moreover, the container should be foldable without requiring too much knowledge and experience. However, this will impose high technical design requirements on the container.
- *The number of actors involved in the logistic chain:* ranging from a few (concept I) to many (concept IV). As the number of actors involved in the logistic chain increases, the transport organisation becomes more complex. By using foldable containers in (more or less) closed logistic chains, the involvement of many actors can be avoided. Therefore, the chain control over foldable containers becomes simpler.

5.3 Product marketing

Being major potential operators of foldable containers, marketing to shipping lines and/or container lease companies seems most obvious. There is a major task for the manufacturers of foldable containers to polish the negative image and to convince potential users of system benefits. The potential savings in transshipment and transport costs offer a substantial financial margin for a container design, which might have commercial perspectives (see Annex A). However, substantial marketing is required to change the perception of shipping lines on these savings.

Another difficult obstinate phenomenon is the conservative attitude within the transport industry, which can be largely explained by market forces. The competition is very intense and as a result the profit margins are often small. This mitigates the willingness to invest, particularly in less well-known developments.

In addition, the influence of the standard container on the arrangement of industrial processes should not be underestimated: because of scale advantages industrial processes are optimised to the physical characteristics of the 20 ft and 40 ft standard containers. This is observed at container terminals as well as at depots, but also in the whole organisation of transport in which containers are used. This reinforces an inertia to change logistical processes. Under

such circumstances pilot projects are not just instructive, they are necessary to achieve innovations in a complex transport environment.

Of course the merits of foldable containers could be tested in a small pilot, but the real system benefits will only show through above a certain threshold transport volume. Therefore it is important that potential users can also lease the foldable container instead of buying them. In this way the investment risk for the users are reduced to a minimum, and the threshold for trials is scaled down.

6. Conclusions

Transport of empty containers is an expensive business, particularly for shipping companies who are usually responsible for container repositioning and have to bear these container management costs. Reducing these costs involves a number of strategies. A common characteristic of their strategies is optimising matches of cargo and containers in order to avoid (long distance) empty transport. Without doubt these strategies are successful, but to some extent empty transport cannot be avoided because of trade imbalances. Foldable containers offer the potential to save transport, transshipment and storage costs, but so far they have not proved an attractive proposition.

Although the economic advantages of foldable containers seem evident, these types of boxes have to cope with commercial scepticism. This attitude concerns the technical performance, the complexity of the folding and unfolding process in particular, as well as logistical and organisational problems with using foldable containers.

Experiences with previous initiatives, the Six-In-One container in particular, indicate that this attitude is justifiable and that the technical features of foldable containers should be improved (i.e. the folding and unfolding). Here lies an important technical challenge for designers and container producers to develop a container that can be folded and unfolded easily.

Technological innovations form the basic condition to enhance the economic viability of these boxes, as well as gaining the confidence of potential users. The logistic concept according to which foldable containers are used, proves decisive to overcome logistic and organisational barriers.

The most promising market opportunities for foldable containers are in logistic chains with a limited number of links within closed loops. In this situation, expertise, experience and scale advantages regarding the folding and unfolding process can be used and the bundling of empty transport flows can be done with low organisational costs.

These conditions inevitably impose a number of restrictions to the areas of application. So the foldable container may have to resort to a niche-market. Nonetheless, there are trade lanes with permanent imbalances, where foldable containers may be ideally suited. As the transport volumes of empty containers increase some of the objections may diminish, because foldable containers could increasingly benefit from scale advantages and the use of foldable containers could further expand, even into more fine-meshed networks.

However, reducing market scepticism requires more than improvements to the container features. Product familiarity and a low threshold for use, for instance by offering leasing possibilities, are important aspects in achieving use at a larger scale. Herein lies a major marketing task for the container manufacturers.

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Annex A. Financial margins in the use of foldable containers

To explain to what extent additional costs of foldable containers are acceptable while remaining competitive with the standard containers, some cost-benefit results are presented here as a case study. The calculations apply to a transport chain in which foldable containers are used in a port-to-port concept⁵ (see section 5.2). This case aims to give an indication of the potential cost advantages, given the fact that a transport chain can be defined very well, but that it may often be subject to, unpredictable, changes in daily practice. In order to obtain cost data that represent common practice several companies from the container industry have been consulted. Based on their information the following general assumptions are made:

- There is an imbalance in cargo flows so that empty containers have to be repositioned over sea (deep sea).
- Duration of sea leg: 20 days (single journey).
- Duration of land leg: 20 days (total of both land sides).
- Container depots in seaports are situated in the direct vicinity of the seaport terminals.
- The average distance between shipper and port of origin: 400 km.
- The average distance between port of destination and consignee: 400 km.
- Inland transport takes place by road transport.
- Exploitation costs per container: US \$ 1 per day.
- Terminal Handling Charges: US \$ 100.
- Cost of transport from terminal to depot: US \$ 25 per container.
- Tariff for depot receipt or discharge: US \$ 10 per container.
- Tariff for depot storage: US \$ 0.50 per day.
- Average duration of an empty container in the depot in one chain cycle: 10 days.
- Sea ship is of average size; slot costs per TEU: US \$ 15 per day.
- Overhead costs (administration and so forth) of sea transport: US \$ 50 per container.
- Empty standard containers are not temporarily stored in depots in the surplus area, but are returned immediately to the terminal for their journey back to the deficit area.
- For temporary storage at the terminal the free standing period can be used: there are no additional costs.

⁵ This concept will provide the most conservative estimation of benefits, because empty containers are only transported by sea in their folded state.

Table A1. Chain costs for the transport of a standard and foldable 20 ft container according to the port-to-port concept (in US dollars)

Activities	Standard container US \$	Foldable container US \$
Movement costs:		
1. Unfold container		F
2. Depot discharge (<i>as a standard container</i>)	10	10
3. Transport port – shipper (empty)	275	275
4. Transport shipper – port (full)	275	275
5. THC (full)	100	100
6. Sea transport (full)	350	350
7. THC (full)	100	100
8. Transport port – consignee (full)	275	275
9. Transport consignee – port (empty)	275	275
10. Depot receipt (<i>as a standard container</i>)		10
11. Fold container		F
12. Depot discharge		> 2
13. Transport depot - terminal		T
14. THC (empty)	100	20
15. Sea transport (empty)	350	110
16. THC (empty)	100	20
17. Transport terminal – depot	25	5
18. Depot receipt	10	> 2
19. Storage (empty)	5	1
Container costs:		
Exploitation costs	60	60 + E
TOTAL	2310	1890 + 2F + E + T

In table A1 the total chain costs, divided according to activities, are shown. Further details about these cost elements can be found in Binsbergen et al. (2000b).

With respect to the use of foldable containers the following specific assumptions are made:

- Five empty foldable containers can be bundled into a unit the size of one standard container.
- The receipt and discharge of a package of folded containers puts greater demands on the equipment at the depot and requires more supervision activities (e.g. inspection); moves at the depot become relatively more expensive (activity 12 and 18).
- Inspection activities with respect to incoming or outgoing unfolded containers belong to the process of folding and unfolding (activity 11 and 1); there is therefore no reason to suppose that the costs of depot discharge (activity 2) or depot receipt (activity 10) would alter.
- Although the costs for the maritime shipping company of the sea transport of empty containers are frequently assumed to be close to zero, a correct assignment of sea transport costs requires the inclusion of the slot cost per TEU⁶: US \$ 60 (= 300/5).

⁶ When the ship is only partly filled with full containers, the marginal costs to transport empty containers are small. The ship has to sail anyway and empty containers merely use spare capacity. However, this is a short-term view. In the long run all costs must be covered.

- Associated overhead costs for the sea transport (administration and so forth) remain the same for folded and standard containers (US \$ 50).
- Insofar as the costs of depot storage (19) are exclusively determined by the space taken up, the storage costs for empty containers then decline by a factor of five.
- The stevedore’s handling costs for a package of folded containers are the same as for one standard container.

In this example the costs and benefits for the chain as a whole are as follows:

- The potential chain savings amount to US \$ 420 and are built up as follows:
- Sea transport: US \$ 240 (opportunity costs for a shipping company).
- Terminal Handling Charges (THC’s): US \$ 160 (2 x US \$ 80).
- Transport from terminal to depot: US \$ 20.

These benefits of US \$ 420 must be capable of covering the following costs:

- The costs of folding a container (plus the associated inspection costs and so forth) (F).
- The costs of unfolding a container (plus the associated inspection costs and so forth) (F).
- The additional exploitation costs of a foldable container (on the basis of 60 days’ use) (E).
- The costs of any transport between depot and terminal in the surplus area (T).

Since the exploitation costs and costs of folding and unfolding are design dependent and a certain trade-off between these costs exists, it is difficult to estimate these costs. However, the margins for these costs can be indicated.

Table A2. Break-even costs (in US dollars) for folding and unfolding a container for different purchase prices of foldable containers, turnaround rates (# cycles/year) and costs for transport from depot to terminal

purchase price (US \$)	4000			5000			6000		
	4	6	8	4	6	8	4	6	8
number of transport cycles/year									
transport costs depot – terminal (US \$)									
0*	177	258	298	115	217	268	95	177	238
50	127	208	248	65	167	218	45	127	188
75	102	183	223	40	142	193	20	102	163
125	52	133	173	loss	92	143	loss	52	113

* Container depot is located at the site of the seaport terminal

Table A2 shows how much the folding and unfolding may cost for the chain costs to equal the costs for the use of standard containers, for various circumstances regarding the exploitation costs of the container (which is assumed to be a linear function of its purchase price), the turn-around rate of the container and the cost level of supplementary transport to locations where containers can be folded and unfolded. For example, lets assume that the purchase

price of a foldable container is \$ 6000, the container can make six transport cycles a year⁷ and that folding and unfolding the container can take place at the site of the seaport terminal. Under these conditions, folding and unfolding the container may cost \$ 177 per roundtrip to have equal chain costs of using a standard and foldable container. In other words, these are the costs for which the foldable container would be competitive to the standard box⁸.

From table A2 it follows that the higher the purchase price and the higher the transport costs between depot and terminal⁹, the smaller the financial margin for folding and unfolding, while the higher the container productivity the larger this margin. Finally, it is interesting to note that although the purchase price might be high and costly transport to a depot might be needed, high container productivity could still give the foldable container a competitive edge.

⁷ The number of transport cycles depends on the turnaround time of the container, which is defined by Jarke (1981) as the time from when a container is sent to a shipper for stuffing, to when it has returned to the same area and is once again sent to a shipper.

⁸ Based on costs of operational processes only. It can be expected that using foldable containers leads to some additional overhead costs (i.e. organisational costs), but these are difficult to estimate.

⁹ That is to say, the longer the distance from terminal to depot where containers can be folded and unfolded.