Commercial Viability of Foldable Ocean Containers

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***Abstract*—This study investigates the commercial viability of foldable containers from a carrier's perspective. A cost-benefit and sensitivity analysis is conducted for operating regular and foldable containers over their respective lifespans. Results suggest that the case for foldable containers is compelling and savings of over 50% are viable, even after taking into account the higher upfront purchase cost, higher maintenance costs and lower expected lifespans of foldable containers. If used in inland intermodal operations, savings of over 60% can be achieved. However, the benefits that can be realized from foldable containers are contingent on their ability to withstand the rigors of ocean voyages. This study also does not address benefits related to time-savings, such as during the stowing, stacking and ship berthing activities. Should foldable containers prove feasible operationally, they have the potential to emerge as a truly disruptive innovation in the container shipping industry in the coming decades. While savings of up to 75% from foldable containers is widely mentioned, the complete cost trade-offs have often been neglected in the extant literature. This paper shows that 50% to 60% net savings is much more realistic.**

Keywords— Foldable container, shipping, ocean carrier, empty repositioning, intermodal

I. Introduction

Due to globalization, international trade has increased substantially in the past 15 years. Given Asia's role as a manufacturing base for the global economy, increasingly more exports are shipped from China and other parts of Asia to the rest of the world. Although around 2 million twenty-foot equivalent units (TEU) of ocean containers are manufactured yearly, the number of empty containers being repositioned back to Asia has risen in tandem with the volume of containerized exports. This contributes greatly to the increasing overall operations cost incurred by container carriers.

The global cost of repositioning containers is huge. According to Drewry Maritime Research (2015), in 2013 and 2014, 24% of all containers handled by port terminals as well as those transported from port to port are empties A report by the United Nations estimates that each empty movement (covering terminals, box hire, damage, storage, etc.) costs US$400 per TEU for carriers and therefore imbalance costs are $20 billion in 2009. Landside repositioning of empty containers would contribute another $10.1 bllion. The total cost of repositioning would therefore reach $30.1 billion or 19 per cent of global industry income in 2009.

There are four main factors explaining why several transport flows are empty: imbalanced flows, cargo and equipment specialization, short hauls and regulatory constraints (Rodrigue, 2013). Several interesting strategies have been mooted to reduce the cost of imbalance. Maersk Line reported that the use of 'Non-Operating Reefers.' (a reefer container that is used to ship dry cargo) has helped Maersk save approximately USD $50 million in 2011 (Churchill, 2012). Such a strategy is however limited to trade lines for which there is an imbalance of containers for reefer and non-reefer containers in the opposite direction, such as Asia-South America. Some industry players have also proposed the "grey box" concept to pool containers among various carriers to reduce the need for repositioning. For instance, Jahn & Schlingmeier (2015) found that six percent of imbalances are company-specific, hence avoidable.

Another innovation that is at least decades old (but only gaining traction in the past 3 years) is that of the foldable container. No innovation in the container shipping industry is probably more potentially disruptive in the foreseeable future. The benefits of foldable containers are numerous in theory. They can not just help reduce transportation costs (Konings & Thijs, 2001) but also alleviate space constraints at sea ports (Bandara et al, 2015).

Miller (2010) : Cut cost of moving empties by 75%. Foldable containers would cost at least US$4,000 each, roughly double the cost of normal containers. Stacked 10 high and withstand 350 tons of weight. 100 million container movements a year, but 20% of containers at seas at any one time are travelling empty, due to imbalance in trade. Several designs have been proposed.

It would appear that most technical challenges related to foldable containers will soon be (if not already) solved. The challenges of folding/unfolding are not insurmountable and most new designs can be folded by a two or three-person team with a forklift (Konings, 2012). It should also be noted that folding is not new to the industry, as flat racks (which are used to transport vehicles) are also routinely folded. Cost (initial as well as operating) and lifespan are among the greatest uncertainty that hinders the adoption of foldable containers. Current estimates of the cost of foldable containers vary widely, from 130% that of regular, non-foldable containers (Staxxon), twice (Miller, 2010) to “three to four times” (Konings, 2012).

The concept of foldable storage is certainly not new. A good example exists in the bulk shipping industry, in which Goodpack (www.goodpack.com) has pioneered the metal intermediate bulk container (IBC) commonly used for the shipping of natural and synthetic rubber. In use for at least the past 20 years, IBCs are each approximately the size of a pallet and stackable. When these IBCs are repositioned, their side-walls are collapsed onto the base and stacked for shipping. In the collapsed state, each 40-foot container can hold up to 192 IBCs (versus 32 in the uncollapsed state)

There have been several similar attempts in the container shipping industry since the 1990s.. Examples include Fallpac, Six-in-One (SIO), Cargoshell, 4Fold by Holland Container Innovations and Staxxon. The first 4 designs rely on the horizontal folding technique, in which side-walls are folded downwards or can be detached to lay flat with the roof and floor pieces. The latter relies on a vertical folding technique such that the roof and floor pieces are collapsible (much like an accordion). Of these, Staxxon (www.staxxon.com) and 4FOLD (www.hcinnovations.nl)) appear to be closest in the path towards commercial adoption. Staxxon’s ISO 20ft container obtained its received a Convention for Safe Containers (CSC) Certificate for its folding container design while in 2014, Holland Container Innovations claims that its 4FOLD foldable container is the first 40-foot high-cube (40HC) foldable container that is ISO certified and CSC-compliant. HCI has completed production for their first series of the foldable container. These containers were used in the pilot projects together with their partners. Multiple trials were conducted with shipping lines, returning with good results in ports of Asia, America and Europe. Several carriers participated in the testing of the 4FOLD Container in two laden voyages, with further trials in the pipeline.

Table I points out some key points regarding to benefits that foldable container may bring into actual operations. The Main key benefit would be “Storage Space”, given that regular container size is similar as foldable container when it is unfolded, it will be possible to capitalize on space which foldable containers brings. Upon folded and stacked, 4 foldable 40’HC containers can fit into a two TEU slots (1 FEU), where regular containers requires 4 times the space in either vessel slots, depot or port terminal yard space.

TABLE I. OPERATIONAL ATTRIBUTES OF REGULAR AND FOLDABLE CONTAINERS

	Regular	**Foldable (based on 4FOLD)**
Storage space @ depot / port	(12.192 x 2.438 x 2.896 mm) x 4	12.192 x 2.438 x 2.896 mm
Lifespan	15years	10 - 12years (estimated)
Max Payload	28,500 kg	26,600 Kg
Building cost	USD 2,000	USD 4,000 to USD 6,000 (estimated)
Folding time	N.A	4 - 6 mins
Trucks for haulage	4	1 (when stacked for repo)
"Gate in" Queue	4 truck length	1 truck length
"Gate in" Time	x4 processing time	x1 processing time
4 containers repositioning cost	(USD 500 - 700*) x 4	USD 500 - 700*
4 containers repositioning slots	4	1

Another benefit would be the amount of trucks & trucker required for haulage. First, there will be fewer trucks queuing to enter and exit terminals, reducing the. Secondly, the amount of time required to complete the gate-in and gate-out processes for folded containers is also reduced, as compared against regular containers. However, the time required to fold the container at depots may offset this time advantage. Lastly, ports which have throughput restrictions, foldable containers can help to reduce the required number of moves required for stowage operations. Similarly, for ports which have berthing time restrictions, with folded containers, the number of moves required for vessel stowage operations will be reduced, allowing more time for either more empty or laden containers to be loaded, taking in consideration of the vessel’s capacity capability.

Both move-count and berthing time are exceptionally sensitive for the shipping industry especially for ports terminals which have heavy vessel traffic and draft issues. From the amount of savings described, this may ultimately provide the flexibility for ship operator’s vessel to either call on more ports, reducing the need for long berthing time, reducing move counts requirements or improve the entire shipping service voyage time.

As a result of the many moving parts of these containers, these designs have faced scepticism with regard to their ability to withstand the rigours of ocean voyages. However, as foldable containers have not yet entered widespread service in the global shipping industry, there has been no actual lifespan though given that a foldable container has much more moving parts, lifespan can be expected to be shorter.

This study investigates factors that would affect the commercial viability of foldable containers in real-world operations. It is motivated by an actual study of feasibility the use of foldable containers by an Asia-based container rshipping line.

II. Literature Review

This review briefly introduces selected relevant literature on optimizing empty repositioning, but focuses on past studies on foldable containers. There is an extensive wealth of recent literature on the repositioning of empty containers and the reader is referred to Theofanis and Boile (2009), as well as Khakbaz and Bhattacharjya (2014)'s papers for more comprehensive syntheses of the key developments and issues on empty repositioning.

That foldable containers can save on repositioning costs is well-covered in literature. Konings (2005) advocated that use of foldable containers can lead to substantial net benefits in the total chain of container transport. These benefits increase as foldable containers are used on longer distances and through more links in the chain, because the costs of empty transport are reduced. The net benefits actually depend on the additional costs of foldable containers, namely: folding/unfolding, incremental purchase/utilization ("exploitation") costs and additional transport movements required for folding and unfolding to take place. However, foldable containers constitute a threat to income for providers of physical transport and storage services (such as terminal operators and truckers).

Shintani et al (2009) modeled different strategies in empty container flow itinerary using integer programming and found that foldable containers can substantially save on repositioning costs compared to the use of standard containers, especially in the situation of a long returning distance from the inland depot to the seaport with a largely imbalanced trade. However, this requires the availability of handling equipment at inland depots to fold/unfold containers Consequently, cost savings by using foldable containers could only be realized in a transport segment between the inland depot and the seaport.

Konings (2012) argued that given the purchase price of a foldable container can be three to four times the price of a standard box, a substantial number of boxes is required to reveal the system benefits of foldable containers. Konings (2012) suggested that the introduction of foldable containers can be via the container lessor industry. Container lessors should not only be willing to offer lease contracts, but should also become involved in operations with foldable containers. The lessor needs to take responsibility for the folding and unfolding of containers. That is to say, the leasing company should organise the assembly and dismounting processes. Containers need to be delivered erected to the shipping line user, so the customer should virtually notice no difference in using a standard box or a foldable container.

Moon et al (2013) compared the cost of foldable containers to that of standard containers in the case of empty container repositioning. They developed mathematical models, among which one considers the use of a mix of foldable and standard containers. The model was used to carry out sensitive analyses across four dimensions of costs: repositioning storage purchasing and folding/unfolding.

Bandara et al (2015) conducted a limited small-scale questionnaire on practitioners and a case study on the Port of Melbourne. They found that foldable containers could help lead to an 80% decrease in the number of empty containers handled by the port. However, Konings & Thijs (2001) suggested that the greatest barrier was commercial skepticism concerning the technical performance, the complexity of the folding and unfolding process in particular, as well as logistical and organizational problems with using foldable containers. Despite industry skepticism,

To round up, previous studies have been largely optimistic about the hypothetical potential of the foldable containers, but does not attempt to quantify attributes of foldable containers that would decrease its attractiveness, such as the costs of folding/unfolding and a shorter lifespan. This paper thus aims to address this gap by investigating the major variables that could possibly impact the attractiveness of folder containers from a financial perspective.

III. Approach and Methodology

A. Activities and Cost Components in Container Shipping and Repositioning

Consider a simple round-trip network with a single shipper and a single consignee (Fig. 1). The carrier faces an imbalance trade situation in which there is only demand for freight in the head haul direction.

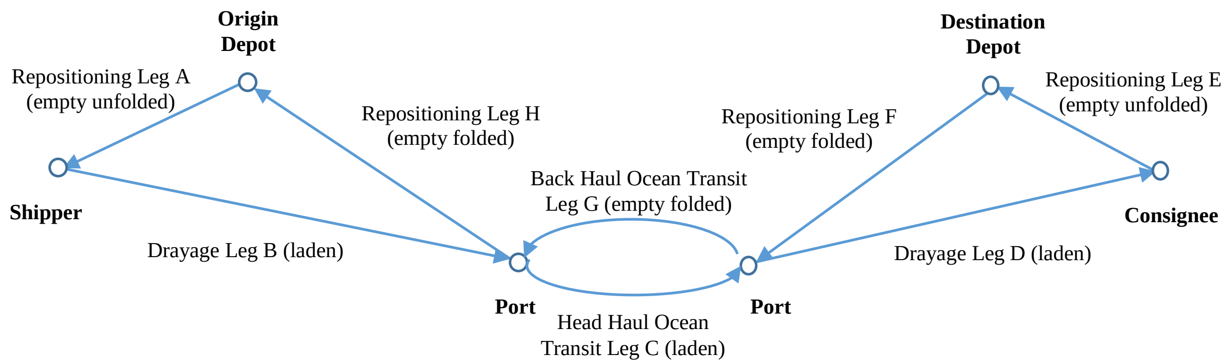


Fig. 1. Typical Movement of Laden and Empty Containers in Their Various Folded and Unfolded States

Table II shows a comparison for the activities for which costs will be incurred in moves for a foldable container (versus those for a regular container).

TABLE II. ACTIVITIES FOR FOLDABLE VERSUS REGULAR CONTAINERS

No.	Activities	Leg	Foldable Container	Regular Container
1	Ground rent	Origin	Empty (Folded)	Empty
3	Unstacking, unbundling & unfolding	Origin	Empty (Unfolded)	Not applicable
3	Trucking from deport / port to Shipper	Origin	Empty (Unfolded)	Empty
3	Trucking from Shipper to port	Origin	Laden	Laden
4	Port terminal handling	Origin	Laden	Laden
5	Ocean freight	Ocean	Laden	Laden
6	Port terminal handling	Destination	Laden	Laden
7	Trucking from port to Consignee	Destination	Laden	Laden
8	Trucking from Consignee to depot	Destination	Empty (Unfolded)	Empty
9	Folding, bundling & stacking	Destination	Empty (Folded)	Not applicable
11	Ground rent at depot	Destination	Empty (Folded)	Empty
12	Trucking from depot to port	Destination	Empty (Folded)	Empty
13	Port Handling cost	Destination	Empty (Folded)	Empty
14	Ocean Freight	Ocean Leg	Empty (Folded)	Empty
15	Port Handling cost	Origin (or other shipper's location)	Empty (Folded)	Empty
16	Trucking from port to depot	Origin (or other shipper's location)	Empty (Folded)	Empty

At origin, an empty container is dispatched to the shipper and the shipping process remains in common between a regular and a foldable container. The difference begins only after the empty container is shipped back to the depot near the origin port. In Table II, it is assumed that unfolding/folding is conducted only at deport rather than at shipper/consignee's premises.

If empty containers are folded and stored at the port or depot that translated to lesser storage space is required, which reduce both space requirements and costs at both the port and depot. Assuming that 4 foldable containers can be stacked into a size of one 40'HC, port handling and ground rent costs per unit can be reduced up to 75% as compared to dealing with 4 full size 40HC. Less handling means higher efficiency.

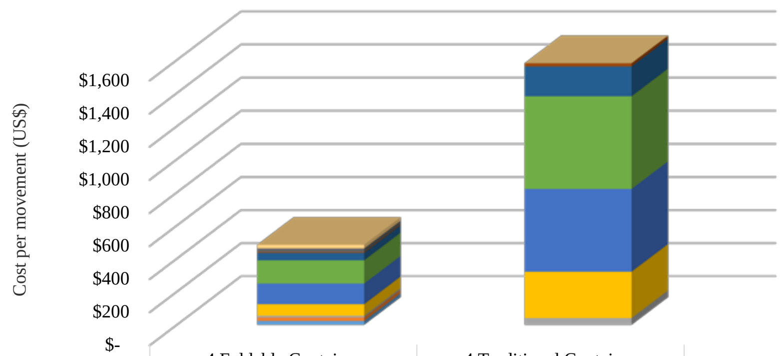
Similarly as port handling & transshipment, the amount of trucks, chassis, man-hours, and fuel to move these empty containers into storage depots can be reduced as high as up to 75% upon having the foldable stacked. The same applies for inland trucking, instead of having 4 trucks to drag the empty containers back to depot or ports, upon unfolding and stacking, we can just utilize one truck to accomplish the same, achieving a 75% cost and resources savings. In terminals, each container handling cost is charged regardless of laden or empty. Thus, likewise a 75% in cost reduction may be achieved.

In theory, during the ocean leg, the cost for empty repositioning would also be reduced by up to 75% when foldable containers being stacked 4 into 1, as this required one 40' slots (2 TEUs) on the vessel as compared to four 40' slot (8 TEUs) in the case of regular containers. The benefit of foldable container on the ocean leg would clearly apply for Shipper-Owned-Containers (SOC). However, for ship liner owned containers, this benefit would not be significant given that the incremental cost of loading on an empty on a ship in the return ocean leg is marginal. Besides, ships on the return leg may reach deadweight capacity before reaching slot capacity. For these reasons, the savings from the ocean leg of a repositioning operation would be neglected for the purpose of this study.

B. Operational Cost Analysis – Foldable versus Regular Containers

Based on the comparison in the previous section, the main cost differences between regular & foldable containers will largely occur during the land-side movement of empty repositioning from the destination back to the origin. At this point, upfront purchase costs and maintenance costs will not be taken into consideration.

Fig. 2 illustrates the cost comparison of moving 4 Regular against 4 foldable containers. As can be seen in Fig. 2, the storage and port handling costs for each folded container (4 of which are bundled into the footprint of one container) would be approximate 25% those for a regular container. As foldable containers are still in pilot stages no actual cost is readily available, it will assumed that the folding activity would cost an additional 10% on top of current rates for folding 40' flat racks (US$20 each).



	4 Foldable Container (Collapisble into 1 FEU)	4 Traditional Container
10 Destination Depot unfolding cost	$22	$-
9 Destination Unbundling Cost	$22	$-
8 Destination Store rent at depot	$5	$20
7 Destination Trucking from port to depot	$45	$180
6 Destination Port Handling cost	$140	$560
5 Origin Port Handling cost	$125	$500
4 Origin Trucking from depot to port	$70	$280
3 Origin Store rent at depot	$10	$40
2 Origin Bundling Cost	$22	$-
1 Origin Folding/stacking cost at depot	$22	$-

Fig. 2. Movement Cost Comparison Between Four Regular and Four Foldable Containers

The following analysis is based on moving 4 traditional containers compared against 4 foldable containers stacked into the size of one 40-foot high cube (40HC) container. To better understand the net cost-benefit from foldable containers, Table III shows the estimated cost components for the land-side port-to-port container move, between the ports of Hamburg and Shanghai

TABLE III. COST COMPONENTS FOR FOLDABLE VERSUS REGULAR CONTAINERS

		Cost (USD)	
Location	**Activity**	**4-in-1**	**40HC**
Origin	Stacking	22	0
Origin	Unfolding	22	0
Origin	Ground rent at depot	10	40
Origin	Trucking from depot to port	70	280
Origin	Port handling cost	125	500
Destination	Port handling cost	140	560
Destination	Trucking from port to depot	45	180
Destination	Ground rent at depot	5	20
Destination	Unbundling cost	22	
Destination	Depot unfolding cost	22	
	Total	483	1580

While the benefits that accrue to foldable containers and any incremental maintenance costs are realized over the lifespan of the container, the purchase costs are incurred upfront (whether by a leasing company or a carrier). To obtain an appropriate comparison, discounts are required to be applied for these future values in order to account for their present value. Net present value (NPV) is the current value of entire project net benefits minus costs discounted using the discount rate, such that:

$$NPV \quad = Upfront\ purchase\ cost + \sum_{t=1}^{T} \frac{Cost_t}{(1+r)^t} \qquad (1)$$

Where:

- NPV is the Net Present Value of costs incurred over the useful life of each type of container
- $Cost_t$ is the cost (port handling, folding, bundling, drayage etc) incurred in an annual period
- r is the discount rate
- t is the year in which $Cost_t$ is realized
- T is the lifespan of the container

The results of the cost benefit analysis would be dependent on the discount rate used, which would be in turn be dependent on a company's weighted average cost of capital (WACC). For example, according to Bank of America Merrill Lynch (2013), the WACC of container carriers range from about 8% to 11%, while those of ship leasing and container leasing companies range from 6.2% to 7.3%.

Since foldable containers are likely to have shorter lifespans than regular containers, an Equivalent-Annual-Annuity (EAA) approach for projects with unequal useful lives is used to compare the upfront and operating costs of both containers. The NPV of the life time costs of both type of container are first calculated, then the EAA are computed over their respective lifespan, as calculated in Equation (2).. The container with the higher EAA would therefore offer the superior return. In this analysis, the salvage values of containers are neglected.

$$EAA \quad = \frac{\mathrm{r(NPV)}}{1-(1+r)^{-T}} \qquad (2)$$

Container turns is another important variable that will affect the commercial viability of foldable containers. Turns per year is defined as the number of times that a container is circulated between head haul and backhaul movements. For example, a turn in the Transpacific trade would mean that a container is move on a revenue-earning leg from Asia to the Americas and back to Asia (but often on a non-revenue earning or non-cost recovery basis). However, for the purpose of this study, it is not necessary for turns to be completed within the route trade route.

In the base case, the following parameters are used:

- Discount rate: 9%

- Lifespan: 10 years (versus 15 years for a regular container)
- Cost of foldable container: 3 times that of a regular container
- Container turns: 6 per year
- Carriage term: Container yard (CY)-to-CY (i.e. inland trucking cost is not applicable)
- Maintenance cost: US$600 per annum (assumed 20% above that of regular containers)

Purchase cost of foldable containers is probably one of the greatest barrier to adoption of foldable containers at the moment, but with greater adoption, economies of scale would likely help drive down unit costs. On the other hand, the lifespan of foldable containers is currently uncertain, while containers turns and discount rates are carrier-dependent. A sensitivity analysis is therefore performed on each of these variables across a range as follows:

- Discount rate: 8 to 11.5%
- Lifespan: 10 to 16 years
- Cost of foldable container: 1.25 to 4 times that of a regular container
- Container turns: 4 to 9.5 per year
- Transport mode: Inland trucking with one-way costs of US$0 to US$2,200

IV. Results and Discussion

In the base case, the EAA of the lifetime operating cost for a 40HC foldable container is US$4,433, compared to $10,228 for regular 40HC container, which represents a savings of 56.7%. Table IV and Fig. 3 show the relative benefit of foldable container, expressed as the reduction of the EAA for the discounted lifetime costs of foldable container as a percentage of the EAA of the corresponding costs for regular containers.

TABLE IV. Sensitivity analysis of Conatiner LifEspan versus Purchase Price

		Purchase cost (Times cost of regular container)				
		1.25	**1.5**	**2**	**3**	**4**
Lifespan (years)	**5**	60%	58%	56%	51%	46%
	6	60%	59%	57%	53%	48%
	7	61%	60%	58%	54%	50%
	8	61%	61%	59%	55%	52%
	10	62%	61%	60%	57%	54%
	16	63%	62%	61%	59%	56%

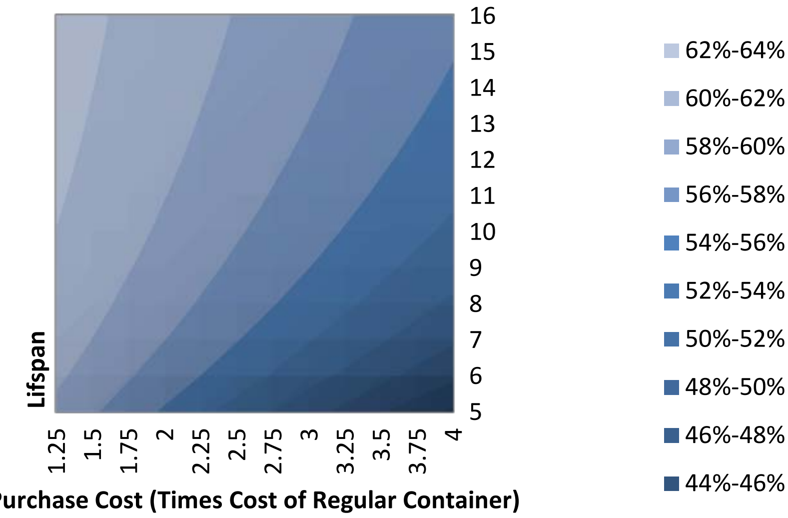


Fig 3. Sensitivity Analysis of Container Lifespan versus Purchase Price

Table V to Table VIII and Fig. 4 to Fig. 6 show the results of the sensitivity of savings to WACC, Container Turns, Inland Trucking Cost and Annual Maintenance Costs respectively.

TABLE V. SENSITIVITY ANALYSIS OF WEIGHTED AVERAGE COST OF CAPITAL VERSUS PURCHASE PRICE

		Purchase cost (Times cost of regular container)				
		1.25	**1.5**	**2**	**3**	**4**
WACC (%)	6%	62%	62%	60%	58%	55%
	7%	62%	62%	60%	57%	55%
	8%	62%	61%	60%	57%	54%
	9%	62%	61%	60%	57%	54%
	10%	62%	61%	59%	56%	53%
	11.5%	62%	61%	59%	56%	52%

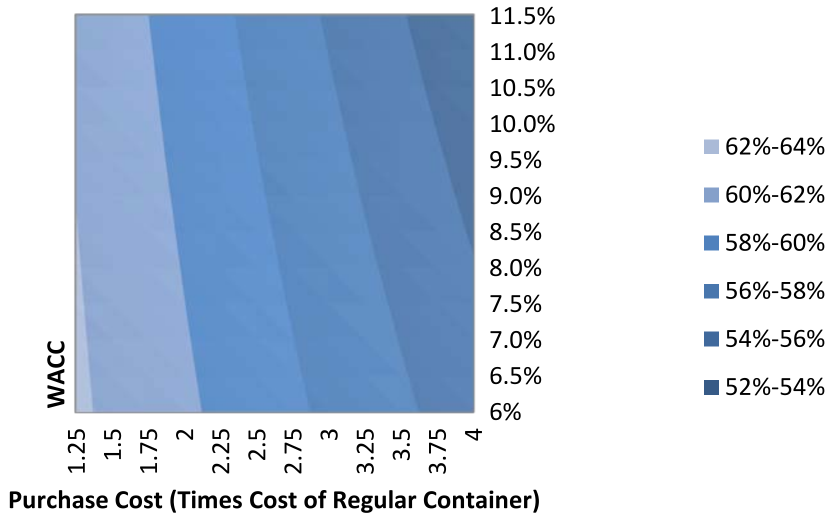


Fig 4. Sensitivity Analysis of Discount Rate (WACC) versus Purchase Price

Under most investment decisions (such as to replace a fleet of containers), the cost of capital is highly critical, but as shown in Table V and Fig. 4, the benefits of using foldable containers are relatively insensitive to WACC

TABLE VI. SENSITIVITY ANALYSIS OF CONTAINER TURNS VERSUS PURCHASE PRICE

		Purchase cost (Times cost of regular container)				
		1.25	**1.5**	**2**	**3**	**4**
Container Turns per Year	4	59%	58%	55%	51%	47%
	5	61%	60%	58%	54%	51%
	6	62%	61%	60%	57%	54%
	7	63%	62%	61%	58%	56%
	8	64%	63%	62%	60%	57%
	9.5	65%	64%	63%	61%	59%

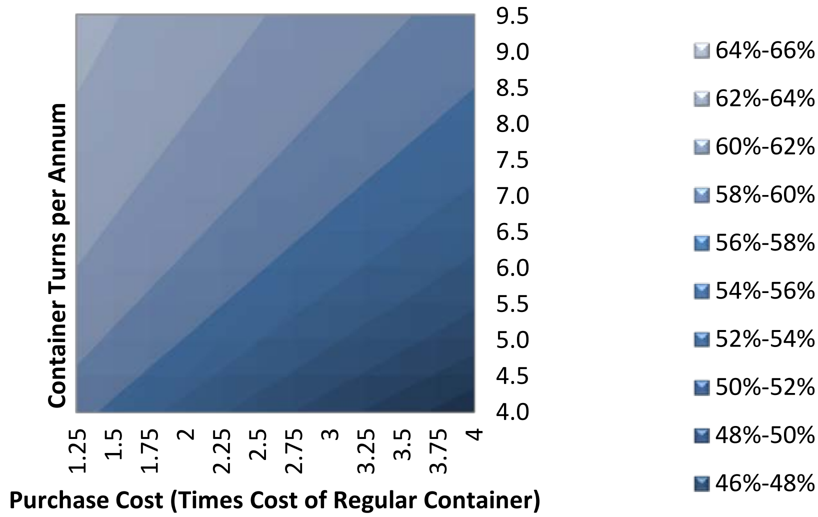


Fig 5. Sensitivity Analysis of Container Turns versus Purchase Price

As might be expected, the number of container turns has a highly significant effect on the amount of possible savings (Table VI and Fig. 5). Even for inefficient trade lanes in which container turnaround and/or detention times are long (which lead to low turns of just 4 per year), foldable containers would still exceed 40%.

TABLE VII. SENSITIVITY ANALYSIS OF INLAND TRUCKING COST VERSUS PURCHASE PRICE

		Purchase cost (Times cost of regular container)				
		1.25	**1.5**	**2**	**3**	**4**
Inland Trucking (US$ single trip)	0	62%	61%	60%	57%	54%
	200	63%	63%	61%	59%	56%
	600	65%	65%	64%	61%	59%
	1,200	67%	67%	66%	64%	62%
	1,600	68%	68%	67%	66%	64%
	2,200	69%	69%	68%	67%	66%

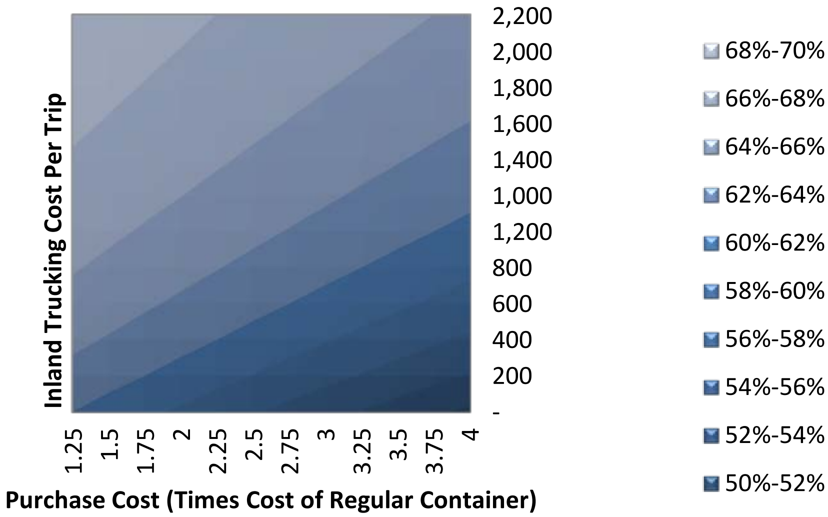


Fig 6. Sensitivity Analysis of Inland Trucking Cost versus Purchase Price

As shown in Table VII and Fig. 6, foldable containers are probably the most attractive for inland locations (whether at origin or destination) that have an imbalance of trade. In the case of landlocked locations such as Prague where trucking from the nearest water port would cost around $1,200, savings of more than 60% can be reaped.

TABLE VIII. SENSITIVITY ANALYSIS OF ANNUAL MAINTENACE COST VERSUS PURCHASE PRICE

		Purchase cost (Times cost of regular container)				
		1.25	**1.5**	**2**	**3**	**4**
Maintenance (US$ per contr)	500	63%	62%	61%	58%	55%
	600	62%	61%	60%	57%	54%
	700	61%	60%	59%	56%	53%
	800	60%	59%	58%	55%	52%
	900	59%	58%	57%	54%	51%
	1,000	58%	57%	56%	53%	50%

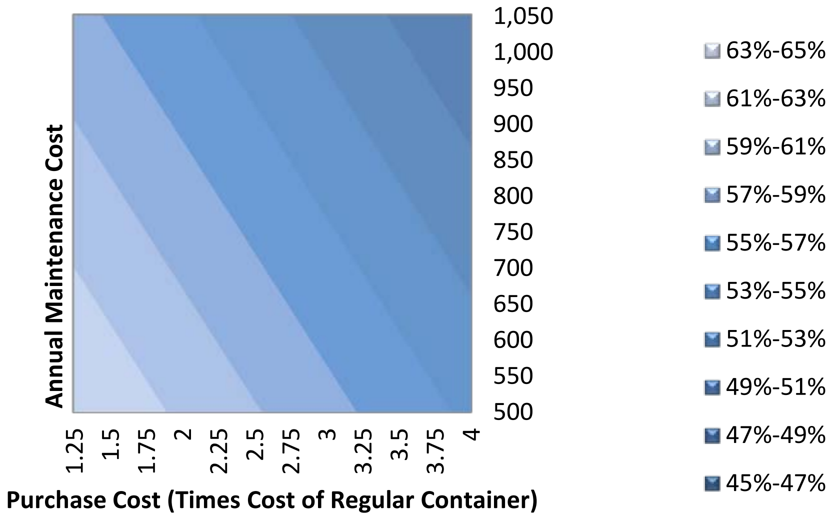


Fig 7. Sensitivity Analysis of Maintenance Cost versus Purchase Price

Since the durability and robustness of foldable containers have been one of the greatest impediments in past designs of foldable containers, a sensitivity analysis is also conducted on the cost of maintenance (Table VIII and Fig. 7). However, the potential savings is only somewhat sensitive to the cost of maintenance. Rather, the larger impact could come from the downturn required in the case when repairs or refurbishment are required.

V. Conclusion

Findings from this paper have shown that there is a clear and compelling advantage from the use of foldable containers from a commercial perspective, although this advantage is not as high as the 75% that has been widely bandied about. On an Equivalent Annual Annuity (EAA) basis (to account for likely different lifespan of a foldable container), the cost advantage of a foldable container over a regular container is approximately 57%. Even when higher upfront purchase costs and annual maintenance costs are considered, foldable containers would be highly viable for carriers and lessors that have a WACC within a range of 6% to 11.5%. Sensitivity analysis indicates a realizable saving that is between 47% (assuming cost of foldable containers at 4 times cost of regular and 4 container turns per year) to 63% (assuming upfront cost 25% above regular container and a lifespan of 15 years). The benefit of foldable containers over regular containers is found to be relatively more sensitive to the lifespan of the foldable container and the number of container turns. Most other variables such as maintenance cost and WACC have relatively smaller impact. When foldable containers are applied to inland shipper and/or consignee locations, the benefits of foldable containers would be even greater, due to avoidance of having to pay full rates for the inland repositioning of empty containers.

This study is however not without its limitations. As foldable containers have not yet entered widespread service in the global shipping industry, the benefits that can be realized from these containers are contingent on their ability to withstand the rigors of ocean voyages. Furthermore, this study also does not address some benefits that are difficult to quantify, particularly those related to time-savings (such as during the stowing, stacking and ship berthing activities). The ability of for port operators to postpone capital investments in storage yards and gantry cranes (due to reduced empty moves) is also not considered in this research.

Despite the foldable container's clear value proposition to carriers, terminal operators and hauliers are likely to be threatened by the introduction of these containers (Konings, 2005). Terminal operators (both seaports and inland depots) face not just potential of revenue leakages due to the reduced number of empty moves, but also reduced "bragging rights" to higher throughput figures at their terminals. Tractor drivers on the backhaul lanes may find themselves hauling an empty trailer/chassis with no container on their way back to the sea port or inland terminals. For foldable containers to gain more traction in the maritime industry, it is necessary to redistribute some of the savings to these stakeholders, for example, via a separate set of tariffs for "folded" containers. An interesting area for future research would therefore be how benefits from the use of foldable containers can be shared with other parties operating in the container shipping value chain (such as truckers and terminal operators) whose support would be needed for the introduction of foldable containers.

Another direction for future research would be to determine the optimal mix of foldable and regular containers that carriers should maintain in their global inventory and deploy across global trade lanes. For instance, if too many foldable containers are deployed in trade lanes that are not sufficiently imbalanced, not only would the benefits of these containers be unrealizable, additional upfront costs would also have been incurred unnecessarily.

To achieve higher utilization of containers, shipping lines and container leasing companies spend much resources on empty containers repositioning. Should foldable containers prove feasible operationally, they have the potential to emerge as a truly disruptive innovation in the container shipping industry in the coming decades. While savings of 75% from foldable containers have been widely bandied, the cost trade-offs have often been conveniently neglected in the extant literature. this paper has contributed to the literature by focusing on a cost-benefit analysis of folder containers from a financial perspective and shown that under the right circumstances, a 50% savings from the use of foldable container is not unrealistic.

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Biography

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