

# Improving Logistics Management Using Foldable/Collapsible Containers: A Case Study



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## Abstract

Foldable containers have the potential to enhance the cost efficiency of the logistics industry and improve the problem of space allocation at seaports. Using primary and secondary data sources the pros and cons of using foldable containers as compared to standard containers are identified, and it is shown that a port can gain cost efficiencies by using foldable containers. A simulation for the Port of Melbourne (Australia) demonstrates that using foldable containers would reduce the projected total number of containers handled by the port in 2035 from 7.057 million to 5.817 million, with an 80% decrease in the number of empty containers. Foldable containers can therefore have a significant impact on the reformation of the transport and logistics systems.

**Key Words :** Containerization, Foldable Container, Standard Container, Loading Centres, Space Constraints, Logistics

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## **I. Introduction**

Contemporary logistics operate in a newly framed and globalized environment where combined transport, information flows and innovation, and the concentration and integration of firms lead the market and each business within the market. The containerization of cargo within this context has been a primary feature in maritime transportation because of the advantages it offers in the rationalization of shipments, security and facility of handling, and the facilitation of multimodal transportation (Li et al., 2007). With the advent of the containerization of cargo, the total logistics chain has embarked on an unprecedented evolution. The Twenty Foot Equivalent Unit (TEU), the general commodity in logistic operations for all stakeholders, has contributed to the enhancement of international and local trade. In this context seaports, as the primary receiver of containers, have also undergone extensive restructuring of their operation, infrastructure and superstructure mainly to accommodate container vessels and their cargo. The extent to which containerization has impacted on seaports is seen by the growth of the market for container handling business in seaports, predominantly the emergence of the number of multinational private stevedoring companies in the major and regional hubs, and the main city ports. Within this context the container as a commodity has also embarked on a technological evolution since its invention by Malcolm Mclean as a solution to the inefficiencies created by break bulk (Johnson, 2010).

With the expansion of international trade in the world container volumes have increased tremendously (Notteboom and Rodrigue, 2008b). Global container traffic (including full and empty containers) reached 560 million TEUs in 2010 (ISL, 2011). The imbalance in international trade activities, mainly between east and west as well as north and south, has resulted in a large volume of empty containers (Theofanis and Boile, 2009). The movement of empty containers in 2002 constituted approximately 20% of the world's total international container throughput (UNESCAP, 2007), which clearly suggests that ships are partially loaded with empty containers. As the world container throughput increases, it is forecasted that the amount of empty container handling will also increase. This will have an impact on operating margins and space constraints in

port container terminals. Large accumulations and longer dwelling times of empty containers in seaports will result in capacity constraints at seaports which could in turn generate additional costs of storage for logistics companies. Further to these issues, the logistics industry will have incentives to minimize empty container movement costs as, in order to realize economies of scale, ships are required to carry cargo at full capacity. Empty container handling is also subject to wharf age, i.e. the container handling charges of seaports. Thus, the high movement of empty containers incurs substantial costs and raises the total logistics costs of the value chain. The impact of empty container movement on the shipping industry cannot be underestimated.

Foldable or collapsible containers have been introduced into the market in order to address the issues mentioned above regarding standard containers. Replacing standard containers, which is a well-established method of cargo transportation, with foldable containers is proving difficult. The advantages of the new method have not been disseminated to the industry mainly because the use of foldable containers is a new technology and has not been widely introduced, used or handled by ports (Konings, 2005).

This study provides an evaluation of the need to replace standard containers and investigates the advantages and disadvantages of foldable containers by examining the existing literature, canvassing the views of professionals working in the logistics sector, and by a simple simulation of the direct benefits to the port sector, using data from the Port of Melbourne (PoM) Corporation, Australia, as a case study.

## **II. Objectives and Scope of the Research**

The logistics and shipping industries are rapidly growing with containers playing an important role in the successful growth of both industries. In modern logistics, minimizing the total supply chain cost is a major concern. In this respect, containerization of cargo has made a significant contribution in minimizing total supply chain cost compared to break bulk shipping and has improved the efficiency and productivity of the whole supply chain. Although containerization conveys numerous

advantages to the logistics industry, there are some disadvantages. The use of foldable containers is proposed as a way of solving the current issues with standard containers, but their use is not widespread yet. The objective of this empirical investigation is to identify the potential benefits of foldable containers in enhancing the cost efficiency of the logistics industry and its operations, and also in improving the efficiency of space allocation at seaports.

### **III. Literature Review**

With the advent of containerisation, a container as a standard commodity in liner shipping has received much attention from both logistics practitioners and academics. As a result there has been range of research conducted on standard container use and its related issues. From its inception the standard container has contributed immensely in shaping contemporary maritime trade and the development of liner shipping. In addition standard containers have played a significant role in the integration of ports and liner shipping networks (Notteboom and Rodrigue, 2008a), Hence the contribution to and the role that standard containers play in the transport sector is unquestionably large.

Some of the literature has focused on explaining the issues involved with standard containers with respect to logistics management. These issues include: the accumulation of empty containers in ports and logistics centres (Boile et al., 2004; Theofanis and Boile, 2009), the problem of repositioning empty containers (Lai et al., 1995; Song and Dong, 2008), the management of empty containers for intermodal transportation (Choong et al., 2002; Boile et al., 2008), and the management of empty containers in ports and logistics centres (Li et al., 2004; Olivo et al., 2005; Song and Dong, 2008). Other technical issues concerning the use of standard containers, such as the difficulty of designing container shipping networks to avoid accumulating empty containers at port, have also been identified (Shintani et al., 2007; Meng and Wang, 2011). Researchers have put forward various technical and operational solutions for empty container repositioning. These solutions mainly come from operational research applications that can be used to reduce the accumulation of empty containers and lower costs (Crainic et al., 1993; Shen and Khoong, 1995;

Cheung and Chen, 1998; Di Francesco et al., 2009; Song and Carter, 2009; Brouer et al., 2011; Song and Dong, 2011b). Further optimizing the reuse of empty containers has also been suggested as a solution to the container flow imbalance (Jula et al., 2006; Li et al., 2015), while establishing an empty container repositioning policy to lower repositioning costs was also proposed to curtail the cost escalation in shipping (Song and Dong, 2011a).

Foldable containers were proposed as a way of solving some of the issues with standard containers, and the possible benefits of foldable containers were identified. These benefits include the cost savings gained by using foldable containers against empty container repositioning (Konings and Thijs, 2001; Konings, 2005; Shintani et al., 2010) and the lowering of the cost of container fleet management in liner shipping networks (Shintani et al., 2012). Konings and Thijs (2001) argue that, on shipping routes with permanent trade imbalances, the use of foldable containers can save transport, transshipment and storage costs as shipping lines responsible for repositioning their empty containers currently bear the cost of repositioning. Further, if there is a land-based transport leg to the logistics operation then the use of foldable containers contributes to substantial cost savings by reducing the empty container repositioning between the seaport and its hinterland (Shintani et al., 2010). For the maritime leg of container transportation, the use of foldable containers in liner shipping networks with high trade volume imbalances can generate substantial cost savings in container fleet management (Shintani et al., 2012). In a comparative study Moon et al. (2013) found that foldable containers are economically feasible in terms of the folding/unfolding cost, the inventory storage cost, the container purchasing cost, and the repositioning cost as opposed to standard containers; but that the purchasing cost and the transportation cost can affect the use of foldable containers.

#### **IV. Current Issues with Standard Containers**

The literature on standard containers highlights several problems. Moisture concentration and condensation inside a standard container is identified as one of the main problems, and adversely affects the cargo structure and its life, Graham (2011). The problem occurs due to temperature variations experienced during the voyage and at the terminal. According to Graham, condensation in containers is caused by saturated air inside the container. In addition, solar radiation causes changes in temperature inside a container. A standard container is made of metal, which is a good heat conductor, and heat can easily exchange through the container walls creating temperature variations within the container. A container, particularly the roof, is often exposed to solar radiation for long periods of time (during a voyage or storage at port), and therefore considerable temperature variations can occur inside a container. Warm air holds more moisture than cold air, therefore if the warm air inside a container comes into contact with colder air outside the container (or the container walls and roof are cooled due to the external climate) moisture will precipitate onto the roof and walls of the inside of the container. The humidity of the air inside a container is also another factor that causes moisture in the containers. For example, cargo that is packed when the air humidity is high, may suffer from greater condensation. Studies have shown that the worst time for condensation inside containers is during winter (Shipping Container Trader, n.d.).

The second problem with standard containers is the interference to the container tracking signals caused by the metal of the container (Hanlon, 2010). In the current logistics industry, shippers use the Radio Frequency Identification (RFID) system to track the current position of the cargo using either an active or passive RFID tag placed on the cargo packaging. The purpose of the tag is to reflect the radio waves transmitted by the transponder. In other words, RFID tags that store cargo information act as an RFID transponder reflector. One disadvantage of this technology is that the radio waves transmitted by the transponder cannot penetrate steel (Rfid Journal, 2012). Metal has three adverse effects on RFID systems: distortions of the electromagnetic field, detuning and shielding. Ultimately this results in reducing readable area of the RFID system (Ciudad et al., 2010).

The third problem are the storage and space constraints at the port created by empty container accumulation (Rodrigue, 2012a). Standard containers require a large port terminal space for their storage. World container traffic has continued to increase. In mid-2012, there were approximately 177.7 million containers in the market and simultaneously port container handling has also increased (World Shipping Council, 2011). Within this context, land scarcity is a serious issue for world ports and diseconomies of scale in some port operations have been the result of limited land for further port expansion (Notteboom and Winkelmanns, 2001). For instance, in 2008 the Port of Singapore handled 29.9 million TEUs of containers and this figure is expected to increase in the future. Spare land is scarce in Singapore and terminal expansion, to accommodate the ever increasing container traffic, is a challenge (Maritime and Port Authority of Singapore, 2008). A similar problem is also faced by the Port of Melbourne, Australia's busiest port (Port of Melbourne Corporation, 2009b). Here, increases in the standard container traffic causes site constraints but also has an impact on port expenses (BITRE, 2009).

Empty container accumulation has created several issues with respect to port capacity and terminal efficiency and affects all the stakeholders in the logistics chain (liner container service operators, terminal operators, inland river operators, leasing companies, local public authorities and cargo owners (Karmelić et al., 2012). Approximately 35 million containers, about 20% of the world's container population, are empty, sitting idle in yards and depots waiting to be used again (UNESCAP, 2007). One of the major problems with the accumulation of empty containers is their utilization of the productive storage space of port terminals and logistics centres. High volumes of empty containers require large storage areas and the development of inland container depots can minimize the total system costs, including the repositioning of empty containers (Boile et al., 2008). However, the development of inland container depots imposes additional investment and transportation costs on loading centres. The efficiency of inland container depots is also subject to the distance from the port, traffic conditions and inland transport infrastructure for port access. Thus the accumulation of empty containers in loading centres and their repositioning, both in ports and logistics centres, along with increasing container transportation volumes are critical issues in the management of

containers (Theofanis and Boile, 2009). These problems and the rising cost of new containers and their repositioning can make standard container leasing businesses less profitable (Rodrigue, 2012b).

## **V. Methodology and Data Collection**

This preliminary study adopted qualitative research methodology to gather predominantly non-numerical, informative and descriptive data. The information gathered by qualitative research can be analysed in an interpretative, subjective, impressionistic and even diagnostic manner (Key, 1997). Following this principle the research method adopted included three research techniques for data gathering; an open ended questionnaire, literature from reputable sources and a case study.

An open ended questionnaire was distributed to 20 randomly selected logistics professionals including professionals from the port industry. Once randomly selected, each recipient was personally invited to take part in the survey. The open-ended questionnaire covered the following topics relating to foldable containers:

- Awareness (of foldable containers).
- The foldable container as an investment in logistics sector.
- The benefits of foldable containers to the port and shipping sector.
- The impact of foldable containers to different transport modes.
- The impact of foldable containers to the environment.

The questionnaire response rate was 100%. The content of the responses provided to the questionnaire were analysed in respect to the available literature. This allowed the reframing of the position of foldable containers in the port and logistics industry in terms of their advantages, disadvantages and the reasons pertinent to their low market share. The results of this exercise were applied to the PoM Corporation to understand the issues, constraints and possible benefits that a port operator would realize from foldable containers. The case study of the PoM is based on the data and information obtained from the PoM Development Strategy 2035 report and the Port's annual reports.



## **VI. Foldable Containers as an Alternative to Standard Containers: The Industry Perspective**

The major issues with standard containers are consequences of trade imbalances along the main trade routes, which are a structural and endemic problem of the global trade (Theofanis and Boile, 2009), there are also some issues that are design and technology related. Many different solutions have been suggested in order to overcome these issues including the use of foldable containers, container houses, logistical solutions, policy solutions and managerial solutions. Among these solutions, the foldable container is an alternative which has originated due to the restructuring of the design of the standard container.

Different types of foldable containers exist and among them two types of foldable containers, *Six in One(SIO)* and *Fallpac*, are at the testing stage in the container market. The SIO container is a fully dismountable 20 foot dry freight box that, once dismantled, can be folded, stacked six high and interlocked to form an equivalent size of the standard TEU. The Fallpac foldable container is a type of foldable container in which four same-type foldable containers can be stacked on top of one another inside an already assembled Fallpac container (Konings and Thijs, 2001).

Responses of the industry personnel surveyed concerning their awareness of the existence of foldable containers suggest that foldable containers are well known to the industry. However, long established logistics practices using standard containers are a key constraint when introducing foldable containers into the market. Foldable containers could generate several advantages as listed below, they could:

- Produce a good investment opportunity to the logistics industry.
- Reduce transshipment and transport costs in loading centres.
- Reduce space requirements in loading centres.
- Provide benefits to the environment.

Foldable containers are considered to be a good investment in the logistics industry. One of survey respondents suggested that *'the foldable container can reduce space constraints on seaport and logistics companies and reduce container handling time in port terminals'*. More importantly, from the point of view of the logistics operator, *'investments in foldable containers can eliminate the imbalance of empty container movement'*.

This suggests that the industry is highly aware of the immediate benefits of foldable containers and their impact on the container trade at large, and can see the long term reduction in storage space and costs, so making foldable containers a real investment. Storage cost is also reduced in the long term because the foldable nature of the containers saves space that would otherwise be used by standard containers. This indicates that investment in foldable containers is suitable for countries such as Singapore and Hong Kong which have limited land areas.

Research highlights the potential savings in transshipment and transport costs that foldable containers offer. The use of foldable containers reduces total transportation costs (land and maritime) (Konings and Thijs, 2001). Since they are stackable, more foldable containers can be transported in a given shipment (land or sea-based transport). For land-based transport, this will significantly reduce the number of container-carrying vehicles on the roads, thereby reducing traffic congestion. Thus, the benefits reaped by society due to foldable containers cannot be underestimated.

Since foldable containers can be stacked and shipped in the same cubic space as standard containers, storage constraints in terminals and ports are reduced and thus ports can provide faster ship turnaround times. Foldable containers will not only improve port efficiency but also shipping efficiency by way of reducing port-stay time. Shintani et al.(2012) showed that the employment of foldable containers in a liner shipping network can potentially reduce the costs of container fleet management. Thus foldable containers lead to savings in storage space, provide faster ship turnaround times, higher shipping efficiency and eliminate empty container repositioning freight costs. Further the issues of moisture concentration and condensation in standard containers and the possible damage to cargos can be solved with the use of foldable containers.

Seaports are the major loading centres for containers. Currently seaports are specialized in handling standard containers particularly due to the specialized container handling companies who have leased or own port terminals around the globe. The shift from standard containers to foldable containers thus has direct implications on the way ports and terminals operate. From the industry point of view, the shift is essential in order to improve port efficiency especially in the presence of the global imbalance in trade. The repositioning of empty containers can be undertaken more efficiently with the use of foldable containers due to their foldable nature

and their ability to be stacked in one container; in this case the foldable containers become a conventional cargo item with a destination port. This however implies that foldable containers require stacking, un-stacking and re-stacking at ports. This additional operation incurs more time and costs. The industry respondents also suggested that foldable containers only provide additional storage capacity at terminals and might not improve port efficiency. Furthermore the sorting of foldable containers from standard containers may take up more of the port management's resources and time.

To be successful in the market, the cost effectiveness of foldable containers is a major concern for the logistics industry. In an era of increased trade imbalance, shipping companies strive to realize economies of scale in their operation in order to maximize gains. Empty container movement hinders productive shipping capacity for cargos. Foldable containers invariably reduce this vulnerability and allow the shipping industry to re-schedule their operations and save costs. The view of the survey respondents was that foldable containers bring a cost advantage only in the long term due to the preliminary stage of their introduction. One of the respondents stated that, *“in the long term when it is standardized and adopted, the foldable container can save time, space and increase efficiency, thus, saving costs”*. They also envisaged that foldable containers will make container storage yards smaller and that in turn the current capacity issues in ports and inland depots will be solved.

The potential implications of foldable containers on the environment cannot be neglected; however there is an uncertainty about the benefits of foldable containers to the environment. Ports and terminals at present require more land as they expand to accommodate increased container traffic. Empty standard containers require additional space in terminals. This has exerted pressure on port authorities to search for land within the foreland and port hinterland. Foldable containers can reduce the land required for port expansion as they require considerably lower storage areas than those required for standard containers. Thus foldable containers reduce the environmental impact of and need for port expansion projects. For land transport, foldable containers will reduce both the carbon footprint and traffic congestion as more empty containers can be transported in a single trip. In addition, the environmental impact of

foldable containers can be reduced if they are produced with recyclable materials.

Although foldable containers have been introduced to overcome standard container issues, there are some disadvantages involved with them. However the benefits of foldable containers over standard ones cannot be underestimated when considering the escalating volume of empty containers and the costs involved in repositioning them.

Foldable containers are not widely used due to some factors such as initial costs, safety issues (Boile et al., 2004) and the perceived costs of additional investments to improve port facilities and equipment to cater for foldable containers. In the short term, the use of foldable containers is expensive because of the high costs involved in production and the operational costs of foldable containers compared with standard containers. This confirms the claim that the initial market price and the costs of folding and unfolding foldable containers are quite high (Konings and Thijs, 2001). Furthermore there can be additional factors constraining the use of and adding to the unpopularity of foldable containers. Foldable container technology is not widely adopted in the industry at large, and therefore the technological mismatch of container handling equipment with foldable containers at ports can also be an issue. The opinion of the survey respondents on the impact of foldable containers on port operation suggests that, despite the benefits accrued to ports from additional terminal capacity and time saved by not having to move empty containers, there may be issues in sorting foldable containers.

Introducing foldable containers may require the re-assessment of the operational procedures and safety standards that apply to the existing standard containers, to suit foldable containers. Overall, the industry responses indicated that there was common agreement on the importance of foldable containers and their introduction into the market. Despite the problem of initial and operational costs, the advantages of foldable containers as identified by the industry professionals surveyed include:

- Improvements in efficiency in ports and shipping.
- A reduction of the burden on loading centres to search for solutions to capacity constraints at their storages and yards.
- A reduction of total transportation system costs.
- The generation of positive social and environmental implications for economies.

The next section presents a case study on the implications of foldable containers on port capacity and capital costs.

## **VII. Case Study: Port of Melbourne Corporation**

### **1. The Port of Melbourne Corporation**

The Port of Melbourne (PoM) handles approximately 36% of Australia's container trade and it is also the primary mainland port for the transfer of Tasmanian (Tasmania is an island state of Australia) cargo to and from domestic and international markets. The port is presently ranked 46th of the world's container ports by total container trade and is Australia's international trading gateway for over 40 shipping lines, providing access to over 300 international markets. The PoM is one of Australia's oldest established city ports and has grown with the city of Melbourne to become the most prominent port in Australia. In 2008, the port handled 2.16 million TEU, worth more than AUD 90 billion of trade (Port of Melbourne Corporation, 2009b). The International Container forecast for the PoM is given in Table 1.

<Table 1> International container forecast for the Port of Melbourne

Year	Forecast container traffic (million TEU)	Compound Annual Growth Rate
2009	2.110	-
2010	2.063	-
2015	2.707	5.60%
2025	4.466	5.10%
2035	7.057	4.70%

Source: Adapted from the Port of Melbourne Corporation (2009b)

As shown in Table 1, PoM container traffic is expected to continue growing. This is mainly due to increased cargo traffic to and from its captive hinterland. The port is expected to undergo rapid changes in many areas which will bring new opportunities and challenges (Port of Melbourne Corporation, 2009b).

The need to change port technology to handle cargo at faster rate is a primary concern of ports to enhance port productivity and efficiency. Accordingly the PoM Corporation has invested in many technological innovations in shipping and cargo including a new berthing facility, an expanded capacity of existing berths and has also encouraged its terminal operators to invest in more efficient cargo handling technology (Ship-Technology.Com, 2014). As a result, the port has become the largest container and general cargo port in Australia (Port Technology International, 2013). Along with these developments, the ownership structure of the port has changed substantially and the port administrative structure has become more corporatized. The commercial orientation of the strategic objectives of the port has led to the leasing out of cargo terminal operations to the private sector. These decisions are possibly the result of pressure from financial constraints and alack of capacity to deal with the increased growth in containers and intra and inter-port competition as a result of port restructuring in Australia. In addition the port is confronted with the requirements imposed by the regulatory authorities, mainly with respect to the establishment of 'green port' operation. Thus changes in port operation that are in-line with what are considered socially and environmentally acceptable operational practices have been the main agenda of the port strategic plan (Port of Melbourne Corporation, 2009b).

The growth of port traffic impacts tremendously on the capacity of the port, mainly in the ability to provide sufficient infrastructure and superstructure for cargo operations and storage. There are two drivers that have influenced the development of the PoM. The first driver is the capacity demand and the delivery of an appropriate level of infrastructure capacity to accommodate and facilitate trade growth. The problem of port capacity can be resolved through asset investment or productivity improvement. Over recent years, capacity has been increased through investment in superstructure and equipment delivering productivity enhancements and this has proved effective on the basis of the continued investment in existing facilities and terminals. As this has proved effective in the past, there is a growing need to deliver certainty of capacity into the future and ensure that the PoM maintains its position as Australia's premium port. The second driver that influences the development of the

PoM is the opportunity to enhance efficiency as a means of achieving and delivering better service level outcomes for the customers of the port.

Given the strategic plan on port development, the PoM, like any other port in the world, faces constraints in achieving its objectives. Among these, land limitation is a critical constraint. Table 2 shows the estimated future berthing infrastructure requirements.

<Table 2> Estimated future international container terminal requirements

Year	Berth Length (m)	Terminal Area (ha)
2009	1828	77
2010	1828	85
2015	2760	120
2025	2760	120
2035	3770	160

Source: Adapted from Port of Melbourne Corporation(2009b)

The Port of Melbourne Corporation has strategized to develop an empty container park; and conduct mandatory infrastructure investments such as channel deepening, terminal improvements and the improvement of land access infrastructure. Providing additional land for other sectors such as equipment maintenance, cleaning facilities, storage, information and communications services, quality control and truck marshalling is a challenge for the PoM.

## **2. Implications of Empty Standard Containers and Foldable Containers on Port Capacity and Capital Costs**

Statistics on container cargo movements suggest that the PoM will continue to experience favourable trade figures. Nevertheless, of the total containers handled at the port, a considerable number of containers are empty. Table 3 illustrates the number of full and empty containers traded through the PoM during 2009.

<Table 3> Composition of container traffic traded through the PoM, 2009  
(‘000 TEU)

Trade	Imports		Exports		Total	
	Full	Empty	Full	Empty	Full	Empty
International and Mainland Coastal	816	48	555	261	1371	309
Tasmanian	84	52	113	31	197	83
Sub-Total	900	100	668	292	1568	392
Transhipped	90	9	69	10	139	19
Total	990	109	737	302	1707	411

Source: Adapted from Port of Melbourne Corporation(2009a)

The volume of empty containers is approximately 20% of the total TEUs handled by the port in 2009 (table 3). Port data indicates that in one year (from 2010 to 2011) empty container movement grew by 6.1% to 527,000. The capacity of the existing port infrastructure, mainly Swanson Dock which has an area of 77 hectares, is limited. The dock will require double the capacity by 2035 to accommodate the forecast traffic. The PoM plans to construct an additional international container terminal which will cost around \$15.5 billion (Rood, 2011). Expanding the capacity of the port terminals is a costly affair and developing a new terminal requires a large capital investment. However the financial position and capability of the port are stable. In 2011, the profit after tax increased to \$99.8 million from \$39 million in 2010 (Port of Melbourne Corporation, 2011). Undertaking new capital investment would however exert an extra burden on the financial position of the port.

The port has spent a considerable amount of its revenue (roughly \$33.6 million in 2011) on the maintenance, rehabilitation and modernization of its existing infrastructure and superstructures and has a large sum of accumulated borrowings, around \$455.5 million. In order to maintain a low debt level and sustain high profitability, the port is required to reduce its investment on high cost port expansion projects. The impact of using foldable containers on reducing port capital expenditure is analysed as a way of tackling the capacity constraints of the port. Table 4 shows the results of this analysis and compares the known (year 2010) and projected standard container traffic (year 2035) with the known and projected foldable container traffic for the same years. The number of actual (2010)



and projected (2035) empty containers (both standard and foldable) is also calculated and shown on table 4.

<Table 4> The situation of Port of Melbourne in 2010 and 2035 with standard containers and foldable containers

	Standard container	Fallpac foldable container
Port expansion cost	\$1.2 billion	Decrease
Existing land	77 ha	-
No. containers handled in 2010	2.036 million	-
%of empty standard containers in 2010	18.60%	-
No. standard empty containers handled in 2010	0.384 million	-
Land requirement in 2035	160 ha	Decrease
Projected total no. containers handled in 2035	7.057 million	5.817 million (=7.057-1.55+0.31)
Projected %of empty containers to be handled in 2035	22% $(= [0.21_{2010}/0.15_{1994}]^{1/(35-1)} - 1)^{1)}$	0.31 million (= 1.55/5)
Projected empty containers to be handled in 2035	1.55 million (=7.057*0.22)	- 80% (0.31-1.55/1.55*100) reduction
Projected full containers to be handled in 2035	5.507 million (=7.057-1.55)	
Projected total no. containers to be handled in 2035	7.057 million	5.817 million (=5.507+0.31)

Based on the compound annual growth rate of empty containers, the share of empty containers handled by the PoM in 2035 will be approximately 22% of the total containers. The PoM forecasts a total of 7.057 million TEUs by 2035 of which 1.55 million will be empty containers. With the introduction of foldable containers, the total number of containers could be reduced to 5.817 million (=7.057-1.55+0.31) by 2035, of which only 0.31 million (=1.55/5) could be empty foldable containers as five empty containers can be folded and stacked as one empty container. This is a substantial 80%  $((0.31-1.55)/1.55 \times 100)$  decrease

1) The figure is arrived based on compound annual percentage estimated by considering the % of empty containers handled in 1994 and 2000, which are 15% and 21% respectively.

compared with the present situation using standard containers. The reduction can be mainly attributed to the foldable nature and the technical standardization of the containers.

Thus, the PoM will require less land for capacity improvements for empty container storage. The port can then reduce the capital cost for port capacity expansion. This will allow the port to realize capital cost savings and invest elsewhere for port development. Although the PoM Corporation is financially strong (Port of Melbourne Corporation, 2009c), probable financial pressure on the port corporation, mainly from borrowings, will be lowered with the use of foldable containers for container cargo transportation.

Container services such as container storage, container repair and maintenance, receiving and delivery of empty containers at the PoM are presently provided by independent container park operators (Port of Melbourne Corporation, 2009c). Introduction of foldable containers significantly affects the business processes of these operators and their turnover. The total ground slot capacity for standard containers by these third party container service providers is 62,120 TEUs, which is approximately 10,353 ground slots with a stacking height of six containers (Port of Melbourne Corporation, 2009c). The use of foldable containers reduces the ground slot requirement to 2,070 slots which is a significant saving of the capacity of existing container parks. This allows the container service providers to allocate vacant land for alternative uses.

Overall, the case of the PoM Corporation suggests that the introduction of foldable containers can financially benefit ports and their operation in terms of reducing the pressure on space and infrastructure expansion requirements that currently stem from the increase in empty container traffic. In addition, container service providers to the port can gain significant benefits from ground slot capacity savings. #

## **VIII. Conclusion and Implications**

Despite the fact that standard containers have transformed the global trade tremendously over the last several decades, the design of the container has created several logistical and spatial issues. Capacity

constraints in ports for storing and repositioning empty standard containers are major concerns in the logistics and port industry. As an alternative, foldable containers have been introduced into the market. The popularity of foldable containers in the current market is relatively low but the industry is willing to accept the shift from standard containers. The industry perceives that foldable containers can generate numerous benefits such as reductions in capacity constraints at loading centres and storage, reduction in port infrastructure expansion costs and large benefits to the shipping industry by way of providing a direct solution to the problem of repositioning empty containers. Foldable containers may allow the port industry to gain substantial capital cost savings and restructure expansion plans. Furthermore the use of foldable containers can have significant impact on the cost of shipping. Shipping companies can save the additional costs of handling and carrying empty containers when they call at a port and the additional capacity in the ship can be used for extra cargo. This means that foldable containers not only reduce the cost and investment for a port and to the shipping lines that use the port, but they have a positive revenue impact on the shipping company.

Nevertheless the real impact and the effectiveness of foldable containers largely rests upon the differential in the price between a standard container and a foldable container, the expected costs for folding and unfolding, the initial cost of purchasing foldable containers, the level of integration capacity into existing logistic chains and their acceptability by the wider logistics industry. Furthermore, given that port terminals or container depots may not have the right equipment for the folding and unfolding of the containers, shipping lines may be hesitant to adopt the technology and this may lead to other issues such as lower durability and high purchasing costs of foldable containers (Ng, 2012).

The introduction of foldable containers into the logistics industry thus has direct implications on the stakeholders of the logistics industry. Container manufacturing firms, container leasing companies, logistics service firms, ports and port terminal companies are required to restructure their infrastructure and operations making them adaptable to foldable containers. Container manufacturing firms are required to adopt new technologies, and enhance their knowledge and skills to shift the production process from conventional standard containers to foldable

containers. Container leasing companies need to re-formulate their business strategies compliant to the foldable container market while mitigating the negative impacts of the market shift. Logistics service firms are required to restructure their logistics operations and storage practices. Most importantly ports and terminals are required to restructure yard planning, storage planning and container repair operations to conform to foldable containers.

This study has some limitations. The findings drew on are view of the literature and responses from industry professionals via emails. The questionnaire was brief and was only intended to obtain the viewpoint of the logistics industry and further improvements would be needed to conduct an in-depth analysis of the industry's perception of foldable containers and the practical issues of introducing them. In addition the case study is based on the statistical data prepared by the PoM. The validity of their methods and the accuracy of their container traffic forecasting, land and terminal area requirements are external to the present study and could have implications on the conclusions.

The study primarily focuses on the prospective benefits that a port can realize due to foldable containers. For future research, the operational and technological implications of foldable containers on port superstructure, terminal planning, handling and management of containers can be considered. Furthermore the impact of foldable containers and standard containers on road and rail haulage in terms of financial and economic costs can be comparatively studied as the inland container transportation business has its own market characteristics.\*

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