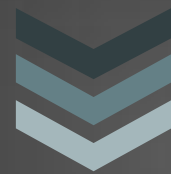


# Looking Inside the Box: Evidence from the Containerization of Commodities and the Cold Chain



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## ABSTRACT

Conventional investigations about containerized transportation tend to overlook the goods being carried to focus upon the associated modes and terminals. The perception of the container as a transport unit must be expanded to consider the container as a supply or commodity chain unit as well. Containerization is entering a new phase in its global diffusion and adoption by freight distribution systems. The first phase of containerization was mainly fuelled by a process of substitution, mostly in the form of the containerization of conventional general cargo. This also led to the development of a global containerized freight distribution system supporting a wide array of supply chains, particularly for manufacturing and retailing. The margin for further substitution is getting smaller as the degree of containerization has already reached high levels, particularly in developed economies, and that the current macroeconomic context is less prone to the growth of consumption, at least in the developed world.

The emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach which inherently creates an array of challenges. For instance, niche markets develop or disappear based on temporary market conditions, the balance of flows on trade routes and the need for market size. Still, the nature of the commodities being carried is a fundamental element in the emerging containerization of commodities. This paper aims at analyzing this emerging niche in the containerization process by “looking inside the box”. It particularly unravels the supply chain dynamics for a number of commodities and demonstrates which role the container fulfills in these commodity markets. The underlying factors that enable the growth or decline of commodity-based niche markets in containerization are discussed. It also looks at the dynamics of the specialized reefer market of cold chain logistics. By doing so, the paper explicitly links supply chain challenges in specific commodity chains to containerization, a link that has been largely ignored in the existing literature.

Keywords: Containerization, Freight distribution, Commodity chains, Cold chain

# LOOKING INSIDE THE BOX: EVIDENCE FROM THE CONTAINERIZATION OF COMMODITIES AND THE COLD CHAIN

## INTRODUCTION

The launching of the first containership *Ideal X* by Malcolm McLean in 1956 is often considered as the beginning of containerization. In the early years of container shipping, vessel capacity remained very limited in scale and geographical deployment, and the ships used were simply converted tankers. Shipping companies and other logistics players hesitated to embrace the new technology as it required large capital investments in ships, terminals and inland transport. The first transatlantic container service between the US East Coast and Northern Europe in 1966 marked the start of long distance containerized trade. The first specialized cellular containerships were delivered in 1968 and soon the containerization process expanded over maritime and inland freight transport systems (Rodrigue and Notteboom, 2009; Levinson, 2006).

Container shipping developed rapidly due to the adoption of standard container sizes in the mid 1960s and the awareness of industry players about the advantages and cost savings resulting from faster vessel turnaround times in ports, the reduction in the level of damages and associated insurance fees, and the integration with inland transport modes such as trucks, barges and trains. The large-scale adoption of the container in combination with the globalization process drove worldwide container port throughput from 36 million TEU in 1980 to 237 million TEU in 2000 and 545 million TEU in 2010. Around 60% of the world port throughput involved laden containers, about 20% are empty containers. The remainder consists of transshipped containers. The world container traffic, the absolute number of containers being carried by sea, has grown from 28.7 million TEU in 1990 to 152 million TEU in 2008, implying an average annual increase of 9.5%.

The container and the associated maritime and inland transport systems proved to be very instrumental to the consecutive waves of globalization. Hence, emerging worldwide container shipping networks allowed changes

in the economic and transport geography as they significantly shortened the maritime cost distances between production and consumption centers around the world. Container shipping also became an essential driver in reshaping global supply chain practices allowing global sourcing strategies of multinational enterprises, pull logistics solutions and the development of global production networks. New supply chain practices in turn increased the requirements on container shipping in terms of frequency, schedule reliability/integrity, global coverage of services, rate setting and environmental performance<sup>1</sup>.

While the dynamics of containerization is a well-researched theme by academics, consultants and the wider business community, the investigation of cargo being carried by containers appears to be underrepresented, particularly for commodities and the cold chain. The perception of the container as a transport unit must be expanded to consider the container as a supply or commodity chain unit as well. This paper will demonstrate that the emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach which inherently creates an array of challenges. This paper aims at analyzing this emerging niche in the containerization process by “looking inside the box”. The underlying factors that enable the growth or decline of commodity-based niche markets in containerization are discussed. It also looks at the dynamics of the specialized reefer market of cold chain logistics.

## REVIEWING THE GROWTH OF CONTAINERIZATION

Containerized freight is commonly characterized by the movement of manufactured goods and parts from manufacturing facilities to retail activities with the whole range of distribution activities in between, such as terminals and distribution centers. This process has substantially benefited from the mobility containerization provided in terms of spatial flexibility and distribution efficiency. The outcome has been the emergence of global production and distribution networks. This underlines that containerization

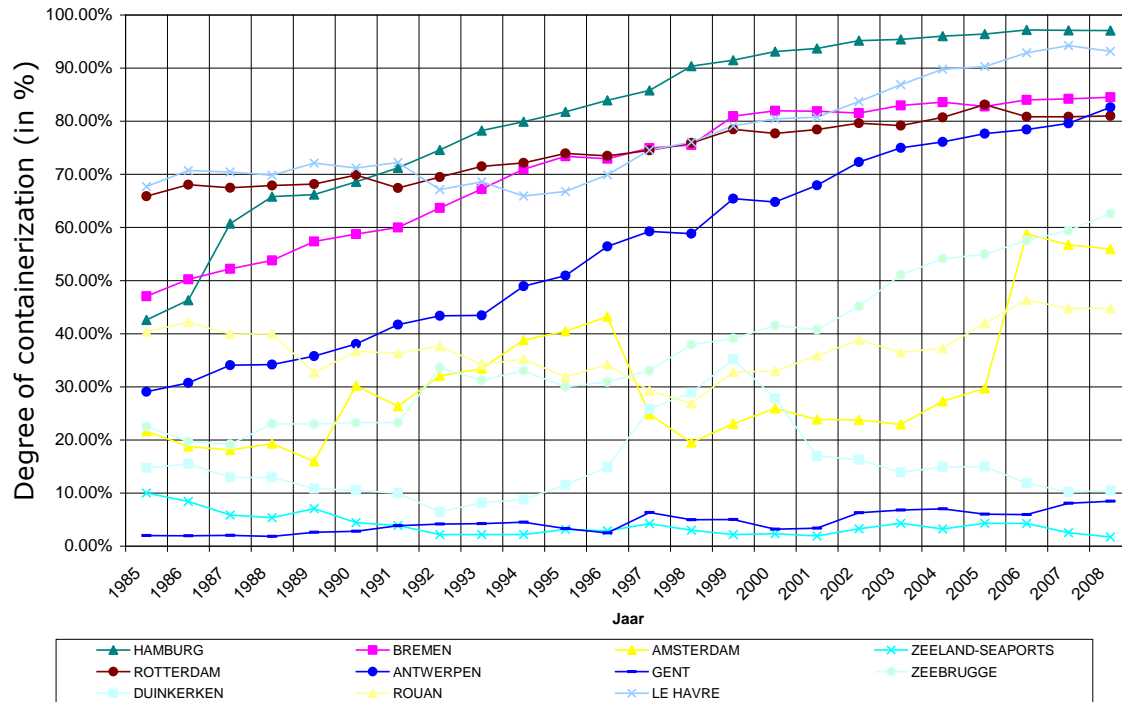
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<sup>1</sup> During the TOC Europe (Terminal Operators Conference) in Antwerp in early June 2011, Eivind Kolding - CEO of Maersk Line - unveiled the new mission for container shipping. Based on an investigation of customers' requirements, the liner shipping industry should according to Maersk focus on three key factors: (1) on time performance / reliability; (2) ease of business (i.e. avoid complexity, increase transparency) and (3) environmental performance. These three aspects should be considered in a supply chain perspective.

has mainly been investigated from the principle of flow, particularly in light of the development of maritime and inland logistics. Issues such as shipping networks and service configurations as well as the setting and operation of maritime terminals and inland ports have received attention to explain the structure of global supply chains (Fremont, 2007; Slack, 1998).

The conventional growth dynamics of containerization have mainly relied on an array of factors, which include:

- Substitution. Initially, substitution was the main factor behind the growth of containerization with the gradual capture of the break bulk cargo market. This process has been particularly visible in many ports as illustrated by rising containerization degrees (i.e. the ratio between containerized throughput of the port and the total general cargo volumes handled in the port). Figure 1 shows the evolution of the containerization degrees in the ports of the Hamburg-Le Havre range in Europe. Not all ports have embraced or were in a position to embrace containerization (i.e. Ghent, Zeeland Seaports and Dunkirk). Except for Zeebrugge, all large container ports in the range (i.e. Rotterdam, Antwerp, Hamburg, Bremerhaven and Le Havre) have reached containerization degrees above 80%. Since almost all break-bulk cargo that can be containerized (i.e. in terms of dimensions, weights, etc.) has been containerized this substitution process is essentially near to completion in developed economies. It is also rising rapidly in emerging economies and developing countries. Particularly for developed economies this leaves the possible containerization of niche markets, namely commodities and temperature sensitive cargo (cold chain).



**FIGURE 1: EVOLUTION OF THE CONTAINERIZATION SEAPORTS OF THE LE HAVRE – HAMBURG RANGE IN EUROPE (IN %)**

- Substitution.** Production and trade imbalances in the global economy are reflected in physical flows and transport rates. Containerized flows are almost never balanced, implying that empty containers must be repositioned to locations where export cargo is available (Table 1). For the United States, the imbalance with Asia peaked to more than 10 million TEU in 2006/2007 with containerized freight flows between Asia and USA three times as voluminous as containerized flows between the United States and Asia. Still, on a global scale the empty incidence in port throughput has remained rather stable at around 20% (table 2). The more imbalanced the traffic is, the more containerized capacities are required. This also leaves opportunities to take advantage of empty back hauls and the lower freight rates they imply.
- Incidental.** Production and trade imbalances in the global economy are reflected in physical flows and transport rates. Containerized flows are almost never balanced, implying that empty containers must be repositioned to locations where export cargo is available (Table 1). For the United States, the imbalance with Asia peaked to more than 10 million TEU in 2006/2007 with containerized freight

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- **Induced.** Global freight distribution implies a transport chain where several modes are used to move cargo between its origin and destination. On the maritime segment, this has led to the emergence of intermediary hubs connecting different systems of circulation. This requires transshipment and consequently additional containerized capacities. Intermediary hubs emerge in places where the hub-and-spoke and interlining/relay solutions offer clear advantages over direct port calls at mainland ports. They are particularly located along the equatorial round-the-world route (Figure 2). The creation of intermediate hubs does not occur in all port systems, but around specific regions ideally suited for maritime hub-and-spoke distribution patterns, thanks to geographical, nautical and market-related advantages (see Rodrigue and Notteboom, 2010 for a more comprehensive discussion). Transshipment has proven to be a major driver for the growth world container port throughput. The worldwide transshipment incidence has steadily increased from around 18% in 1990 to over 28% in 2008 (Table 2).

**TABLE 1: EVOLUTION OF CONTAINER IMBALANCES ON MAJOR TRADE ROUTES<sup>2</sup>**

Year	Asia-USA Eastbound	USA-Asia Westbound	EB / WB (*) imbalance	Asia-Europe Westbound	Europe-Asia Eastbound	EB / WB (*) imbalance	USA-Europe Eastbound	Europe-USA Westbound	EB / WB (*) imbalance
1995	4.01	3.47	1.15	2.83	2.31	0.81	1.21	1.45	0.83
1996	4.10	3.52	1.17	3.14	2.58	0.82	1.22	1.42	0.86
1997	4.66	3.62	1.29	3.29	2.73	0.83	1.28	1.56	0.82
1998	5.22	3.33	1.57	3.49	2.71	0.78	1.33	1.70	0.78
2000	5.59	3.25	1.72	4.53	3.59	0.79	2.19	2.94	0.74
2001	7.19	3.86	1.86	5.93	4.02	0.68	2.71	3.62	0.75
2002	8.81	3.94	2.24	6.13	4.16	0.68	1.50	2.59	0.58
2003	10.19	4.05	2.52	7.26	4.92	0.68	1.72	2.90	0.59
2004	12.40	4.20	2.95	8.90	5.20	0.58	1.70	3.20	0.53
2005	12.40	4.40	2.82	10.80	5.50	0.51	2.10	3.80	0.55
2006	15.00	4.70	3.19	15.30	9.10	0.59	2.50	4.40	0.57
2007	15.25	4.99	3.06	17.24	10.09	0.59	2.71	4.46	0.61
2008	14.53	5.61	2.59	16.74	10.50	0.63	2.94	4.34	0.68
2009	11.5	6.9	1.67	11.5	5.5	0.48	2.5	5.3	0.47

<sup>2</sup> (\*) Eastbound traffic compared to Westbound traffic (a value of 1 implies a perfectly balanced trade).

Source: UNCTAD, Review of Maritime Transport, various years.

TABLE 2: COMPOSITION OF WORLDWIDE CONTAINER PORT THROUGHPUT

	Total port handling million TEU	Full container handling million TEU	Empty container handling million TEU	Transshipment handling million TEU	Empty incidence	Transshipment incidence
1990	88	70.2	17.8	15.5	20.2%	17.6%
1995	145.5	118.7	26.8	31.2	18.4%	21.4%
2000	236.6	186.4	50.2	59.2	21.2%	25.0%
2005	399	316.3	82.7	106.3	20.7%	26.6%
2008	524.6	415.4	109.1	148.6	20.8%	28.3%

Source: based on Drewry (2009)

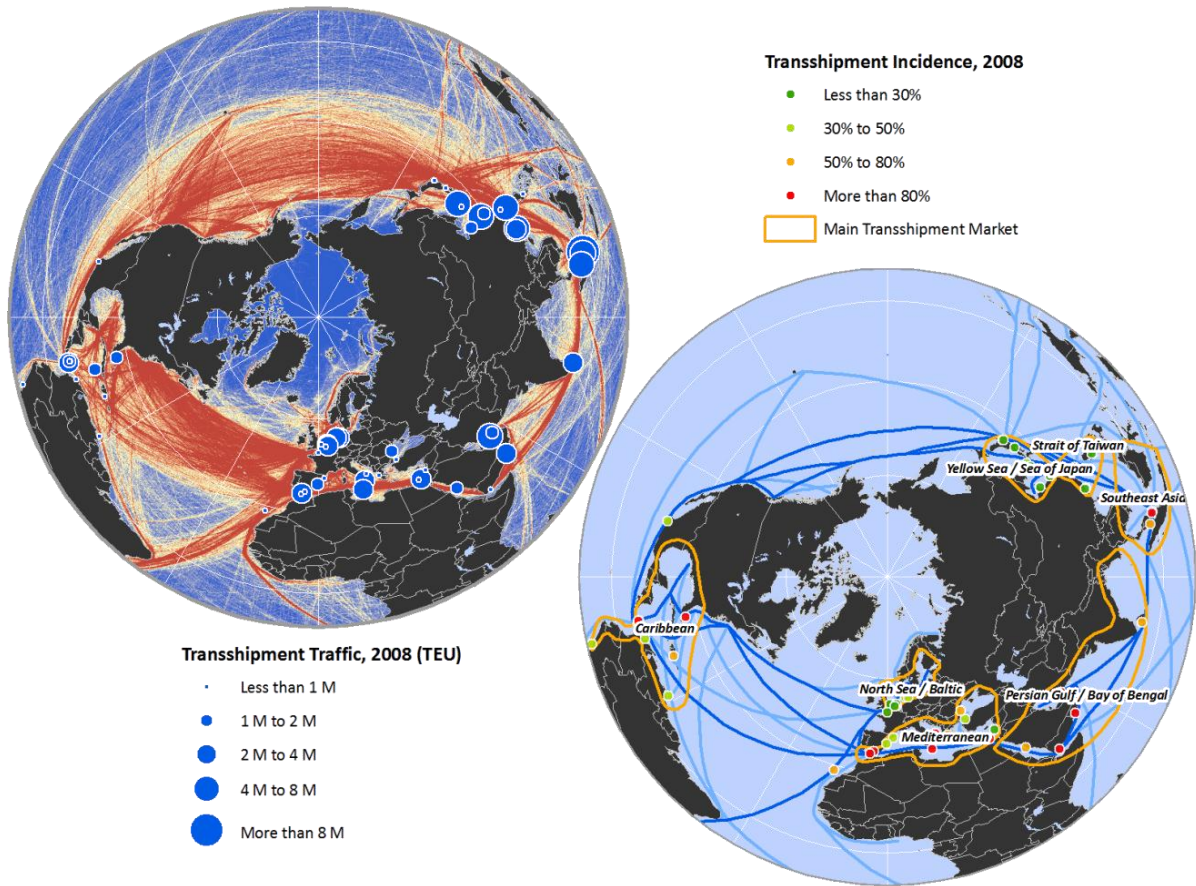


FIGURE 2: THE GLOBAL TRANSSHIPMENT MARKET

- **Derived** (often labeled as organic growth) or an outcome of economic and income growth where there is a growing quantity of freight in circulation. Additionally, globalization has relied through the exploitation of comparative advantages on a fragmentation of production that implied a growth of the average distance over which containerized freight is being carried. In both cases, greater

containerized capacities are required. The dynamics based on derived demand may have reached maturity in terms of its containerization potential as many global supply chains are now fully containerized. For the conventional containerized market, this implies that changes are derived from the ebb and flows of commercial activity and much less from the geographical and functional diffusion of the container.

Given that the derived growth function of containerization is becoming less dynamic, that the substitution effect is getting weaker in developed economies and that empty incidence has remained rather stable, an increasing share of the growth will (have to) come from increased transshipment volumes and the development of niche markets and opportunities that were initially bypassed. For the latter, it is thus important to consider commodity and cold chains as components of containerization.

Commodities, from grain, chemicals, to wood products, are among a large array of goods being traded in the global economy. Temperature sensitive products, particularly food, also represent a niche for containerization. It can thus be argued that a subsequent phase in the geographical and functional diffusion of containerization will relate to commodities and the cold chain, which represent a notable market potential being realized. Both transport systems - bulk and containerized - have a role to play implying that the containerization of commodity chains is more likely to be a process based on a complementarity rather than on competition since each transport chain has its own advantages.

It is clear that for several commodities such as grain, iron ore and coal, containerization will at best perform a niche role in the total volume handled. Both are likely to benefit since containerization offers speed and flexibility, while bulk offers the lowest transport cost possible. Because of vested interests, in terms of accumulated infrastructure investment and long standing practices, many opportunities could be captured by commodity producers, large and small alike, over niche markets (high quality grains, organics, etc.).

The emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach which inherently creates an array of challenges. For instance, niche markets develop or disappear based on temporary market conditions, the balance of

flows on trade routes and the need for market size. Still, the nature of the commodities being carried is a fundamental element in the emerging containerization of commodities.

## MARKET POTENTIAL

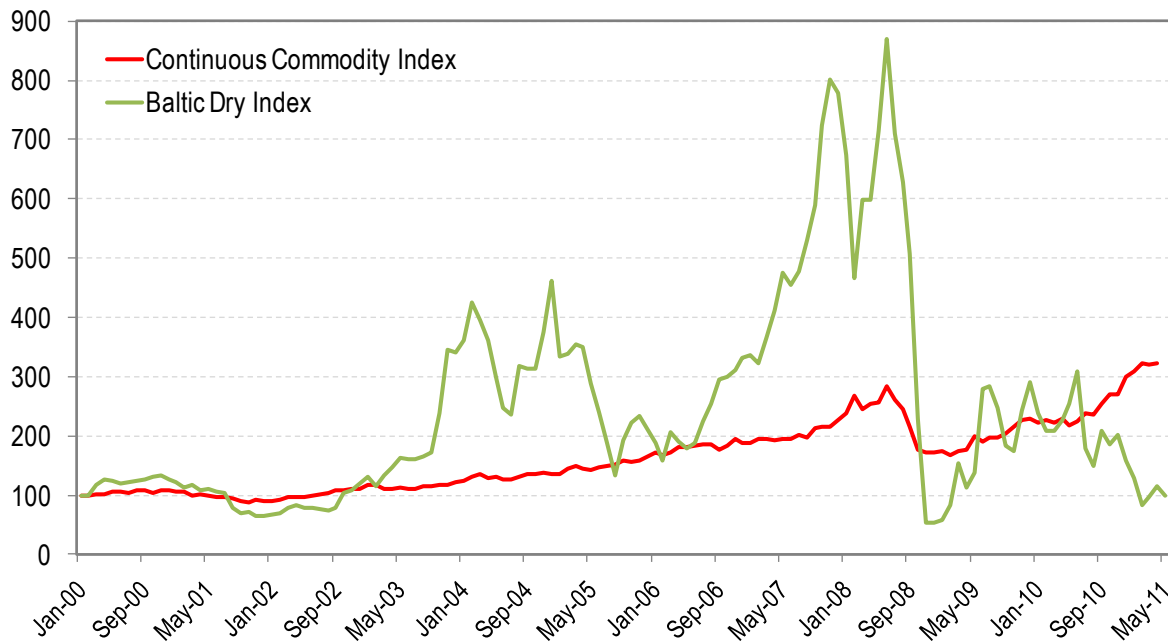
The degree of market penetration of containerization remains to be assessed and there is a wide variety of levels to which the container can be embedded within various commodity and cold chains. Some commodities are already fully containerized, while for others containerization is still in its infancy. For instance, 95% of all European coffee imports are containerized since coffee is a commodity of high value and its consumption rather ubiquitous. The demand structure of coffee is thus well suited for the benefits of containerization. Many segments of raw materials and food commodity chains are in the process of being containerized, which is starting to account for a notable share of international trade. This process is supported by several factors:

- A growing number and availability of containers in transport markets around the world is making it a rather ubiquitous transport product. Yet, this ubiquity is challenged by temporal shortages of containers (as for example reported by market players in mid-2010<sup>3</sup>) and of specific container sizes in some markets. Since 2000 the global inventory of containers grew 6.9% annually while the container ship fleet increased 11.1% per year. The box-inventory-to-vessel capacity ratio is expected to reach 1.99 by the end of 2011 compared to 2.03 in 2010 (figures Alphaliner). This is the lowest ratio on record and compares with the capacity ratio of 2.99 boxes per slot in 2000. The lower ratio is partly the result of a more efficient asset management by shipping lines, but also reflects increased pressures on container availability;

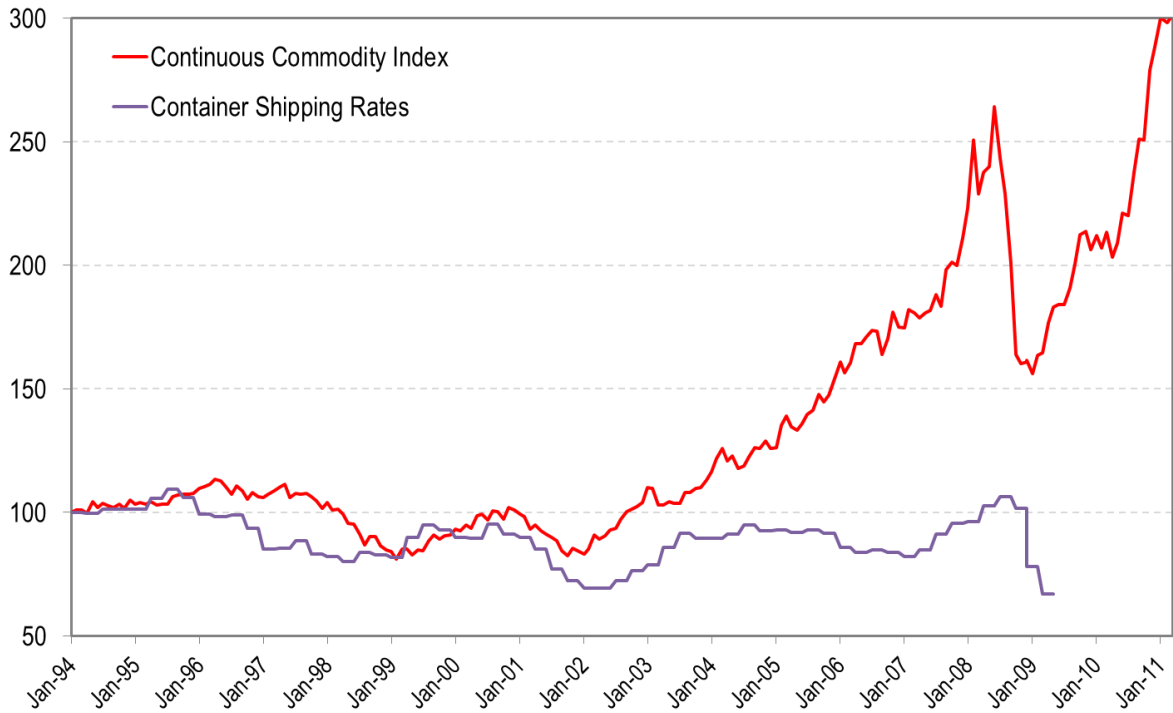
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<sup>3</sup> Container shipping demand in 2010 was rebounding so fast after the crisis year 2009 that there were not enough containers available for Asia's exporters during the peak season that runs from June to October (Wright, 2010). During 2009, shipping lines and container leasing companies hardly ordered any new containers as market expectations were weak. Neither the shipping lines nor their customers had anticipated the unprecedented surge in demand in most trades. The container shortage was further exacerbated by labor shortages in Chinese container factories and slow steaming practices which lower container round trip time. Also in 2011 the problem of container shortages reemerged as production of boxes lagged growing cargo capacity.

- A general rise in commodity prices and growing demand in new markets have made many commodities more prone to be containerized from a value proposition standpoint;
- Fluctuations and rises in bulk shipping rates have incited the search of options to bulk shipping. The increased volatility in bulk shipping (as illustrated by the Baltic Freight Index on Figure 3) also makes long term planning for bulk shipping complex and subject to risks;
- Relatively stable and even declining container shipping costs, particularly in light of rising commodity prices, rendered the container even more attractive since shippers can be more confident about shipping rates (Figure 4);
- Global trade imbalances are transcribed in imbalanced container shipping rates, which represent a notable export subsidy for return (backhaul) cargo. For markets having notable imbalances, such as China (exports) and the United States (imports), incentives are acute;
- Empty container repositioning has created opportunities by making available pools of empty containers that can be filled for backhauls.

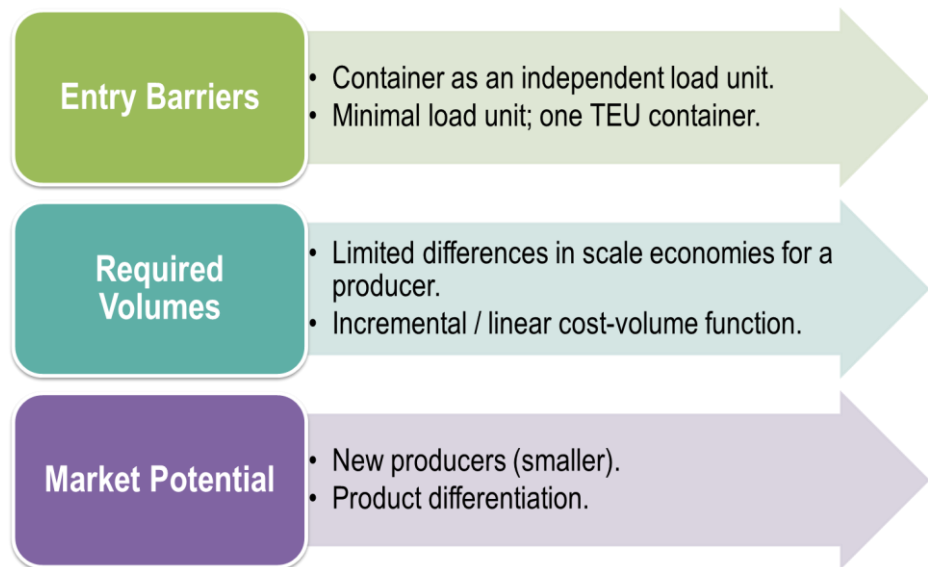


**FIGURE 3: CONTINUOUS COMMODITY INDEX AND BALTIC DRY INDEX, 2000-2011 (2000=100)**



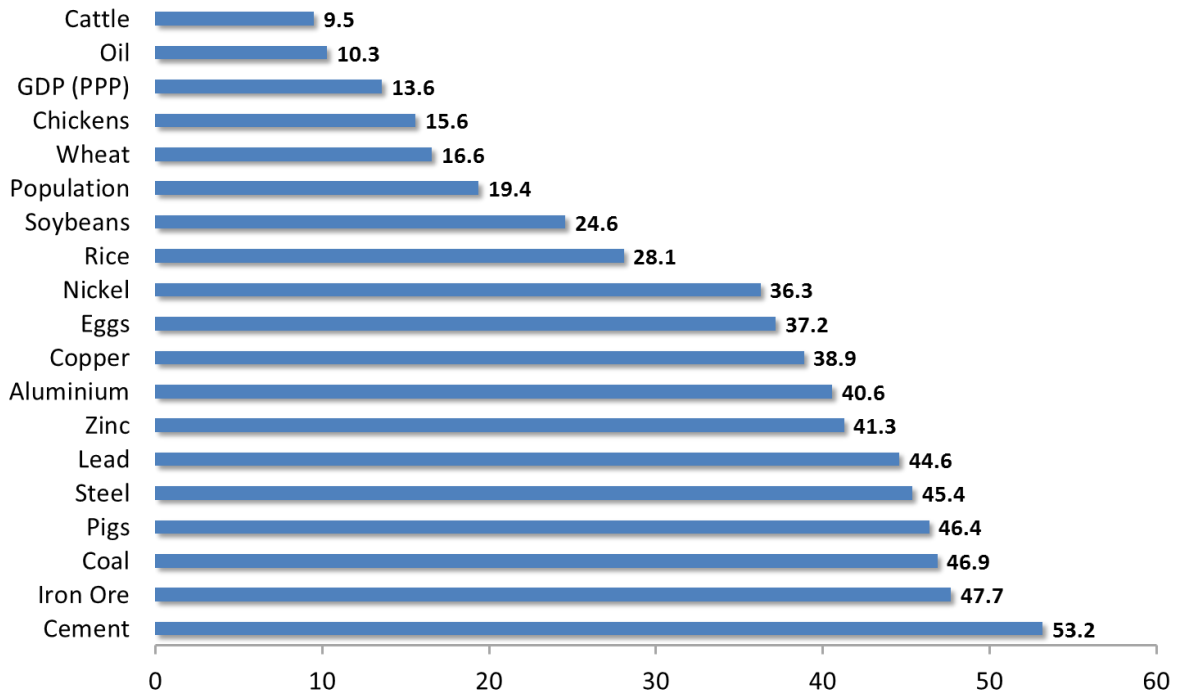
**FIGURE 4: CONTINUOUS COMMODITY INDEX AND AVERAGE CONTAINER SHIPPING RATES, 1994-2011 (1994=100)**

Containerization has benefited substantially from economies of scale, particularly for maritime shipping. The container confers few differences in scale economies for a producer as each container is a unique transport unit and since containerized shipping networks are fairly ubiquitous (Figure 5). Barriers to entry are thus quite small as each container is an independent load unit that can accommodate lower volumes without much drawbacks as long as other containerized volumes are present (economies of scale are very important for terminal operators and maritime shipping). For instance, farmers (or cooperatives) may develop their own markets by sending small agricultural commodity loads through regular containerized supply chains. Thus, containerization can provide the double benefit of permitting the development of global niche markets where numerous small exporters may compete as well as offering new economic development venues in commodity sectors which could not previously access foreign markets.



**FIGURE 5: FROM BULK TO CONTAINERS: BREAKING ECONOMIES OF SCALE**

The growth of China as an export-oriented economy has been accompanied by an impressive growth in the consumption of key commodities (Figure 6). The consumption of 53% of the world's cement production is reflective of massive capital investment and the related construction activity. It must be considered that a share of the national commodity consumption is used in the manufacturing of goods that will be exported to foreign markets. Thus, a share of China's commodity consumption is attributed to consumption taking place elsewhere, such as in the United States and Western Europe.



**FIGURE 6: CHINA’S SHARE OF THE WORLD COMMODITY CONSUMPTION, c2009**

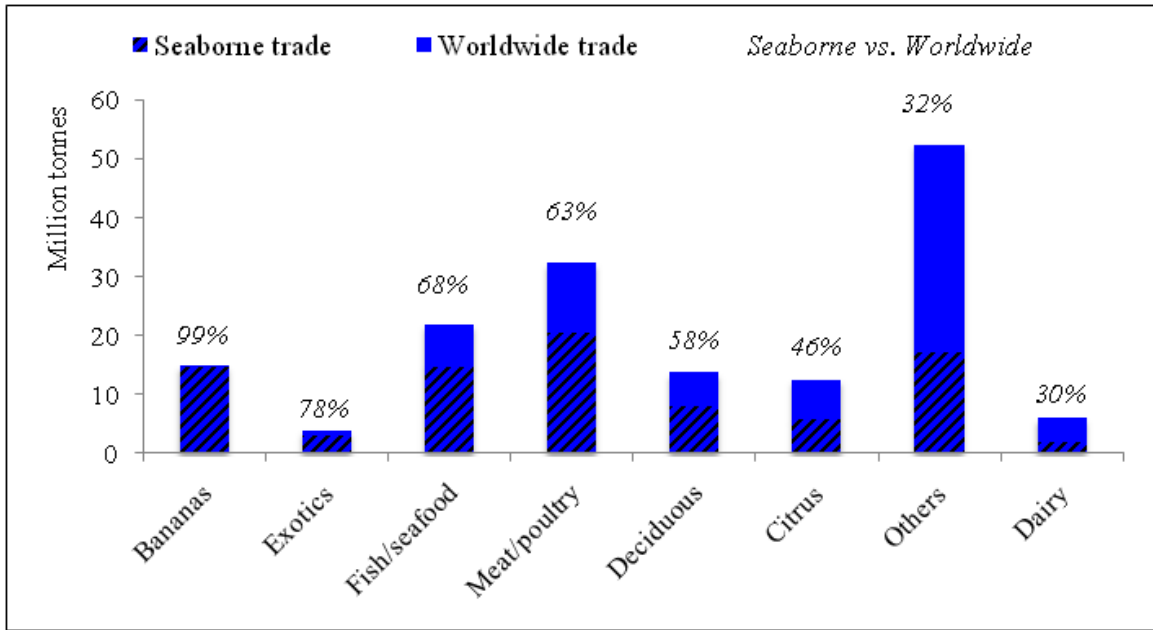
Source: United States Geological Survey (2009), BP Statistical Review of World Energy (2009), Food and Agriculture Organization of the United Nations (2008), International Monetary Fund (2010).

Yet, more attention should be placed on analyzing the potential, particularly the time and flexibility benefits, for the containerization of commodity markets. For instance, the opportunity created by trans-pacific trade imbalances has yet to be better captured by the North American commodity sector, particularly in light of expected Chinese demand. The same applies for the European commodity sector in terms of the imbalanced Pacific-Indian-Mediterranean routes.

Temperature control in the shipment of foodstuffs is a component of containerization that has continued to rise in necessity with international trade. As a growing number of countries focus their export economy around food and produce production, the need to keep these products fresh for extended periods of time has gained in importance. Increasing income levels create a change in diet with amongst others a growing appetite for fresh fruit and higher value foodstuffs such as meat and fish. Persons with higher socioeconomic status and of more economic means are more likely to consume vegetables and fruit, particularly fresh, not only in higher

quantities but also in greater variety (Darmon and Drewnowski, 2008). Consumers with increasing purchase power have become preoccupied with healthy eating, therefore producers and retailers have responded with an array of exotic fresh fruits originating from around the world. Any major grocery store around the world is likely to carry tangerines from South Africa, apples from New Zealand, bananas from Costa Rica and asparagus from Mexico.

A cold chain industry has emerged to service these commodity chains. In 2002, an estimated 1200 billion dollars' worth of food was transported by a fleet of 400,000 refrigerated containers (reefers). Alone, the United States imports about 30% of its fruits and vegetables and 20% of its food exports can be considered perishables. Figure 7 shows the percentage of seaborne trade in relation to the total worldwide trade for eight different reefer commodity groups. These eight clusters are further divided into: (a) during transport living cargo and (b) during transport non-living cargo. Bananas, exotics (pineapples, kiwifruit, avocados), deciduous (apples, grapes, pears) and citrus (oranges, lemons/limes, grapefruit, others) are a part of the living group. The non-living commodities exist out of fish/seafood and meat (poultry, pork, beef/veal, offal, sheep meat). The dairy (cheese/curd, butter) and others group (tomatoes, frozen potatoes, stone fruit, berries, melons, frozen vegetables, fresh vegetables) contain living and non-living commodities. Making the distinction between the living and the non-living is of vital importance for the transport mode because of the distinction in temperature setup and atmosphere control. Living commodities will be transported under refrigerated conditions with a limited lifespan, non-living commodities can be frozen, resulting in a longer lifespan. Out of the 156.9 million tons of worldwide reefer trade in 2009, it is estimated that 54% was seaborne, although the percentage varies significantly by commodity, as shown on Figure 7.



**FIGURE 7: TOTAL WORLDWIDE AND SEABORNE TRADE OF PERISHABLE REEFER CARGO BY COMMODITY, 2009<sup>4</sup>**

Source: own compilation based on Drewry Shipping Consultants (2010)

## COMMODITIES IN CONTAINERS

Because of the nature of the freight it handles, the containerization of commodities and the cold chain create a unique set of challenges. There are several problems related to placing and removing commodities from containers.

## LOCATION AND LOAD UNIT

The locational and load unit availability of containers imply that containers must be available in proximity, in sufficient quantities and be of a suitable load unit. While for light commodities the load unit is secondary, for ponderous commodities the twenty foot container is the most suitable. For hinterland transportation, this is an issue as maritime shipping companies own the majority of the global container assets and prefer these containers to be within the maritime system where they generate income for the carriers as opposed to the inland system where they generate income for truck, rail and barge companies.

<sup>4</sup> Note: The difference between seaborne and worldwide trade is the result of two major reasons: (a) transportation via air and (b) international trade via truck and/or rail.

Perishable or temperature sensitive items are carried in refrigerated containers (called "reefers"), that account for a growing share of the refrigerated cargo being transported around the world. While in 1980 33% of the refrigerated transport capacity in maritime shipping was containerized, this share rapidly climbed to 47% in 1990, 68% in 2000 and 90% in 2010. About 1.1 million TEUs of reefers were being used by 2004. All reefers are painted white to increase the albedo (share of the incident light being reflected; high albedo implies less solar energy absorbed by the surface) with the dominant size being 40 high-cube footers (45R1 being the size and type code). For instance a low albedo container can have its internal temperature increase to 50 °C when the external temperature reaches 25 °C on a sunny day while a high albedo container see its internal temperature increase to only 38 °C under the same conditions.

## CONTAINER HANDLING

Another issue involves container preparation. Containers are well adapted to handle packaged freight either directly ("floor loaded") or on pallets. This is another matter for commodities, particularly bulks. Some, like grains, would require a container to be thoroughly cleaned before being loaded to avoid any form of shipment contamination. In many cases, container liners will be used to protect the products being carried. The most common liners are made of polyethylene to protect common dry bulk products such as chemicals and minerals. For commodities that require a level of air circulation, such as coffee or cacao, polypropylene liners are used. Another form of lining concerns thermal protection so that goods can be shielded against temperature spikes that could degrade or damage them. It is often required that containers to be cleaned once unloaded, so it can be used for other purposes without contaminating other shipments. The usage of dedicated containers is also a possibility as it would reduce preparation costs, but would likely imply empty movements and high repositioning costs, which tends to defeat the purpose of containerization (a ubiquitous load and transport unit). Still, specialized containers exist for liquids and for refrigerated cargo.

The next issue is related to container loading, unloading and transloading. Containers carrying manufactured goods are dominantly loaded horizontally either manually or with fork lifts. Loading a container horizontally with bulk cargo is a complex task often requiring a panel to block the back door and hold the loose cargo. Alternatively, containers can be flipped vertically to be loaded or unloaded, but this requires specialized handling equipment. Still,

this is an attractive option in situations of constant volume. The usage of different modes to reach the load center (such as rail hopper cars) or the switch from domestic (53 footer) to maritime (40 footer) containers require a transloading operation, which represents additional costs. Some commodity chains, such as grains, also benefit if the integrity is maintained from the origin to the destination as it guarantees the quality of the shipment and product differentiation. This requires the source loading of containers.

The refrigeration unit of a reefer requires an electric power source during transportation and at a container yard. It is important to underline that the refrigeration units are designed to maintain the temperature within a prefixed range, not to cool it down. This implies that the shipment must be brought to the required temperature before being loaded into a reefer, which requires specialized warehousing and loading / unloading facilities. A new generation of reefers is coming online, which are equipped with an array of sensors monitoring effectively the temperature and shutting the cooling plant when unnecessary. This enables to improve the reliability of temperature control and well as extend the autonomy of the reefer.

## WEIGHT

Weight also is a major issue as container loads are much lighter for conventional (mainly retail) freight than for commodities. The shipping industry has adapted to this characteristic and prefers using larger containers (40 footers, high cube when possible) as they offer more volume for the same handling costs. Retail goods tend to have a higher volume to mass ratio than commodities. Shipping commodities such as grain tends to rely on 20 footers (one TEU) for the simple reason that they can each load around 26 to 28 tons while a 40 footer, because of structural integrity issues, has a loading capacity of about 30 tons, but this load is occupying twice the shipping volume. Consequently, the commodity sector mostly rely on a load unit (20 footer) which is different than many containerized supply chains, such as retail, that are relying on the 40 footer, particularly the high cube. This results in a problem of load unit mismatch between inbound and outbound logistics.

Weight distribution is also a related problem as containerships are designed to accommodate a specific weight load and distribution. Figures of 10 to 14 tons per loaded TEU are common in operational considerations when allocating containers on a containership. It has been noted that in North

America, export containers tend to be twice as heavy as import containers. If a ship is presented with a significant container volume of more than 20 tons per TEU, adjustments in the distribution of this load must be made. Under normal circumstances where there is an equilibrium between inbound and outbound traffic, a containership presented with a full load of heavy containers could only be filled to 75% of its capacity. This can be mitigated by considering the current structure of trade imbalances in North America with much of the containers leaving West Coast ports being empty. A scenario implying a full distribution of containers loaded with commodities and empties is thus applicable.

## TERMINAL AND TRANSLOADING ISSUES

Considering that most commodities extracting regions tend to be located inland, while manufacturing and consumption tend to take place more in coastal regions, the containerization of commodities relies on a closer dynamics between gateway ports and inland terminals. A fair amount of containerized freight is transloaded once they reach a gateway. For the North American West Coast, this amounts to about 20 to 25% of all containers. Maritime shipping companies are reluctant to have their containers moving inland as they prefer to keep them within their networks. There is thus a preference at major gateways to transload maritime containers (mainly 40 footers) into domestic containers (mainly 53 footers) in addition to the significant unit advantage it confers as the contents of three maritime containers are transshipped into two domestic containers. However, domestic containers are not well adapted for shipping commodities (less structural integrity) and cannot be forwarded on export markets. Transloading also results in less maritime containers available inland to be used for exports.

Bulk and containers rely on very different terminal characteristics and dynamics. Many bulk terminals were built to handle specific commodities and cannot readily be converted to other uses. Bulk commodities can be stored at port terminals in a relatively compact manner, such as grain into grain elevators or coal and iron ore in simple large piles. The same volume of containerized commodities can consume as much as four times the terminal space. Still, this could be mitigated if the loading process takes place inland, either at a load center or at a satellite terminal. Additionally, the intermodal velocity of containerized freight tends to reduce its spatial imprint since a container spends much less time at a terminal. A container

port that is experiencing a growing role as a platform to export containerized commodities is expected to see a notable increase in the demand for storage space and pressures on dwell time. Since containerized commodities tend to be heavier than regular container loads, it may require adaptations in terminal management and operations (stacking and equipment usage). With volumes large enough, terminals could start to have dedicated sections for containerized commodities, as they already have to accommodate reefers.

The growth of the intermodal transportation of reefers has increasingly required transport terminals, namely ports, to dedicate a part of their storage yards to reefers. This accounts between 1% to 5% of the total terminal capacity, but can be higher for transshipment hubs. The stacking requirements simply involve having an adjacent power outlet, but the task is more labor intensive as each container must be plugged and unplugged manually and the temperature to be monitored regularly as it is the responsibility of the terminal operator to insure that the reefers keep their temperature within preset ranges. This may also forbid the usage of an overhead gantry crane implying that the reefer stacking area can be serviced by different equipment. Even if reefers involve higher terminal costs, they are very profitable due to the high value commodities they transport.

## CONTAINERIZED COMMODITIES AND COLD CHAINS

### AN EMERGING COMPLEMENTARITY

There is limited evidence underlining that the containerization of commodities is competing with existing bulk commodity chains. The process is more one of an emerging complementary between bulk and containerized commodity chains within global freight distribution, each having its own characteristics:

- Bulk commodity chains. These chains are commonly based on the specialization of terminals; often by specific commodity since each require specialized handling and storage facilities. There is also the issue of empty return movements as modes carrying commodities do so in only one direction with backhaul cargo opportunities almost non-existent. For instance, a crude oil tanker comes back empty after unloading its cargo. Thus, from a transportation perspective, this distribution system is prone to inefficiencies and

has a level of usage which is in theory 50%, but lower in reality because of the seasonality of some commodity markets, notably agricultural production.

- Containerized commodity chains. They are increasingly being used and it is becoming a matter of embedding commodity flows within the containerized freight distribution system. This would mainly concern niche markets where product separation (e.g. different grades of grain), smaller batches, delivery time and accessibility are more important. The containerized commodity chain, like its bulk counterpart, also faces the empty movement challenge. However, considering the current structure of international trade, a higher integration of commodities in containerized freight distribution would actually play a positive role in mitigating imbalances.

The transport of commodities is already characterized by substantial investment in bulk handling equipment, both for modes and terminals. There is thus a lot of accumulated inertia in existing distribution channels making stakeholders such as freight forwarders reluctant to change practices. In light of these powerful stakeholders, it remains to be seen how containerized commodity chains can take shape. The most likely processes involve the capture of niche markets, accommodating seasonal and regional demand surges, servicing new or expanding markets where bulk infrastructures are not adequate, or accommodating low volume situations where economies of scale are difficult to achieve.

### MISMATCHES AND SEASONALITY

In spite of the presence of substantial imbalances, the empty container backhauls cannot be fully exploited because of demand mismatches. It is common for commodity trade that import regions are not the same than exports regions. While imports regions tend to be consumption related and correspond to large metropolitan areas, exports regions are mainly rural areas or resource extraction areas with low population densities. One thus attracts a large quantity of full containers but may not necessarily provide a similar volume of exports while the other could generate a substantial export volume, but does not have a significant import volume. The setting of a cargo rotation would permit repositioning opportunities and help mitigate the availability of containers for exports. Sometimes, due to time and cost issues, a repositioning is not performed and the empty container goes straight back to the port instead of being loaded for the backhaul.

Many commodities such as agricultural products have a seasonality. This implies that for a region there will be a surge in demand at specific times of the year, while at other times demand would be considerably less. Additionally, seasonality has a geography since harvesting time varies between different regions of the world, which implies temporal and geographical fluctuations in the repositioning of empty containers. Seasonality is also linked with commodity price fluctuations, implying that as one get closer to the delivery time of a futures contract the market price tends to reflect better the real physical relationship between supply and demand. It is common in the agricultural sector that commodity prices will drop during the harvest season as real output is finally known and that uncertainties are removed. If the output is higher than expected, then prices drop, making containerization a less appealing alternative.

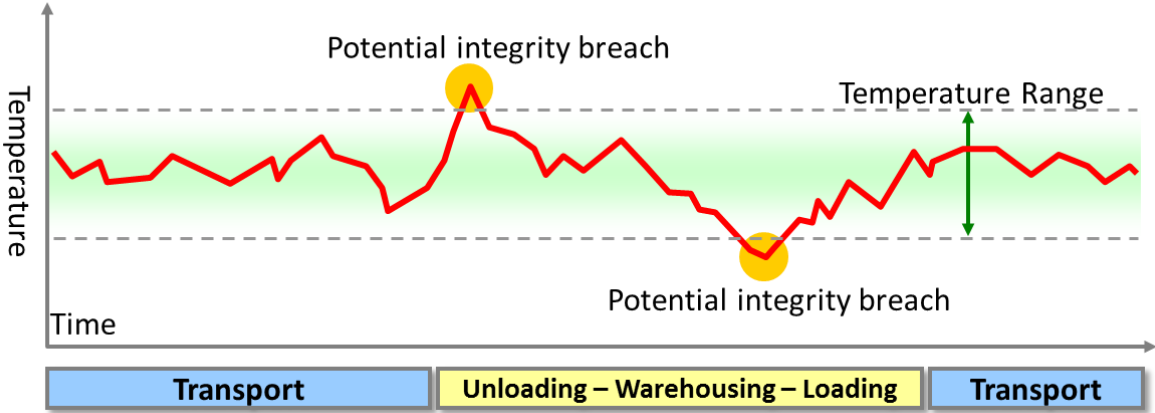
The further developments of containerized niche markets lean on supply chain integration since containerized commodity movements are particularly suitable where there is a significant backhaul movement of empty containers. Since the inbound flows relate to a very different supply chain (mostly retail), an effective use of backhaul containerized assets requires a concerted efforts between major commodity producers, rail operators, container owners (shipping and container leasing companies) and terminal operators.

### COLD CHAIN INTEGRITY

A chain is as strong as its weakest link. This is of particular relevance for a cold chain which preserves the integrity of a product by maintaining its temperature within a specific temperature range (2 to 8 degrees C is common; Figure 8). Many products, such as food, pharmaceuticals and some chemicals, can be damaged when not kept within a specific temperature range. Thus, supply chain integrity for temperature-sensitive products includes the additional requirements of proper packaging, temperature protection, and monitoring, which is fueling the growth of in-transit temperature monitoring. Attaching monitoring devices to the freight insures the recipient that the product integrity was maintained during transportation, and whenever a breach occurs, it helps identify the location along the supply chain where the breach of integrity took place (identification of the liability).

Reefers have become a crucial element of the cold chain as they offer a temperature controlled transport and storage unit, but are often too large

for many types of cold chain shipments such as pharmaceuticals. While a cold chain can be maintained over several transport activities, but with two potential breaches in its integrity. In the first case, it could involve the cargo being left exposed during the unloading process (or a reefer not connected to a power source during transshipment or the door left open for a too long time). In the second case, the product could have been stored in a refrigerated warehouse at a temperature below the product's storage specifications.



**FIGURE 8 - TEMPERATURE INTEGRITY ALONG A COLD CHAIN**

Due to the growth of temperature controlled shipments, a particular attention must be placed at identifying the locations, the equipment and the circumstances in which a breach in integrity can take place:

- Transportation issues. During transport, a malfunction (or an involuntary interruption of power) of the refrigeration equipment can in a couple of hours compromise the cold chain. Since the refrigeration equipment is designed to maintain a specific temperature level, a batch that was not previously cooled may place an undue stress on the equipment to the point that the temperature cannot be brought to the specified range. The reefer, due to wear and tear or defective equipment, may offer an improper cold storage environment, namely poor air circulation and defective insulation at seals (such as doors). Drivers may also voluntarily shut down the refrigeration unit to save on fuel costs, leave doors open for too long during deliveries or may be forced by local legislations to cut idling time.

- Transshipment and warehousing issues. During the loading, unloading or warehousing of a product, there are many potential situations where a cold chain can be compromised. For instance, a product can be left on the loading dock for an extended period or the refrigeration unit can be turned off during transshipment. Some warehouses can have poor temperature maintenance and control, while others do not have different temperature storage facilities so all the freight is stored at the same temperature.

## CONCLUSION

The first phase of containerization was mainly fuelled by a process of substitution, mostly in the form of the containerization of conventional general cargo. This also led to the development of a global containerized freight distribution system supporting a wide array of supply chains, particularly for manufacturing and retailing. As derived growth of containerization becomes less dynamic, the substitution effect is becoming weak in developed economies and as empty incidence has remained rather stable, an increasing share of the growth will (have to) come from the development of niche markets and opportunities that were initially bypassed. In this context we argued it is important to consider commodity and cold chains as a key component in a new phase in the global diffusion of containerization and its adoption by freight distribution systems.

The emerging phase of containerization encompasses a complementarity with the commodity sector and the extraction of niche market opportunities to satisfy new demands. This phase is driven by a commodity-wise approach which inherently creates an array of challenges. For instance, niche markets develop or disappear based on temporary market conditions, the balance of flows on trade routes and the need for market size. Other challenges emerge from more operational considerations linked to the availability, specialization and use of boxes.

Integrating the movements of commodities and the cold chain within containerized distribution systems thus involves a new set of challenges as their dynamics differ. Still, there is substantial potential for growth in the usage of containers to carry various commodities on global markets. With the continuing growth of the global population, the agricultural sector and its commodity chains, has much to gain from the velocity, ubiquity and flexibility of containerized freight distribution.

This paper sets the scene for more detailed research that links supply chain challenges in specific commodity chains to containerization, a link that has been largely ignored in the existing literature.

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