Distribution and value added logistics in the cold chain product market with application to the role of seaports

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Abstract:

A crucial question for logistics services providers is to decide where in the supply chain network to operate value added logistics services (VALS). When handling cold chain products, this question becomes even more complex due to the unique logistics characteristics of this kind of products. A cold chain is a supply chain which deals with temperature sensitive and often highly perishable goods. Each step along the whole cold chain needs special care to ensure the quality of the products and to optimize shelf life. The global market of cold chain products is increasing rapidly due to the development of cold chain techniques and transportation efficiency. This market is further characterized by a specific economic geography of cold supply chains and competition between market players such as supermarkets and producers for chain control.

This paper discusses distribution and value added logistics in relation to cold chain products. We are particularly interested in understanding how location decisions regarding value added logistics services are made when dealing with cold chain products. This study aims to present (1) the current dynamics in the organization of cold chain logistics; (2) the specific logistics characteristics of cold chain products, and comparison among different cold chain products, and (3) the effect of the specificities of cold supply chains on location decisions regarding VALS. This study also presents case studies on bananas, pineapples and kiwifruits cold chain to illustrate the optimal location selection process regarding VALS for different cold chain products.

Key words: cold chain, value added logistics services, logistics characteristics, distribution center, perishable goods

1. INTRODUCTION

A number of literature contributions have underlined the importance of developing value added logistics services (VALS) to meet customers' satisfaction (Peters et al., 1998; Ryan, 1996). By definition, value-added services refer to unique or specific activities that firms can jointly develop to enhance their efficiency, effectiveness, and relevancy (Bowersox et al., 2010), and provide competitive advantage in the market place (Gordon, 1989). Apart from its contribution to achieving customization, value-added services can also contribute to the horizontal integration of the supply chain (Hoek, 2001). It is difficult to generalize all possible value-added services because these services tend to be customer specific, and it is the customers' perspective of service quality that determines their satisfaction level (Bowersox et al., 2010; Mentzer et al., 2001). Thus, logistics service providers offer unique or specific VALS to enable customers to achieve their objectives. For example, Nike produces and delivers customized shoes to individual customers to add value to a rather standard product; Katoen Natie from Antwerp tailored their service for customer by offering pre-assembly of car dashboards and wiring for the former Opel Belgium plant in the port area (Drewry Shipping Consultants, 1999).

Several common VALS offered by logistics services providers are identified in recent literature, including repacking, labeling, assembling/re-assembling, quality control, order picking, cross docking, reverse logistics, distribution, localizing and customizing, installation and instruction, purchasing/procurement, price tagging, and offering information services (Lai, 2004; Hoek, 2001; Bowersox et al., 2010).

Where to perform these VALS is a crucial decision to logistics service providers but received little attention in academic literature. When handling cold chain products, this question becomes even more complex due to the unique logistics characteristics of this kind of products. A cold chain is a supply chain which deals with temperature sensitive and often highly perishable goods. Each step along the whole cold chain needs special care to ensure the quality of the products and to optimize shelf life. We are particularly interested in understanding how location decisions regarding value added logistics services are made when dealing with cold chain products. This study aims to present (1) the current dynamics in the organization of cold chain logistics; (2) the specific logistics characteristics of cold chain products, and comparison among different cold chain products, and (3) the effect of the specificities of cold supply chains on location decisions regarding VALS. This paper also presents case studies on bananas, pineapples and kiwifruits cold chain to illustrate the optimal location selection process regarding VALS for different cold chain products.

2. COLD CHAIN AND ITS LOGISTICS

2.1 Cold chain products and trade

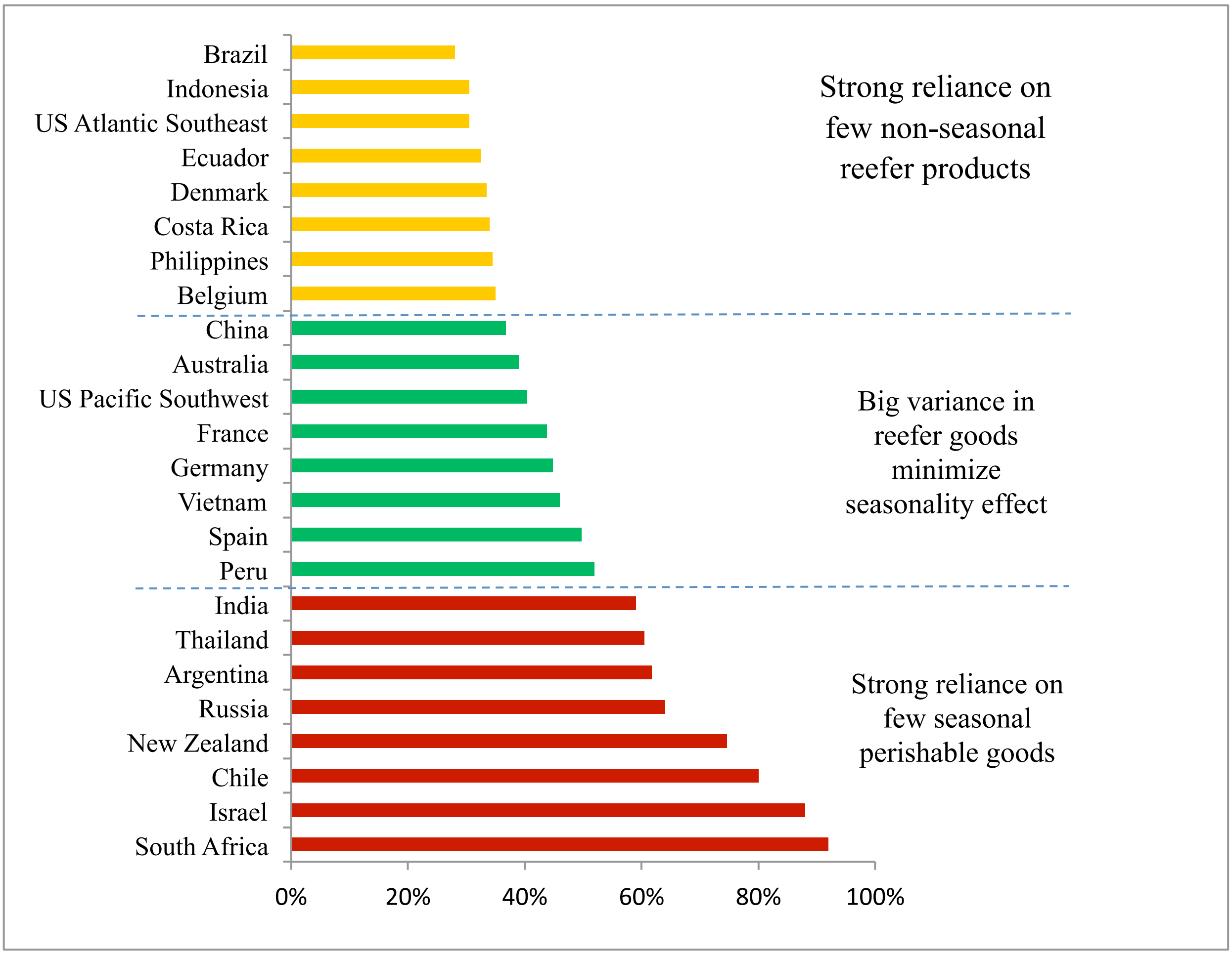
The definition of cold chain is "the transportation of temperature sensitive products along a supply chain through thermal and refrigerated packaging methods and the logistical planning to protect the integrity of these shipments" (Rodrigue and Notteboom, 2011a). Cold chain products are normally high profile, potentially high-profit products, which require special attention to supply chain details (Smith, 2005). There are different ways to classify cold chain products. Arduino and Parola (2010) divided cold chain products into two groups, chilled products and frozen products. Chilled products are mainly fruit cargoes and require a temperature around 0℃ or higher; while frozen cargo needs to be maintained at -18℃ or lower, including meat and seafood. Drewry Shipping Consultants (2010) considers eight major product categories, namely bananas, exotics (pineapple, kiwifruit, avocados, etc...), fish/seafood, meet/poultry (pork, beef, etc…), deciduous (apples, pears), citrus (oranges, lemons, grapefruit, etc...), dairy (cheese, butter), and others (mainly frozen potatoes and vegetables). Bananas, exotics, deciduous and citrus are often part of chilled products, while fish/seafood, meat and dairy are normally frozen cargo.

Worldwide perishable reefer trade has seen a strong increase over the past twenty years, in 2009, the trade amount increased to 156.89 million tons (44.3 million tons more than the quantity in 2000), and it is expected to see strong growth over the coming years (Drewry Shipping Consultants, 2010). Growth in the global market of cold chain products is supported by decreasing tariffs (WTO, GATT), a permanent improvement of transportation efficiency, the development of communication and information technology, and the development of cold chains techniques (Bogataj et al., 2005).The strong growth of international perishable trade also related to the increase of global gross domestic product (GDP) (Daman, 2011). Increasing income level provided customers more purchasing power to create a change to a healthy diet towards more fresh fruits and higher value foodstuffs, such as fish and seafood. Therefore, producers and retailers have responded with an increasing trend of reefer trade from all over the world (Daman, 2011). A good example of this trend is found in eastern and central Europe where, after the fall of the Iron Curtain in the early 1990s, the consumption of fresh fruits rose from insignificant levels (mainly caused by the poor availability of such products in shops and low income levels) to a consumption pattern comparable to western Europe.

Weather conditions (such as windstorms, floods, droughts, and extreme cold), natural disasters, pests, and economic recession are primary factors affecting reefer trade because of their influence on the supply and demand of products (Dole annual report, 2010; Arduino and Parola, 2010). Sales volumes of cold chain products, especially for fresh fruits experience seasonal earnings characteristics, because fresh fruit prices traditionally are lower in the second half of the year, when summer fruits are in the markets (Dole annual report, 2010). An efficient inventory planning is key to face competition in the perishable product market, because of the seasonality and other characteristics of reefer goods, and has received considerable attention from academics. Nahmias (1982) reviewed academic studies on models and ordering policies for managing the inventory of perishable products. Blackburn and Scudder (2009) introduced the term MVT (marginal value of time) to describe the rate at which the product loses value over time in the supply chain. Hence, the value of a perishable product deteriorates over time in the supply chain and is highly temperature/humidity dependent.

The extent of seasonality influence on perishable export at each country is not the same because of the difference in reefer products each country relies on (see figure 1). Some reefer products have more seasonal characteristics than others, such as fresh fruits. According to Seabury (2011), the biggest difference in percentage of export volume between peak month and slack month can be seen in South Africa, Israel and Chile; the export quantity shows a 30% difference for Brazil, Indonesia and US Atlantic Southeast between peak and slack month. Figure 1 also shows that countries in the middle group export big variance of cold chain products that minimizes the influence of seasonality.

Figure 1: Difference in reefer exports between peak month and slack month per country



Source: Seabury (2011)

2.2 Transportation method

Sea and air are major transport modes for handling the long haul physical movement of perishable products (Lam, 2010). Some reefer products with an extremely short life or high value are sent to customers by air. For example, because the shelf life of fresh salmon is around 14 days, Marine Harvest in Oslo operates their fresh salmon trading business to international customers by air to ensure the lead time is within 3 days (Mikkelsen, 2011). However, due to technical improvements of maritime reefer transportation, products, such as flowers, traditionally transferred by air, are now shipped partly by sea (Arduino and Parola, 2010). For example, a flower case study done by FloraHolland indicated that the average life time for Dutch and Kenian roses is 220 degree days. The transport of these roses via sea from Colombia to the Netherlands for 25 days at 1 ℃ consumes 25 degree days, accounting for only 11.36% of total life time. In this way, final customers can still enjoy the roses at room temperature in their homes for around 7 days (see table 1) (Wenink, 2011). Although air transportation can reach destinations much faster, it does lack the environment control and transfer ease of the ground and sea transports (Rodrigue and Notteboom, 2011).

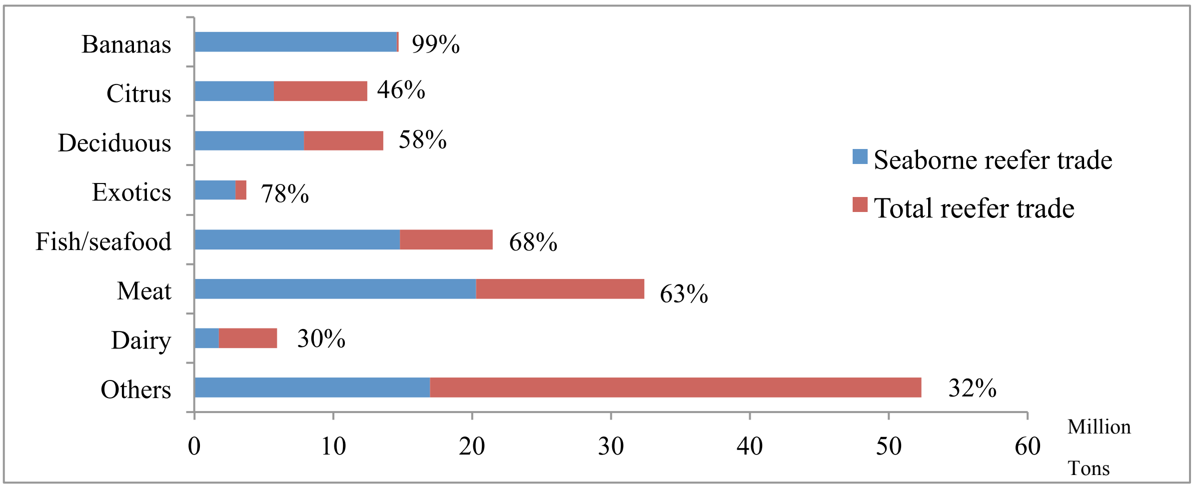
Table 1: Dutch and Kenian roses life phase when shipped via sea

Phase	Days	Temperature	Life time
Sea transit	25	1℃	25 degree days
Road transport and Handling	2	8℃	16 degree days
Store	2	20℃	40 degree days
Final customer	7	20℃	140 degree days
		Total:	221 degree days

Source: Wenink (2011)

The sea transportation of perishable commodities started from the second half of 19^{th} century, many shipments of frozen meat were imported from Paraguay to France, and from Australia to Great Britain (James et al., 2006). In 2009, the total amount of worldwide perishable reefer trade amounted to 156.89 million tons; around 54% was transported via sea. The percentages vary for each reefer commodity; almost 99% of bananas were seaborne cargo, and only around 30% of dairy were estimated to be shipped by sea (see figure 2) (Daman, 2011).

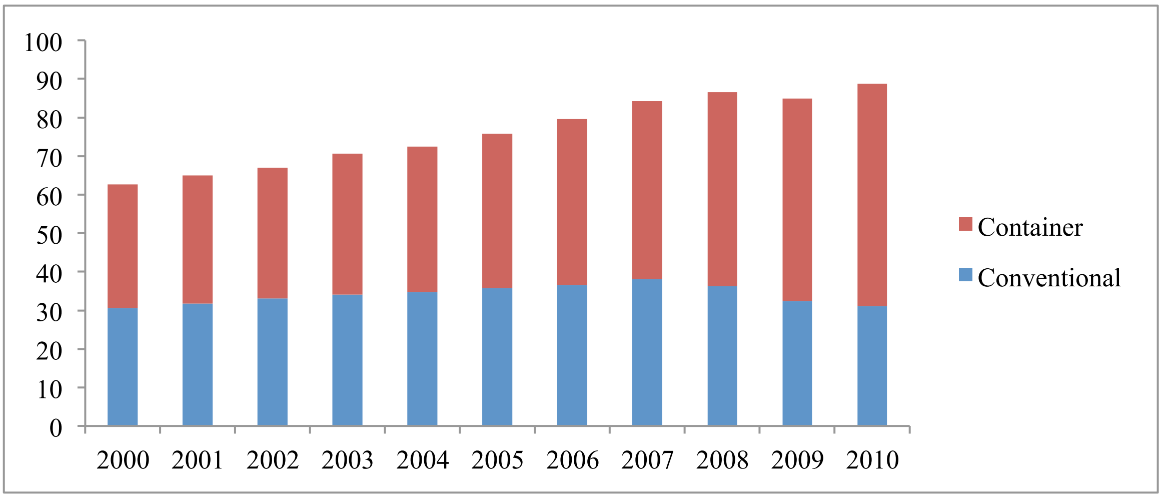
Figure 2: Seaborne and total reefer trade by commodity category, 2009 (Million Tons)



Source: Drewry Shipping Consultants (2010) and Rodrigue and Notteboom (2011b)

There are two major types of vessels in use for perishable shipping industry: conventional reefer vessels and container reefer vessels. Within perishable seaborne trade, a clear trend is emerging since the 1990s that the market share of conventional reefer vessels is declining, while on the contrary, the container fleet has shown a continuous growth (Arduino and Parola, 2010; Rodrigue and Notteboom, 2011b). Figure 3 describes the development of perishable seaborne trade of the specialized reefer fleet and container fleet from 2000 to 2010. It can be seen that in 2000, the market share of conventional reefer vessels was around 49%, however, in 2010, it has reduced to around 35%.

Figure 3: Development of perishable seaborne trade 2000-2010 (million tonnes)



Source: Visser (2011) and Drewry Shipping Consultants (2010)

Both conventional reefer vessels and container reefer vessels offer their own unique advantages to their customers (see table 2). Despite the comparative advantages, the specialized reefer business is continuing losing market share as long as capacity cost remains the determining factor in decision making. However, the remaining market share of conventional reefer ships is based on strong value-based reasons and cannot be counteracted by increased capacity and equipment alone. Ultimately, it has been forecasted that the market will likely reach a balance: conventional reefer ships serving a high value market, and container reefer vessels serving cost-oriented markets (Daman, 2011). Competition between reefers vessels and reefer containers will continue to be influenced by factors such as the supply and availability of reefer vessels, reefer containers and reefer slots on board of container vessels and the changes in the economic geography of the production and consumption areas for perishable products.

Table 2: Advantages of conventional reefer ship and container reefer ship

Conventional reefer ship	Container reefer ship
• Short transit time	• Cheaper
• Fixed schedule	• The growth in size and equipment of the ship (up to 15% of slots on modern container vessels can be dedicated to reefer containers)
• Better temperature control (not only control the temperature, but also atmosphere)	• Products can be shipped in smaller quantities with specific temperature and humidity requirements
• Constant monitoring of the products	• Easier for intermodal transfer in port

Source: own compilation based on personal interview at Sea-Invest, Arduino and Parola (2010)

2.3 Challenges

2.3.1 Integration of cold chain

The integration of the cold chain must be preserved from the point of origin, through each supply chain phase, including loading, unloading, handling, and storage, and extends to storage at the final customers (Salin and Nayga, 2003). If the cargo being left exposed during loading and unloading outside cold warehouses, the product temperature can exceed the upper or lower limits, although such circumstances may last only a very short time (Bogataj et al., 2005). The supply chain integrity for cold chain products includes the additional requirement of proper packaging, temperature protection, and monitoring, which is fueling the growth of in-transit temperature monitoring (Rodrigue and Notteboom, 2011b). For example, the Belgian stevedoring group Sea-Invest cooperated with Dole to build the first automatic fruit terminal at Antwerp. This terminal disposes of a computer guided system for handling, tallying, custom clearance and stock management. It requires that growers put a label at the right position outside the packaging when packing the fruits in the country of origin. In this way, the products can be handled much cheaper, faster and more accurate at the receiving terminal facility in Europe (personal interview at Sea-invest).

2.3.2 Last mile distribution of perishable products

Companies providing 'last mile' distribution experience a number of challenges when delivering reefer commodities, including technical issues and human issues (Guenther, 2011).

First of all, they face a series of technical issues including (Guenther, 2011):

- Different size of pallet, box, and product to load to truck
- Different temperature ranges of products. In some cases, the combination of fresh products cannot be put in the same truck
- Different loading and unloading time rulings
- Different use of packing: one way or reusable

Secondly, they are confronted with some human issues:

- Mishandling of equipment or improper load securing (Guenther,2011)
- Drivers may 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 (Rodrigue and Notteboom, 2011b)
- Customer relationship

To solve these issues, companies can offer more direct deliveries to customers, constantly adjusted the fleet of different truck types, use computer based tour planning, and maintain constant contact to the client base.

3 LOCATION SELECTION FOR VALS ON COLD CHAIN PRODUCTS

When performing value added logistics services (VALS) to perishable products, especially fresh fruits, companies can enjoy significant benefits when performing the service at the right location. In this section, we will analyze why VALS location for cold chain products is important, what are the determinants that influence on location decision of VALS in general, and what are the factors influencing on such decision-making for fresh fruits.

3.1 Importance of selecting the right location for VALS on cold chain products

The right location of operating VALS will be able to provide significant benefits to a company as described below:

- *Logistics advantages*:
  Companies benefit from logistics advantages when operating VALS at the right location to enhance competitiveness in the marketplace, such as balanced logistics costs and service level, minimized responding time, minimized transportation cost and risk cost, flexibility to unpredictable market demand, and minimized information cost for customized VALS. For instance, some added value customization functions for the

European market have to be performed in proximity of final markets as market fragmentation renders source-based prohibitive for many ranges of goods (e.g. a change from ISO-pallet to a Euro-pallet or a change in packaging to meet local tastes and languages).

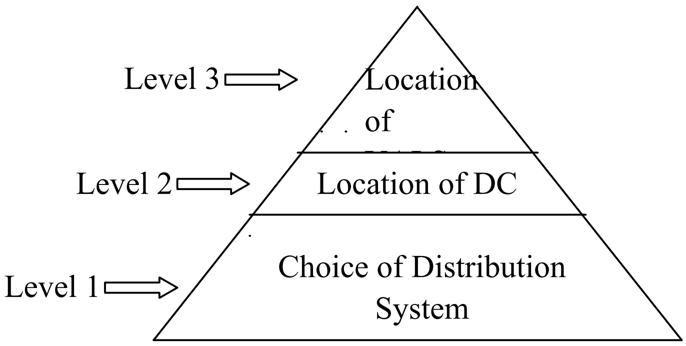
- *Quality of the supply chain*:
  -Supply chain efficiency: Performing VALS at a location with excellent infrastructure support, easy access to the market, or availability of an excellent labour force can certainly improve the efficiency, enhance integration and minimize the transaction costs linked to the supply chain.
  -Ensure product safety: The right location for VALS can ensure safety of products during shipment. Most fresh fruits in nature are very delicate or temperature sensitive, so appropriate packaging from production origin is needed to ensure the quality and to reduce the risk of cargo damage during shipment.

- *Indirect benefits*:
  Companies can enjoy indirect benefits when operating VALS at the right location such as the attraction of more economic activities, an increase in customers' satisfaction, and a stimulation of the growth in the local economy.

3.2 Determinants of location selection for VALS

Chen and Notteboom (2012) designed a conceptual framework (figure 4) to illustrate the determinants of location selection for VALS. It was indicated that the optimal VALS location is determined by a complex interaction between the choices of distribution system, the location of distribution center(s), product logistics characteristics, and the nature of the VALS itself. When deciding where to operate VALS for some products, companies first select their distribution system (level 1), such as centralized distribution center, a group of regional distribution centers, or a hybrid system with one centralized DC and several regional DCs. Then, the company will choose a specific location for the distribution center(s) (level 2) according to facility location criteria, and finally decide what kind of VALS to perform in each of the DCs (level 3). However, in other cases the VALS that need/can be developed can also have a significant impact on the selection of the distribution type and the location of distribution center(s).

Figure 4: Value-added logistics location analysis framework



Source: Chen and Notteboom (2012)

Different situations exist mainly due to different logistics characteristics of products. The mix of structural logistics factors related to products will have a significant impact on determining which distribution network structure companies will adopt, where to locate distribution centers, as well as where to operate VALS. When considering VALS, the most relevant logistics characteristics of products are (Chen and Notteboom, 2012):

- Distribution focus measurements: services vs. costs
- Intensity of distribution and economies of scale
- Replenishment lead time and demand uncertainty (supply/demand characteristics)
- Ratio of transportation costs as part of total costs
- Product life cycle
- Market response flexibility
- Product profit margin
- Country-specific products or packaging requirement
- Value that is added to the product: McCann (1993) applied an inventory model to the standard Weber-Moses location production problem, and concluded that with linear homogeneous production function, the higher the total value added per unit of output at the point of production, the closer is the firm’s optimum location to the market. The higher the total value added per product, the higher the costs of holding inventories, and more frequent delivery. Operating VALS closer to customers with high value added cargo can also minimize the risk of delays and cargo damages.

3.3 Determinants of location selection for VALS on fresh fruits

Logistics characteristics are quite different for the different sorts of fresh fruits. For example, when storing apples under a controlled atmosphere at 0°C, the shelf life of the apple is around 8 month. However, the best storage condition for bananas is around 13°C-14°C, but this will only keep bananas fresh for around 2-3 weeks at most. Delivery frequency of fresh fruits is normally higher for more basic/popular fruits, and lower for more expensive/non-popular fruits. The most important fresh fruit related logistics characteristics that influence on VALS location selection are described here. In the next section, we will conduct case studies to compare the logistics characteristics of bananas, pineapples and kiwifruit, and to discuss the determinants and impacts of VALS location selection to these three different types of perishable commodities.

- *Distribution frequency and product shelf life*

Cold chain products with longer shelf life can operate VALS at a centralized low cost site at low risk. On the contrary, products with a shorter shelf life would be better to perform VALS closer to the final markets in order to quickly respond to market changes. Shorter shelf life products are expected to have higher frequency of distribution, which also implies that a location closer to final customers is more appropriate.

- *Product shelf value*

More expensive fruits normally need a better presentation to customers, often resulting in the need for re-packaging and quality control after arrival at the destination port. The high profit margin also generally demands a closer link with the customers to increase the service level. Low profit margin commodities will have to concentrate on reducing costs and might therefore be better served via a low cost option.

- *Demand variability*

The demand variability of fresh fruits is also a major element affecting logistics decisions. Stable and predictable demand would allow companies to locate their distributions for VALS closer to low cost sites, and centralize their distribution. Unstable and unpredictable demand requires a quicker response and a higher service level, resulting companies to locate closer to the final market and to decentralize their distribution (Chen and Notteboom 2012).

- *Market responsiveness flexibility*

If fresh fruit supply has to respond fast to any changes in the market, it would be better to position the VALS near the customer base.

- *Country-specific products or packaging requirements*

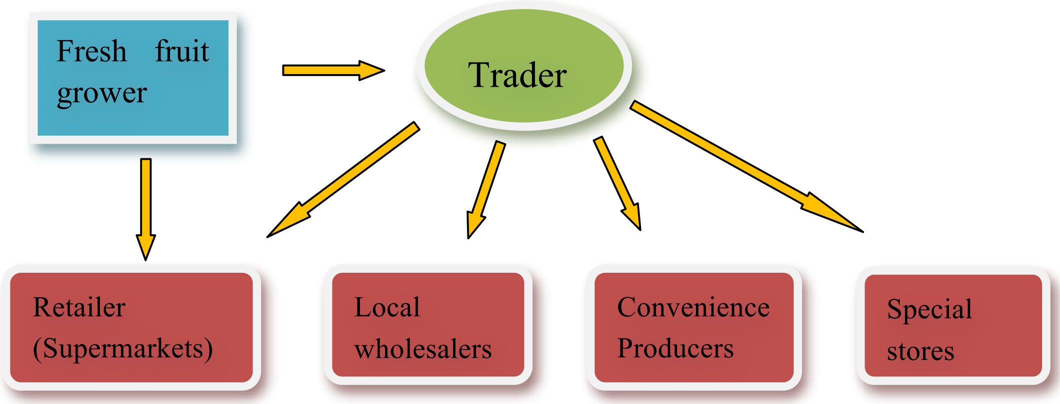
Country-specific products or packaging requirements are likely to show a remarkable flexibility. While this function traditionally took place near final markets, depending on the structure of production and on the product type, it could move directly to the manufacturer or to intermediate locations. Conventionally, market specific packaging was performed at port of entry locations. Standardization and the setting of economic blocks, particularly for Europe, have expanded this range to a major continental gateway. This could pose a challenge to the development of logistical activities in import-oriented regions such as Western Europe and North America. In addition, if the packaging requirements result in product volume increasing significantly, it would be better to perform this activity close to the final market to reduce shipping volume and transportation cost (Chen and Notteboom 2012).

4. CASE STUDIES

In this section, we will discuss the cold chains of bananas, pineapples, and kiwifruits to illustrate the determinants and impacts of VALS location selection to these three different types of perishable commodities.

Around thirty years ago, supermarkets could only get fresh fruits through a trader/ importer or wholesaler who imported fruits from all over the world. Nowadays, however, many supermarkets import fresh fruits directly from the grower in the country of export. The distribution channel of today's fresh fruit supply chain can be seen in figure 5. The new distribution channel decreased the role of the trader; therefore the logistics of fresh fruits became even more important.

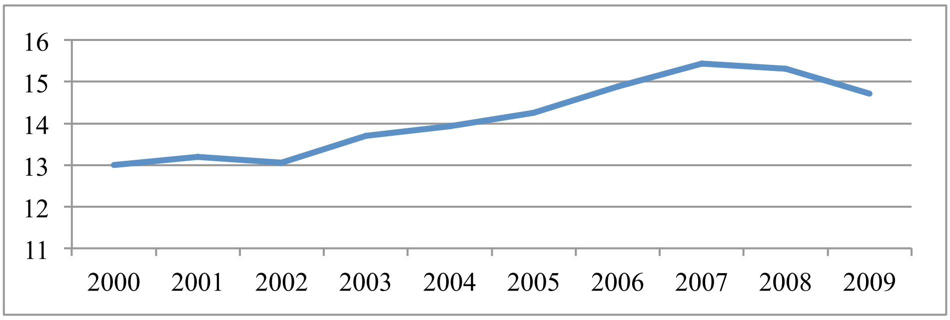
Figure 5: Fresh supply chain distribution



4.1 The cold chain of bananas

Being the most popular fruit in the world, the quantity of banana international trade accounts for the biggest share among worldwide perishable fruit trades (Drewry shipping consultants, 2010). On average, the amount of worldwide banana trade between 2000 and 2009 is 14.1 million tons. Despite the decrease in 2008 and 2009, the quantity of banana trade showed an overall increasing trend over the years (see figure 6). Bananas are harvested and sold all year round. Still, there is still a seasonal aspect to the banana business: because bananas compete against other fresh fruits that come to the market in the beginning of the summer, the price and volumes of bananas are typically higher in the first and second quarters (Dole Annual Report, 2010).

Figure 6: Worldwide banana trade 2000-2009 (million tons)



Source: own elaboration from Drewry2010

There are more than 100 countries producing bananas worldwide. While India, Brazil, Ecuador, China, Philippines, and Indonesia are the top six banana production countries (FAO database); the top six banana exporting countries are not exactly the same (see table 3)

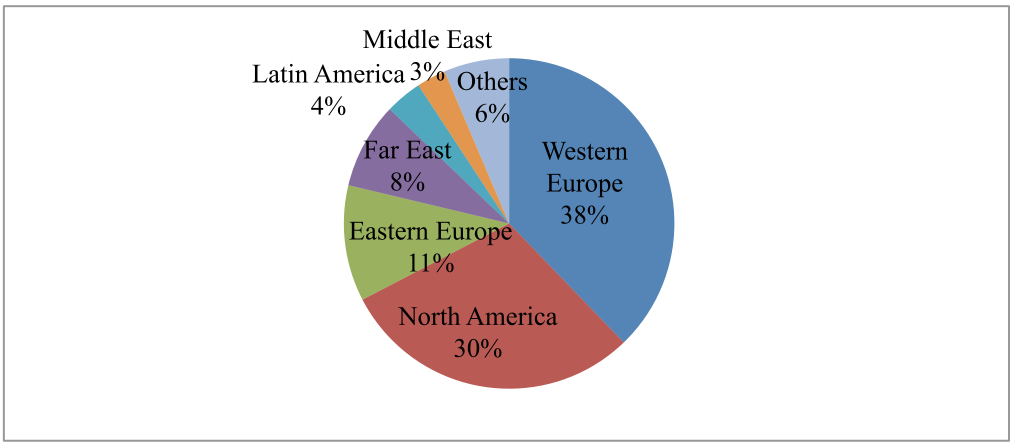
Table 3: Top six banana-exporting countries in 2009

Exporting Country	*2009 (million tonnes)*
Ecuador	5.72
Colombia	2.10
Philippines	1.66
Costa Rica	1.66
Guatemala	1.27
Honduras	0.42

Source: Drewry shipping consultants (2010)

Western Europe imported 5.56 million tonnes of bananas in 2009 and accounts for the biggest share in banana trade. Figure 7 shows that, in 2009, 79% of the bananas were imported by Europe and North America. Major companies doing international trade of bananas are Dole, Del Monte, Chiquita Brands, and Fyffes. Dole is the world's largest producer of bananas with more than 153 million boxes sold in 2010 (Dole Annual Report, 2010).

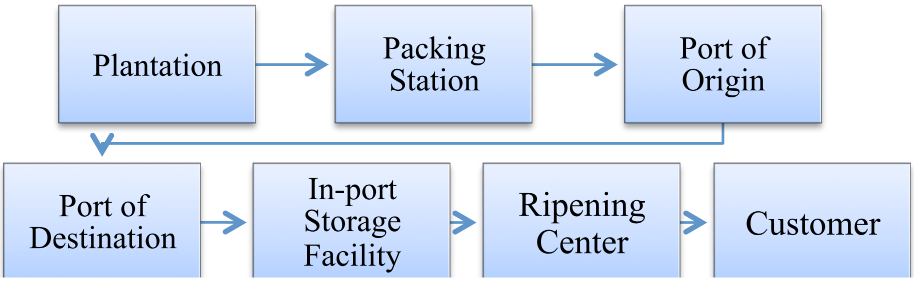
Figure 7: Worldwide banana trade by import region, 2009 (shares based on tons)



Source: own elaboration from Drewry shipping consultants 2010

The supply chain of the banana trade is a typical cold chain. The banana plantation is the starting point of the banana cold chain, and the final customer is the end point (see figure 8).

Figure 8: Banana cold chain



It takes between 5 to 35 days for bananas to reach the final customers, depending on the area being considered. If any bananas ripen during transportation, they not only cannot be sold but also endanger the whole container of bananas (Tixier et al., 2010). Thus, it is important for the banana trade that the ripening process can be controlled until the banana is ready for display or delivery. The value and quality of bananas deteriorate significantly over time at rates that are highly correlated with temperature and humidity (Blackburn and Scudder, 2008). In order to maximize the green life and ensure the quality, bananas need to be transported at a temperature of around 13°C-14°C and a humidity of around 80%-95% constantly across the entire supply chain, including loading, unloading, or warehousing of the products. The ripeness of bananas can be easily examined by color (see table 4).

Table 4: Color and ripeness of bananas

Degree of ripeness	Appearance of skin	Characteristics
1	Green	Color at time of loading
2	Green with faint hint of yellow	Color at time of unloading
3	More green than yellow	Incipient discoloration of skin indicates continuing ripening process
4	More yellow than green	Delivery from ripening warehouse
5	Yellow with green tip	Best condition for retail sale
6	Completely yellow	Fruit appears at its best and is very tasty.
7	Yellow with brown spots	Fruit is fully ripe

Source: Transport information service

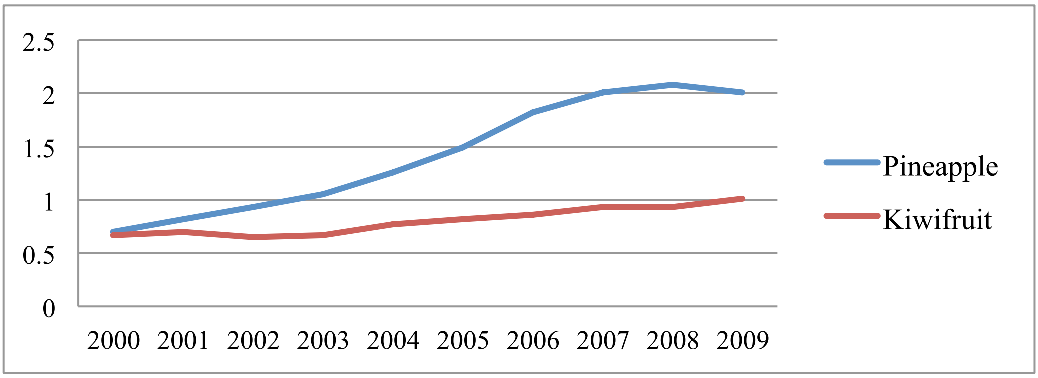
Harvested green bananas are first transported to packing stations to be inspected, washed, treated, labeled, packed, and loaded into a reefer or container ship within a short time (Dole.com). Quite a few of the VALS are operating at this stage, such as quality control, labeling, and packaging. For example, Dole put Dole stickers on their bananas, and label on the box to ensure trace abilityin the packing station (Dole.com); Bananas are packed in the box to prepare for traveling to destination. Proper packaging not only can protect bananas from damage, but also can extend the life span of bananas. There are two major packaging types in use for bananas, namely ‘Polypack’ and ‘Banavac’. ‘Polypack’ packaging, allowing air goes in and out, reduces moisture loss of bananas. With ‘Banavac’ packaging, bananas can maintain even longer green life, but the bag needs to be punctured prior to ripening to allow air to go in. At the port of destination, bananas are handled and transported to in-port cold warehouses. In this stage, possible VALS are quality control, re-palletizing, and putting air into the ‘Banavac’ packed bananas. Within one week time, bananas will be transferred to a ripening center by truck.

Dole Operates 24 ripening and distribution centers in Europe to serve regional market, predominantly in Western Europe. This is a value-added service Dole provides to customers when European retailers do not self-distribute or self-ripen (Dole Annual Report 2010). After around 5 days in the ripening centers, part of the bananas will be sent directly to customers, the other part will be re-packed. In the supermarket, there are both loose bananas and bananas in the plastic bags for sale; the value-added service of proper packaging can extend the shelf life of bananas. For example, Chiquita cooperates with Apio to pack bananas with landec membrane technology (also called Breatheway packaging technology) that controls the rate at which oxygen enters and carbon dioxide leaves, maintaining the optimal gas mix to extend the shelf life of bananas (Food production daily, 2004). Del Monte plans to sell individually-wrapped bananas at petrol stations, convenience stores, leisure centers and gyms, with the price more expensive than loose bananas in supermarket, but extends the shelf-life of the banana by up to 6 days (Packaging News, 2011).

4.2 The cold chain of pineapple and kiwifruit

Pineapple and kiwifruit are two major commodities in the category of exotic fruits. Worldwide trade of both pineapple and kiwifruit had a stable increase over 2000 to 2009. In 2000, the quantity of pineapple trade is similar to kiwifruit, however, in 2009, the international trade of pineapple is 2.87 times of the amount in 2000; the quantity of kiwifruit trade only increased to 150% over the same period (see figure 9).

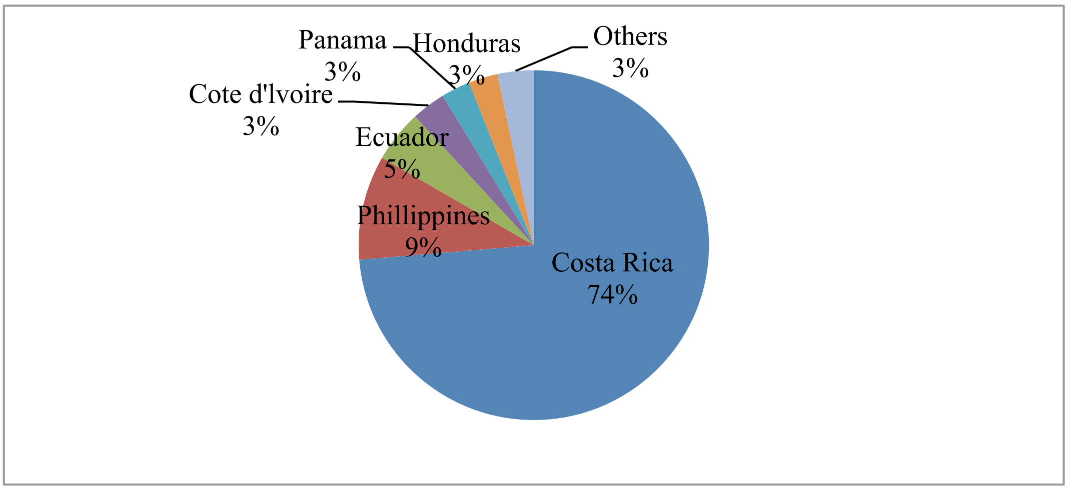
Figure 9: Worldwide pineapple and kiwifruit trade in tons, 2000-2009



Source: own elaboration from Drewry Shipping Consultants 2010

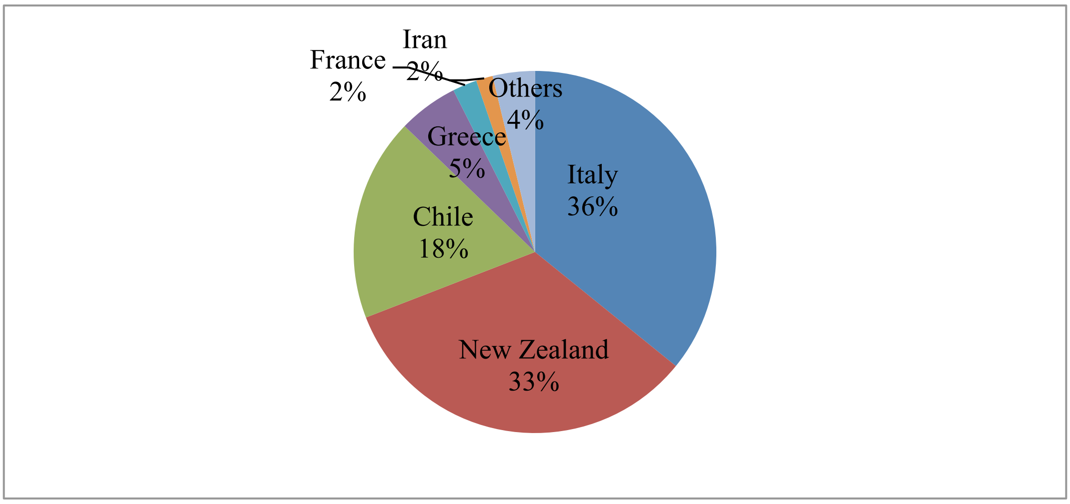
It can be seen in figure 10and figure 11 that 74% of the international trade of pineapples was exported by Costa Rica in 2009; Italy, New Zealand, and Chile are the three major kiwifruit exporting counties, exporting 87% of kiwifruit.

Figure 10: Worldwide pineapple trade by exporting country, 2009



Source: own elaboration from Drewry Shipping Consultants (2010)

Figure 11: Worldwide Kiwifruit Trade by Exporting Countries, 2009

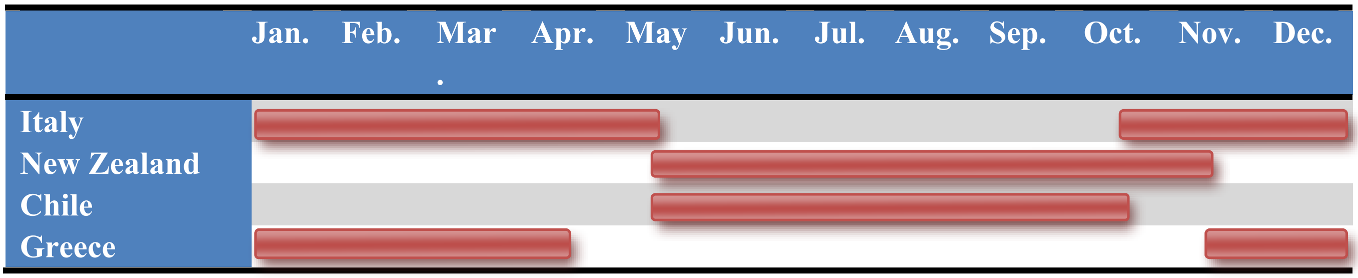


Source: own elaboration from Drewry Shipping Consultants 2010

Pineapples contain the ideal balance of sugar and acidity at the point of harvest, providing good shelf life and exceptional taste. Then they will be quickly transported to the closest packing shed where being sorted by color, size, and quality before being packed. The ideal condition for transportation of pineapples is at around 8℃ and 85%-90% humidity, with a fresh shelf life of around 3-4 weeks (personal interview with Sea-Invest). At the port of destination, pineapples will be stored in an in-port cold warehouse up to one week before delivery to customers. Pineapples are sent to supermarkets as is without re-packaging, the only VALS done in the importing county is quality control. However, pineapples are often used in the value-added packaged fresh fruit bowls. Dole indicated in their annual report (2010) that the value-added food categories, including packaged salad lines, fruit bowls, and other non-canned products, are growing at a faster rate than traditional commodity business and typically generate stronger margins. The processing of fresh fruit into the fruit bowl is done in a distribution center close to the final market. A 250 g of pineapple fruit bowl is sold at EUR 2.49 in a Belgium supermarket, comparing to one whole pineapple at EUR 2.29 in the same supermarket (a pineapple has a typical gross weight of 1.7 kg of which about 1kg is suitable for consumption).

Kiwifruits are available all year round in the market. The seasonality situation for the top four kiwifruit exporting country (2009) is listed in table 5.

Table 5: Seasonality of kiwifruit for top 4 exporting country



Source: Direct Product Suppliers (DPS)

Kiwifruit can be harvested once minimum maturity has been achieved. As with other fresh fruits, efficient temperature control is essential to successful distribution of kiwifruit. They need to be cooled within a few hours of harvest and stored at around 0℃ (Mitchell et al., 1994). Kiwifruits are brushed, cleaned, sorted, and packed in a nearby packing station. During transportation of kiwifruits, attention must be given to ethylene avoidance, temperature control, protection against water loss, and avoidance of various mechanical injuries (Arpaia et al., 1994). Once arrived at the destination port, kiwifruits are sent to an in-port storage center before further distribution. Sea-invest built a State-of-the-art packing facility for kiwifruit at Belgian new fruit wharf in the port of Zeebrugge. Based on customers' requirements, kiwifruits are sorted, packed, quality controlled, labeled, and price-tagged in this in-port packing station and distributed across Europe. The shelf life of kiwifruit is from 3 to 6 months, which allows kiwifruit to stay in this centralized distribution center up to one month to get every VALS done before being transported to customers.

4.3 Discussion

Logistics characteristics and VALS location for bananas, pineapples and kiwifruits have been summarized in table 6. To link back with the value-added logistics location analysis framework presented in section 3.2, we first analyze the distribution system (level 1) and location of distribution center (level 2) of these three types of fresh fruits. Bananas are distributed through a group of regional distribution centers. However, most bananas enter the European market via only few hub ports. For example, the port of Antwerp is with distance the largest European import port for bananas transported in reefer vessels while for reefer containers the port is joined by Rotterdam and Bremerhaven. Kiwifruit is operated in an EDC and pineapples are going to customers through a hybrid system, one EDC and several RDCs. After the ripening process, bananas will be transported quickly to customers, since the remaining shelf life for bananas is only about one week time. Therefore the ripening center /distribution center has to be as close to final market as possible. This is one of the reasons why centrally located import ports, such as the port of Antwerp, are favored. The longer shelf life of kiwifruit allows the fruit to be delivered through a centralized DC across Europe and to enjoy economies of scale. Fresh pineapples can be distributed directly from port of destination since the fruit does not need any further VALS (re-packaging et al.); while for those pineapples used in value-added packaged fresh fruit bowls, are processing in a regional distribution center close to customers.

Table 6: Summary of logistics characteristics and VALS location for bananas, pineapples, and kiwifruits

	Bananas	Pineapples	Kiwifruits
Transportation temperature	13°C	8°C	0°C
Shelf life	2-3 weeks	3-4 weeks	3-6 months
Shelf value	EUR 1.69/kg	EUR 2.29 for one (1.7 kg)	EUR 2.99 per 6 (0.7kg)
Shelf value per kg	EUR 1.69	EUR 1.35	EUR 4.27
Seasonality	All year round	All year round	All year round
Demand variability	More stable	Less stable	Less stable
Delivery frequency	More frequent	More frequent	Less frequent
VALS at origin	Quality control, packaging, labeling	Quality control, packaging, labeling	Quality control, packaging
VALS at port of destination	Quality control, put air in when packed with 'Banavac', re-palletizing	Quality control, re-palletizing	Quality control, re-packaging, labeling, price-tagging, re-palletizing
Time of stay in port warehouse	Up to 1 week	Up to 1 week	Up to 1 month
Distribution center	Regional DC	Regional DC	EDC

type			
VALS at regional distribution center	Ripening, re-packaging	Processing into value-added fresh fruit bowl	Information not available

The reason for choosing an EDC in port for kiwifruits is to reduce transit time. Although normally dock labor is more expensive and involving both direct and indirect costs (Notteboom, 2010), the labor cost for non-sea value-added activities are not as expensive. Processing bananas and value-added pineapple bowls close to customers helps to reduce transportation time and to respond quickly to market changes.

The higher shelf value of kiwifruits linked with more need for a better presentation of the products to the customers than bananas and pineapples. Fresh fruits are delicate; therefore appropriate packaging before shipment at country of export is necessary.

5 CONCLUSION

This paper discussed distribution and value added logistics in relation to cold chain products. A detailed overview of reefer products and trade, transportation methods, and the challenges in the reefer logistics was presented at the beginning of this paper. Worldwide perishable trade has seen a strong increase over the past twenty years and is expected to have even stronger growth over the coming years. More than half of the international reefer trade is transported by sea; a comparison of the advantages of conventional reefer vessel and container reefer vessel has been included in the study. Integration of each node in the cold chain and last mile distributions are the major challenges in cold chain distribution.

When performing value added logistics services (VALS) to perishable products, especially fresh fruits, companies can enjoy significant benefits when performing the service at the right location, such as logistics advantages, improving quality of supply chain, and some indirect benefits. The location selection of VALS is determined by a complex interaction between the choices of distribution system, the location of distribution center(s), product logistics characteristics, and the nature of the VALS itself (Chen and Notteboom 2012). Although logistics characteristics are quite different for the different sorts of fresh fruits, the most important fresh fruit related logistics characteristics have been summarized: distribution frequency, product shelf life, product shelf value, demand variability, market responsiveness flexibility, and country-specific products or packaging requirements.

In last section, we analyzed the cold chain of bananas, pineapples, and kiwifruits to illustrate determinants and impacts of VALS location selection to these three different types of perishable commodities. Bananas are distributed via regional distribution centers close to final customers due to the short shelf life and high frequency of delivery. The longer shelf life and higher shelf value of kiwifruit allows the fruit to be re-packed, labeled, quality checked and delivered through a centralized DC across Europe while fresh pineapples can be distributed directly from port of destination since the fruit does not need any further VALS (re-packaging et al.); for pineapples used in value-added packaged fresh fruit bowls are processing in a regional distribution center close to customers.

The 3-6 months of shelf life and high demand variability of kiwifruits are similar to the logistics characteristics of a totally different type of product: Nike sportswear shoes. Nike operated VALS (quality control, cross-docking, product labeling, shoebox labeling and order picking for Nike's online store orders) in its Centralized European logistics center at Laakdal, Belgium to serve the EMEA region (Chen and Notteboom 2012). While in this study, the VALS on kiwifruits to European market are centrally performed at Belgian new fruit wharf in the port of Zeebrugge. Therefore, both of the products are opted for a centralized distribution system and a central location in order to distribute easily across Europe. The similarity we found of these two totally different types of products in VALS location selection emphasizes again the importance of logistics characteristics in VALS location decision making.

Further study can be developed based on this study to quantify to what extent logistics characteristics, such as shelf life, shelf value, demand variability, distribution frequency have an impact on location decisions for VALS when dealing with cold chain products. A simulation model can be conducted following logistics time cost and out-of-pocket cost of one specific cold chain product when perform VALS at different locations, with different logistics characteristics taken into consideration.

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