Investigating the Forward and Reverse Supply Chains of Plastic Pallets in Canada

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Abstract

In this research project, both forward and reverse supply chains of plastic pallets in Canada, particularly in Nova Scotia, are investigated using different methods such as reviewing the literature and searching the appropriate databases. Some information such as typical forward supply chains of the plastic pallets, and manufacturing processes of the products are gathered and analyzed. In addition, best practices of reverse supply chains of the plastic pallets are found and analyzed with a focus on the recovery options such as reusing, remanufacturing, and recycling. In addition, we find and analyze strengths, weaknesses, opportunities, and threats factors related to establishing a plastic pallets reverse logistics system for the A-1 Pallets Ltd. Finally, managerial insights and recommendations are provided for the company based on the analysis. The results of this applied project will have economic and environmental benefits for A-1 Pallets Ltd, Nova Scotia, and Canada.

Keywords: Plastic pallets; Wooden pallets; Reverse logistics; Recycling

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1. Introduction

There are two types of supply chains: forward (traditional), and reverse supply chains. A lot of researchers have studied reverse logistics (RL). RL is defined as the logistic activities all the way from used products which are returned by users to products that are again usable in a market (Fleischmann et al, 1997). The value of the returned products can be more than hundreds of millions of dollars for one retailer (Guide and Van Wassenhove, 2009). Recovery activities are performed on the returned products. Recovery activities include acquisition of used products, reverse logistics, product disposition, repair or remanufacturing, recycling, and remarketing (Guide and Van Wassenhove, 2009). The goal of the RL is to gain economic and environmental values from returned products; however, the aim of forward (traditional) logistics is to provide products for customers (Akcali and Cetinkaya, 2011). The integration of forward and reverse logistics leads to the closed-loop supply chain (CLSC) networks which usually are more complex networks rather than traditional forward logistics (Guide and Van Wassenhove, 2009; Melo et al. 2009). Copier remanufacturing and paper recycling are two examples of CLSCs (Fleischmann et al, 2001). Fig. 1 illustrates a general CLSC network including both forward and reverse supply chains.

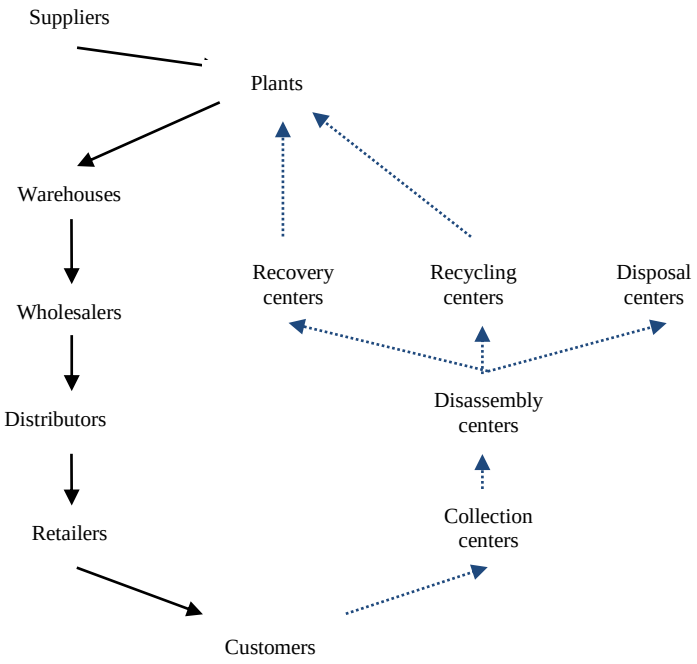

Fig. 1. A general closed-loop supply chain network
(forward supply chain ⟶ , reverse supply chain ⋯▸)

Pallets industry has become an indispensable part of the distribution supply chain since it can aid in the efficient and reliable transportation of products. It is estimated that 2 billion of pallets are used in the U.S. market every day (Buehlmann et al., 2009). There are various types of pallets such as solid wood, wood-based composites, paper, plastic, and metal pallets. Wooden pallets and plastic pallets are more popular than the others. Looking at the pallet market of North America, the sales of new and refurbished pallets will expand by 3.5% a year through 2017 to 1.3 billion units, valued at $16.9 billion (Trebilcock, 2013).

Wooden pallets owing their major advantages in low material and production costs that got an estimated 90-95% pallets market share in the U.S. (Buehlmann et al., 2009). On the other hand, plastic pallets have advantages such as durability, handling safety, quality, and low cost per use (Scheere et al., 1996). Using both wooden and plastic pallets involves economic and environmental factors.

In this research project, we collect and analyze the data related to plastic pallets. We have searched peer-reviewed international journals (search through well-known websites such as Elsevier, Taylor & Francis, Springer, Google Scholar), and some well-known databases.

The structure of this report is as follows: In Section 2, the literature related to wooden and plastic pallets is reviewed. Then in Section 3, the company is introduced. Section 4 is devoted to the problem statement. In Section 5, the characteristics of plastic pallets are discussed. In Section 6, the forward supply chain of plastic pallets is introduced. Then, the reverse supply chain of plastic pallets is investigated in Section 7. In Section 8, the SWOT analysis for the company is provided. Then, conclusions are provided in Section 9.

2. Literature review

Some literature review papers have been published about CLSC networks and reverse logistics (e.g. Akcali and Cetinkaya, 2011; Fleischmann et al, 1997; Govindan et al, 2015; Melo et al, 2009; Guide and Van Wassenhove, 2009).

There are several types of pallets that are used in markets such as metal, plastic, solid wood, soft wood, corrugate paperboard and wood composite pallets. The different materials of pallets own its merits and could meet certain customers' specific needs. Wood solid pallets have their advantages on racking and purchase price comparing with the plastic pallets. For instance, some plastic pallets may be as much as five times expensive that of a comparable wood pallets (Bush and Araman, 1998). However, plastic pallets became a new darling of the pallet industry as Dustin Hoffman advised that "plastics" is the future since 1967 (Bush and Araman, 1998).

2.1. Wooden pallets

For the wooden pallets, there are four general material types of the wooden pallets including solid wood (oak species), softwood (southern pine species), composite wood-plastic and paperboard wood. Two of the sanitation and sterilization were widely used nationally which are the International Plant Protection Convention (IPPC) and International Standard for Phytosanitary Measures (ISPM). Apart from that, the approaches for sanitizing wooden pallets generally include heat treatment, fumigation (by using methyl bromide) and ISPM 15 which are (1) kin-drying; (2) heat-enabled chemical pressure impregnation; and (3) microwave treatment (Bilbao et al., 2011). There are three general end of life options of wooden pallet that include a. Mulching which is a recycling option but it is downcycling which needs demanding application since the need to transportation and additional energy; b. Landfilling, it can recover energy since the anaerobic decomposition of wood generates methane gas which can be captured by modern landfill systems; c. Incineration, it also can recover energy but result in emissions of greenhouse gas (Bilbao et al., 2011). However, combusting wooden pallets that have been treated with methyl bromide will liberate toxic and irritating chemicals (Bilbao et al., 2011).

The Wooden pallet has a long history that has permeated through lots of various industry in our daily life. Wooden pallet is known as its characteristics of environmental friendly which easy to be biological decomposition that has been widely used around the world. However, recent studies have pointed out that wooden pallet owing its short life span and thus consumes vast quantities of plant resources. Therefore, some researchers began to investigate wooden pallet's assessments such as life span, recycling, and industry capacity. Buehlmann et al. (2009) presented an assessment of recycling and industry capacity on a ban on landfilling of wooden pallets in North Carolina by using the nonparametric Wilcoxon test. The noteworthy things

related to this research are triple. Firstly, The State of North Carolina's legislature argues to ban on landfilling pallets for several years. Solid wood pallets are the majority material of pallet have been used an estimated 90-95% of all pallets in the USA. (Buehlmann et al., 2009). Secondly, in the USA, the recycling of wooden pallet is a program that an estimated 450 million new pallets are produced annually and the stock is going to replenished every four years so that leaving the pallet industry's end-users to dispose of by themselves (Buehlmann et al., 2009). The last but not least thing is that, based on the result of Buehlmann's survey, there are four majority recycling options of wooden pallets: 20% of pallets received by a recycling operation were reused, 45% were refurbished, 19% were recycled as well as 16% were carried to ground (Buehlmann et al., 2009). At the same time, more than half of the industry (in that research) thought that a ban on landfilling pallets was a good idea. While only 18% pointed out that it is a bad idea (Buehlmann et al., 2009).

There are also some researchers that put their eyes on the analysis of carbon footprint comparisons using wood pallets. Two of the researchers who came from Spain used the EUR-flat wood pallet as a research sample to get a result that the compound method based on financial accounts (MC3, from its Spanish acronym "Método Compuesto de las Cuentas Contables") is better than process-based analysis method (Alvarez and Rubio, 2015). The details of their findings can be divided into three aspects: Firstly, greenhouse gas emissions from MC3 are 22% higher than ones from the process-based analysis. Secondly, process-based analysis owing its advantage on greater detail in first life cycle phase than MC3 method. Thirdly, calculation time also is drastically reduced by using the MC3 method (Alvarez and Rubio, 2015). Another valuable relative thing that should not be ignored is that Alvarez and Rubio mentioned the

boundaries of MC3 method analysis including physical, organizational, and operational boundaries.

Some researchers focus on the loading problem of wooden pallets. For instance, Nakandala et al. (2015) concerned about the optimization model of the loading problem on the wooden pallet by using GA and fuzzy logic methods. While another review by Terno et al. (2000) tried to use the three-dimensional (3D) solution approach to load a set of distinct products with specific quantities on pallets and to minimize the number of pallets needed.

Numbers of articles have analyzed materials (Corbière-Nicollier et al., 2001; Emiliani and Stec, 2005; Ng et al., 2013; Singh and Walker, 1995; Kim et al., 2009), handling processes and disposal practices (Bilbao et al., 2011; Gasol et al., 2008; Bilbao, 2011; Sreenual et al., 2012), while a few of them have focused on the details of the manufacturing stage (Abbott, 2008; Kellenberger et al., 2007; Ng et al., 2013). A summary of related papers has been written in Table 1.

Table 1
Literature review brief introduction

Authors	Material		Assessment of Recycling	Loading Problem	Assessment of Greenhouse gas emission	Assessment of Material	Closed Loop System for Pallet Management	Material analysis	Handling Processes and Disposal Practices	Manufacturing Stage
	Wooden pallet	Plastic pallet								
Buehlmann et al. (2009)	✔		✔							
Nakandala et al. (2015)	✔			✔						
Terno et al. (2000)	✔			✔						
Alvarez and Rubio (2015)	✔				✔					
Scheerer et al. (1996)	✔	✔				✔				
Bush et al. (1998)	✔	✔				✔				
Elia and Gnoni (2014)	✔						✔			
Kim et al. (2009)	✔							✔		
Corbière-Nicollier et al. (2001)	✔							✔		
Emiliani and Stec (2005)	✔							✔		
Singh and Walker (1995)	✔	✔						✔		
Bilbao et al. (2011)	✔								✔	
Gasol et al. (2008)	✔								✔	
Mazeika (2011)	✔								✔	
Sreenual et al. (2012)	✔								✔	
Abbott (2008)	✔									✔
Kellenberger et al. (2007)	✔									✔
Ng et al. (2013)	✔									✔

2.2. Plastic pallets

In this project, we focus on the forward and reverse supply chains of plastic pallets. Plastic pallets are pallets made of a variety of plastics. Plastic pallets are produced and used widely in the U.S. and Europe, spurred by the adoption of the ISPM 15. Regulatory standards for wood packaging material (WPM) in international trade require it to be either heat treated or fumigated in accordance to ISPM 15 guidelines. The European Pallet Association, established in 1991, monitors the standards set for Euro pallets, which pallets used to export product from America must meet. Both European and American companies have embraced plastic as an attractive alternative to the original wooden material in packaging and shipping pallets. Some plastic pallets have been illustrated in Fig. 2. The benefits of plastic pallets over wooden pallets include the ability to be easily sanitized, resistance to odor, their fire retardant status, longer service life span, durability and better product protection, non-splintering, and lighter weight, thus saving on transportation and labor costs and making them safer and more environmentally friendly (Lee and Xu, 2004).

Fig. 2. Plastic pallets

Unlike the literature of wooden pallets, there are a few papers that have focused on plastic pallets. Bush et al. (1997) discussed pallet recycling and material substitution. They provided information about trends in the use of new wood materials, and in recovery of pallets. Plastic recovery also has been discussed in that paper. In an important publication, Clarke (2004) provided useful information about pallet industry, pallet terminology, factors on the balance design (including strength, stiffness, durability, functionality, and price), pallet materials (wood, plastic, composite wood, paper-based, and metal pallets). Aldaz-Carroll & Raballan (2005) examined the case of pallets to illustrate the impact of multiplicity of standards on trade costs. The authors discussed the reasons to have different pallet sizes, and the related costs. They considered the case of exporters from less developed countries. Bilbao et al. (2011) discussed the characteristics of both wooden and plastic pallets. Overview on pallet industry, design, materials, embodied energy, sustainable development, and life cycle assessment are parts of the investigation. They used mathematical model (mixed-integer linear programming) to design a system that determines the mix of pallets (type, quantity, and pallet management system) for product distribution that balances overall environmental impacts and costs. Michel (2014) provided the results of a survey for pallet trends including purchasing decisions, wooden pallets trends, and block & stringer coexistence. Some papers about plastic pallets have been gathered and classified in Table 2.

In summary, there are a few papers in the literature that have focused on plastic pallets supply chain investigations. However, as we can see from the above literature, the trend of using plastic pallet have raised up significantly since the end of last century. Since the human cannot live without grocery industry and plastic pallets is the most favorite newborn baby in the transportation industry.

Table 2
Some papers about plastic pallets

Authors	Material		Materials	Advantages and Disadvantages	Processes and Energy Consumption	Market Segmentation and Trends	Price	Captive or Closed Loop Warehouse Environments	Recycling Options
	Wooden pallet	Plastic pallet							
Bush et al. (1997)	✔	✔	✔			✔	✔		
Clarke (2004)	✔	✔		✔	✔		✔	✔	
Bilbao et al. (2011)	✔	✔	✔	✔	✔		✔		✔
Aldaz-Carroll & Raballan (2005)	✔	✔					✔		
Michel (2014)	✔	✔				✔			

3. A-1 Pallets Ltd

A-1 Pallets Ltd is a recycler/manufacturer of new and used pallets, crating, dunnage and other wood packaging materials. They are certified via the CFIA for production of heat treated wood packaging materials in both new and used varieties. Their facility is located just minutes off HWY 102 near Stewiacke, Nova Scotia. They have year round open road access to better serve customers and receive stock on a continual basis. Being located on a 15-acre site allows them many opportunities for expansion. Recycling wood pallets is a large component of their business. In 2015, the company reintroduced approx. 10,000 wooden pallets back into the supply chain through their inspection/repair line.

A-1 Pallets Ltd has 4 staffs. In addition to manufacturing new wooden pallets, A-1 Pallets Ltd buys used wooden pallets from customers to refurbish blocks, stringers, lead boards and deck boards by adding new nails or metal brackets only for the standard size which is 48 x 40. A-1 Pallets Ltd owning their location advantage on minutes from highway 102 so that already gained a few market share on Stewiacke, Halifax, Dartmouth, and New Brunswick areas. The limitation traveling distance for the company is approximate 60 miles. Fig. 3 illustrates the location of the company on the map. In addition to the local market, A-1 Pallets Ltd is looking forward overseas markets since they got IPPC (International Plant Protection Convention) certification and on-site kiln. The price of a new wooden pallet is around 12-16 CAD while a re-used pallet is around 5-6 CAD. The company tries to move plastic pallets back into the supply stream but had little success due to the off standard size of most of the pallets and the fact that most

operations have storage and handling equipment geared towards standard size wooden pallets. Fig. 4 shows a facility of the company. Besides, Fig. 5 illustrates some machines of the company.

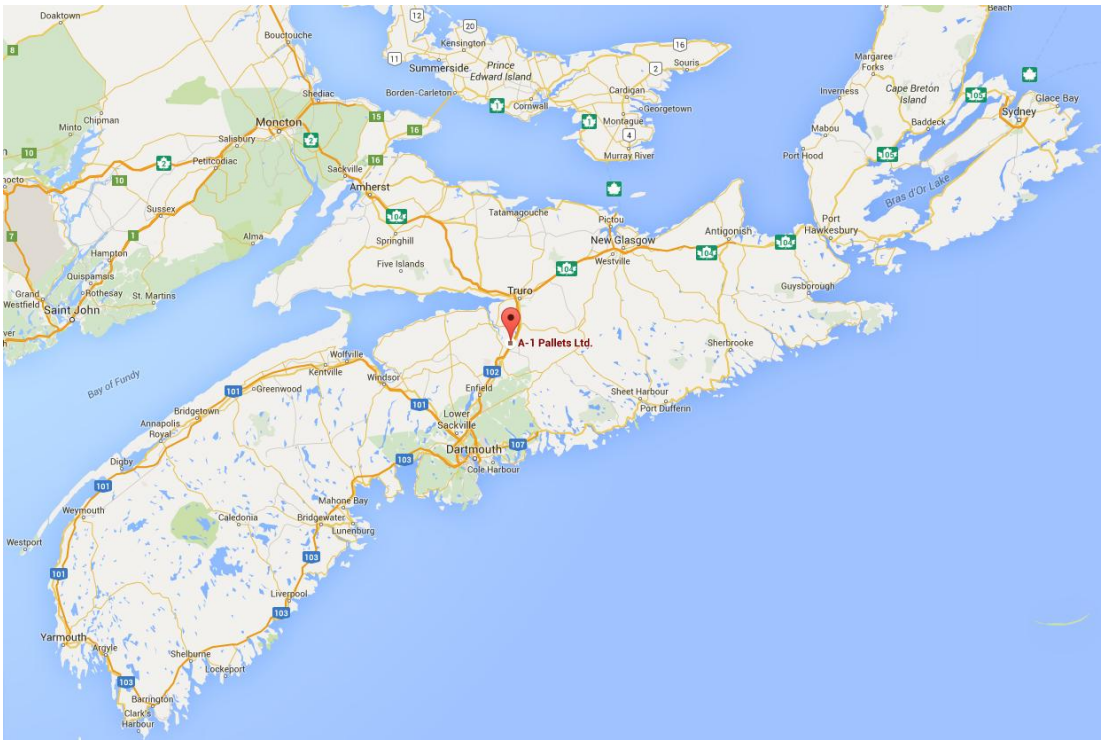

Fig. 3. Location of A-1 Pallets Ltd. on the map (Source: Google Maps)

Fig. 4. Warehouse of A-1 Pallets Ltd.

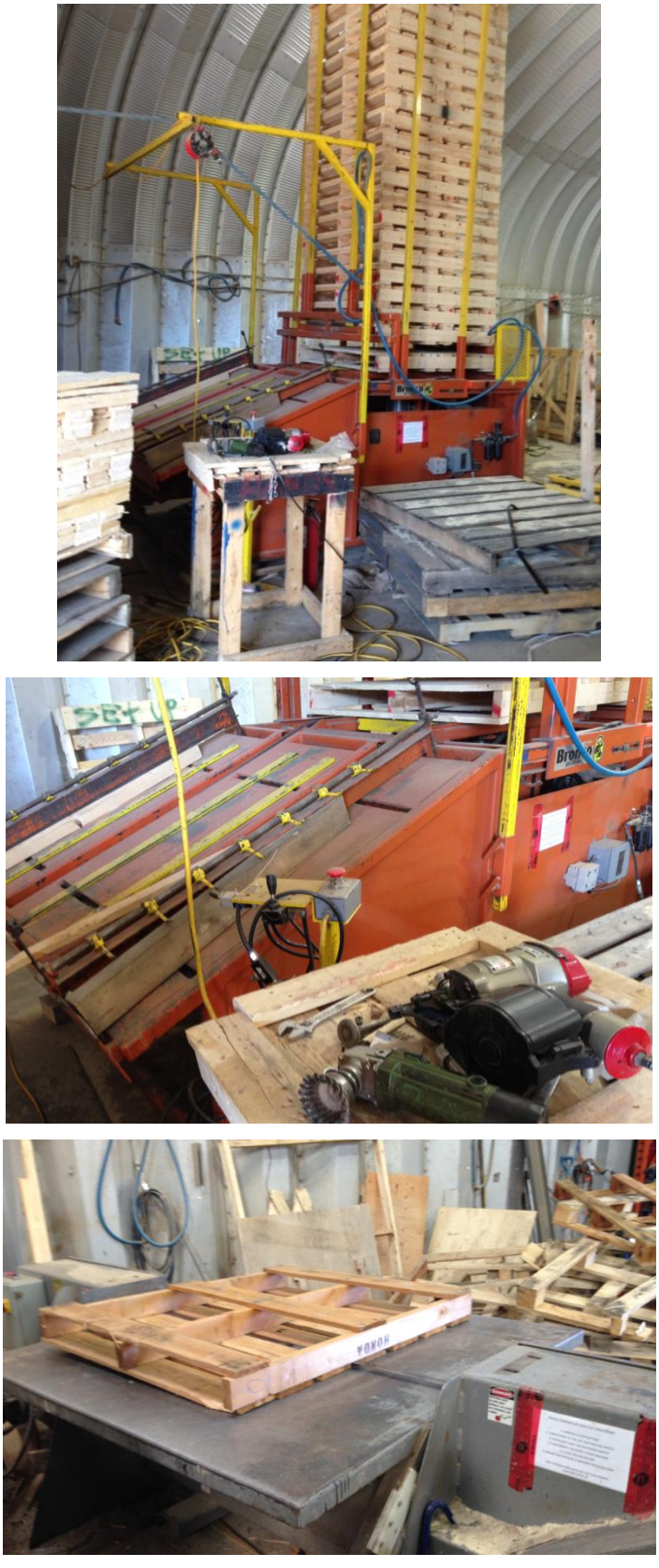

Fig. 5. Some recycling machines at A-1 Pallets Ltd.

4. Problem statement

A-1 Pallets in the course of their operations with used wood pallets came across the issue of plastic pallets accumulating with no obvious reuse or recycling option. Numerous facilities they are in contact with also accumulate these pallets at a rate of approx. 500-600 per month. It is assumed that this is a wide spread problem within Nova Scotia. The company has attempted to move these pallets back into the supply stream but have had little success due to the off standard size of most of the pallets and the fact that most operations have storage and handling equipment geared towards standard size wooden pallets. It appears that a lot of the countries importing into this area are using plastic pallets, especially the large Asian importers. If this is a trend that continues it is expected the province will see a steady increase in the amount of surplus plastic pallets with no apparent reuse opportunities in place.

5. Characteristics of plastic pallets

Most of the plastic pallets are used by grocery relative industries firms. Based on paper of Bush et al. (1997), 20% of firms in the meat industry, 17% of firms in the food industry, and 12% of firms in the construction industry use plastic pallets. Since 1997, plastic pallets were becoming more and more popular in grocery distribution companies while the trends of using wooden pallets seem went down but plastic pallet went up (Bush et al., 1997; Bilbao et al., 2011; Michel, 2014).

The majority materials of manufacturing plastic pallets are a variety of resin formulations, some of them can be recovered but some of them cannot. Three common types of plastic pallets were used in the market that including high-density polyethylene (HDPE) reinforced plastic, polyethylene terephthalate (PET) reinforced plastic, and resin formulations (Bilbao et al., 2011).

The third party service is an important area in pallet industry. Manufacturers realized that customers need more service to beyond only serve begin and end with supporting and protecting a load of plastic pallets. They provide "the third party service" for a customer to dispose of the pallets, such as offered a warranty covering broken pallets and financing of pallet purchases (Bush et al., 1997).

Another fact that cannot be ignored is the price of plastic pallets is higher than regular wooden pallets. Plastic pallets may cost five times as the cost of similar wooden pallets (Bush et al., 1997). Depending on different kinds of materials of plastic pallets (e.g. HDPE, PP, and PVC), each of these plastic pallets usually, is around 3-6 times of the price of wooden pallets (Clarke, 2004).

The most common manufacturing process of plastic pallets is structural foam molding, and other processes also are used in the different situations based on their advantages and disadvantages that including injection molding, profile extrusion, rotational molding, compression molding, and thermoforming (Clarke, 2004). Foam and injection molding would be the best way for manufacturing high volumes of the standard design of plastic pallet, while extrusion and rotational molding may be more suitable for manufacturing 100 pallets in a unique design (Clarke, 2004).

Some of the literatures have pointed out the advantages and disadvantages of plastic pallets comparing with other types of pallets. The commonly acceptable advantages of plastic pallets are durability, cleanliness, no fasteners, bug-free, weather resistance, and design potential (Clarke, 2004). While general disadvantages are the higher price, difficulty to prototype, low friction, low stiffness, lack of repair options, and fire safety ratings (Clarke, 2004). In terms of these general advantages and disadvantages, plastic pallets are generally in captive or closed-loop warehouse

environments and usually made up 50% or more of the reusable pallets pools in some Asian countries (Clarke, 2004). Some papers have mentioned the details of the advantage and disadvantage of plastic pallets. Those statistics may be useful when researchers further doing the financial analysis of plastic pallets. Even though the price of plastic pallets is higher than regular wooden pallets, plastic pallet can last a long time (100 trips, $60 for a new plastic pallet), than wooden pallets (2 trips, $6 for a new softwood pallet) according to the report of World Bank (Aldaz-Carroll & Raballan, 2005).

Energy is an important factor in producing pallets. The manufacturing plastic pallet from HDPE needs an energy intensive polymer injection molding process (665-735 kcal/lb) or other thermoforming operation (e.g. polymer extrusion 262-289 kcal/lb), while transforming oak boards merely needs simple cutting and assembly which without new investment of energy (51.5-56.9 kcal/lb) (Bilbao et al., 2011). While both wood and plastic can be combusted for energy recovery with the net heat of combustion being 4, 760-5,010 kcal/lb for HDPE and only 2,140-2,310 kcal/lb for oak (Bilbao et al., 2011). In conclusion, choosing plastic or wooden pallets requires tradeoffs between using more energy-intensive plastic pallets or longer periods of time versus using more, less energy-intensive wood pallets for shorter periods of time.

Different from wooden pallets, plastic pallets do not need to meet the requirement of IPPC or ISPM 15 internationally. However, some plastic pallets are treated with flame retardants which usually use deca-bromine that may raise concerns about the potential carcinogenic effect in the hydro cooling process for fruits and vegetables (Bilbao et al., 2011). There are generally three options for retired plastic pallets that are recycling (downcycling process), incineration (can get some energy), and landfilling (with no energy recycling because of no decomposing) (Bilbao et al., 2011).

6. Forward supply chain of plastic pallets

Forward supply chain involves sending products from suppliers to manufacturers to distributers to retailers and finally to customers.

6. 1. Relative Associations

There are some associations that play an indispensable role in the supply chain of pallet around the world. Canadian Plastics Industry Association (CPIA) is a non-profit organization that aims at providing leadership on pivotal issues and policies throughout the plastics lifecycle and promoting and defending the sustainable economic, environmental and social benefits of the plastics industry and products. CPIA definitely provides a platform that connected between all of plastic manufacturers and end-user.

As the USA has its geographical advantage on pallet industry, millions of Canadian used pallet may have produced from the USA. Reusable Plastic Container and Pallet Association (RPCPA) has grown significantly. It covers all supply chain partners including distributors, retailers, and end users, all with a commitment to the value and message of re-use since the year of 1999 (History, 2014).

There are some wooden pallet relative associations that play an important role in the supply chain of the pallet. For instance, Canadian Pallet Council (CPC) was providing an exchange system of the wooden pallet. In this system, members of CPC carry the responsibility to repair the damaged pallets at certain approved locations. There are two general ways of wooden pallet management: one is pallet exchange program which means running tally of pallets is maintained; the other one is pallets involves renting them. Some of the retailer joined the pallet exchange program with CPC, such as Sobeys, Shoppers Drug Mart, and Metro Inc. (Ontario and Quebec).

RRFB Nova Scotia (Resource Recovery Fund Board Inc.) is a not-for-profit corporation in Nova Scotia which is working to improve the province's environment, economy, and quality of life by recovery activities such as reusing, and recycling. Under the effort of RRFB, Nova Scotia has been the leader province who has the highest beverage containers recycling rate in Canada. In addition to manage recycling beverage containers, RRFB provides funding to support the local environmental protection activities. Apart from that, RRFB provides funding for researchers to find solutions to the related problems, and analyze opportunities, and threats for the province.

6. 2. Plastic pallet industry in Canada

Plastic pallets are popularly used across the whole grocery industry. It is not difficult to imagine that how many plastic pallets are running on highways every day by transporting foods, meats, and fruits. Plastic pallets owning their advantages at durability, easy to sanitizer, lighter to handle. Therefore, they have got lots of market share especially in Canadian big grocery and franchising companies such as Sobeys, Nofrills, NSLC, Superstore, Burger King, Subways MacDonald, etc. Generally, most of those kinds of containers are used in closed-loop supply chain networks which means empty plastic pallets go back and forth between points in the supply chain (Bregar, 2011; Clarke, 2004; Litco, 2014). Moreover, the manufacturers of plastic pallets spread out through the whole domestic and international markets which including USA, Europe, Asia, etc. The majority of domestic plastic pallets manufacturers are located outside of Nova Scotia. We have found 33 plastic pallets manufacturers by searching through Canada Company Capabilities official website, Government of Canada. Some of them have been listed in Table 3.

Table 3
Some companies working in pallet industry in Canada

Company Name	Location	Manufacture	Distribution	Products	Size	Website	Number of Employees	Export	Total Sales
Agrico Plastics ltd	Quebec	Yes	Yes	plastic material handling equipment and accessories such as containers, pallets, bulk containers, trays, carts, tanks and much more	Food-grade plastic pallets and industrial pallets of 20” x 48”, 24” x 40”, 32” x 48”, 40” x 48” and 48” x 48”	http://www.agricoplastiques.com/en	5	Yes	$1,000,000 to $4,999,999
Barr Plastics Inc.	British Columbia	Yes	Yes	a Master Distributor and Custom Fabricator of plastic tanks, containers and related accessories for a wide variety of liquid and materials handling systems for Water, Wastewater, Stormwater Control, Rainwater Harvesting, Fire Protection, Chemical Handling and Processing and Food and Beverage Handling and Processing	48" x 40" x 6.6" Flat Top Plastic Pallet, 48" x 40" x 6.9" Ridged Edge & Slots, 48" x 40" x 6.9" Ridged Edge & Slots, 48" x 40" x 6.5" 4 way Rackable Pallet, 48" x 40" x 6.4" 4 way Rackable Pallet	http://www.barrplastics.com	13	Yes	$5,000,000 to $9,999,999

Buckhorn Canada Inc.	Ontario	Yes	Yes	full production line of Buckhorn, Akro-Mills, Ameri-Kart, Allibert Contico and Kadon. We have perfected the world's largest selection of reusable containers, pallets, carts and dunage.	48" x 40" x 6", 48"x 40" x 6" Nestable, 48" x 40" x 7" Stackable, 3-Rail, 48" x 40" x 7" Stackable, 5-Rail, 48" x 45" x 6" Nestable, 48" x 45" x 7" Stackable, 3-Rail (Including light; medium; high-duty pallets)	http://www.buckhorninc.com/	15	Yes	N/A
Commercial Pallet (824218 Ontario Ltd.)	Ontario	Yes	Yes	Wood pallet and export packaging manufacturer and capable of supplying contract packaging services. Manufacturing location for the Sun Pump and the Muskoka Surfboard.	Many size depends on functions (connected to http://www.uline.ca/)	http://www.commercialpallet.net	6	Yes	$500,000 to $999,999
CSI Sertapak Inc.	Ontario	Yes	Yes	Thermoformed Plastic Pallets, etc	Custom	http://www.csisertapak.com	50	Yes	$10,000,000 to $24,999,999
Enviro-Pack Material Handling Inc.	Ontario	Yes	Yes	Supplier of material handling containers small or large also collapsibe bulk containers from plastic; Steel; & Wire mesh. Pallets: Stainless Steel; Steel; Aluminum and plastic Special fabrications for nuclear applications. Supply Plastic, pallets; containers; storage boxes	Many size depends on functions	http://www.enviro-pack.biz	N/A	N/A	N/A

6. 3. Manufacturing processes of plastic pallets

There are generally six common processes to make plastic pallets with their advantages and disadvantages on the aspects of costs, time cycle, and technical requirements, etc. They include

1. High pressure injection molding
2. Structural foam molding
3. Thermoforming
4. Compression molding
5. Rotational molding
6. Profile extrusion

High pressure injection molding

There are two major parts of an injection molded including a heated barrel with a rotating screw and a mold part. The virgin plastic (usually is copolymer polypropylene or high density polyethylene resin) and colorants are melted together in barrel. After that, the melted plastic is then injected into the mold part which used to champ it together, and high force pressure is applied (Pallet Enterprise Article).

Structural foam molding

Different from high pressure injection molding, structural foam molding is a form of low pressure injection molding that the mold itself could be less expensive. The polyethylene or polypropylene plastic pellets and nitrogen gas are injected together into the mold cavity. The heat activated the blowing agents to create a cellular core with a solid outer skin (Witt, 1998).

Thermoforming

There are two major steps of this process. Typically, heating polyethylene pellets is the first step to create an extruded plastic sheet of the desired thickness. Then, one or two sheets are formed against molds as air between the mold and the sheet is evacuated (Witt, 1998).

Compression molding

Compression molding could use many different types of recycled materials including various plastic, rubber, synthetic resins, and other recycled waste products. There are two steps of this process. First, loaded the two piece molds with material manually, robotically, or through extruders. Once loaded, a press forces the mold closed, and pressure forces the material to fill the mold cavity (Pallet Enterprise Article).

Rotational molding

Rotational molding usually begins with granular or powdered plastic material loaded into a shell-like mold. Two planes perpendicular will heat and rotate the mold to distribute and fuse the material to the mold. The materials of this process usually are linear low-density polyethylene (LLDPE) and cross-linked polyethylene (Crawford and Throne, 2002).

Profile extrusion

Profile extrusion is a process that highly similar to wooden pallets and constructed in similar fashion. Industrial re-grind and post-consumer recycled material, even wood fiber could be the raw materials in this process (Soury et al., 2009). Raw material is melted and forced through an extruder. After cooling down, the extruded material is cut to size like lumber and fastened with nails, screws, glue or heat welds (Witt, 1998).

Table 4 provides a summary of 6 different processes and the related machine costs.

Table 4
Six Different Processes to Manufacture Plastic Pallet

Type	Machine Price Range/set	Materials	Advantages	Disadvantages
High pressure injection Molding	$25,000-$50,000 (USD)	Copolymer polypropylene; high density polyethylene	Fast cycle time; multifunctional for other products	High cost
Structural Foam Molding	$20,000-$40,000 (USD)	Polyethylene; polypropylene plastic pellets (with nitrogen gas)	Lighter less expensive mold materials; lower startup costs than injection process; good for smaller volumes; excellent strength to weight ratios	Lower production speeds.
Profile Extrusion	$10,000-$90,000 (USD)	Industrial re-grind; post-consumer recycled material	Suitable for wood-plastic composite pallet	Product limitation
Rotational Molding	$100,000-$150,000 (USD)	Linear low-density polyethylene (LLDPE); cross-linked polyethylene	Low cost tooling	Spin slowly (lower output); high cost since material limitation
Compression Molding	$3,500-$40,000 (USD)	Various plastic; rubber; synthetic resins; other recycled waste products.	Various material require; easy to convert and object; could create very complex parts; cost effectiveness	Greater waste of its materials; slower process time
Thermoforming	$5,000-50,000 (USD)	polyethylene pellets	More adaptable to customer's design needs; fast turnaround time; lower tooling costs; rigid packaging	Limited to thin walled parts; limitation to complexity of shapes; slow cycle time (each piece requires timing and process)

7. Reverse supply chain of plastic pallets

In a reverse supply chain, the products are returned from customers to the remanufacturers. In this section, some issues related to the reverse supply chain of plastic pallets are discussed.

Based on our search, it is hard to estimate the total number of plastic pallets that are circulated/received in Nova Scotia. In our opinion, the best way to get a good answer is preparing a survey and distribute it in certain areas. For example, we can mail the survey to the store managers of grocery stores located in Halifax and Sydney. The survey questions can be: how many plastic pallets are distributed, stored per day? Do the plastic pallets need to transport directly back to the suppliers? Is the distribution of plastic pallets managed by the third-party logistics company? The survey can also provide useful information about SWOT factors including strengths, weaknesses, opportunities, and threats. In the current situation, applying the survey method is beyond the project scope.

As mentioned in the previous sections, there are very few plastic pallets manufacturers located in Nova Scotia. Besides, supply chains of plastic pallets could be across all national and international boundaries because of the role of plastic pallets in distribution of the products.

Generally, every plastic pallet is a part of at least one reverse supply chain system because the main material of a plastic pallet is polyethylene which is almost 100% recycled content material. Plastic pallet plays a critical role for all firms especially for logistics service providers (LSPs) (Marasco, 2008). Open and closed-loop systems for pallet management are applied widespread. The variation in reverse logistics process is the major reason that makes the closed-loop networks complex in the plastic pallet industry.

Elia and Gnoni (2015) utilized observation approach to analyze the reverse supply chain of pallets. 30 Italian LSPs companies have been studied. The reverse supply chain model in these

30 companies is that the LSPs companies may or may not return empty pallets but the reverse flows of empty pallets have to be managed from downstream companies to upstream ones (Elia and Gnoni, 2015). Multiple utilization of empty pallets could allow the companies to reduce replenishment costs as well as to contribute to the reduction of the overall environmental impacts of pallets logistics systems. Based on the LSPs companies' viewpoint, the inbound pallet flows to the empty pallet storage system can derive from three sources: (1) new pallets from pallets suppliers; (2) pallets derived from unloading activities of palletized deliveries from upstream customers; and (3) empty pallets returned back to the LSPs storage center from its downstream customers (e.g. final retailers). Some of the outbound pallets flows from the LSPs storages are high defectiveness old pallets that usually are sent to disposal, or to companies which can recycle them. On the other hand, pallets are required for deliveries to downstream customers. The empty pallets have to be returned back to upstream customers after delivery in a closed-loop system. Fig. 6 shows the closed-loop system of pallets.

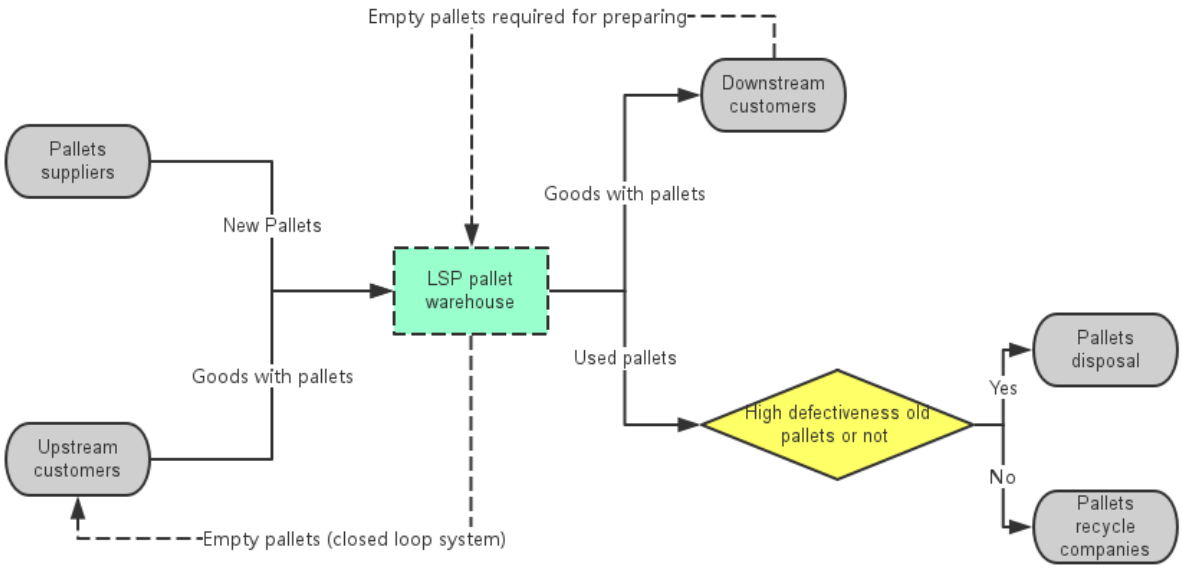

Fig. 6. The closed-loop system of pallets (based on LSPs' view)

Without LSPs companies' involvement, the most common reverse supply chain of plastic pallets usually performs as a part of closed-loop systems of assembly plants returning containers and pallets to the vendors. The earliest concept of closed-loop systems of the plastic pallet has been recorded in 1990s. Witt published many articles indicated that, in the 1990s, the plastic pallet involved 10 percent of the total pallet use market in America (Witt, 1993). During that period, those markets remained based on the closed-loop system in which a clean pallet is required. There were some managers among plastic pallet producers that pointed out that closed-loop system was the key to both environmental and economically sustainable development (Witt, 1990).

As decades' development of plastic pallet industry, instead of only provide the warranty of their products, lots of plastic pallets manufacturers provide various "customer care" services such as account management, product tracking program, product washing program, product repair program, as well as the recycling program. In other words, nowadays the manufacturers of plastic pallets not only customize the products but also customize the way of the reverse supply chain in order to maximum the profit.

Buckhorn Canada Inc., Myers Industries, Inc. is one of plastic pallets manufacturers which is one of the North America's leading providers of reusable plastic packaging systems. Buckhorn is one of the plastic pallet manufacturers which provides a closed-loop system for its plastic products. They call it product management options including tracking program, washing program, repair program and recycling program. Fig. 7 shows the reverse supply chain in the Buckhorn Canada Inc. Hypothesizing the Buckhorn Canada Inc. has partnership companies as *i*th, *j*th, *k*th and *l*th. The reverse supply chain of plastic pallets starts after downstream customer used plastic pallets. The empty pallets will go to partnership companies of Buckhorn Canada Inc.

Besides, the numbers and functions of partnership companies could be various depend on the actual circumstance in different areas.

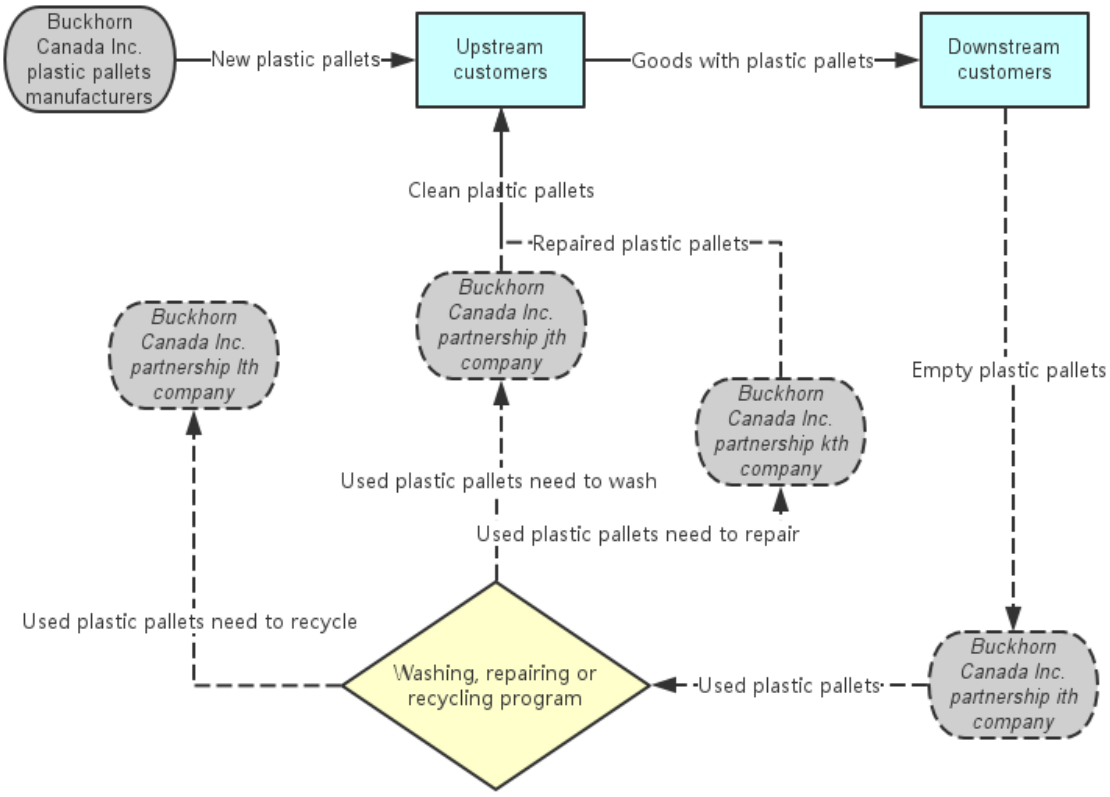

Fig. 7. Buckhorn Canada Inc. reverse supply chain of plastic pallets flows chart

High defective plastic pallets could be used regrind into small portions and be reused in other products or pallets based on the applications. Some of the manufacturers use a lot of recycled plastics in their products which all depend on the requirements of the products. However, some of the manufacturers do not regrind back into their own products. There is a problem with regrind material: we cannot always be sure where and what it is been hauling, or whether it was properly formulated, to begin with (Witt, 1990).

8. SWOT analysis

SWOT is the acronym of Strength, Weakness, Opportunity, and Threat which is well-known as a strategic management tool. Lots of researchers have utilized SWOT analysis. It provides the foundation for the realization of the desired alignment organizational variables or issues (Ansoff, 1965; Andrews, 1987; Porter, 1991; Mintzberg et al., 1998). Typically, the SWOT analysis can be inserted in a SWOT matrix which is considered by some experts as a consequence of an internal and external diagnosis of the organization (Helfer et al., 2010). The analyzer first considers internal strengths and weaknesses (at the 2*2 grid) which can include image, structure, access to natural resources, capacity and efficiency and financial resources about the target organization. Then, at the bottom of the SWOT grid, external opportunities and threats including customers, competitors, trends in the market, partners and suppliers, social changes and new technology, and various environmental economic, political and regulatory relationship as well as development of suitable paths for countries, organization, or other entities to follow (Proctor, 1992). SWOT analysis is recognized as a critical approach that is a useful tool for learning about the circumstances of an institution. It can be used as an effective methodology to access the current situation about the target institution by combining the macro industry environmental impaction in the wide range of market competition. Besides, SWOT analysis has been extensively applied in a variety of disciplines for investigating problems from a strategic planning perspective (Li et al., 2016). Helms & Nixon (2010) stated that over the past decade, SWOT analysis approach has concentrated on analyzing companies for recommended strategic actions. Generally, SWOT analysis approach can help to portray what information is needed and what decisions are likely to be made that help an organization to identify the strategic planning action (Balamuralikrishna & Dugger, 1995).

The objective of this SWOT (strengths, weaknesses, opportunities, and threats) analysis is to help A-1 Pallets Ltd to develop its strategic planning to fulfill the expectations of transferring manufacturing the products from the wooden pallets to the plastic pallets. The SWOT analysis tool is used widely across almost every industry in the world that can be done in a qualitative as well as quantitative way. However, the common view of the limitations of SWOT analysis is that the qualitative characters highly depend on the expertise and capabilities of the people involved (Kurttila et al., 2000). Table 5 includes the identified SWOT factors. The results of the SWOT analysis are based on the current circumstances of A-1 Pallets Ltd, as well as the external economic and industrial environment.

Table 5
The SWOT analysis of A-1 Pallets Ltd

Strengths (internal)	**Weaknesses (internal)**
S1. Extensive manufacturing knowledge and experience in pallet industry S2. Accessibility to big land and space S3. Location of the company S4. Accessibility (connection) to potential customers	W1. Shortage of staff W2. Lack of investment W3. Limitations in the current transportation and delivery system
Opportunities (external)	**Threats (external)**
O1. Lack of local competitors O2. Knowing the local market and businesses O3. Provincial and national funding supports (e.g. Divert NS) O4. Benefits of plastic pallets industry O5. Receiving several retired plastic pallets	T1. Monopoly market because of large companies T2. Fluctuation in Canadian dollar exchange rate T3. Competition between internal wooden and plastic pallets

Strengths (internal)

S1. Extensive manufacturing knowledge and experience in pallet industry: The majority of internal strengths benefit from the experiences related to the wooden pallets manufacturing. A-1 pallets Ltd has long history on manufacturing wooden pallets. Both the wooden pallets and the plastic pallets are subcategories of pallet industry. As a result, there are some similarities in the manufacturing processes.

S2. Accessibility to big land and space: Being located on a 15-acre site, A-1 Pallets Ltd has lots of spaces for setting up new facilities, warehouses, and machines to manufacture plastic pallets.

S3. Location of the company: A-1 pallets Ltd has a good location. It is only a few minutes away from highway 102 near Stewiacke, Nova Scotia. In addition, it is located in the middle of the province.

S4. Accessibility (connection) to potential customers: A-1 pallets Ltd already has gained some market share on Stewiacke, Halifax, Dartmouth, and New Brunswick areas. The market share can be converted to potential customers for plastic pallets.

Weaknesses (internal)

W1. Shortage of staffs: There are a few staffs in the company. In addition, there is a lack of internal experts in the field of manufacturing plastic pallets. A-1 Pallets Ltd should hire more staffs and experts in the future to be successful in the plastic pallets industry.

W2. Lack of investment: The current machines and equipments are devoted to manufacture wooden pallets. The company should invest more to be successful in the plastic pallets industry. The investment can be a challenge for A-1 Pallets Ltd because of the size of the company.

W3. Limitations in the current transportation and delivery system: Currently, the maximum traveling distance and distribution of the products for A-1 Pallets Ltd is 60 miles approximately.

Opportunities (external)

O1. Lack of local competitors: There is not any industrial competitor located in Nova Scotia for plastic pallets. Therefore, A-1 Pallets Ltd has the potential to be the first vanguard of a supplier of plastic pallets locally.

O2. Knowing the local market and businesses: A-1 Pallets Ltd is familiar with the local economic situation. As a result, the company is able to be flexible and responsive to react the trends of the local changes. Nova Scotia is one of largest seafood output provinces on the east coast of North America that can be a good advantage for A-1 Pallets Ltd to enter the new market based on the logistic services of seafood industry.

O3. Provincial and national funding supports (e.g. Divert NS): The plastic pallets industry can be a new manufacturing product born in Nova Scotia since there is no company involves in this industry locally. The majority of plastic pallets materials can be recycled. Thus, business and research about plastic pallets are eligible for some of the environmental protection programs operating by the non-profit corporations and research agencies. For instance, Divert NS (known as RRFB formerly) has solid waste diversion program that includes recycling of plastic products. Divert NS also provide various funding programs to build culture of recycling in the province. A-1 Pallets Ltd can get support from this kind of environmental protection organizations (Our Funding Program).

O4. Benefits of plastic pallets industry: As mentioned in this report, the benefits of the plastic pallets industry include the ability to be easily sanitized, resistance to odor, non-splintering, and

light weight (Lee and Xu, 2004). With these benefits since 1997, plastic pallets have become more and more popular in grocery distribution companies while the trend of using plastic pallets has gone up. We believe that it is a good moment for A-1 Pallets Ltd because of the rising stage of plastic pallets industry.

O5. Receiving several retired plastic pallets: Luckily, A-1 Pallets Ltd has gained lots of retired plastic pallets that it is a good opportunity to do value-added manufacturing with the free initial materials.

Threats (external)

T1. Monopoly market because of large companies: There are some big plastic pallets manufacturing companies such as Buckhorn Inc, Litco International and ORBIS corporation which are famous and powerful in grocery, and fast-food industries. It is difficult for A-1 Pallets Ltd to compete with such large and powerful companies in terms of price and market share.

T2. Fluctuation in Canadian dollar exchange rate: The fluctuation of the Canadian dollar exchange rate is another threat if A-1 Pallets Ltd enters the international market. Significant changes in the exchange rate can hurt the profit of the company.

T3. Competition between internal wooden and plastic pallets: Producing and selling plastic pallets can decrease the demand of wooden pallets produced by A-1 Pallets Ltd. As a result, the company should find new customers to sell the plastic pallets instead of selling the plastic pallets to the existing customers.

9. Conclusions

Plastic pallets have become an essential transportation tool, especially in food supply chain. There are billions of plastic pallets "running" on the road every day. The reverse supply chain of plastic pallets is critical from both economic and environmental aspects. Due to the various types of materials (e.g. high-density polyethylene and polyethylene terephthalate reinforced plastics) of plastic pallets, there is no natural decomposition in some cases. As a result, the used plastic pallets may bring some types of pollutions to our environment.

In this report, closed-loop supply chain including both forward and reverse supply chains were introduced. In addition, the related literature was reviewed with focus on pallet industry in Canada. Then, the problem in A-1 Pallets company was discussed. In Section 5, the characteristics of plastic pallets were discussed. Furthermore, forward supply chain of plastic pallets including relative associations, plastic pallet industry in Canada, and manufacturing processes of plastic pallets were discussed. In Section 7, we provided useful information about reverse supply chain of plastic pallets and related recovery options. Then, with SWOT technique, 4 strengths, 3 weaknesses, 5 opportunities, and 3 threats with details were found about establishing a recovery system for plastic pallets in the company.

Based on our analysis, the following recommendations are provided for the company:

Recommendation 1: Partnership with an existing big plastic pallet manufacturer company

It is suggested that the company becomes partner and collaborates with existing plastic pallet manufacturer companies in Canada. The big companies such as Buckhorn Canada Inc. have a lot of experiences in this field. In addition, it would reduce the financial burden on running of plastic pallets CLSCs.

Recommendation 2: Partnership with a local company to get the local market

It is suggested that the company becomes partner with a local economic developed company such as a local seafood export company for renting or selling the plastic pallets. This would help the company to enter the new plastic pallet market quickly. Besides, it can be helpful in reducing the transportation cost of empty plastic pallets.

Recommendation 3: Establishing a system for determining the price of both new and returned plastic pallets

Usually it is not a challenge to set the price of the new products. However, the prices of the retuned products depend on some factors such as the quality of the returned products. Because of the variations in the quality of the returned plastic pallets, there is a challenge in determining the price of them. Therefore, it is necessary to have a systematic approach in this case.

Recommendation 4: Establishing a system for inspection and separation of the returned products

It is useful to create a reasonable system to separate and inspect different returned products because of the differences in their qualities. With this system, the company can save money and decrease the time during the reverse logistics.

Recommendation 5: Forecasting the demand of plastic pallets in Nova Scotia and the Atlantic Canada

Since the plastic pallets can be utilized instead of wooden pallets and their demand is unknown, it is recommended to forecast the demand of plastic pallets in the area before starting

this business. The forecast can help the company to have estimate about the capacity of the facilities. One way of forecast is providing surveys to the current wooden pallets customers. After this process, the company will find out how big is the plastic pallets market in Nova Scotia and the Atlantic Canada.

Recommendation 6: Hiring new staffs and providing training programs for the current staffs

It is useful for the company to hire technical experts on manufacturing plastic pallets and to recruit new staffs or train existing ones who are good at management of plastic pallets. It is noticeable that one of the identified weaknesses in SWOT analysis was "W1. Shortage of staffs".

Recommendation 7: Considering cannibalization and the effects of it

The concept of cannibalization happens in the pricing strategy stage that refers to the reduction in sales volume or revenue as a result of the introduction of a new product or service (Yeoman, 2012). In the circumstances that A-1 Pallets Ltd. encounters, the cannibalization may happens related to the new products (plastic pallets), and the traditional products (wooden pallets). In this case, there will be a competition between the demand of plastic and wooden pallets as long as they are substitutable for the customers. In other words, more sale of plastic pallets can lead to decrease in sale of wooden pallets.

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