

NEWBio

MARKET OPPORTUNITIES FOR LIGNOCELLULOSIC BIOMASS: ANALYSIS OF THE PAPERBOARD INDUSTRY IN THE UNITED STATES

November 8, 2015

Prepared by

Kusumal Ruamsook

Evelyn Thomchick

Center for Supply Chain Research

Department of Supply Chain & Information Systems

Smeal College of Business ✦ The Pennsylvania State University

Copyright © 2015 by NEWBio

All rights reserved. No part of this publication may be reproduced, distributed, or transmitted in any form or by any means, including photocopying, recording, or other electronic or mechanical methods, without the prior written permission of the publisher, except in the case of brief quotations embodied in critical reviews and certain other noncommercial uses permitted by copyright law.



United States
Department of
Agriculture

National Institute
of Food and
Agriculture

PENNSSTATE



Cornell University



Delaware State
University



ESF



iNL
Idaho National Laboratory

TABLE OF CONTENTS

Introduction	6
The Ambit of the Industry.....	8
The Scope of Products	8
Geographic Scope	10
Overview of the Paperboard Industry: Key Products and Industry Status.....	12
Key Product Segments: Grades and Categories	12
Paperboard Categories by Usages.....	12
Paperboard Grades by Production Materials	14
Status of the US Paperboard Industry.....	16
Demand by Usages.....	16
Demand by Grades.....	18
Industry Structure.....	19
Production Capacity.....	23
Revenue	26
The Five Competitive Forces in the Paperboard Industry.....	28
Threat of Entry	29
Trends to Watch: Strategic Changes in the Paper Industry.....	31
Rivalry among Existing Competitors.....	37
Market Share Concentration and Key Players	37
Intensity of Rivalry	38
Basis of Competition.....	46
The Power of Suppliers	48
Market Pulp Suppliers.....	49
Virgin Wood Fiber Suppliers.....	55
Recovered Fiber Suppliers: Old Corrugated Containers (OCCs).....	58
Nonwood Fiber Suppliers.....	70



The Power of Buyers	76
Cardboard Box Manufacturers.....	78
Converted Paper Product Manufacturers	80
The Threat of Substitutes: Packaging & Container Markets	81
Secondary Packaging.....	84
Primary Packaging.....	86
Trend to Watch: Bio-based Plastics.....	89
Implications for Raw Biomass Suppliers.....	90
Demand Market Implications	90
Supply Market Implications.....	95
References.....	101

List of Figures

Figure 1/ Key Product Grades and Share of Industry Revenue in 2014	14
Figure 2 / US Paperboard Mills by Employment Size	20
Figure 3 / Import and Export of Paper and Cardboard International Comparison in 2012 (in 1,000 metric tons)	22
Figure 4 / Production Volume of Paper and Cardboard in the Pulp and Paper Industry in Selected Countries from 2009 to 2012 (in 1,000 metric tons).....	24
Figure 5 / Global Furnish Capacity by Fiber Type.....	25
Figure 6 / US Containerboard Operating Rates.....	26
Figure 7 / The US Paperboard Industry Revenue 2006–2020 (projected)	26
Figure 8 / Producer Price Index: Paperboard Mill Industry	27
Figure 9 / The Porter’s Five Forces Analysis of the US Paperboard Industry	28
Figure 10 / Market Share Concentrations in the US Paperboard Mill Industry	37
Figure 11 / US Wood Pulp Production 2005–2014.....	49
Figure 12 / Major Wood Pulp Manufacturing Firms in the United States.....	50
Figure 13 / US Wood Pulp Mills by Employment Size.....	50



Figure 14 / US Wood Pulp Mill Product Segments 2014	51
Figure 15 / World Price of Wood Pulp	53
Figure 16 / Monthly Wood Pulp Prices Delivered to the United States	53
Figure 17 / Global Wood Fiber Price Indices	57
Figure 18 / US Northeast Price Relative to Other Regions	58
Figure 19 / Uses of Recovered Paper 2013	59
Figure 20 / Recovered Old Corrugated Containerboard	60
Figure 21 / Baled Old Corrugated Containers (OCCs)	61
Figure 22 / US Average Corrugated Grade 11 Selling Price	66
Figure 23 / Monthly Prices of OCCs on the US Open Market	66
Figure 24 / Global Kraft Paper and Linerboard Capacity Installed 2000–2010	67
Figure 25 / Past and Projected Demand for Virgin Wood Pulp and Recovered Fiber by World Region	68
Figure 26 / Global Production of Nonwood Raw Fiber and Market Pulp Prices	73
Figure 27 / Variations of Pulp Fiber Properties	75
Figure 28 / Major Buyer Market Segments	77
Figure 29 / Global Packaging by End Markets: 2012	81
Figure 30 / Packaging Material Spectrum	83
Figure 31 / Market Share by Packaging Materials: 2012	84
Figure 32 / Plastic Resin Pricing Trend	86

List of Tables

Table 1 / US Corrugated Box End-use Markets Classified by Growth Potentials	18
Table 2 / Business Locations of US Paperboard Mills 2014*	20
Table 3 / Major Paper Companies in the United States	32
Table 4 / Key Players' Profiles and Paperboard Businesses	39
Table 5 / Example Uses of Nonwood Fibers in Paperboard Making	48
Table 6 / Key Pulp Processes, Advantages, Drawbacks, and End Uses	54



Table 8 / Key Recycle Material Supplier Industries..... 63

Table 9 / US Production Capacity of Wood and Nonwood Pulp for Paper and Paperboard
..... 71

Table 10 / Major Buyers in the Packaging Industry 76

Table 11 / Key Opportunities and Challenges for Purpose-grown Lignocellulosic Biomass
in Serving the US Paperboard Industry 96



INTRODUCTION

Biomass is one of the most plentiful resources available globally and includes a wide variety of biomass fuel types. The past few years have witnessed the rapid development of plant biomass-based energy, such as heat and power, and biomass-based fuels such as bioethanol and biodiesel. The basis of development constitutes both the supply sources of plant biomass and refining technologies.

Among the different biomass categories, lignocellulosic biomass raw materials have been more seriously considered as alternatives to food-based biomass (sugar- and starch-based biomass) used in the 1st generation (1G) refining technologies. The bioenergy industry and US governments now focus on the 2nd generation (2G) refining technologies that rely on lignocellulosic biomass as raw materials (Biofuels Digest 2010).

Despite the high expectations of 2G bioenergy, one of the key issues shared by all bioenergy sectors remains whether or not the supply of biomass can be guaranteed in the long term (IFP Energies nouvelles 2011). Large-scale production of high yielding energy crops that can supply sustainable amounts of low-cost biomass feedstocks is widely accepted and promoted as a means to mitigate the supply issues.

The prospect of energy crops as long-term, low-cost biomass sources for the bioenergy industry is made complicated by the commercial marketplace of biomass that still faces a number of challenges. On the demand side, many bioenergy companies are still in pilot and demonstration stage, and are not able to generate revenue through commercial sales of their products or services (Son 2013), thus creating *price and demand uncertainties* for cellulosic energy crops. On the supply side, farmers growing cellulosic energy crops are faced with *production uncertainties* that are inherent in agriculture (e.g. due to pests and diseases, and adverse or unfavorable weather conditions), and made more prominent by the relative novelty of specific energy crop production techniques. In other words, *revenue uncertainties* for energy crop growers remain exorbitant (Song, Zhao, and Swinton 2011). Adding to the challenges is the fact that purpose-grown biomass or



energy crops are not the one and only source of lignocellulosic biomass raw materials. Other sources of note, competing with purpose-grown biomass, are non-food terrestrial plants (e.g. woody plants like trees and bushes, and nonwoody plants like grass and oleaginous crop), agricultural waste (e.g. stover, straw, sugarcane bagasse, stalks, leaves, chaff, and husks), and forestry biomass (e.g. logging residues and forest clearing/thinning).

Consequently, there is a growing interest in exploring market opportunities for biomass beyond the energy markets to enhance the development and commercialization of both the energy crop and bioenergy industries. A number of potential uses of *raw biomass materials* in complementary non-energy markets have been identified in research and industrial publications. These alternative markets span pulp, paper, paperboard, composite material, industrial polymer and plastic material, livestock feed/forage, and absorbency (e.g. animal bedding, mulch, and erosion-control product) markets.

Given the varieties of market alternatives, suppliers of raw biomass materials have the challenge of determining which markets to enter. The increasing demand for wood-based products and concerns of how wood raw materials for these products are sourced are driving the search for alternatives (Rainforest Alliance 2013). In this light, this paper focuses on the paperboard industry in the United States. Applying the *Porter's Five Forces Analysis Framework*, this paper aims to serve as a resource for raw biomass suppliers in understanding the US paperboard industry circumstances, how the industry may develop in the future, and strategic implications for raw biomass suppliers.

The paper begins by explaining the ambit of the paperboard industry, followed by an overview of the industry, describing key product categories and current status. Assessment of each of the Porter's Five Forces in the US paperboard industry is then discussed. The paper concludes with business implications for raw biomass suppliers interested in participating in the supply markets for the US paperboard industry.



THE AMBIT OF THE INDUSTRY

The overall US pulp, paper, and paperboard manufacturing industry includes about 250 companies with combined annual revenue of about \$80 billion in 2014, of which paper accounts for 60 percent, paperboard 35 percent, and pulp 5 percent. The industry as a whole is *highly concentrated* with the top-50 companies accounting for 90 percent of the industry revenue (Hoover's 2014a). For the purpose of industry analysis in the paper, the ambit of the paperboard industry is described by two primary dimensions: the scope of products, and geographic scope (Porter 2008).

The Scope of Products

Companies in the paperboard industry (NAICS 322130; SIC 2631) primarily engaged in turning fibrous materials, mainly wood pulp, into heavy paper-based and pulp-based board. Paperboard product varieties include, for example, unbleached and bleached packaging paperboard, coated paperboard, recycled paperboard, and industrial converting paperboard (e.g. furniture board, filter frame paperboard, construction/flooring protection board). These paperboard products are intermediate products that are typically sold in sheets, mainly to cardboard box and container manufacturers, and a range of consumer-product and industrial-product producers for further processing (Hoopes 2014a). Different product categories are discussed in further details in the following section.

Paperboard mills can be further categorized into *integrated* and *independent* paperboard mills. Integrated mills may manufacture wood pulp and other fiber pulp, and/or may also convert the paperboard they make to converted paperboard products such as corrugated boxes and containers (Highbeam Business 2014; NAICS Association 2014). Thus, an integrated mill's primary product may be paperboard, but it also manufactures pulp and/or converted paperboard products. On the other hand,



independent mills do not make pulp, but purchases pulp from external sources to make paperboard. Nor do they engage in the production of converted paperboard products, but sell paperboard they make to downstream industries involved in such operations.

Thus, for the purpose of analysis in terms of business environment and competition in this paper, the paperboard industry is distinguished from the following relevant industries with respect to the scope of products:

- ❑ **The pulp mill industry** (NACIS 322110; SIC 2611) that manufactures pulp from wood or from other raw materials (e.g. rags, linters, wastepaper, and straw) without manufacturing paperboard.
- ❑ **The paper industry** (NAICS 322121; SIC 2621) that produces paper rolls and reams of varieties, including printing and writing paper, newsprint, household and sanitary papers, and industrial paper, notably packaging material used to create paper bags, folding cartons, food containers, and other disposable packaging products.
- ❑ **The converted paper and paperboard product manufacturing industry** (NAICS 3222; SIC 2621) that converts paper and paperboard into various products, using paperboard purchased from external sources.

It is worth noting that the paper industry is, in some cases, considered in conjunction with the paperboard industry, mainly because some paper mills also make paperboard along with other paper varieties. In this paper, we distinguish the two industries, instead of analyzing them as a single paper-and-paperboard industry. This is because the paper industry is highly diversified, much more so than the paperboard industry, in terms of products, raw materials, distribution channels, and end uses. For example, while paperboards are typically intermediate products used as inputs in the production of downstream value-added products, other paper products, such as tissue and office papers, are generally distributed to consumers without further conversion (Hetemäki, Hänninen, and Moiseyev 2013). Furthermore, the majority of the paper



industry revenue is derived from the sale of uncoated printing and writing papers, rather than the small amounts of industrial and packaging papers (Petrillo 2014a; Hoover's 2014a) that serve the same industrial buyers as those of the paperboard industry.

Geographic Scope

The United States is a geographic scope of the paperboard markets analyzed in this paper due mainly to the marginal level of foreign trade and different structures of the paperboard industry (e.g. rivals, buyers, market development, government assistance and regulation) that exist across different countries.

International trade is a major determinant of an industry's geographic scope of markets (e.g. global, regional, domestic) and forms a core component of global industries. The US paperboard industry has *marginal* level of international trade, despite the fact that the United States is a powerhouse of paperboard production. The majority of US paperboard consumption was served by US paperboard mills (Highbeam Business 2014), whereas *imports* served a very small share of domestic demand, accounting for 2 percent of US paperboard consumption in 2014. The majority of imports (60% of total paperboard imports) originated from Canada (Hoopes 2014a).

Similarly, while US paperboard mills have increasingly targeted emerging economies for *export sales*, due to declined demand from domestic markets (Petrillo 2014b), exports remain a weak source of growth for the industry. Exports account for a marginal share of the industry revenue at 0.8 percent in 2014, a slight increase from 2009 when exports contributed 0.4 percent of revenue.¹ US paperboard industry exports are

¹ This level of international trade is in contrast to that in **the pulp-and-paper industry** that are rapidly expanding *global* industries, with the industry's largest mills dominating parts of North Asia, Europe, and North America. International trade in pulp and paper is increasing, both absolutely and relatively (share of exports in total production). Globally, the share of exports to production was on average 27 percent in the 1990s. This share increased to 30 percent on average in the 2000s



primarily shipped to Mexico, which purchases about 47 percent of total exports. Both Mexico (major export market) and Canada (major import source) benefit from geographic proximity and favorable trade conditions established by the North American Free Trade Agreement (Hoopes 2014a).

Paperboard industry development in different domestic markets also showed a clear diversity in the past decade. On one hand, there has been the significant rise of emerging economies in *Asia and South America*, notably the BRIC nations (Brazil, Russia, India and China) as consumers and producers of paper and paperboard. China, in particular, experienced a 143 percent growth in paper and paperboard consumption, and a 182 percent increase in production between 2000 and 2010 (Hetemäki, Hänninen, and Moiseyev 2013). China's rapid emergence has been largely attributed to *government subsidies*, which totaled more than \$33 billion between 2002 and 2009 (Hoover's 2014b). On the other hand, there has been a simultaneous decline of downstream demand for and production of paperboard in many *European and North American countries* (Hetemäki, Hänninen, and Moiseyev 2013). This is mainly due to ongoing offshoring of manufacturing that result in diminished manufacturing activities in these developed countries. Consequently, demand for paperboard which is widely used for bulk packaging of industrial commodities has also declined (Hetemäki, Hänninen, and Moiseyev 2013; Petrillo 2014b; Woodall et al. 2011a). Essentially, while North America and Europe markets continue to slowly decline, expansion and competition has become increasingly fierce in emerging economy markets (Petrillo 2014b).

The scope and stringent of industry regulations for paperboard mills also varies across countries and economic unions. The majority of the industry's regulations pertain to environmental, health, and safety standards, all of which vary depending on the prevailing laws of each operator's host country. To wit, it is more difficult to open

(Hetemäki, Hänninen, and Moiseyev 2013). In terms of revenue, exports make up 27 percent of the estimated \$657.1 billion revenue of the global pulp-and-paper industry in 2014 (Petrillo 2014b).



mills in markets such as the United States, Australia, and the European Union where occupational safety and environmental regulations are quite high (Petrillo 2014b).

Summarily, the diversities in product offerings and operation activities suggest that distinct industries may well be present and are best understood separately. Moreover, while some major US paperboard manufacturers are present in many parts of the world, the marginal level of international trade suggest that competition is largely contained within the US markets.

OVERVIEW OF THE PAPERBOARD INDUSTRY: KEY PRODUCTS AND INDUSTRY STATUS

Key Product Segments: Grades and Categories

The paperboard stocks produced by paperboard mills are *intermediate* products that comes in a wide variety of styles and qualities, making different paperboard stocks favoring different raw materials (thus, supplier markets) and suitable for different usage requirements (thus, buyer markets). Accordingly, key products of the paperboard industry can be segmented by its uses and by types of materials used in production.

Paperboard Categories by Usages

Paperboard can be divided into three categories based on its uses, including: (1) containerboard, (2) boxboard, and (3) card stock.

Containerboard / Cardboard accounts for the majority of paperboard produced in the United States. Containerboard is a special kind of heavy paper used to make two components of *corrugated fiberboard* (also called *combined board* and *corrugated case*



material [CCM]),² namely *corrugating medium* (or *fluting* or *medium* as it is often called in the trade) and *linerboard*. Linerboard is the flat facing that adheres to the medium (as seen in the outer faces, or layers, of corrugated boxes). The medium is the wavy, rippled or fluted paper in between the liners. Corrugating medium is made from both semichemical pulp and recycled fiber (Corrugated Packaging Alliance 2014a; Highbeam Business 2014; ThomasNet 2014), whereas linerboard is made mostly from softwood fibers. However, linerboard may contain up to 20 percent hardwood pulp or recycled fiber. Most softwood pulp for linerboard is produced using the kraft pulping process (AF&PA 2014a; Highbeam Business 2014). Corrugated fiberboard is used by downstream industries that make a wide range of corrugated boxes and containers (Highbeam Business 2014; ThomasNet 2014; White and Hamner 2005).

Boxboard / Carton board includes white lined chipboard, folding boxboard, set-up boxboard, milk carton, food service boxboard, and solid bleached sulfate board (Highbeam Business 2014; White and Hamner 2005). The boxboard product group is used for many kinds of consumer packaging such as food, liquor, light industrial products, medicine, healthcare products, cosmetics, and electronics (Hetemäki, Hänninen, and Moiseyev 2013).

Card stock is the thinnest type of paperboard, but still thicker than most traditional writing paper. More flexible than the other forms of paperboard, card stock is often used in postcards, for catalog covers, and in some soft-cover books (ThomasNet 2014).

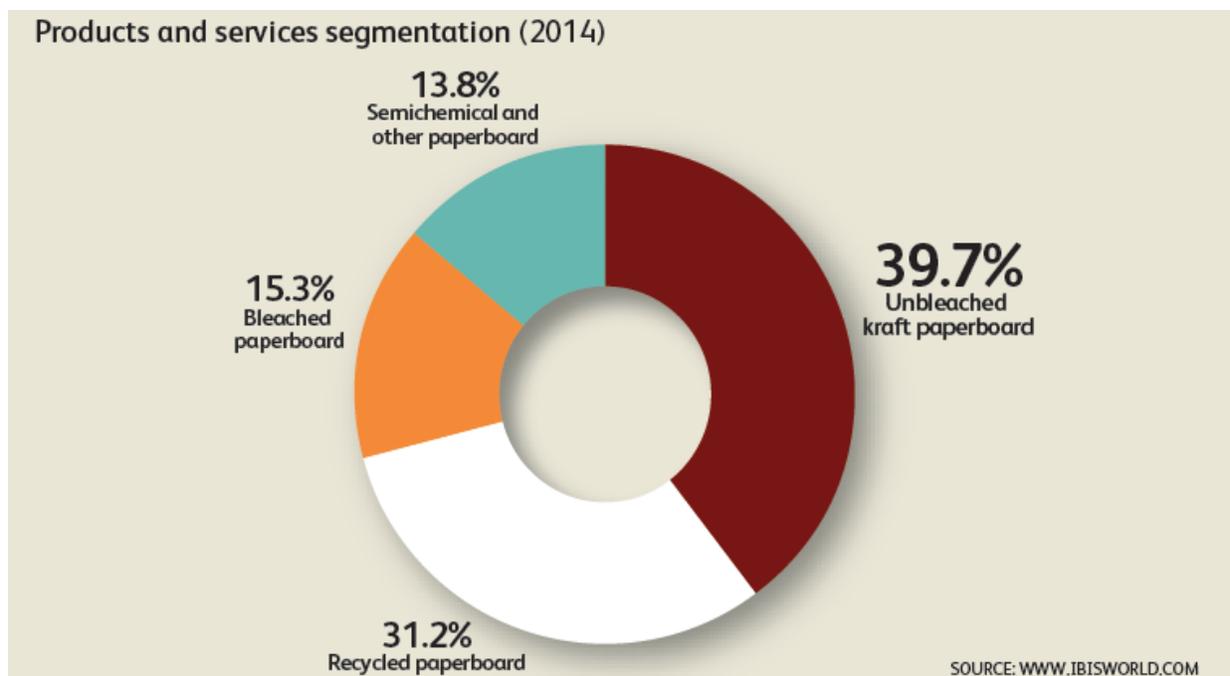
² Four primary **types of corrugated fiberboard** are: (1) *Single face*, with one medium glued to one flat sheet of linerboard, (2) *Single wall or double face*, with one medium glued between two sheets of linerboard, (3) *Double wall*, with three sheets of linerboard with two mediums in between, and (4) *Triple wall*, with four sheets of linerboard with three mediums in between (Corrugated Packaging Alliance 2014a).



Paperboard Grades by Production Materials

Depending on the types of materials used in production, paperboard comes in different grades, primarily including: (1) unbleached kraft paperboard, (2) recycled paperboard, (3) bleached paperboard, and (4) semichemical and other paperboard (AF&PA 2014a; Hoopes 2014a). Figure 1 shows share of industry revenue in 2014 of these different paperboard grades.

Figure 1/ Key Product Grades and Share of Industry Revenue in 2014



Source: Hoopes (2014a)

Unbleached kraft paperboard / natural kraft paperboard / solid unbleached sulfate (SUS) is a *superior strength* paperboard grade that contains at least 80 percent virgin unbleached, natural wood pulp produced by the sulfate (kraft) process (AF&PA 2014a; Hoopes 2014a). Since it is unbleached, this type of paperboard retains a brown color and is usually used for industrial purposes and for cardboard box manufacturing. Unbleached kraft paperboard is the *largest source of US paperboard*



industry revenue, estimating to account for 39.7 percent of revenue in 2014 (Hoopes 2014a). Most unbleached paperboard is coated, called **coated unbleached kraft paperboard (CUK)**. It may be coated with a pigment such as kaolin clay to improve its printing surface, or with polyethylene (PE) resin to make it impermeable to air and liquids. CUK is commonly used for frozen food packaging, pharmaceutical packaging, and beverage carrying containers (AF&PA 2014a; Highbeam Business 2014).

Bleached paperboard / solid bleached sulfate (SBS) is a premium paperboard grade that is produced from a furnish³ containing at least 80 percent virgin bleached wood pulp. With weight ranging from 40 to 100 pounds, SBS is white and used for consumer packaging and retail packaging applications, such as milk cartons and frozen food packaging (Highbeam Business 2014; Hoopes 2014a). Like unbleached kraft paperboard, most US-produced SBS is coated with a clay solution to improve its surface for printing. SBS used as linerboard, folding boxboard, and for food packaging (e.g. milk carton stock) is often coated with PE resin. SBS is also used in products such as disposable cups and plates, and displays that need an outside surface for high-quality, four-color printing (Highbeam Business 2014).⁴

Recycled paperboard is the *fastest growing* product line in the industry, with sales as a percentage of revenue estimated at 31.2 percent in 2014 (Hoopes 2014a). It is manufactured from a combination of recycled fibers recovered from various sources and grades of *paper stock*,⁵ with the larger portion of the pulp being recycled fibers and the

³ **Furnish** is *finished stock* that has been converted from *raw stock*, involving processes of blending different pulps, diluting, and adding chemicals. The raw stocks used are the various types of chemical pulp, mechanical pulp, and recovered paper. The finish-stock mixtures are available in the form of bales, loose material, or, in the case of integrated mills, as suspensions (Bajpai 2012).

⁴ Another product made by some mills that produce SBS is **bleached bristol**. This product, usually a lightweight grade, is used for greeting cards, paperback book covers, and telephone directories, among other products. Bristol is usually classified under paper, rather than paperboard, production (Highbeam Business 2014).

⁵ **Paper stock** is a term used in the paper recycling industry, equivalent to *recovered paper* or *waste paper* (EPA 2014).

lesser amount being virgin fibers. Recycled paperboard that contains no virgin fibers is commonly called *100 percent recycled paperboard* (Highbeam Business 2014). Recycled paperboard can be coated or uncoated. Major market segments that use *uncoated* recycled paperboard are: (1) shoeboxes, (2) composite cans and fiber drums, and (3) coated paperboard. Major market segments that use *coated* recycled paperboard are: (1) soap and laundry detergent packaging, (2) cookie and cracker packaging, (3) paper goods packaging (e.g. facial tissue and napkins), (4) cake mix packaging, (5) cereal boxes, and (6) other dry food packaging (AF&PA 2014a).

Semichemical paperboard is made from pulp containing no less than 75 percent virgin wood fibers, the majority of which is produced by a semichemical pulping process. The semichemical pulps have chemical and strength properties intermediate between softwood, groundwood, and full chemical pulps. The *smallest category*, semichemical paperboard is most widely used to produce corrugating medium (Hoopes 2014a).

Status of the US Paperboard Industry

The US paperboard industry is a *mature* industry as characterized by a high level of market acceptance of industry products, limited introduction of new industry products, and significant merger and acquisition activity (Hoopes 2014a). The key elements that determine the status of the US paperboard industry—namely demand, structure, capacity, and revenue—are discussed as follows.

Demand by Usages

In terms of demand by usages, more than two-thirds of all paperboard produced by the industry is converted into *cardboard boxes, containers, and packaging*, with a much smaller proportion delegated for other products. Accordingly, demand for *cardboard* and *boxboard* is inherently tied to the manufacturing, agriculture, food service, and retail



sectors that use these paperboard materials for product packaging, and corrugated containers (made from cardboard medium and linerboard) to form a unit load for storage and transportation.⁶

Economic recessions. Business activities of the demand-market sectors are, in turn, mainly influenced by demand for consumer goods (Hoopes 2014a). The recent economic recession brings with it decreased demand for consumer goods, particularly discretionary non-food goods. Demand for corrugated packaging was adversely affected as decreased production resulted in fewer goods being transported (Hoopes 2014a; Woodall et al. 2011a).

Manufacturing offshoring. In recent years, the US manufacturing sectors have been increasingly moving operations offshore. As US manufacturing activities are moving overseas, domestic manufacturing levels have decreased. As a result, demand for US domestically-produced paperboard for uses in packaging is weakened; while demand for paperboard in Asia and South America, notably the BRIC nations (Brazil, Russia, India and China) continues to grow with the rising industrial production in the regions (Hetemäki, Hänninen, and Moiseyev 2013; Hoopes 2014a; Petrillo 2014b; Woodall et al. 2011a).

Looking forward, opportunities for *corrugated packaging* in the food and beverage segment are expected to flourish as Wal-Mart and other ‘big box’ retailers continue to commit to the use of sustainable packaging materials such as corrugated packaging (RISI 2012). Moreover, increasing interest in corrugated retail point-of-sale displays is expected to drive demand for corrugated packaging (Hoover’s 2014c). Since corrugated retail point-of-sale displays require higher quality product (e.g. printing and coloring) than the traditional container markets, this market would allow higher pricing for the products.

⁶ In today’s logistics system, most consumer products and industrial products are formed into **unit loads** for storage and transport. A unit load is a single item, a number of items, or a bulk material, that is arranged and restrained so that the load can be stored, picked up, and moved between two locations as a single mass. A typical unit load consists of corrugated containers stacked on a pallet and stabilized with stretch wrap or other materials (White and Hamner 2005).



E-commerce is growing rapidly, bringing with it increases in the overall demand from online merchants for corrugated boxes used in the fulfillment and delivery of online orders. The continuing healthy growth of online shopping will propel market opportunities for corrugated shipping containers, thus containerboard product groups (medium and linerboard) (Hoover’s 2014c; Petrillo 2014b; Reportlinker 2012; Woodall et al. 2011b). Table 1 depicts growth potentials across various US corrugated box end-use markets.

Table 1 / US Corrugated Box End-use Markets Classified by Growth Potentials

Average Annual Growth in Corrugated Shipments (2012–2016)					
Growth Markets		Stagnant Markets		Declining Markets	
Beverage products	5.7%	Metal, machinery & transport equipment	0.8%	Miscellaneous manufacturing	-2.0%
Fresh fruit & vegetables	3.5%	Bakery products	0.7%	Plastics, rubber & petro products	-2.8%
Dairy products	3.0%	Frozen & canned food	0.6%	Milled grain & oilseed	-3.2%
Chemical products	2.7%	Furniture & wood products	0.2%	Mineral products	-4.1%
Other food products	2.5%	Services	-0.1%	Electrical equipment & computers	-4.8%
Meat products	2.3%	Sugar & confectionary	-0.2%		
Retail trade	1.2%	Textile, apparel & leather products	-0.3%		
Paper, printing & allied products	1.1%	Wholesale trade	-0.4%		

Source: RISI (Weiss 2012)

Demand by Grades

In its August 2013 statistics review, the American Forest & Paper Association (AF&PA) noted that total paperboard production increased by 2.8 percent compared to the same period the year before. Overall, unbleached kraft paperboard production, total solid



bleached paperboard and linerboard production, and recycled paperboard posted gains as the economy recovers (Hall 2013). However, demand specific for *bleached paperboard* has *declined* over the five-year period 2009–2014 because of the high cost associated with producing the product, and high cost of input pulp of this grade and chemicals (Hoopes 2014a). Meanwhile, demand for *recycled board* is outpacing that for paperboard grades made from virgin kraft pulp inputs amid pressures from consumers, industrial customers, and governments for more environmentally friendly packaging (Hoover's 2014c).

It is expected that increasing consumer demand for biodegradable packaging material will continue to boost the demand for paperboard in general over the next six years, for paperboard is perceived to be a more eco-friendly materials compared to plastic materials (Transparency Market Research 2014a). Opportunities are particularly strong for paperboard made from *recycled materials*, as the industry's major customers (cardboard box and paperboard product converters) have been devoted to the pursuit of more eco-friendly end products that involve increasing volume and type of recycled material used (Hoopes 2014b). This fastest-growing product line in the paperboard industry is further enabled by the industry improvements in the texture and quality of products made from reusable inputs to compete in the growing recycled markets (Hoopes 2014a). This trend could put non-recycled materials (including biomass) at a disadvantage from eco-friendliness viewpoint.

Industry Structure

For most of its history, the US paperboard industry was highly fragmented and generally lacked the ability to raise prices without undergirding of higher demand or input prices. However, falling sales and declining profitability in the industry as a result of two major recessions since 2000 have led companies in the paperboard industry to restructure and downsize their operations to *reduce operating costs and salvage profitability* (Hetemäki, Hänninen, and Moiseyev 2013; Hoopes 2014a). Merger and acquisition activity has been



a common trend over the past five years as companies have integrated their paperboard with pulp production, acquired other paperboard companies, and/or acquired packaging companies in order to *boost revenue* (Hoopes 2014a; Petrillo 2014b).

Number of US paperboard establishments has been on a *decline*, reflecting *structural changes* in the industry. As of 2014, the US paperboard manufacturing industry is home to an estimated 174 manufacturing facilities, decreasing from 181 in 2009 due to the *continued consolidation* in the industry. As a result, the top-four companies are estimated to account for 30.4 percent of total industry revenue in 2014, up significantly from 25.1 percent in 2009 (Hoopes 2014a). In general, the industry is characterized by moderately large firms, with 40 percent of enterprises having 500 or more employees (see Figure 2). Table 2 provides a summary of paperboard mill locations in 2014.

Figure 2 / US Paperboard Mills by Employment Size

Companies by employment size	
No. of employees (People)	Percentage of total (%)
0-4	11.8
5-9	4.7
10-19	7.0
20-99	16.5
100-499	20.0
500+	40.0

SOURCE: US CENSUS BUREAU

Source: Hoopes (2014a)

Table 2 / Business Locations of US Paperboard Mills 2014*

Top Regions	Key States	Business Attractions
The Southeast (35.9%; increased over the five years to 2014)	Georgia (7.2%), North Carolina (5%), and Alabama (5%)	Supply sources. Most of the nation’s pulp mills are located in the Southeast, providing vicinity to sizable sources of raw materials (e.g. wood chips and pulp). Customer markets. Key markets, like paperboard converters, are in proximity as they are attracted to major consumer markets, such as Atlanta, New Orleans, and Miami.



Top Regions	Key States	Business Attractions
The Great Lakes (20%; decreased slightly over the five years to 2014)	Ohio (6.1%) and Wisconsin (5%)	Supply sources. The region is a major manufacturer of wood pulp, giving the benefit of the proximity to raw material suppliers.
The Mid-Atlantic (13.7%; increased slightly over the five years to 2014)	New York (7.7%) and Pennsylvania (4.4%)	Customer markets. Many cardboard box manufacturers, a major market segment of the paperboard industry, are located in this region to be near large consumer markets and considerable food, beverage, tobacco, and engineered product manufacturers.
West (10.5%; no data on changes)	California (6.1%)	Port accesses. Pacific ports provide advantages for imports and exports, making the Western coastline a popular location for paperboard mills engaging in international trade.

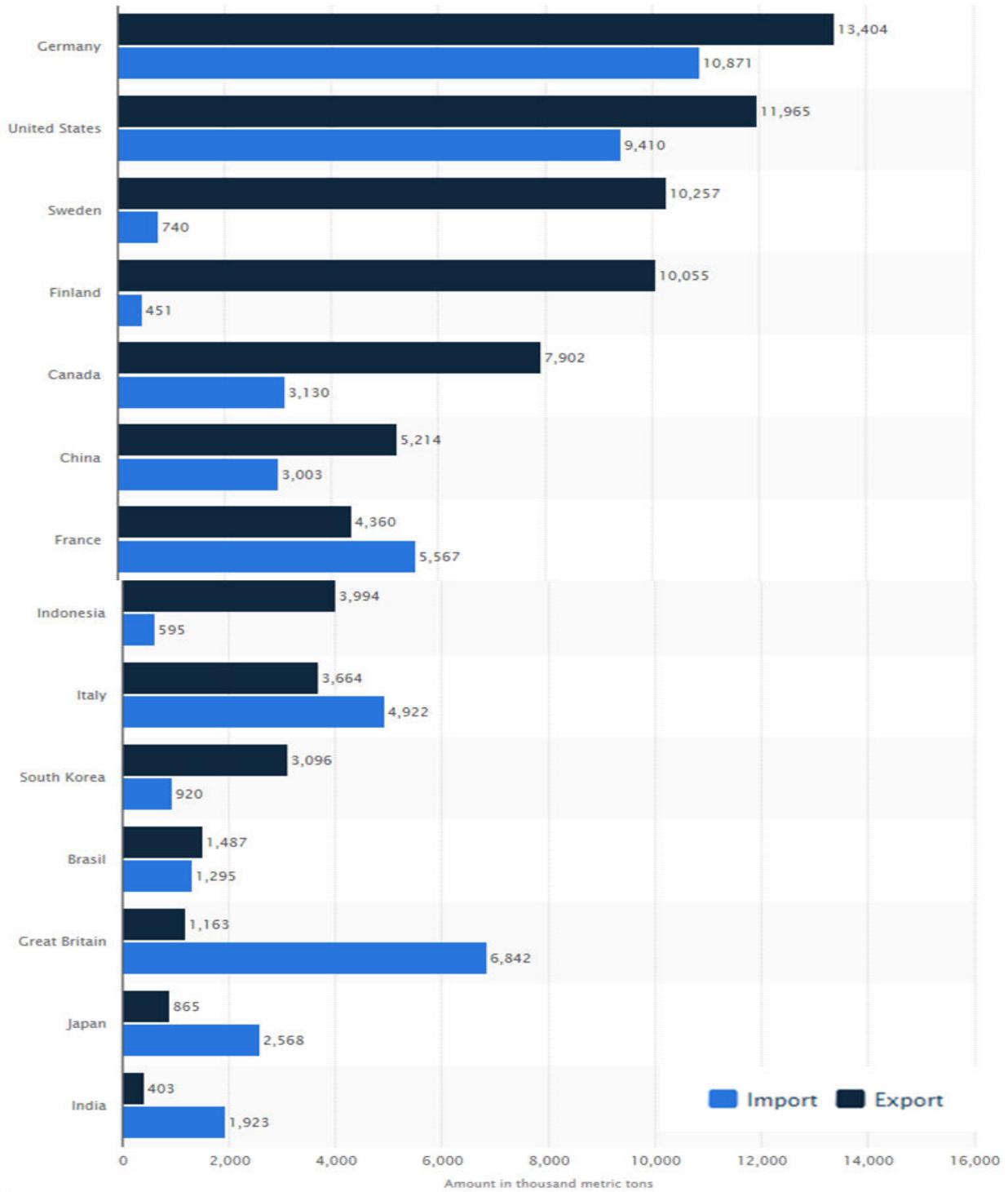
Source: Hoopes (2014a)

* Numbers in the parentheses represent share of the nation's total number of establishments in 2014.

Industry structure outlooks. As a result of consolidation activities discussed earlier, the US paperboard industry has experienced significant structural changes, including reductions in the number of mills, lower rates of capacity growth, and employment cutbacks. The outcomes have made the US paperboard industry more efficient and competitive in the global market, enabling its role as an important exporter of paperboard thus far, and in the foreseeable future (Hetemäki, Hänninen, and Moiseyev 2013; Woodall et al. 2011a). Figure 3 provides a snapshot of major importers and exporters in 2012.



Figure 3 / Import and Export of Paper and Cardboard International Comparison in 2012 (in 1,000 metric tons)



Source: Statista (2015)



Production Capacity

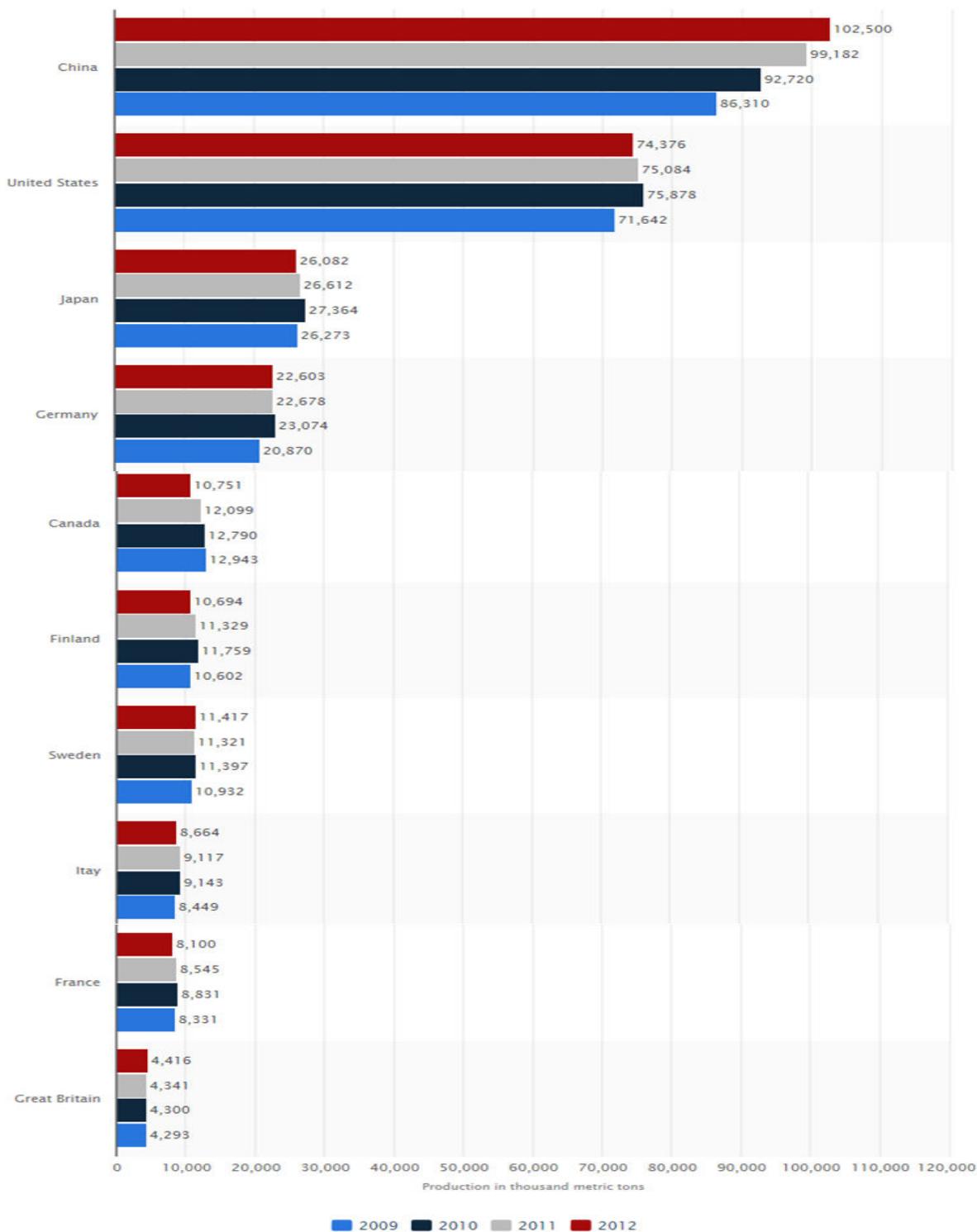
Levels of production of paperboard mills in the United States are at their *lowest point* in more than 30 years, according to the National Paper Trade Association (NPTA) (Hall 2014).⁷ US output of paper and paperboard peaked historically in 1999, having more than doubled since the 1960s. However, affected by the *economic recession*, industry output has not recovered to preceding peak levels. By 2011, US paper and paperboard output was running about 16 percent lower than the peak output of 1999 (Woodall et al. 2011a). Drop in production continue as companies sold assets, downsized operations, and reduced staff numbers in an attempt to reduce operating costs and salvage profitability (Hetemäki, Hänninen, and Moiseyev 2013; Hoopes 2014a).

Offshoring activities among US manufacturing firms to low-cost countries also contribute to the decrease in paperboard production in the United States. Since growth or decline of paperboard production is highly correlated to the consumption of paperboard used for bulk packaging of industrial commodities (Hetemäki, Hänninen, and Moiseyev 2013; Hoopes 2014a; Petrillo 2014b; Woodall et al. 2011a), paperboard production in low-cost countries has grown noticeably as shown in Figure 4. A significant portion of paperboard packaging produced and used in the low-cost countries (notably China) ends up in the United States and Western Europe through US- and European-bound imports of goods manufactured by these low-cost countries (Hetemäki, Hänninen, and Moiseyev 2013).

⁷ Similar trends are also observed in related industries, including pulp mills, paper mills, paperboard container and packaging manufacturing, and treated paper product manufacturing (Hall 2014).



Figure 4 / Production Volume of Paper and Cardboard in the Pulp and Paper Industry in Selected Countries from 2009 to 2012 (in 1,000 metric tons)

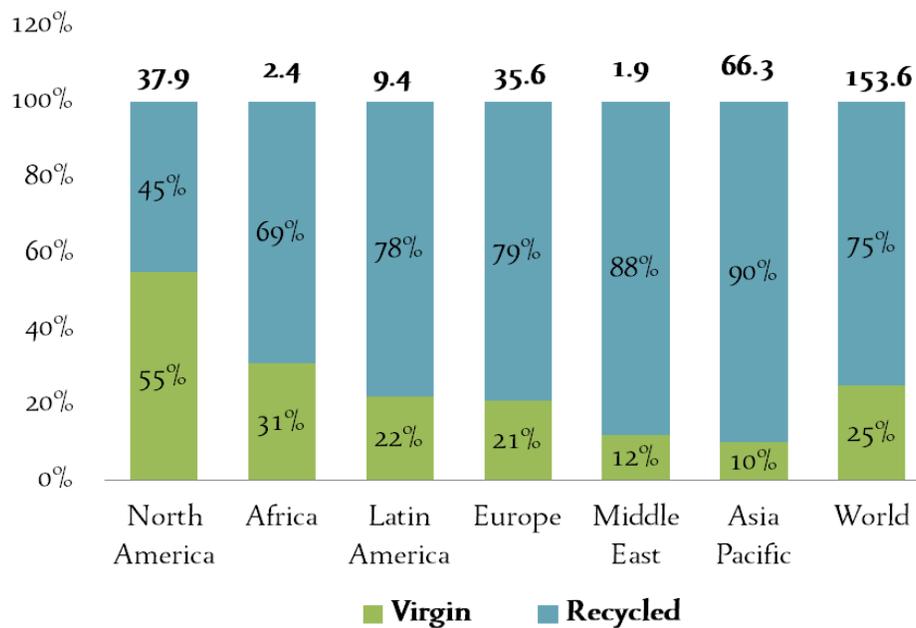


Source: Statista (2015)



With respect to **furnish capacity by fiber type**, virgin paperboard grades' shares of total capacity have declined as a result of increased production of recycled products, especially in products in which the reclaimed pulp does not need to be cleaned (Highbeam Business 2014). Even so, as shown in Figure 5, virgin fiber maintain its dominant share of total furnish capacity in North America, accounting for 55 percent versus 45 percent recycled in 2012. The relatively low production share of recycled fiber is unique to the paperboard industry in North America, as the opposite holds for the rest of the world.

Figure 5 / Global Furnish Capacity by Fiber Type



Source: June Qtr 2012 FisherSolve (Rock-Tenn 2012)

Capacity utilization in the US paperboard industry typically ranges from about 88 percent to 98 percent of total capacity, depending on economic conditions (Highbeam Business 2014). As shown in Figure 6, US containerboard operating rates, including linerboard and corrugating medium, were at 96.1 percent in mid-2012, improving from a low of 70–90 percent during the 2008–2009 economic recessions. Production volume and



operating rate continue to improve in the paper and paperboard industry as a whole. Paper and paperboard mills in the United States ran at their highest average operating rate since the recession at 95.5 percent in September 2014 (0.8 percent higher than September 2013 output) (RISI 2015a).

Figure 6 / US Containerboard Operating Rates



Source: Rock-Tenn (2012)

Revenue

The US paperboard industry revenue is estimated at \$30.3 billion in 2014. As shown in Figure 7, industry revenue was volatile over the 2009–2014 five-year period, albeit it is projected to be relatively more stable in the next few years.

Figure 7 / The US Paperboard Industry Revenue 2006–2020 (projected)

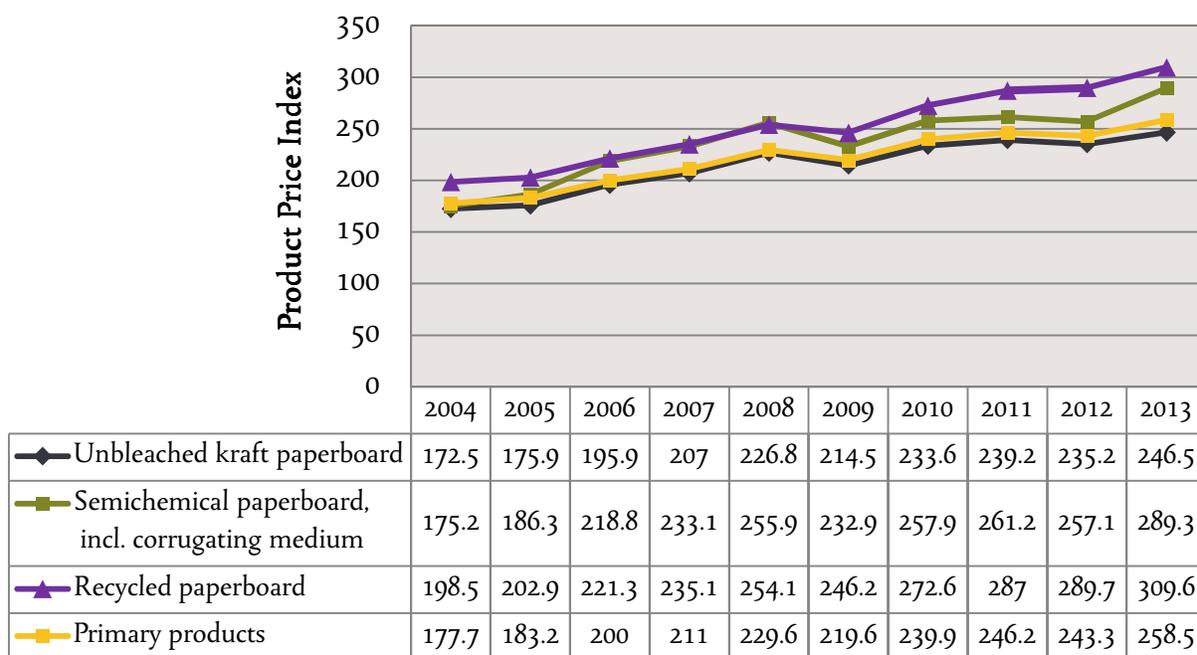


Source: Hoopes (2014a)



Paperboard prices are an important factor affecting industry revenue. Paperboard prices declined 4.7 percent in 2009 due to lower demand during the recession, and then increased 9.1 percent in 2010 as the recession began to rebound (see Figure 8). From 2011 to early 2012, prices peaked and subsequently fell following overcapacity for most pulp, paper, and paperboard commodities. In contrast, the price of *recycled paperboard* rose at an estimated annualized rate of 5.1 percent over the 2009–2014 five-year period, which is significantly faster than the price of the average paperboard industry primary product of 3.6 percent. As a result, recycled paperboard sales have increased as a percentage of industry total revenue, reaching an estimated 31.2 percent in 2014 (Hoopes 2014a).

Figure 8 / Producer Price Index: Paperboard Mill Industry



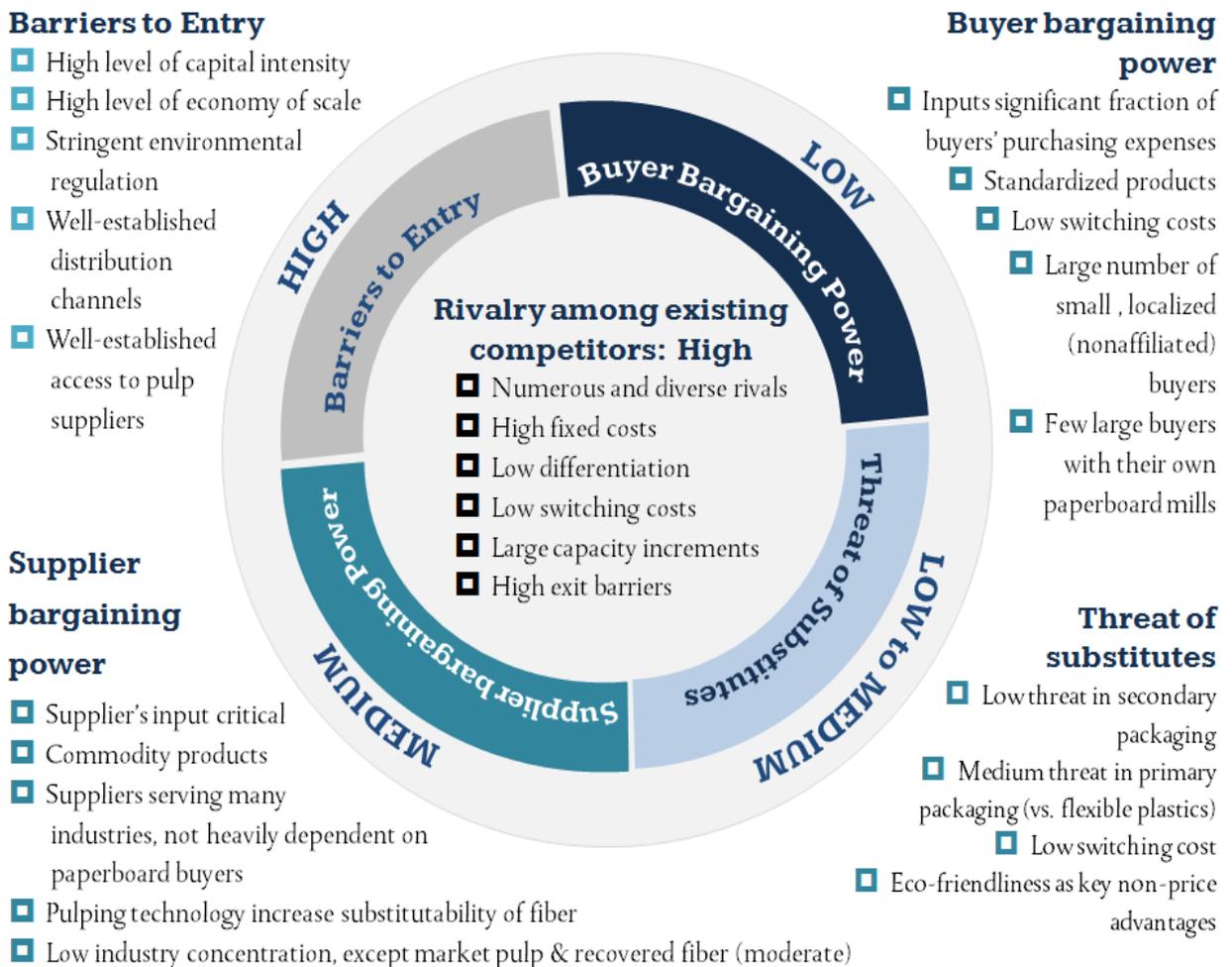
Source: Bureau of Labor Statistics (2014)



THE FIVE COMPETITIVE FORCES IN THE PAPERBOARD INDUSTRY

Figure 9 depicts the five forces that shape competition in the US paperboard industry, including: (1) Threat of entry, (2) The power of suppliers, (3) The power of buyers, (4) The threat of substitutes, and (5) Rivalry among existing competitors.

Figure 9 / The Porter’s Five Forces Analysis of the US Paperboard Industry



Source: Authors



Threat of Entry

New entrants to an industry bring new capacity and a desire to gain market share that puts pressure on prices, costs, and the rate of investment necessary to compete.

Particularly when new entrants are diversifying from other markets, they can leverage existing capabilities and cash flows to shake up competition (Porter 2008). The threat of entry in an industry depends on the level of entry barriers that are present. The paperboard mill industry has *high barriers to entry* because of the following conditions of the industry.

- ❑ **High level of capital intensity and economy of scale.** Today's paperboard production takes place in facilities characterized by high capital intensity, high production volumes, and the application of the latest techniques of materials handling, continuous production, and process control (Hoopes 2014a; Iggesund Paperboard 2014; Transparency Market Research 2014a). The reliance on capital has increased significantly over the past few years, with approximately 88.6 percent of the total capital in 2014 spent on new machinery and equipment that results in more efficient, more labor-productive, and less labor-intensive operations (Hoopes 2014a).
- ❑ **Stringent environmental regulation.** Regulation imposed on the paperboard industry is mainly pertinent to the industry's environmental effect on natural resources.⁸ The barriers created by the stringent environmental protection guidelines imposed by federal and state governments and monitored by the Environmental Protection Agency are twofold. First, adhering to these strict regulations can significantly delay the process of entering the industry and increase the cost of starting a business. Second, the industry faces high ongoing

⁸ **Environmental regulatory focuses** differ somewhat in related industries. The major regulation with respect to production of converted paperboard products is noise pollution, while pulp-making regulation is dominated by effluent, or wastewater emissions and treatment (Hoopes 2014a).



costs of operations that adhere to the strict regulations. Moreover, regulations relating to the extraction of wood from native forests limit the available supply of virgin wood fiber. Meanwhile, competition for recycled fiber grows, and technological advancements in alternative non-wood fibers have not yet become financially viable on a large scale (Hoopes 2014a).

- **Well-established access to distribution channels.** Most existing firms in the paperboard industry sell directly to the major buyers, cardboard box manufacturers, with well-established contracts and long-standing relationships. In contrast, uses of wholesale channels, as opposed to direct sales, have been declining. The product's intermediate nature further accentuates the trend of wholesale bypass because the marketing and advertising typically done by wholesalers is not required. These characteristics make it difficult for new entrants to encroach into customer markets unless they can demonstrate significant cost savings to potential customers (Hoopes 2014a).
- **Well-established access to pulp suppliers and/or own pulp production or forestry operations.** Competing for access to low-priced wood pulp can be very difficult for new entrants because major paperboard companies either: (1) have established long-term supply contracts with pulp manufacturers, (2) have their own pulp production capability through vertical integration, or (3) have purchased timberland properties and established forestry operations to plant, grow, and harvest timber for their operations (Hoopes 2014a).

Threat of entry from large paper manufacturing companies. Considering the size of operations, and the already well-established distribution channel and access to suppliers for large players, competitive new entrants are likely to be large companies that already operate in similar industries, notably those with economies of scale, vertical integration, and diversified portfolios across other paper manufacturing industries



(Hoopes 2014a; Petrillo 2014a). Note that it is the threat of entry, not whether entry actually occurs, that holds down profitability (Porter 2008).

Overall, potential threat of entrants from paper mills is assessed to be **low**, coming mainly from large paper makers with operating flexibility and diversified portfolios that allow them to place more emphasis on the growing corrugated cardboard and paperboard markets. The number of potential large entrants is few, given that the majority of the US paper mill industry's 147 operators are medium-sized companies with less than 1 percent market share each (Petrillo 2014a). In addition, paper companies tend to *specialize by end-use industry* (e.g. publishing, home or office paper products, or packaging), thus limiting threat of entrants to those specialized in packaging grades. Moreover, many companies are shifting focus to sell larger percentages of *higher-margin products of their specialties*, such as premium papers relative to commodity items (Hoover's 2014a) rather than shifting or expanding to other end-use industries. Table 3 highlights major paper makers in the United States, their businesses, and threat assessment.

Trends to Watch: Strategic Changes in the Paper Industry

The following trends are driving strategic changes in the paper industry, including *more emphasis on paperboard product lines*⁹ (Petrillo 2014b).

⁹ The shift of emphasis towards paperboard product lines is one of strategic changes in the paper industry. **Outside paperboard markets**, the paper industry have been shifting their focus from manufacturing traditional paper products (e.g. envelopes, business forms, and application forms) to developing differentiated and innovative products (Niemelä-Nyrhinen and Uusitalo 2013). In particular, there has been a steady increase in demand for *high-quality imaging paper* and *technology-supporting products* (e.g. clay coated printing and converting papers) as driven by the growing popularity and wider use of jet printers (Petrillo 2014a).



Table 3 / Major Paper Companies in the United States

Companies	Business Profile	Threat Assessment
<p>Domtar Corporation (2014 market share: 8.6 percent)</p>	<p>Domtar is the largest integrated manufacturer and marketer of uncoated freesheet paper products in the United States. Today, Domtar’s operations mainly center in South Carolina. The company operates through three business segments: pulp and paper, distribution, and personal care. The company generates the majority of its revenue through its pulp and papers segment (90% of its revenue). Paper products include: business and office papers, commercial printing papers, digital printing papers, publishing papers, converting papers, speciality papers, EarthChoice® papers, and Xerox papers and media.</p>	<p>Low: Key paper products are in commercial printing markets.</p>
<p>NewPage Corporation (2014 market share: 6.3 percent)</p>	<p>NewPage is the largest coated paper manufacturer in North America, producing 2.9 million short tons of coated paper annually. The company specializes in coated freesheet paper for high-end applications (e.g. corporate annual reports, and magazine covers). The company also produces a substantial amount of coated groundwood paper for use in magazines, textbooks, and catalogs. Other products include: digital paper, speciality papers (e.g. flexible packaging, label and image printing, multipurpose), book papers, super-calendered papers, uncoated papers, and certified recycled products.</p>	<p>Low: Specialties are in commercial printing markets.</p>



Companies	Business Profile	Threat Assessment
<p>International Paper Company (2014 market share: 5.4%)</p>	<p>International Paper participates in the paper industry through its printing papers segment. US operations in this division are estimated to make up 37.4 percent of the company's revenue in 2014. The printing papers division manufactures Bristol board, envelope papers, information papers, and white copy papers for use in home and office printing, commercial printing, publishing and industrial purposes.</p>	<p>Already a major player in the paperboard industry through its industrial packaging business segment</p>
<p>Verso Paper Corp. (2014 market share: 3.1%)</p>	<p>Verso Paper is a leading producer of coated papers for use in catalog and magazine publishing. Other paper products include: uncoated printing papers, and speciality papers (e.g. flexible packaging, cut and stack labels, and pharmaceutical insert). Additionally, the company manufactures market kraft pulp. Verso paper conducts operations through eight paper machines at three mills, with a combined capacity of 1.3 million tons of coated and super-calendered paper, 160,000 tons of speciality papers, and 930,000 tons of kraft pulp.</p>	<p>Low: Specialties are in commercial printing markets.</p>
<p>Boise Inc. (2014 market share: 2.9%)</p>	<p>Boise is a division of Packaging Corporation of America (PCA). Boise manufactures office papers, pressure sensitive papers, printing and converting papers, and pulp. The company operates largely in the United States, with 5,300 employees. Boise Inc. benefits from its long-term supply agreement with OfficeMax.</p>	<p>Moderate: While key products are in office papers and printing markets, its parent company, PCA, is a major packaging manufacturer, with speciality expertise in corrugated products.</p>



Companies	Business Profile	Threat Assessment
Resolute Forest Products (2014 market share: 2.9%)	Resolute Forest Products is headquartered in Montreal, Quebec, and is the third-largest publicly-traded paper and forest products company in North America. The company produces newsprint and a range of coated and speciality papers, market pulp, and wood products. The company has shifted its customer base, with about half of its newsprint now shipped to India and other countries in Asia and South America where demand for newspapers is growing.	Low: Key products are in commercial printing and newsprint markets.

Source: Boise Inc. (2014); Domtar Corporation (2014); International Paper Company (2014); NewPage Corporation (2014); Packaging Corporation of America (2014a); Petrillo (2014a); Verso Paper Corp. (2014)



- **Digital replacements for printed materials.** Demand for paper in the United States is in the midst of a long-term decline due to digital replacements for printed materials. Printing and writing papers represent the largest single product for the paper industry that has played a major role in providing paper mills with a steady stream of revenue. This segment mainly consists of uncoated freesheet or wood-free papers, which contain less than 10 percent mechanical pulp. However, the increasing popularity of digital media and communication, particularly in mature markets such as Europe and North America, has weakened demand in these downstream industries and along with it demand for paper inputs (Petrillo 2014a, 2014b). Growing substitution for electronic communication media will further diminish paper consumption in the United States, resulting in long-term decline across many of the paper industry's product lines (Petrillo 2014a). Examples are magazines and company annual reports affecting *coated mechanical and wood-free paper*, business and office forms affecting *uncoated wood-free paper*, and home-delivered advertisements affecting *uncoated mechanical paper* (Hetemäki, Hänninen, and Moiseyev 2013).
- **Increased competition from paper imports.** Competition from paper imports has intensified over the past decade with the rapid development of paper industries in developing countries, especially China, Indonesia, and Mexico (Petrillo 2014a). In fact, the United States is no longer the world's largest producer of paper, having been overtaken by Chinese manufacturers in 2009. The paper industries in developing countries have significantly improved the *quality* of products, increasing the level of competition from *high-value paper product imports* in the United States. They also have *cost advantages* on the global market. For instance, China engages in currency manipulation, employs predatory pricing strategies, and has very lax government oversight of timber manufacturing industries. These tactics have prompted the United States to initiate anti-



dumping protection against coated paper imports in 2010.¹⁰ Nevertheless, while the countervailing duties on coated paper from China and Indonesia—which are to remain in place until at least 2015—have help to reduce the level of import penetration from these countries in recent years, other varieties of paper remain free of tariffs. Thus, the pressure from intensified import competition on US paper mills is expected to continue and likely to increase as the paper industry in developing countries continue to evolve (Petrillo 2014a).

- **Growing online commerce and demand for shipping containers.** In contrast to the adverse effects on printing and writing paper, the shifts toward digital media and online advertising materialize along with growing e-commerce that, in turn, boost the overall demand for corrugated cardboard and paperboard products (Hoover’s 2014c; Petrillo 2014b). According to the latest report issued by Smithers Pira, *The Future of Packaging in North America to 2017*, paperboard and corrugated packaging markets are expected to grow from \$169.1 billion to \$186 billion by 2017 (Western Container 2013). Thus, the fast growing e-commerce presents a positive opportunity for the paper industry to expand the production of paperboard product line to serve these downstream packaging markets (Woodall et al. 2011b).

¹⁰ **The anti-dumping initiation** prevents industry operators from selling paper outputs at a cheaper price in foreign markets than they would normally charge in the domestic market. In October 2010, prompted by this initiation, the US International Trade Commission approved **punitive duties** on Chinese and Indonesian exports of *speciality paper* to the United States. The ruling set in place margins of up to 135.83 percent against Chinese coated paper products and 20.13 percent for Indonesian exports to the United States (Petrillo 2014a).



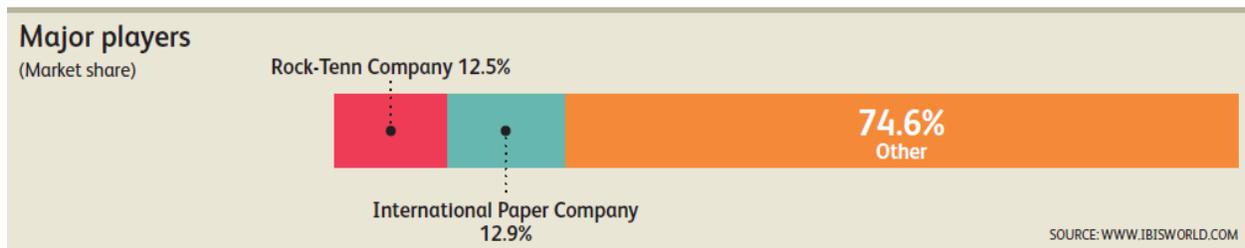
Rivalry among Existing Competitors

Companies in the paperboard industry compete against other integrated and independent paperboard companies that manufacture various grades of paperboard (pulp, and/or converted paperboard products, in cases of integrated mills). To a limited extent, US paperboard companies also compete against manufacturers outside of the United States.

Market Share Concentration and Key Players

Low, but increasing, market share concentration. As shown in Figure 10, market share concentration within the US paperboard industry is low, with the top four players accounting for an estimated 30 percent of total industry revenue in 2014 (vs. 25% in 2009). However, the level of concentration has increased in recent years due primarily to facility closures, capacity changes, cost-cutting measures, and increased acquisition activities. These activities are projected to continue as companies focus on keeping costs low, suggesting that increases in market share concentration maintains in the foreseeable future (Hoopes 2014a).

Figure 10 / Market Share Concentrations in the US Paperboard Mill Industry



Source: Hoopes (2014a)

Note: Chicago-based Smurfit-Stone Container Corporation filed for Chapter 11 bankruptcy in early 2009 (Highbeam Business 2014; Hoopes 2014a).



Because large paper mills produce large quantities of both paper and paperboard, many key competitors in the paperboard industry are also listed under the paper mill industry. However, some large companies have much larger interests in paperboard than other companies in the industry (Highbeam Business 2014). Table 4 provides highlights of key players' business profiles and participations in the paperboard industry.

Intensity of Rivalry

High level of competition. Competition within the US paperboard industry is *high* because of the low market share concentration in the industry in which a significant number of manufacturers operate with little market power. High rivalry limits the profitability of an industry. The US paperboard mills industry has relatively *low profit margins*, similar to other paper and paper product industries in the United States (Hoopes 2014a).

Competitive advantages of large vertically integrated players. However, few, larger operators profiled earlier, with economies of scale and multiple locations, tend to have higher profit margins than the average industry operator. All of the major players in the US paperboard industry are vertically integrated. They manufacture and recycle raw materials required for paperboard production, and convert the paperboard products to boxes and containers themselves. In times of good economic conditions, they have more capital to expand production as demand increases; while in times of poor economic conditions, they have the power to purchase other operators in order to expand operations and increase market share. This flexibility gives large paperboard mills significant advantages over their smaller competitors (Hoopes 2014a, 2014b).



Table 4 / Key Players' Profiles and Paperboard Businesses

Key Players	Company Profiles	The Paperboard Markets
<p>International Paper Company (2014 market share: 12.9%)</p>	<p>Locations. Headquartered in Memphis, TN, International Paper (IP) is the largest forest products company in the world, and the largest manufacturer of containerboard in the United States. IP operates in primary markets and manufacturing industries in North America, Europe, Latin America, Russia, Asia, and North Africa.</p> <p>Products and services. IP's products include containerboard, corrugated packaging products, uncoated freesheet (or wood-free) papers, coated paperboard, and fluff pulp. IP also owns a large merchant distribution business that sells products made by IP and other companies making paper, paperboard, packaging, graphic arts supplies, and maintenance and industrial products. Sales offices are located throughout the United States as well as internationally.</p> <p>Facilities. <i>Worldwide</i>, the IP has 39 pulp, paper and packaging mills, 252 converting and packaging plants, 20 recycling plants,</p>	<p>Business segment. IP participate in the paperboard markets through its <i>industrial packaging</i> business which accounted for 48 percent of total revenue in 2013, 84 percent of which are in North American markets.</p> <p>Paperboard products. IP products include linerboard, medium, whitetop, recycled linerboard, recycled medium, and saturating kraft.</p> <p>Paperboard production. Its production capacity is about 13 million tons annually. Additionally, IP recycle approximately 1 million tons of OCC, and mixed and white paper through its recycling plants, making it one of North America's largest recyclers of recovered office paper and corrugated boxes.</p> <p>Paperboard sales and marketing. About 80 percent of its production is converted domestically into corrugated boxes and other packaging by its 172 US container plants. IP sells paper, packaging products, and other products directly to end users and converters, principally through over 81 distribution branches in the United States, and to a smaller extend through agents, resellers, and paper distributors.</p>



Key Players	Company Profiles	The Paperboard Markets
<p>International Paper Company (<i>continued</i>)</p>	<p>and 3 bag facilities. The majority of these production facilities are in the United States. As of December 31, 2013, IP operates 25 pulp, paper, and packaging mills (with annual dried pulp capacity of about 1.7 million tons), 181 converting and packaging plants, 18 recycling plants, and 3 bag manufacturing facilities in <i>the United States</i>. These US facilities represent 61 percent of its pulp, paper, and packaging mills, 71.5 percent of its converting and packaging plants, and 90 percent of its recycling plants and all of its bag facilities.</p>	
<p>Rock-Tenn Company (2014 market share: 12.5%)</p>	<p>Rock-Tenn is a leading manufacturer of paperboard, containerboard, consumer and corrugated packaging, and merchandising displays. The company is headquartered in Norcross, GA, and has 213 facilities located throughout Argentina, Canada, Chile, China, Mexico, Puerto Rico, and the United States.</p>	<p>Business segments. Rock-Tenn operates through three segments: consumer packaging, corrugated packaging, and recycling.</p> <p>Paperboard products. Consumer packaging produces 100 percent coated recycled paperboard, solid-bleached paperboard, and folding cartons. The corrugated packaging segment manufactures containerboard and boxes.</p> <p>Paperboard production. Rock-Tenn's containerboard mills and corrugated container</p>

Key Players	Company Profiles	The Paperboard Markets
<p>Rock-Tenn Company <i>(continued)</i></p>		<p>operations are integrated, with the majority of its containerboard production used <i>internally</i> by its corrugated container operations. Rock-Tenn also operates 24 recycling facilities that collect and grade recovered paper for use in its paperboard mills or for sales to third-party fiber brokers. The recycling operations procure recovered paper from factories, warehouses, commercial printers, office complexes, grocery and retail stores, document storage facilities, paper converters, and other wastepaper collectors. Thus, a wide variety of grades of recovered paper is collected, including old corrugated containers, office paper, box clippings, and newspaper and print shop scraps. As of 2011, its total paperboard capacity was 9.4 million tons, with fiber mix of 55 percent virgin and 45 percent recycled.</p> <p>Paperboard sales and marketing. During fiscal 2013, Rock-Tenn sold approximately half of its coated recycled paperboard mills' production and bleached paperboard production to <i>internal customers</i>, primarily to manufacture folding cartons. It also sold approximately two-thirds of its containerboard production, including trade swaps and buy/sell</p>

Key Players	Company Profiles	The Paperboard Markets
		<p>transactions, to <i>internal customers</i> to manufacture corrugated products. Sales of converted corrugated packaging products to <i>external customers</i> accounted for 68.6 percent, 65.7 percent, and 49.7 percent of net sales in fiscal 2013, 2012, and 2011, respectively. Rock-Tenn markets its products primarily through its own sales force, but also markets a number of its products through independent sales representatives, independent distributors, or both.</p>
<p>Georgia-Pacific (2014 market share: 3.3%)</p>	<p>Locations. Atlanta-based Georgia-Pacific Corporation (GP) is one of the nation’s leading corrugated box manufacturers. Bought by Koch Industries Inc. in January 2006, GP continues to do business worldwide under the Georgia-Pacific name and operates its businesses from its Atlanta headquarters as an independently managed company.</p> <p>Products and services. GP manufactures market pulp, paper, tissue, building products, cellulose and related chemicals, containerboard, and many speciality packaging products, including double- and triple-wall boxes, bulk bins,</p>	<p>Business segments. GP operates in the paperboard industry through its packaging segment.</p> <p>Paperboard products. Paperboard varieties include bleached board, containerboard, and corrugated board.</p> <p>Paperboard production. Its annual capacity is over 600,000 tons of bleached paperboard.</p>

Key Players	Company Profiles	The Paperboard Markets
<p>Georgia-Pacific (continued)</p>	<p>water-resistant packaging, and high-finish and preprinted packaging for point-of-sale displays. GP specializes in produce, poultry, and bulk containers.</p> <p>Facilities. GP has more than 80 facilities in the United States and Canada.</p>	
<p>MeadWestvaco Corporation (2014 market share: 1.7%)</p>	<p>Locations. MeadWestvaco (MWV) is headquartered in Richmond, VA, with operations in 30 countries throughout North America, South America, Europe, and Asia. About 66 percent of its total revenue in 2013 was in US markets.</p> <p>Products and services. MWV is a global producer of packaging, consumer and office products, and speciality chemicals.</p> <p>Facilities. The company has 63 production facilities worldwide.</p>	<p>Business segments. MWV participates in the paperboard industry through its packaging business which accounted for 82 percent of total sales in 2013 (the rest were from specialty chemical business). The company's revenue from its US paperboard production is estimated to increase at an annualized rate of 4 percent during 2009–2014 to reach \$524.4 million.</p> <p>Paperboard production. Its Mahrt facility, AL, produces 1.1 million tons of coated paperboard; Evadale facility, TX, produces 700,000 tons of SBS paperboard; and the Covington facility, VA, produces 936,000 tons of paperboard for distribution to customers around the globe.</p>



Key Players	Company Profiles	The Paperboard Markets
<p>MeadWestvaco Corporation (continued)</p>		<p>Supply initiative. MWV had initiated a <i>Eucalyptus Leasing and Management Program</i> to provide a reliable, cost effective source of <i>hardwood fiber</i> for MWV’s Evadale Texas Paperboard Mill. Approximately 9,000 acres of eucalyptus plantations have already been established (with variable lease lengths, typically 9–10 years), and are managed on a short rotation (about 5 years).</p>
<p>Packaging Corporation of America (no market share data)</p>	<p>Locations. Based in Lake Forest, Illinois, PCA is the fourth largest producer of containerboard in the United States based on production capacity at the end of 2013. PCA operates primarily in the United States, but have some converting operations in Europe, Mexico, and Canada.</p> <p>Facilities. PCA has over 120 facilities across the United States, including 5 containerboard mills, 1 containerboard machine at Wallula, Washington, white paper mill, and 100 manufacturing locations. Its Counce, Tennessee, mill is a kraft linerboard mill; DeRidder, Louisiana, mill both linerboard and newsprint; Valdosta,</p>	<p>Business segments. PCA participates in the paperboard industry through its packaging business.</p> <p>Paperboard production. PCA operates six containerboard mills in the United States—Counce, Tennessee; DeRidder, Louisiana; Filer City, Michigan; Tomahawk, Wisconsin; Valdosta, Georgia; and Wallula, Washington.</p> <p>Paperboard sales and marketing. During 2013, PCA produced about 2.7 million tons of containerboard for PCA’s own converting facilities as well as for numerous domestic and international customers. Containerboard sales group is responsible for the coordination of linerboard and corrugating medium sales to its corrugated plants, to other domestic customers, and to export customers.</p>

Key Players	Company Profiles	The Paperboard Markets
Packaging Corporation of America (<i>continued</i>)	Georgia, mill a kraft linerboard mill; Tomahawk, Wisconsin, mill a semi-chemical corrugating medium mills; Filer City, Michigan, mill a semi-chemical corrugating medium mill; and Wallula, Washington, mill a white paper mill that also produces corrugating medium on one of its paper machines. The company has no 100 percent recycled mills, or mills that solely use recycled fiber.	Containerboard is shipped by rail or truck. Rail shipments typically represent approximately 60 percent of the tons shipped and the remaining 40 percent is comprised of truck shipments. Supply management. PCA procures wood fiber through leases of cutting rights, long-term supply agreements, and market purchases.

Source: Georgia-Pacific (2014); Highbeam Business (2014); Hoopes (2014a, 2014b); International Paper (2014); MeadWestvaco Corporation (2014a, 2014b); Packaging Corporation of America (2014a, 2014b); Petrillo (2014b); Rock-Tenn (2011, 2014)

Basis of Competition

Competition among US paperboard mills is largely based on **price** and **quality**. Their customers are price sensitive because paperboard is primarily intermediate products that are largely indistinguishable, and are sold in bulk to downstream industries using them as input materials.

Price competition of standard products. Therefore, *price-based competition* is intense among industry players to achieve recurring sales. Accordingly, to keep cost low, much of the efforts in research and technology development in the paperboard industry focus on creating newer machinery and equipment that will produce a wider web of paperboard at higher speeds to improve mill productivity. In addition, mill processes are becoming more automated, less subject to product variation, and less labor intensive (Highbeam Business 2014).

Quality competition of high-end products. Meanwhile, product *quality* is growing in importance as a trend toward more expensive boxes continues to gain popularity and traction in North America. Key products include *retail-ready or shelf-ready* packaging,¹¹ *corrugated retail display stands*,¹² and corrugated types, folding cartons that offer *high-quality graphics and printing* (Hall 2013; I.T. Strategies 2013; Reportlinker 2012). The focuses on quality control and improvement (e.g. durability, shine, graphics

¹¹ **Retail-ready packaging (RRP)** refers to packaging delivered to a retailer in a self-contained unit, which is immediately ready for on-shelf product display without the need for assembling or unpacking. This type of packaging provides an attractive structure that both advertises and displays a product, while cutting down on retail operation costs as the shipping package itself arrives shelf-ready (Western Container 2013).

¹² **Corrugated retail display stands** are becoming more popular. Manufacturers of consumer goods usually pay a premium to supermarkets and other retailers for the in-store floor space used to exhibit the retail display stand and its goods. Corrugated displays are an economical way to temporarily promote specific products in a display intended to highlight that products specific benefits. Due to variations in floor spaces, thus output sizes, these display stands are often made in shorter-run production (I.T. Strategies 2013).



and printings) among US paperboard mill operators reflect these trends (Hoopes 2014a; Western Container 2013).

Threat of substitutes, notably plastic materials, also contributes to the industry focus on quality. Paperboard mills, as suppliers of input materials, have focused on increasing product *durability* and *quality*. Such improvements aim to expand the number of applications with which paperboard uses are appropriate, and make paperboard more applicable for shipping heavy products (Hoopes 2014a). The increasing technological advancements, high strength, and durable rigid paper packaging that have been discovered are enabling accelerated shifts to paper-based packaging from plastic-, metal-, and glass-based rigid packaging materials (Transparency Market Research 2014b).

Research and technological changes. In addition to quality improvement, another prominent area of research and technological changes in the industry has been driven by growing demand for *eco-friendly products and business operations*. Areas of concentrated efforts are resource consumption reduction (e.g. water, energy, and chemicals), increased use of recycled fibers and nonwood materials in pulp and paperboard production (Hoopes 2014a), and alternatives to wax- and polymer-coated technologies. The nonwood portion of paper and paperboard furnish typically varies from 20 percent to 90 percent, and can be even up to 100 percent depending on the paper grade and required quality. Some example uses for nonwood pulps in paperboard making are shown in **Table 5**. In terms of coatings, the current petroleum-based coatings used to provide paperboard moisture-barrier properties and add strength/rigidity are raising concerns regarding recyclability among downstream customers, prompting many leading retailers like Wal-Mart and Costco to demand an eco-friendly alternative from their suppliers of paperboard and corrugated boxes (Rosato 2014). Some of the coating technologies that are explored and/or implemented are biopolymer coatings, water-based coatings, and coatings made from seaweed extracts and starch for application to paper and paperboard in the form of a spray. Given the downstream customer demand and threat of substitutes, the industry focus on



developing new coating technologies that are renewably sourced, readily recyclable, and/or biodegradable will continue (Lifshitz 2014; Rosato 2014).

Table 5 / Example Uses of Nonwood Fibers in Paperboard Making

Nonwood Fiber	Paperboard Products	Furnish	
		Named Nonwood Fiber	Balance of Furnish
Abaca	Linerboard	10–30%	Bagasse or straw pulp
Bagasse	Corrugating medium	60–90%	Wastepaper
	Linerboard	50–80%	Kraft pulp
Bamboo	Linerboard	60–100%	Kraft pulp
Kenaf (bast fiber)	Linerboard	50–100%	Kraft, bagasse, straw or wastepaper pulp
Kenaf (whole stalk)	Corrugating medium	50–100%	Wastepaper
	Linerboard	40–50%	Kraft & wastepaper pulp
Phragmites communis reeds	Corrugating medium	60–90%	Wastepaper
	Linerboard	50–70%	Kraft pulp
Straw (cereal & rice)	Corrugating medium	60–90%	Wastepaper

Source: Hurter (2001)

The Power of Suppliers

A paperboard mill depends on a wide range of different supplier groups for inputs. In this report, the analysis focuses on suppliers of key direct inputs, namely fibrous materials. Paperboard is made from fibrous materials that comes mainly from two sources—*virgin sources*, mainly wood pulp, and *recycled paper products* such as old corrugated containers (OCC) (EPA 2013; Hoopes 2014a)—with *nonwood fiber* (e.g. pulp made from different grass species and agricultural residues) used in a smaller extent (Bajpai 2012; Hoover’s 2014a; Iggesund Paperboard 2014; Singh et al. 2013).

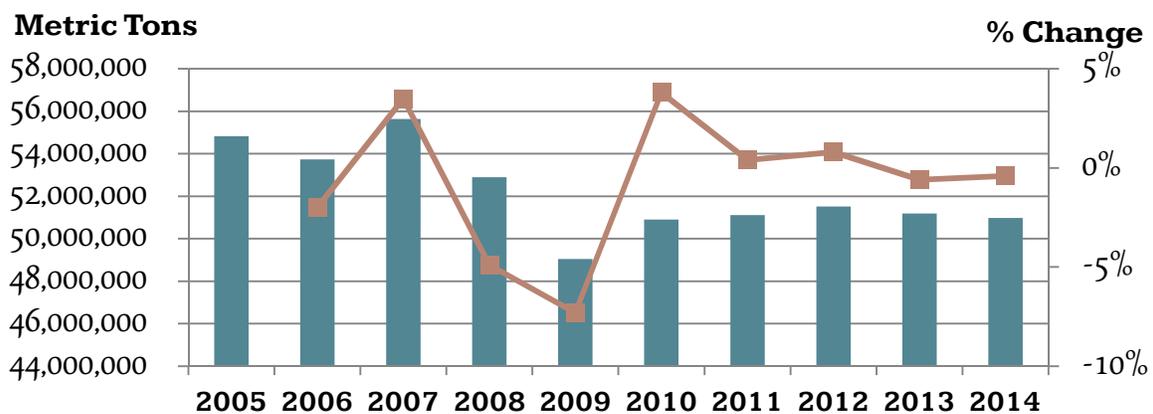


Integrated paperboard mills manufacture paperboard using pulp they produce through their own separate pulp mill business, while *independent paperboard mills* purchase pulp from external parties such as pulp mills, and other paper or paperboard mills with pulp operations (Petrillo 2014b). Accordingly, paperboard companies, depending on whether they buy or make pulp, rely on four supplier groups for inputs: (1) market pulp suppliers, (2) wood fiber suppliers, (3) recovered fiber suppliers, and (4) non-wood fiber suppliers. Each of these supplier groups is discussed in more details in the subsequent sections.

Market Pulp Suppliers

Globally, wood fiber makes up 90 percent of pulp production, with the remaining 10 percent composed of bagasse, linters, straw, bamboo, kenaf, cotton, flax, recycled paper and others. US domestic wood pulp mills typically manufacture northern and southern bleached softwood kraft, which is suitable for fluff pulp used in hygienic products manufacturing. By contrast, Europe and Asia produce northern bleached hardwood kraft, while Brazil and Australia produce bleached eucalyptus kraft (McKenna 2014). Wood pulp production in the United States shows a general downward trend in the past five years as depicted in Figure 11.

Figure 11 / US Wood Pulp Production 2005–2014

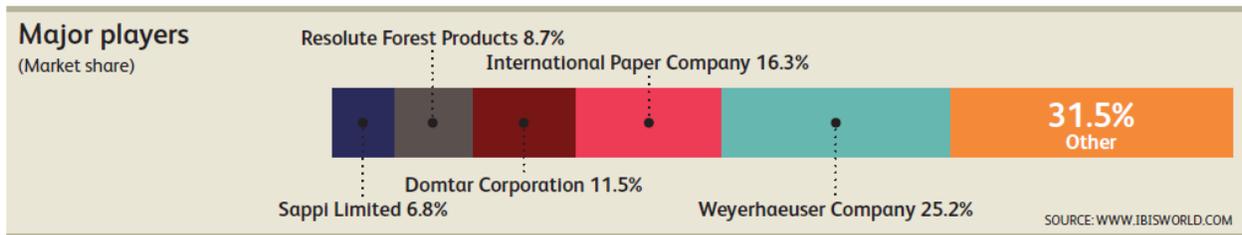


Source: McKenna (2014)



Medium concentration with moderately large firms. As of 2014, US wood pulp mills industry is estimated to have a medium level of market share concentration, with the four largest firms accounting for slightly over 60 percent of industry revenue (see Figure 12).

Figure 12 / Major Wood Pulp Manufacturing Firms in the United States



Source: McKenna (2014)

In general, the US wood pulp industry is characterized by *moderately large firms*, with 40 percent of enterprises having 500 or more employees (see Figure 13) (McKenna 2014). The US Southern and the Northwest states are two major pulp-producing regions of the country. Pulp mills tend to *specialize by type of pulp*, and tend to use an *in-house sales force* in the United States. They may have sales offices in Europe and Asia, in addition to agents and brokers (Hoover's 2014a).

Figure 13 / US Wood Pulp Mills by Employment Size

Enterprises by employment size*	Share (%)
Employees	
0 to 4	16.7
5 to 9	3.3
10 to 19	6.7
20 to 99	23.3
100 to 499	10.0
500 or more	40.0

*Latest available data
SOURCE: US CENSUS BUREAU COUNTY BUSINESS PATTERNS

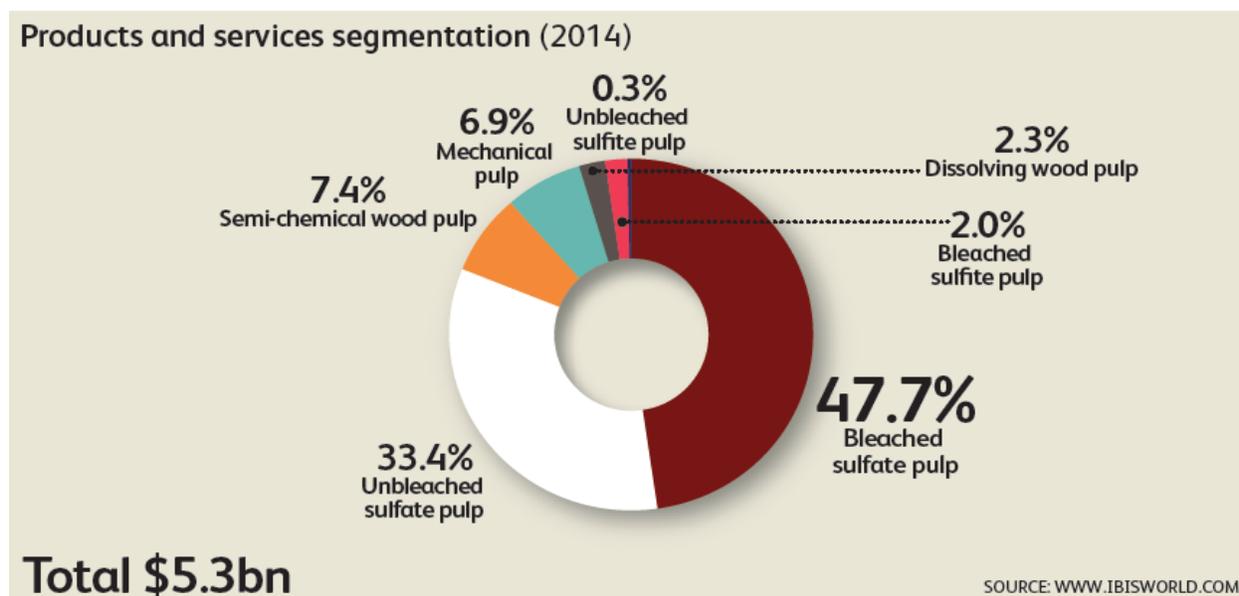
Source: McKenna (2014)

Market pulp types. Market pulps are typically classified by a combination of factors, including: (1) original wood species or raw materials (e.g. softwood, hardwood, and recovered fiber), (2) production process used (e.g. chemical, semichemical, thermal, mechanical, and deinked), and (3) bleach condition (e.g. bleached, semibleached, and



unbleached (JK Paper 2014).¹³ Figure 14 shows shares of the US wood pulp industry revenue by different pulp market segments. As traditional markets for paper face long-term decline as a result of digital media and communication, a notable trend is a gradual shift within market pulp sectors toward *fluff pulp* (used in absorbent products like diaper) and *dissolving pulp* (largely used in textile products) (Nordström and O’Kelly 2013).

Figure 14 / US Wood Pulp Mill Product Segments 2014



Source: McKenna (2014)

¹³ Examples of pulp grades are the followings (JK Paper 2014):

- Bleached Kraft (or sulphate) Pulp (BKP) particularly used for graphic papers, tissue, carton board, wrappings, sack and bag papers, envelopes and other unbleached speciality papers.
- Chemo-Thermo-Mechanical Pulp (CTMP) used in printing and writing grades
- Deinked Pulp (DIP) made from recycled fiber
- Groundwood Pulps (GWP) or Stone Groundwood Pulp (SGWP) used mainly in newsprint and wood-containing papers, like lightweight coated and super-calendered papers
- Northern Bleached Hardwood Kraft Pulp (NBHKP)
- Northern Bleached Softwood Kraft Pulp (NBSKP)
- Semi-chemical Pulp (SCP) suited to tissue manufacture
- Southern Bleached Hardwood Kraft Pulp (SBHKP)
- Southern Bleached Softwood Kraft Pulp (SBSKP)
- Thermo-Mechanical Pulp (TMP) mainly same end-uses as stone groundwood pulp



Business transactions. Market pulp is either sold by integrated mills that have an excess capacity or by independent pulp mills. And vice versa, that is, purchasers of market pulp are independent paperboard mills, or integrated mills that do not have enough capacity or do not produce a certain pulp grade (Carlsson et al. 2009). The United States is also a *significant exporter of pulp* because it offers varieties of wood pulp that may not be produced elsewhere in the world. Vice versa, US wood pulp mills also compete with imports because many types of wood pulp are not produced in the United States. Canada is the primary source of imports due to its geographic proximity and strong forestry sector (McKenna 2014).

Most pulp is transacted between long-standing suppliers and buyers who have a written contract (e.g. *fixed-term* and *evergreen*¹⁴), or have an ongoing unwritten relationship that involves regular transactions over time. In a *contract transaction*, buyers and sellers must agree to a price each month and then apply a discount that has been agreed on up front. These discounts are about 18–25 percent in North America during 2013–2014. However, contract discounts are smaller in some cases, especially for buyers of small volumes, or buyers who are locked into multi-year contracts with lower prevailing specified discount rates. In the circumstance when pulp producers have excess inventory and buyers have exceptional needs for pulp which cannot be satisfied from their usual suppliers, the buyers and sellers in these cases may agree to a transaction of *individual one-time lots* at a *spot price* with no further discounts, allowances, or performance rebates (RISI 2013, 2014, 2015b).

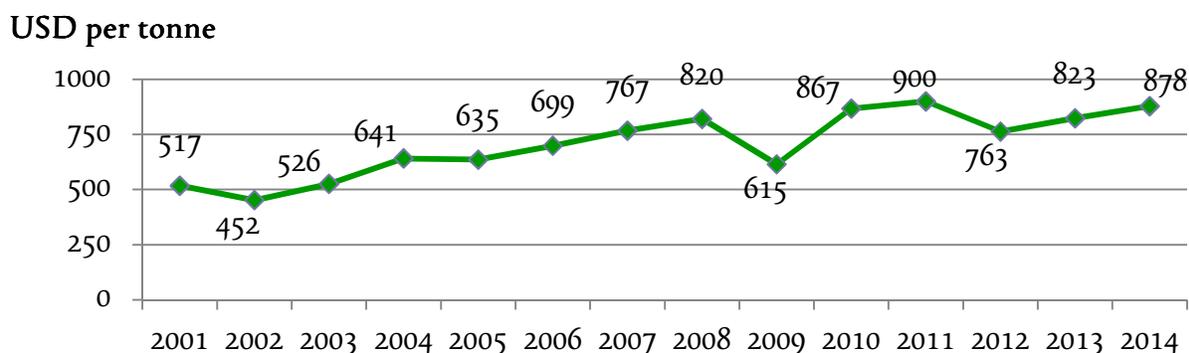
Market pulp prices. Revenue of the wood pulp industry in the United States has been volatile over the past five years due to unstable wood pulp prices. The price of wood pulp is estimated to increase on average 7.2 percent per year during 2009–2014, however, year-on-year growth has fluctuated (McKenna 2014). As shown in Figure 15, after falling 25 percent in 2009 due to a significant drop in demand during the global

¹⁴ **Evergreen contracts** are agreement between two parties that is automatically renewed (rolled over) after each completion, or maturity period, until canceled by the either party.



economic recession, the world price of wood pulp rebounded 41 percent in 2010, partly due to supply shortages following the earthquake in Chile, one of the world's largest suppliers of wood pulp (Petrillo 2014b). Monthly prices of wood pulp delivered to the United States in recent years are shown in Figure 16.

Figure 15 / World Price of Wood Pulp



Source: Global Economic Monitor (GEM) Commodities (World Bank 2014)

Note: Sweden wood pulp prices c.i.f. North Sea ports for softwood, sulphate, bleached, air-dry weight. Price in 2014 shows January–August average prices.

Figure 16 / Monthly Wood Pulp Prices Delivered to the United States

Market Pulp Price Summary
US Dollars per Tonne

	Dec 2012	Jan 2013	Feb 2013	Mar 2013	Apr 2013	May 2013	Jun 2013	Jul 2013	Aug 2013	Sep 2013	Oct 2013	Nov 2013	Dec 2013	Jan 2014
DELIVERED TO UNITED STATES – EFFECTIVE LIST PRICES FOR CONTRACT TRANSACTIONS														
Northern														
Bl. Softwood Kraft	870	890	900	900	930	930	950	950	945	945	970	990	990	1,010
Bl. Hardwood Kraft**	755	770	785	820	835	850	875	875	875	870	860	860	860	870
Maple ***	765	780	795	830	—	—	—	—	—	—	—	—	—	—
Mixed	755	770	785	820	835	850	875	875	875	870	860	860	860	870
Aspen	755	770	785	820	835	850	875	875	875	870	860	860	860	870
Southern														
Bl. Softwood Kraft	830	850	860	860	890	890	910	910	905	905	930	950	950	970
Bl. Hardwood Kraft	745	760	785	815	835	850	875	875	875	870	860	860	860	870
Bl. Kraft Fluff (Untreated)	920	920	920	920	920	940	940	940	940	940	960	960	960	960
Bl. Eucalyptus Kraft	830	840	850	870	870	890	895	895	880	870	860	860	860	870
Bl. Softwood CTMP	735	755	765	765	795	815	835	835	830	830	855	875	875	895
Deinked Pulp	730	730	730	745	755	755	755	755	755	765	770	770	770	775

** Reflects wet lap pulp prices as well as dried; not an average of the maple, mixed, and aspen prices.

*** Price index discontinued as of April 2013 due to declining market size

Source: RISI World Pulp Monthly (2014)

Note: (1) The effective list price for contract transactions is the price on which buyers and sellers agree to be the baseline price before pre-agreed discounts or performance rebates. (2) Prices shown



include transactions between *unaffiliated* parties, expressed per air-dried metric tons (ADMT) for pulp delivered to the customer’s receiving dock (within a standard delivery zone). (3) Northern Bleached Softwood Kraft Pulp (NBSKP) is the industry’s benchmark grade of pulp. (4) Market pulps are usually dried to reduce freight costs, although some may be *wet lap* (50% water).

Pulp processing technology. Typical pulp-making process began by debarking timber logs, followed by separation or defibration process, commonly using either mechanical or chemical methods to separate the fibers (Bajpai 2012; Iggesund Paperboard 2014). The latter, chemical pulping, is the most common pulping process in the United States (EPA 2012b). With improvements in pulp processing technology, many pulp mills can now easily switch between using soft woods, hard woods, and recycled fiber as the major raw materials, depending on the relative costs (Hoover’s 2014b). In recent years, the use of recycled, postconsumer paper content during pulp production has been a prominent research area for the industry. Emphasis has been placed on alternative pulp-making technologies (biotechnology-based processes called *biopulping*), and improved methods to remove ink from recycled materials. These developments have led to increased use of recycled materials in pulp production (Petrillo 2014a). Table 6 summarizes advantages, drawbacks, and end uses of the three pulping processes.

Table 6 / Key Pulp Processes, Advantages, Drawbacks, and End Uses

MECHANICAL PULPING	ADVANTAGES	DRAWBACKS	END USES*
	<ul style="list-style-type: none"> ▣ Excellent fiber yield (over 90% of wood is transformed into pulp) ▣ High opacity ▣ Good printing characteristics 	<ul style="list-style-type: none"> ▣ Low strength ▣ Yellowing ▣ High energy consumption 	<ul style="list-style-type: none"> ▣ Newspapers ▣ Periodicals ▣ Books ▣ Paperbacks

* Products that do not require long storage periods.

Continued



Table 7 / Key Pulp Processes, Advantages, Drawbacks, and End Uses (*continued*)

CHEMICAL PULPING	ADVANTAGES	DRAWBACKS	END USES
	<ul style="list-style-type: none"> ❑ Resistance to yellowing ❑ Energy self-sufficiency at mills ❑ Good strength (sulphate) ❑ Easier bleaching (sulphite) 	<ul style="list-style-type: none"> ❑ Low fiber yield (60% of the tree is transformed into pulp) ❑ More waste to be purified 	<ul style="list-style-type: none"> ❑ Writing ❑ Printing, copy ❑ Envelopes ❑ Industrial papers ❑ Paperboard ❑ Packaging ❑ Sanitary
RECYCLED PULPING	ADVANTAGES	DRAWBACKS	END USES (% of RECYCLED FIBER)
	<ul style="list-style-type: none"> ❑ Lower energy consumption than in mechanical pulping processes ❑ Fiber recycling 	<ul style="list-style-type: none"> ❑ Low opacity ❑ Low bulk 	<ul style="list-style-type: none"> ❑ Boards (0–100%) ❑ Packaging (0–100%) ❑ Newsprint (0–100%) ❑ Printing paper (0–100%) ❑ Soft tissue (60%) ❑ Forms, envelopes (0–100%)

Source: UPM (2011)

Virgin Wood Fiber Suppliers

Pulp producers require a steady stream of raw materials at predictable prices. Integrated paperboard mills that make their own *wood pulp*, the major raw materials used to make paperboard, transact with virgin wood fiber suppliers for the materials (i.e. hardwood timber, softwood timber, and varieties of woodchips). According to FAO annual survey of world pulp and paper capacities, about 16 percent of wood pulp produced in the United States was market pulp during 2012–2014 (FAO 2013, 2014), suggesting that majority of pulp produced for paper and paperboard are made by integrated mills for their own operations. Therefore, integrated paperboard mills in this scenario compete for access to wood fiber with independent pulp mills, integrated pulp-and-paper mills, and other forest product industrial users such as pellet mills and oriented strand board (OSB) mills.



Virgin wood fiber sources. Wood chips from residues from logging activities, sawmills, furniture manufacturers, and other sources are dominated virgin sources used by pulp and paper mills in the United States (EPA 2013). In general, more than 65 percent of the nation’s pulpwood harvest is derived from the Southeastern region. As of 2012, this percentage has risen to over 81 percent, all of which comes from forestland privately owned by individuals and families, private investment groups, and the forest industry (Bowyer et al. 2014). Costs of procuring these wood fibers account for between 50–55 percent of the production costs for pulp mills in the United States (MarketWatch 2015). In general, most small pulp producers enter long-term supply agreements with local or regional suppliers to manage raw material costs; while larger producers own timberland properties and establish forestry operations to plant, grow, and harvest timber for their production (Hoover’s 2014a).

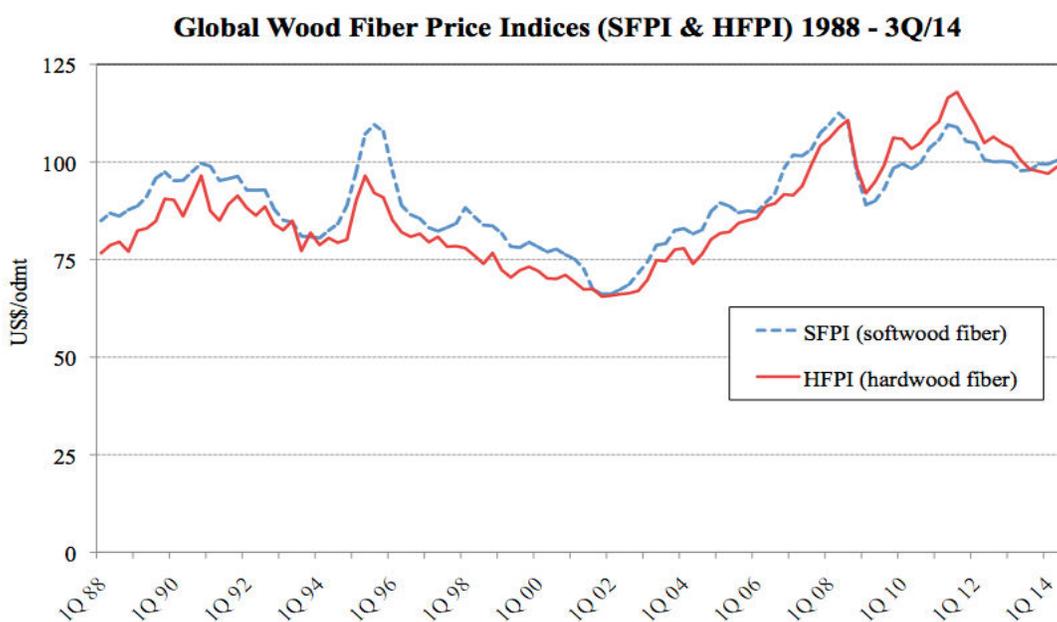
Types of virgin wood fiber. As discussed earlier, paperboard comes in different grades depending on type of material used in production, with *unbleached kraft* paperboard representing the largest source of US paperboard industry revenue. These unbleached paperboards retain the characteristic brown color of the pulp material, and are commonly used for the production of corrugated boxes. The more expensive bleached (whitened) boards are often used in packaging applications for food and beverage, cosmetics, and other high-profit products. In general, *kraft softwood* has been the preferred pulp for making *paperboard* because of its superior strength characteristics. Meanwhile, the main raw material used in making *corrugating medium* is *semichemical hardwood pulp*. Hardwoods are used because they are less costly and help to make the corrugating medium stiff; while semichemical process maintains some lignin, the chemical “glue” that holds fibers together in the tree, thus also beneficial for medium stiffness (Highbeam Business 2014).

Price trends. As shown in Figure 17, in the past three years, global prices for *hardwood fiber* have trended downward to reach its lowest level since 2009 in the 3Q/14 when the Hardwood Fiber Price Indices (HFPI), which track prices for pulplogs and



wood chips worldwide, fell to \$96.76 per oven-dry metric ton (odmt) (IHB/WRQ 2014b). The biggest declines in prices from the 2Q/14 occurred in Sweden, Russia, Brazil, and Australia. On the other hand, the Softwood Fiber Price Indices (SFPI) has been fairly steady over the past two years, fluctuating between \$98/odmt and \$100/odmt. The major changes in fiber prices in 2014 were those of sawmill residuals in Western United States, Western Canada, Germany, and Brazil (IHB/WRQ 2014b).

Figure 17 / Global Wood Fiber Price Indices



Source: Wood Resource Quarterly

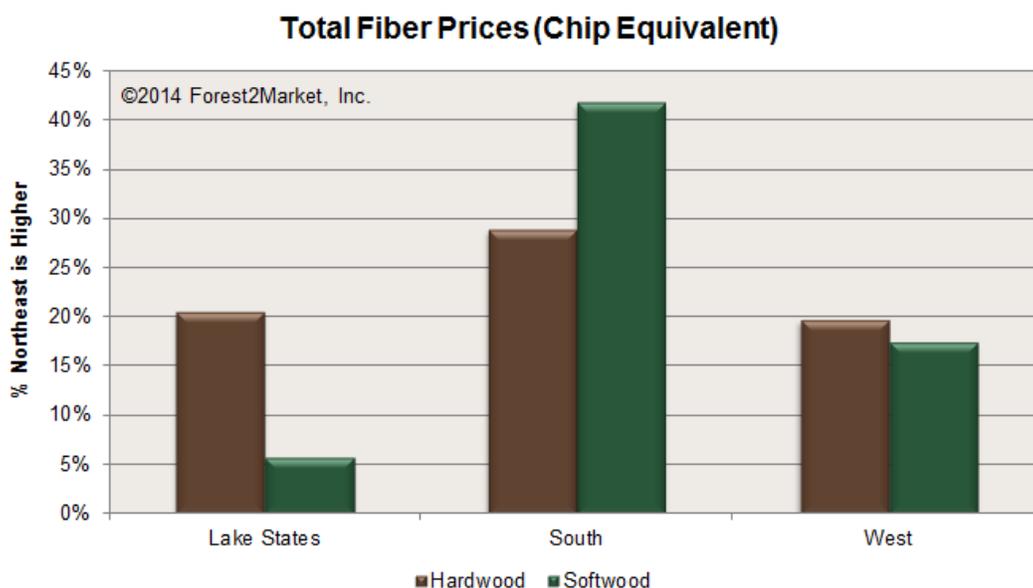
Source: IHB/WRQ (2014a)

A look specifically in the United States shows that in recent years, prices of softwood chips, the major fiber source for pulp producers in the Northwest regions, are trending downwards. Comparatively, wood chip prices in the South, although still lower than those in the West, are trending upwards; while prices for softwood and hardwood pulplogs, the major fiber source for pulp producers in the region, remain relatively unchanged (MarketWatch 2013). As shown in Figure 18, average hardwood and



softwood fiber costs in the Northeast region are higher than in other areas of the United States (Coutu 2014).

Figure 18 / US Northeast Price Relative to Other Regions



Recovered Fiber Suppliers: Old Corrugated Containers (OCCs)

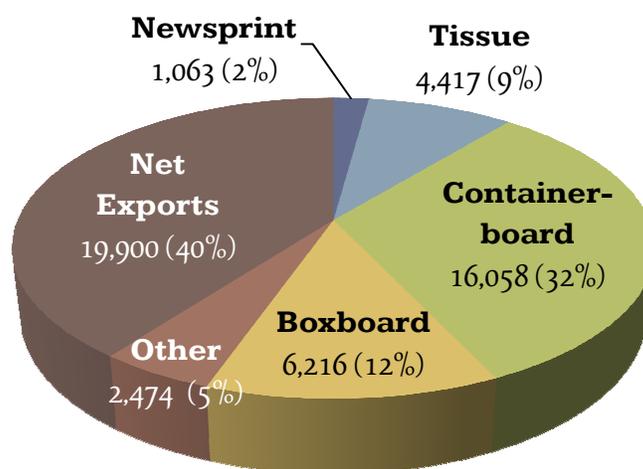
Along with virgin wood fibers, *recovered fibers*, also known as *secondary fiber* and *recovered paper and board*, are one of the two main fiber sources for paper and paperboard production (ISRI 2013; Singh et al. 2013). In this paper, analysis focuses on old corrugated containers (OCCs) due to its role as a major source of recovered fibers in the paperboard industry.

Recovered fiber sources and usages. Recovered fibers come from two primary sources, *pre-consumer waste* and *post-consumer waste* (PCW). Approximately 50 percent of recovered paper comes from industry and business (pre-consumer), including dry paper and paperboard waste generated *after* completion of the papermaking



process.¹⁵ Well over a third of recovered paper comes from households (post-consumer), including OCCs, mixed waste paper, old magazines, newspapers, and high-grade deinked paper¹⁶ (BIR n.d.; EPA 2014; The World Resources Institute and The World Business Council for Sustainable Development 2014a). Data for the year 2013 (see Figure 19) show that 40 percent of the paper and paperboard collected for recycling in the United States was exported, 32 percent went to local production of containerboard, and 12 percent went to local production of boxboard (AF&PA 2014c).

Figure 19 / Uses of Recovered Paper 2013



Source: AF&PA (2014c), showing thousand tons recovered and share of total

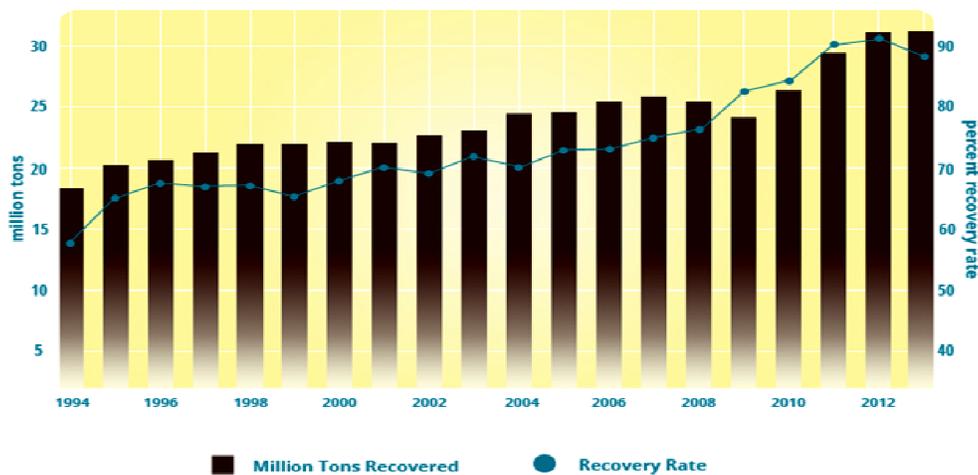
¹⁵ Including: (1) envelope cuttings, bindery trimmings, and other paper and paperboard waste resulting from printing, cutting, forming, and other converting operations; (2) bag, box, and carton manufacturing wastes; and (3) butt rolls, mill wrappers, and rejected unused stock. Mills can use these as **pulp substitutes** in place of virgin materials to make high-grade paper products. **Mill broke**, which is any paper waste generated in a paper mill *prior* to completion of the papermaking process, is usually returned directly to the pulping process. Thus, mill broke is *not* considered as “recovered fiber” (EPA 2014).

¹⁶ High grade paper includes letterhead, copier paper, envelopes, and printer and converter scrap that has gone through the printing process. It must be undergone **deinking**, the industrial process of removing printing ink from paper fibers of recycled paper to make **deinked pulp**, before it can be reprocessed into high-grade paper products such as printing and writing papers or tissue (The World Resources Institute and The World Business Council for Sustainable Development 2014a).



Old corrugated containers (OCCs). OCCs are the *most-recycled* packaging materials in the United States and worldwide (AF&PA 2014b, 2014c; Moore & Associates n.d.). OCCs also command relatively *high recovery values*, compared to other types of recovered paper,¹⁷ due to the generic nature that maintain a variety of potential applications (Great American Group 2013). As shown in Figure 20, *volume* of recovered OCC has risen steadily since 2009. In 2013, volume of recovered OCCs used by US mills increased 3.9 percent from 2012 to reach 19.8 million tons. However, the OCC *recovery rate*¹⁸ decreased from an all-time high of 91 percent in 2012 to 88.5 percent in 2013, mainly due to 8.9 percent drop in US OCC exports during 2013 (AF&PA 2014c).

Figure 20 / Recovered Old Corrugated Containerboard



Source: AF&PA (2014c)

¹⁷ Recovered paper can be grouped into several main categories including: (1) old corrugated containers (OCC), (2) old newspaper (ONP), (3) mixed waste paper – a broad category that often includes items such as discarded mail, telephone books, paperboard, magazines, and catalogs, (4) high-grade deinked paper, and (5) pulp substitutes – also high-grade papers that often include shavings and clippings from converting operations at paper mills and print shops (ISRI 2013). **Recovery values** tend to be higher for products that are generic in nature, such as blank cardboard boxes, as these items maintain a variety of potential users. In contrast, recovered paper that is customized in some way via special logos, unique dimensions, and other specialized enhancements, generally tend to experience lower recovery values (Great American Group 2013).

¹⁸ **Recovery Rate** = Total Recycled ÷ Total Generated (or Total Recycled + Total Disposed); all by weight



OCCs acquisition and the paperboard industry. Paperboard mills are major users of recovered OCCs. More than half of recovered OCCs in 2013 were used to make *new containerboard* for shipping boxes. An additional 13 percent was used to make *boxboard*, and more than 31 percent was *exported* (Corrugated Packaging Alliance 2014b).¹⁹ Paperboard mills typically obtain OCCs in bales (see Figure 21) from the *commercial sectors* such as supermarkets, distribution centers, and retail outlets. OCCs obtained from commercial sectors are clean, high quality OCCs, while OCCs obtained from *residential recycling stream* are much dirtier as they are mixed with a variety of contaminants found in residential wastes.²⁰ Paperboard mills typically acquire OCCs from commercial

Figure 21 / Baled Old Corrugated Containers (OCCs)



Image courtesy of BIR

sectors through *waste recovery vendors* called *suppliers* in the recycling industry. These suppliers may be a business entity affiliated with integrated mill company, or they may be an independent *recycling / material recovery facilities (MRFs)* (Kinney 2014). Selling of recovered fibers may also involve recyclable material wholesalers, brokers, and importers (Kinney 2014; Moore & Associates n.d.; PaperIndex 2014).

¹⁹ Small percentages of recovered OCCs in 2013 were used in packaging and industrial converting (1.6%), tissue (0.9%), and others (0.8%) (Corrugated Packaging Alliance 2014b).

²⁰ **Two commonly used collection methods for paper recovery** are **single-stream** collection and **sorted-stream** collection, of which single-stream waste systems are more widespread in the United States (Nordström and O’Kelly 2013). *Sorted-stream collection* requires that each recyclable material be placed in the appropriate collection bin when the item is discarded. Recovered paper can be collected separately by grade (e.g., white office paper, newspapers, magazines, and corrugated cardboard boxes), or more commonly, collected as mixed paper separated from other recyclable materials. *Single-stream collection* programs collect recyclable materials (e.g., paper, bottles, cans, etc.) in one collection container. These materials are then sorted, usually at a central point such as a materials recovery facility (MRF). In the case of paper, all grades are mixed together as well as with other materials. Thus, in both methods, recovered paper is often collected as mixed paper that needs to be segregated to meet market specification (EPA 2012a).



Common practices among *large commercial companies* (pre-consumer sources of OCCs) involve contracting with *waste collection service companies*²¹ to remove cardboard shipping boxes from their waste streams. The service fees are normally based on the frequency of collection, cost of disposal, equipment or containers provided and the type and volume of waste (Harris 2015). The commercial companies generally receive a payment or rebate that is tied to the price paid to the waste collection service companies by buyers of the recyclable materials, primarily *material recovery facilities (MRFs)* (Kinney 2014; Moore & Associates n.d.; PaperIndex 2014). Table 88 highlights business activities, status, and trends of these key supplier industries.

²¹ Waste management services have traditionally been the responsibility of municipal governments that fund public waste collection services through the local tax base. Over time, however, many municipalities have discontinued this service, allowing private operators to take their place. Operators in the **waste manager service industry** does not include government-provided waste collection services, which currently carry out one-quarter of all waste collection in the United States (Harris 2015)



Table 8 / Key Recycle Material Supplier Industries

Recycle Material Supplier Industry	Primary Business	Industry Status and Trend
<p>Waste collection service industry</p>	<p>Collect waste for service fee from commercial, industrial, and residential customers.</p>	<ul style="list-style-type: none"> <li data-bbox="879 358 1879 711"> <p>❑ Key service segments. The largest share of the industry revenue in 2015 is anticipated to be generated through the provision of commercial and industrial waste collection services (32%), followed by residential waste collection services (25%). All other service segments, including hazardous waste collection services, construction and demolition site waste collection services, transfer and storage facility services, and recyclable material collection services, each account for less than 10 percent.</p> <li data-bbox="879 719 1879 1027"> <p>❑ Small, but growing recycle materials segment. The share of revenue from the collection of recyclable material has grown over the past five years 2009–2014, and is expected to continue increasing as a component of municipal government waste collection contracts. Increased demand for recycling services will likely boost the number of companies specializing in collecting and sorting recyclable materials.</p> <li data-bbox="879 1036 1879 1403"> <p>❑ Industry concentration moderate and increasing. The industry has a moderate level of market share concentration, with the industry’s four largest companies expected to generate 44.2 percent of industry revenue in 2015. There are a few very large companies offering waste collection services on a national basis, amid a numerous number of very small firms offering collection services on a local basis. Industry concentration has increased, primarily as a consequence of merger and acquisition activity by large companies.</p>



Recycle Material Supplier Industry	Primary Business	Industry Status and Trend
<p>Recycling facility / Material recovery facility (MRF) industry*</p>	<p>Accept or purchase unsorted waste and recyclable materials, and sorts them into specific recyclable material streams. MRFs process and refine these materials into raw materials that can be used to produce new goods.</p>	<ul style="list-style-type: none"> <li data-bbox="879 285 1866 548"> <p>▣ Key service segments. The vast majority of the industry’s revenue is derived either directly or indirectly from municipal governments by providing recovery and processing services (67%), followed by sales of recycled materials that MRFs collected, sorted, and processed (17.6%), and state governments, nonprofit organizations, and individuals (15%).</p> <li data-bbox="879 557 1866 1052"> <p>▣ Low industry concentration. The industry has a low level of market share concentration, with the industry’s four largest companies generating less than 30 percent of overall industry revenue. The majority of industry operators are small companies, operating only one or two recycling facilities that service a local area’s recycling needs. It is estimated that 74 percent of industry operators have 20 or fewer employees. While small companies still make up the majority of industry operators, and its number is growing, large players, such as Waste Management Inc. and Republic Services, are expanding their influence in the industry with large technologically advanced recycling facilities.</p> <li data-bbox="879 1060 1866 1328"> <p>▣ Recycled paper processing technology. Most technological progress in this industry has been composed of advances in recycled goods processing equipment. Developing paper-recycling technologies include processes that involve de-inking and bleaching, many of which focus on reducing the volume of water pollution generated by these processes.</p>



Recycle Material Supplier Industry	Primary Business	Industry Status and Trend
Recyclable material wholesalers	Purchase recycled materials from recycling facilities for sale to downstream manufacturers, other wholesalers, and scrap material exporters.	<ul style="list-style-type: none"> <li data-bbox="877 284 1858 641"> ▣ Key service segments. Direct sales to downstream manufacturers are estimated to generate 67 percent of overall industry revenue in 2014, while sales to other wholesalers are estimated at 27 percent. The industry generates the majority of its revenue from sales of scrap steel and other metals (81.8% of industry revenue in 2014), with sales of paper and paperboard scrap generating an estimated 9.2 percent of industry revenue. Scrap metal is expected to continue to represent the most important product sold by industry operators. <li data-bbox="877 649 1858 738"> ▣ Low industry concentration. The industry is highly fragmented, composing primarily of small-scale merchants.

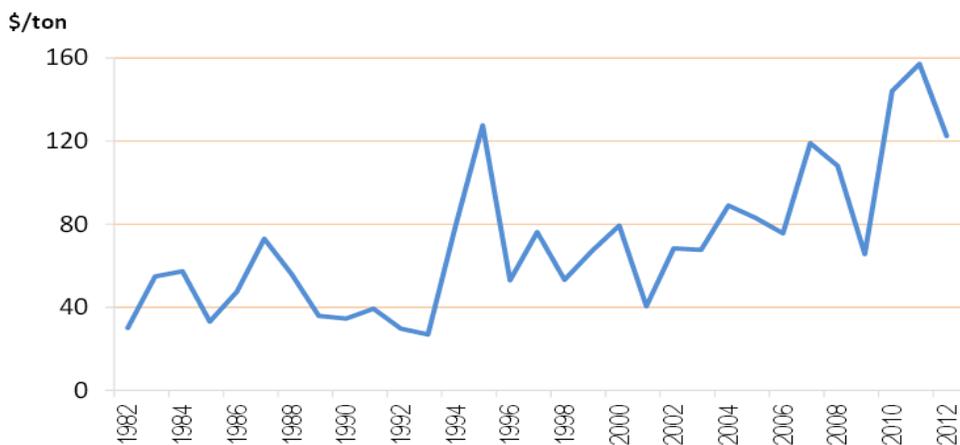
Source: Harris (2014a, 2014b, 2015)

*Note: As discussed in the industry status section, large operators in the paperboard industry are operating recycling facilities for recycled materials used in their own operations and for sales.



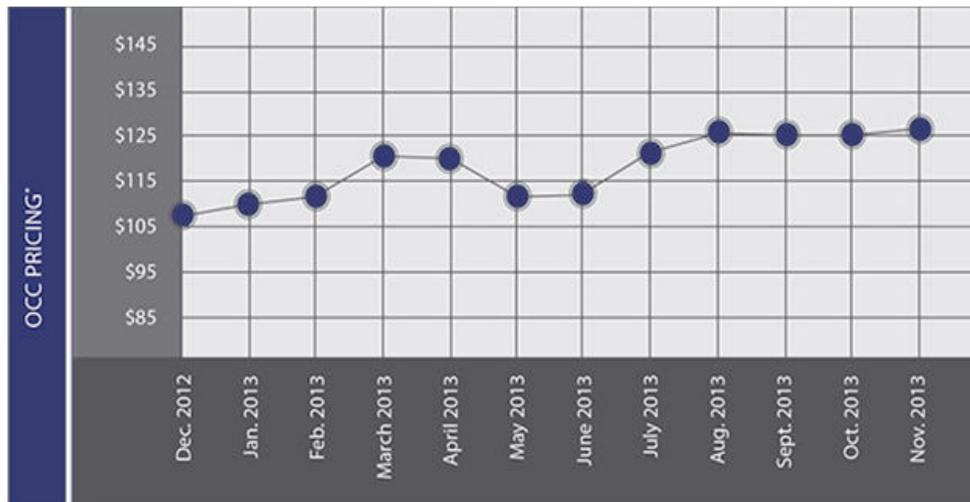
OCC price upward trends. Prices of OCCs have been increasing and highly volatile. Volume weighted average *open market* prices for OCC in the United States have ranged widely from \$82.87 per ton to \$181.99 per ton during 2011–2013, and from \$81.66 per ton to \$168.05 per ton for *contract purchases* (Kinney 2014). As shown in Figure 22 and Figure 23, OCC prices display general upward trends that are expected to continue owing to both demand and supply factors as to be discussed subsequently.

Figure 22 / US Average Corrugated Grade 11 Selling Price



Source: RISI (cited in International Paper n.d.)

Figure 23 / Monthly Prices of OCCs on the US Open Market

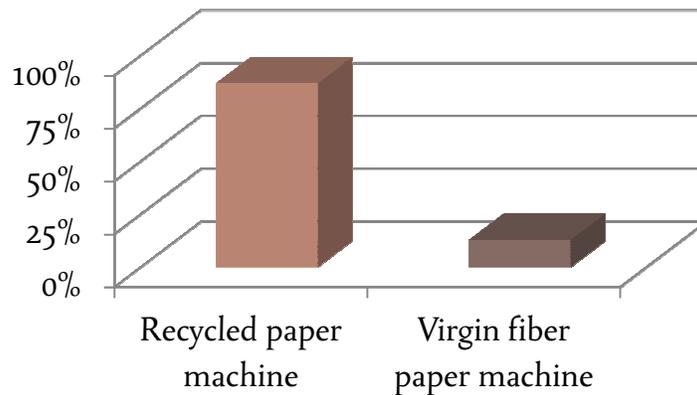


Source: *Recycling Today* (2014), showing price for bailed, full truckloads of OCC Grade 11 on the open market as reported on December 9, 2013



Increasing demand for OCCs. There has been an increase in demand for products packaged in 100 percent recycled paper, and the shift by manufacturers of virgin paperboard and corrugated packaging to the production of products with some recycled paper content both in international and domestic markets. In fact, in the past 15 years, majority of expansions in containerboard capacity used recycled fiber as furnish, with most new machines consisting of 100 percent recycled paper machines. Figure 24 depicts this trend, showing a snapshot of global installed kraft paper and linerboard capacity from 2000 to 2010.

Figure 24 / Global Kraft Paper and Linerboard Capacity Installed 2000–2010



Source: International Paper (n.d.)

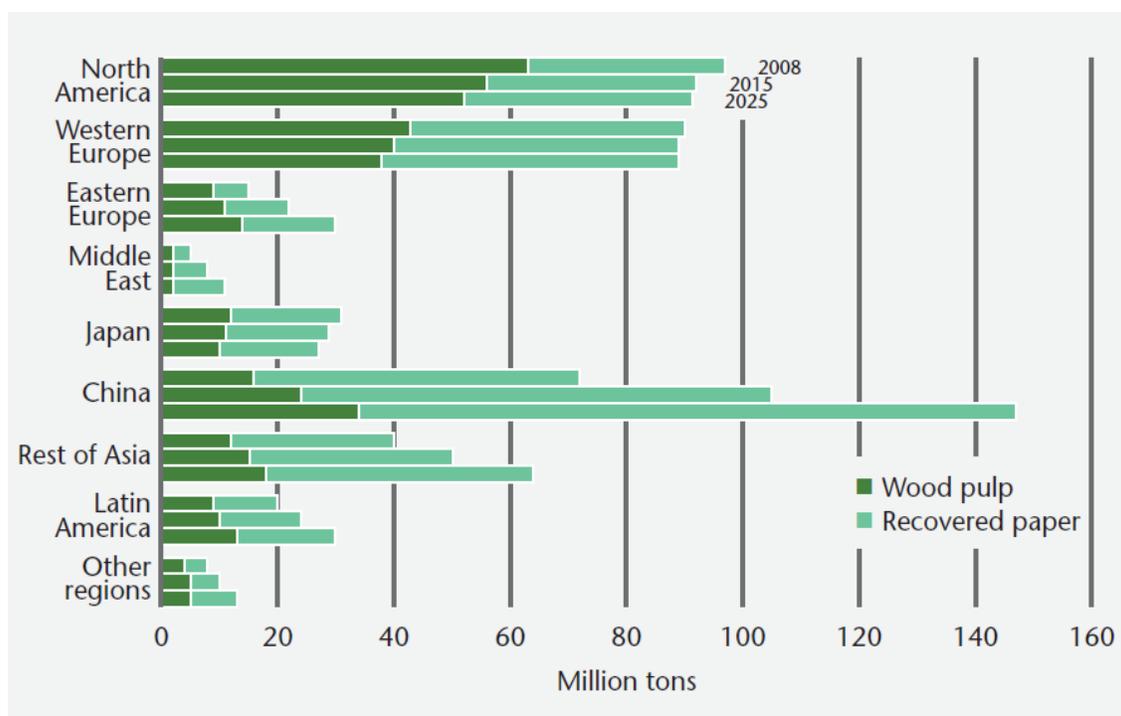
Note: Virgin fiber paper machines defined as capacity that has *any* onsite pulping capacity

Accordingly, demand for recycled fiber as furnish for paper and paperboard production worldwide has doubled from 95 million tonnes in 1995 to 195 million tonnes in 2013 (Nordström and O’Kelly 2013). This trend is expected to continue as shown in Figure 25, depicting trends in regional and country demand for recovered and virgin fiber. China alone is estimated to account for 8 million tonnes per year of confirmed additional capacity in containerboard in 2012–13, representing 63 percent of the total estimated expansion in containerboard capacity worldwide. In 2013, China imported over 30 million tonnes per year of recycled paper, almost as much as the combined exports of the



United States, Europe, and Japan. It is projected that by 2020 China will need to import 40 million to 50 million tonnes annually to meet supply requirements of its containerboard industry (Nordström and O’Kelly 2013). At the same time, demand for virgin wood pulp is decreasing in Europe and North America as that for recovered fiber increases (The World Resources Institute and The World Business Council for Sustainable Development 2014a).

Figure 25 / Past and Projected Demand for Virgin Wood Pulp and Recovered Fiber by World Region



Source: WBCSD 2012, Figure from Fibre, data from Poyry (cited in The World Resources Institute and The World Business Council for Sustainable Development 2014a)

Tightening supply of high quality OCCs. Increasing demand for recycled paper has already stimulated high recovery rates, which some analysts deem to be approaching their collectable limits. If all the new capacity of paper and paperboard production expected to come on stream by 2020 were to use recycled fiber as furnish, the *average global recovery rate* would need to exceed 70 percent, compared with its 57 percent



in 2013. In annual volume terms, this increase in recovery rate translates into 70 million to 80 million tonnes more recycled paper as furnish, about 35–40 percent more than the volume used today. As of 2013, the adjusted recovery rate in the United States is approximately 65 percent (Nordström and O’Kelly 2013), suggesting that the collection of recovered paper is approaching its collectable potentials. This circumstance is shared by most western countries, leading to world supply of recycled paper becoming increasingly inelastic and marginal cost curve turning upward (Suhonen 2013).

The US paperboard industry is also competing for *high quality* OCCs against booming exports. In general, most high quality OCCs from commercial sectors are exported at prices higher than US domestic prices by \$5-\$20 per ton, mainly because of their high quality. Thus, US mills are forced to use *lower quality* materials from residential sectors (Kinney 2014)), commonly collected through single-stream collection methods in which recovered paper of all grades are mixed together as well as with other recyclable materials (e.g. plastics, metals, and glass) (Nordström and O’Kelly 2013).

Increasingly, paperboard mills are using more expensive mixed-grade and high-grade recovered paper to fill their OCC supply gaps in the production of recycled paperboard (ISRI 2013; Moore & Associates n.d.; Nordström and O’Kelly 2013). However, a worrisome trend has been brewing. The poor outlook for newsprint that has been replaced by digital media is *indirectly* encroaching into these supply grades for containerboard production. Since tissue producers use large amounts of old newspapers (ONP) as furnish, lower output of ONP has led to tissue producers competing for these same sources of recycled fibers, namely mixed grades and high grades (Nordström and O’Kelly 2013).

Increased costs of producing recycled paperboard. Another impact of limited supply of high quality OCCs is increased costs of producing recycled paperboard. A reflection of its quality, average prices for low-quality post-consumer OCCs continue to decline, dropping from a national median average of \$119 per ton in April 2014 to the average low of \$95 per ton in September of that same year (Boulanger 2014). Despite the



lower prices, these OCCs, commonly collected in single streams of all recyclable materials, incur *higher costs of sorting and processing*. It is estimated that single-stream collection adds 20–30 percent to paper-sorting costs and 5 percent to the cost of preparing stock, compared with recovered paper collected through systems with separate collection (Nordström and O’Kelly 2013).²²

In addition, lower quality recycled fiber results in *lower yields*, requiring a higher ratio of OCCs purchased to recycle-based finished products than high quality OCCs. In turn, demand for recycled fiber increases because paperboard mills need to use more lower quality OCCs to make the same amount of containerboard (Dillon and Armstrong 2013; Kinney 2014; Nordström and O’Kelly 2013), hence, further distressing OCC supply availability.

Nonwood Fiber Suppliers

The role of nonwood fibers, compared to wood fibers and recovered fibers, remained marginal from *global standpoint*, estimating at 17 million tonnes, or about 4.2 percent of global pulp production in 2011. Putting in perspective, in that same year, recovered paper consumption was 223 million tonnes and wood pulp consumption was 166 million

²² Typically, kraft papers, corrugated board, and packaging boxboard are **segregated** from graphical papers at the collection and sorting step (Nordström and O’Kelly 2013). Today’s technology designed to handle, identify, and separate paper grades for recycling allows segregation of paper fibers according to fiber length, coarseness, and stiffness through a sequential centrifuging and screening process (EPA 2012a). Once recovered paper is sorted by grades, the collected OCCs are compacted and baled for space-efficient **storage** and **handling** either at the point of end-use (e.g. recovered pulp mills) or at recycling facilities for **processing** (e.g. pulping, cleaning, and deinking) (FBA 2005). Processing required depends on the types of recovered paper and the final applications. For certain applications—typically hygienic products, tissue, printing and copy paper, magazine papers, and coated paperboard and containerboard—ink has to be removed from the recovered paper to increase the whiteness and purity. Thus, processing involves both *mechanical cleaning and deinking*. For others—typically corrugating medium, uncoated paperboard and boxboard—processing is *exclusively mechanical cleaning* (without deinking) (The Institute for Industrial Productivity 2010).



tonnes (Suhonen 2013). As of 2014, nonwood fibers accounted for about 7 percent of global pulp production, with most of the nonwood pulp production located in countries that have limited forest resources, such as China, India, Pakistan, Egypt, and Columbia (Hurter 2014). A similar trend can be observed in *the United States* where nonwood fiber *pulp production* is not common, as shown in Table 9, and nonwood fibers account for less than 1 percent of fiber raw material supplied to US paper and packaging facilities (Pollock 2011). Their uses are largely limiting to the manufacture of *speciality* and *niche paper products* that command premium prices in the marketplace (National Council for Air and Stream Improvement 2013). However, there has been a renewed public interest of nonwood fiber for industrial applications, including paper-based products, in North America. That a draft of the Alternative Natural Fiber (ANF) stewardship standard for the production of nonwood plant fibers designed to encourage the responsible management of purpose-grown plant crops is underway²³ attests to the significance of growing interests in nonwood fibers.

Table 9 / US Production Capacity of Wood and Nonwood Pulp for Paper and Paperboard

Year	Wood Pulp		Nonwood Pulp	
	Total capacity	of which market pulp	Total capacity	of which market pulp
2011	56650	9189	153	n/a
2012	56595	9285	157	n/a
2013	56335	9079	160	n/a
2014	56078	8868	163	n/a
2015	56078	n/a	163	n/a
2016	56078	n/a	163	n/a

Source: FAO (2012)

Note: (1) Shown in 1,000 Metric Tons (Air Dry) Per Year. (2) More recent 2013 and 2014 annual surveys had no reported data for nonwood pulp production capacity.

²³ The process of developing a global stewardship standard for natural fibers began in July 2013 (Rainforest Alliance 2013).



Categories of nonwood fibers. Generally, nonwood plant fiber pulps can be grouped into two broad categories: (1) *common nonwoods* or *hardwood substitutes* such as cereal straws, sugarcane bagasse, bamboo (shorter fiber species), reeds and grasses, esparto, kenaf (whole stalk or core fiber), corn stalks, sorghum stalks etc.; and (2) *specialty nonwoods* or *softwood substitutes* such as cotton staple and linters; flax, hemp and kenaf bast fibers; sisal; abaca; bamboo (longer fiber species); hesperaloe etc. (Hurter 2001).

Potential sources of nonwood fibers. Potential sources of nonwood fiber that have been considered for papermaking in North America include: (1) *annual or industrial crops* grown specifically for fiber, such as kenaf, jute, flax, hemp, and more recently, perennial warm season grasses such as switchgrass; and (2) *agricultural residues* (or *agrifibers*) from the harvest of food-based crops such as wheat and other cereal straws (barley and oats), rye seed grass, cornstalks, and bagasse from sugar cane (National Council for Air and Stream Improvement 2013). Thus far, market penetration of these nonwood fibers for papermaking remains limited due to a number of market and technical factors.

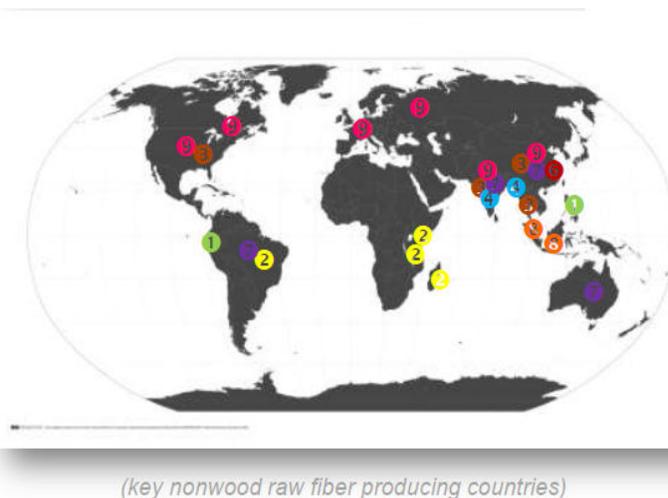
Market factors. Availability and pulp prices vary widely from year to year and across different types of nonwood raw fiber (see Figure 26) due to a number of reasons. First, *supply volume, seasonality* and *spatial distribution* of agrifiber post supply disruption risks and high cost of acquisition to mill users. Agrifibers mostly comes from *small-scale growers*, selling relatively small amounts to the mill in a time frame consistent with the harvest of the crops (instead of throughout a year). To wit, in US straw-rich regions, soil conservation and various agricultural uses may together account for about 60 percent of the total straw produced, leaving a potential average of 40 percent available for other uses. Straw yields also vary by growing season, which markedly lower production in abnormally dry years (Bowyer et al. 2014). Furthermore, farmers are reluctant to sign long-term supply contracts for the sales of a byproduct that would restrict their cropping flexibility, adding to long-term supply stability concerns and imposing limitation to the



capacity of nonwood mill users (Girouard and Samson n.d.; Seger, Kühn, and Borner 2012; The World Resources Institute and The World Business Council for Sustainable Development 2014b).

Figure 26 / Global Production of Nonwood Raw Fiber and Market Pulp Prices

Raw fiber - global production	in ['000 MT/year]	Typical pulp market price [€/ADMT CIF]
1 Abaca	80	3.100
2 Sisal	430	3.300
3 Kenaf	340	2.700
4 Jute	2.700	2.900
5 Hemp	80	2.750
6 Bamboo	1.250.000	850
7 Bagasse	200.000	625
8 Oil Palm Residues	200.000	475
9 Wheat Straw	330.000	975



Source: Seger, Kühn, and Borner (2012)

Note: Commonly grown cereal straws such as wheat, barley, and oats appear to be the most promising source of agrifibers in the United States. An estimate by Bowyer et al. (2014) suggests that estimated annual available straw yield in the United States was 10.1 million tons, an equivalent of only about 12 percent of US pulpwood production in 2011.

The alternatives to agricultural residues are annual fiber crops. It is conceded among mill users that nonwood fibers would have to be grown as intensively-managed fiber crops over large areas in order for the mills to sustain their large-scale manufacturing operations. Annual fiber crops can provide stability to the industry because they have the potential to produce large volumes of material for pulping, whereas the supply of crop residues is more limited. Moreover, unlike farmers, long-term production contracts can be signed between the mills and growers for a given price,



time period, and acreage (Girouard and Samson n.d.). However, as can be discerned from Figure 26, industrial fiber crop production in the United States is mainly Kenaf, but large-scale commercial plantations have yet to be developed. In fact, key producing countries of Kenaf are emerging countries, notably China, India, and Thailand (Chen and Liu 2013).

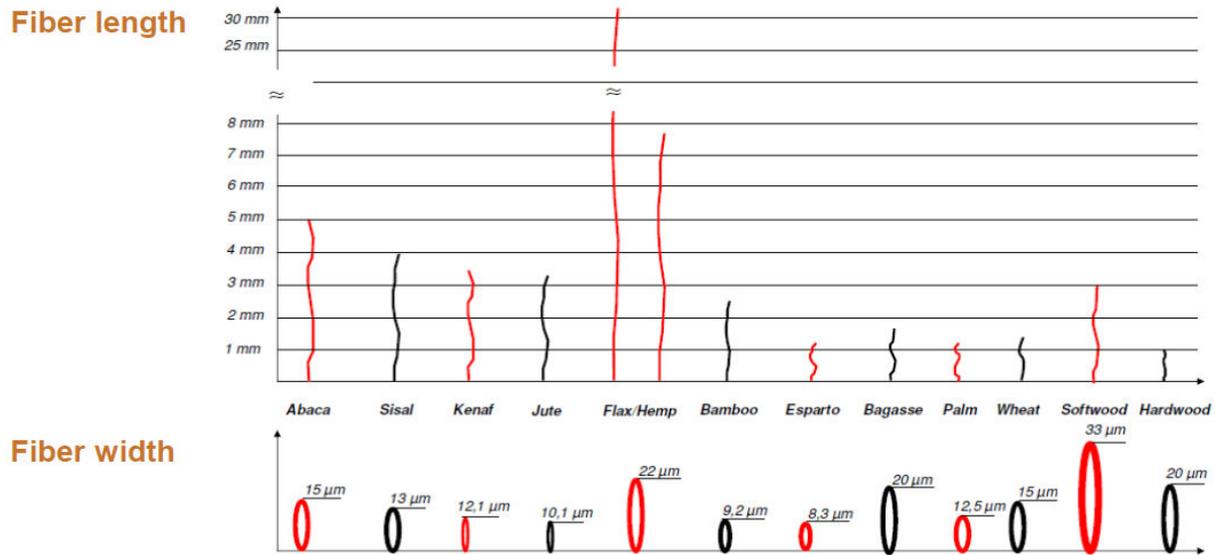
Without assurance that fiber supply will be available for the years ahead either from agricultural residues or annual crops, mills are reluctant to make investment in large scale nonwood fiber-based production (Girouard and Samson n.d.). Capacities of existing nonwood pulp mills are small, typically smaller than 10,000 air-dried metric ton (ADMT) per year. Majority of these mills are *integrated pulp-and-paper mills* with locations concentrated in Asia, often in deforested areas (Seger, Kühn, and Borner 2012).

Technical factors. While seasonality issue inherent in agrifiber supply can be addressed to some extent by using a broad range of nonwood fibers with different harvesting periods, the large amount of fiber required for mill production still need to be transported from a large number of small supply location and stored at the mills. Nonwood fiber are less dense than wood, making *transportation and storage costs* relatively more overbearing. Results are limits of the economic collection radius for the materials that put nonwood fiber-based mills at disadvantages to wood fiber-based mills in terms of the economies of scale (National Council for Air and Stream Improvement 2013).

Added further to the technical challenges is the fact that, in comparison to wood pulps, nonwood pulps produced from specific plants are more heterogeneous in terms of physical properties (see Figure 27).



Figure 27 / Variations of Pulp Fiber Properties



Source: Seger, Kühn, and Borner (2012)

Nonwood pulps can be divided into short- and long-fiber pulps. In papermaking terms, short nonwood fibers behave like hardwood fibers, while long nonwood fibers can be used to replace softwood fibers in the paper furnish. For paperboard production, short nonwood fibers such as straw have been traditionally used to improve stiffness of corrugating medium (Paavilainen 1998; Seger, Kühn, and Borner 2012).

Such physical varieties require significantly different stock preparation and produce different paper characteristics (Seger, Kühn, and Borner 2012). Currently, *material handling* and *pulping systems* designed for wood, wood chips, and wood pulps are not compatible with most agricultural fibers. The processing cost of nonwood fibers requires that the mills incur substantial costs for technology that still does not produce a substantially improved quality for intended end products. To be competitive, nonwood-pulping technology needs to be further developed to an adequate level of sophistication equivalent to modern wood-pulping counterparts (Petrillo 2014a; National Council for Air and Stream Improvement 2013; The World Resources Institute and The World Business Council for Sustainable Development 2014b).



The Power of Buyers

All the paperboard produced by the industry is sold to *converters* that make other products such as corrugated/cardboard boxes, coated and laminated paperboard, and office stationery.

Business transactions. *Large buyers* typically have vertically integrated operations that often include ownership and management of timberlands; manufacture of pulp, paper, and paperboard; and production of various converted paper and paperboard products (Hoover’s 2014c). Most of *smaller buyers*, on the other hand, operate only converting plants, and typically make products from paper or paperboard materials purchased from other parties (Hoover’s 2014b, 2014c). Paperboard mills sell their products on a spot basis, under “evergreen” contracts directly with buyers that are renewable annually, and through wholesalers/distributors that purchase an estimated 15.2 percent of products produced by paperboard mills in 2014 (Hoopes 2014a; Hoover’s 2014a).

Packaging dominating buyer markets. Among several converted products, paperboard is used to make *packaging* more than in any other application. As shown in Figure 28, more than two-thirds of all paperboard is converted into cardboard boxes, containers, and other packaging products, with a much smaller proportion delegated for other products (Highbeam Business 2014; Hoopes 2014a; Hoover’s 2014a; Petrillo 2014b). Table 10 profiles major buying companies in the packaging segments. Note that majority of these key buyers are *internal customers* of their *affiliated suppliers*.

Table 10 / Major Buyers in the Packaging Industry

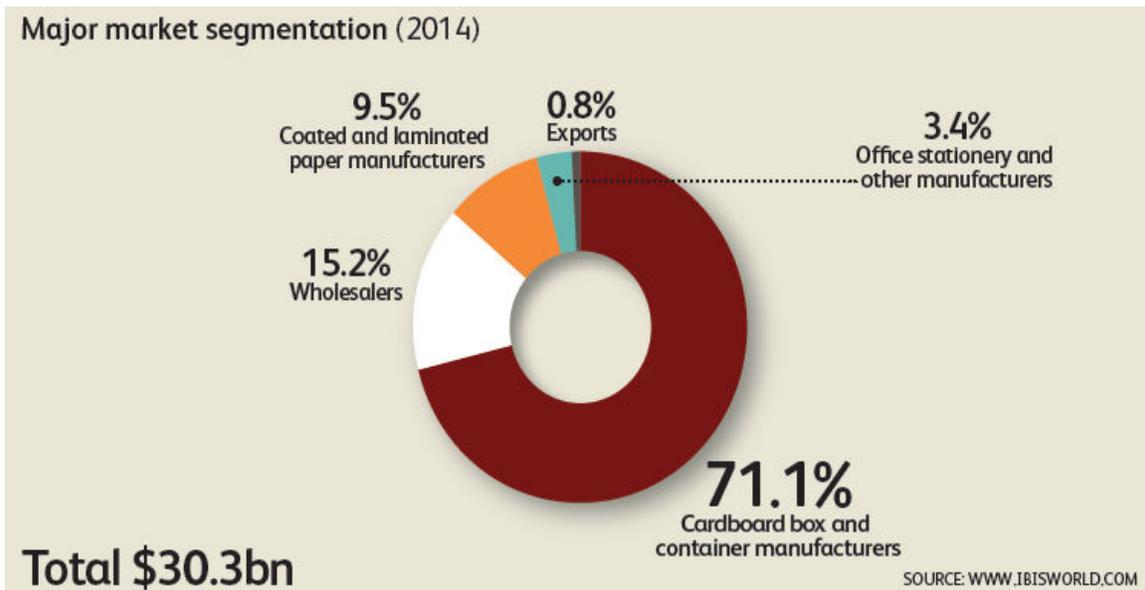
Companies	Packaging Business Profile
International Paper Company	The company’s <i>industrial packaging</i> segment produces corrugated packaging, containerboard, and kraft products. The company’s <i>consumer packaging</i> segment produces coated paperboard products used for packaging food, beverages, and other manufactured products.



Companies	Packaging Business Profile
Rock-Tenn Company	The company's <i>consumer packaging</i> segment produces 100 percent coated recycled paperboard, solid bleached paperboard, and folding cartons. The <i>corrugated packaging</i> segment manufactures a range of containerboard, linerboard corrugated sheets, and packaging that are primarily sold to industrial product manufacturers.
Koch Industries Inc. (Georgia-Pacific Corporation)	The company primarily operates in the industry through its US-based subsidiary, Georgia-Pacific Corporation. It produces a range of packaging products, including corrugated containers, bulk bins, double- and triple-wall boxes, as well as other corrugated packaging boxes for large-scale shipping. Its products are mainly used for shipping industrial and agricultural products, automotive parts, and chemicals.
Smurfit Kappa Group	Through its US segment, the company manufactures paper, corrugated packaging, paper sacks, and folding cartons. Sixty percent of its corrugated customers are in food, beverage, and household consumable markets.

Source: Hoopes (2014b)

Figure 28 / Major Buyer Market Segments



Source: (Hoopes 2014a)



Two notable trends pertinent to major market segments are observed as follows. Discussions of key downstream industries are presented subsequently.

- **Coated and laminated paper a key non-packaging market on a decline.** Manufacturers of coated and laminated paper are key buyers in nonpackaging segments. Import competition in these downstream industries has increased over time, causing companies in these industries to downsize their operations. As a result, paperboard mills' sales (primarily *cardstock*) to the coated and laminated paper manufacturing industry have decreased over the five-year period, accounting for 9.5 percent of paperboard industry revenue in 2014 (Hoopes 2014a).
- **Continuing limited exports.** Exports have been and continue to be a weak source of revenue and growth for the paperboard industry, accounting for a marginal share of revenue at 0.8 percent in 2014. Of this marginal share, *linerboard* is one of the strongest export products. US mills, mostly in the South, have traditionally been among the world's lowest-cost producers. However, by the mid-2000s, other nations, particularly China, were gaining shares of the world market (Highbeam Business 2014).

Cardboard Box Manufacturers

Cardboard box manufacturers are major buyers within the packaging market segment, accounting for about 71 percent of the paperboard industry's sales in 2014 (Hoopes 2014a). Operators in this downstream industry produces *corrugated* and *solid cardboard packaging*²⁴ for a wide range of industries, including manufacturing, agriculture,

²⁴ **Paper packaging products** can be classified into two subsegments: **flexible** and **rigid** paper packaging products. *Flexible paper packaging* products include wrappers, pouches, and packaging bags. *Rigid paper packaging* products include paperboard containers, such as corrugated and solid fiber boxes, folding solid paperboard boxes, setup paperboard, and nonfolding sanitary food containers. Folding solid paperboard boxes include shoe boxes and food containers; whereas setup



wholesale, shipping, and retails. Cardboard box manufacturing operations mostly concentrate on a *limited product lines* that are *made to order* since most of the customers have unique quality, size, volume, and printing requirements.²⁵ Most large cardboard box companies produce more than one variety of the packaging within their product lines, allowing them to easily switch between the productions of different end products (Hoopes 2014b; Hoover's 2014c).

Corrugated boxes primary applications. Among the solid cardboard packaging products, corrugated boxes are cardboard box manufacturers' primary products (Hoopes 2014b), which, in turn, make containerboard grade (linerboard and corrugated medium) vital to the paperboard industry as a supplier. Most paperboard mills *sell directly* to cardboard box manufacturers due to long-standing relationships between mills and converters. Large paperboard mills, however, often forward integrate into this market, producing both containerboard and corrugated boxes (Highbeam Business 2014).

Folding paperboard boxes/cartons second largest applications. Folding cartons, rigid boxes, rigid cylinders, and folding cartons with printed paperboard top sheets represent the second largest group of products produced by cardboard box manufacturers (Hoopes 2014b). In 2013, the cardboard box manufacturing industry shipped 5.03 million tons of these commercial packaging with an average value per ton of \$1,742, over 60 percent of which is destined for *consumer goods packaging*. Notable industrial end users are *food product segments* such as beverages and dairy products, candy and confections, dry foods including cereals, and frozen foods (Paperboard Packaging Council 2013).

board consists of rigid-sided boxes, paper cans, mailing cases, and wastebaskets. Nonfolding sanitary food containers include milk cartons, paper cups, and dishes (Advisen 2012).

²⁵ Rolls of kraft paper for corrugating are available in many sizes to fit the production equipment at different corrugating plants. The most common roll sizes are 67 inches (170.18 centimeters) wide and 87 inches (220.98 centimeters) wide. An 87-inch roll of heavier paper can weigh up to 6,000 pounds (2,724 kilograms). As many as 22 rolls of 87-inch paper can be loaded into one railroad boxcar for transportation to a corrugating plant (Miller 2014).



Localized and fragmented industry. The majority of companies in the cardboard box manufacturing industry operate locally, providing cardboard and other solid packaging to local commercial customers within 150–200 mile radius of their facilities. This is primarily driven by the relatively bulky and inexpensive characteristics of the industry’s products that render transportation costs a significant part of the total delivered cost. As a result, the industry is fragmented, with the world’s top companies accounting for just 8 percent of the global industry’s revenue (Bodimeade 2012; Hoopes 2014b). While market shares of the industry’s largest players, like International Paper and Rock-Tenn, have increased in recent years (International Paper from 3% to 4%, Rock-Tenn from 0.6% to 1.7% during 2009–2014), and are anticipated to continue to grow over the five years to 2019, the industry’s market share concentration is forecasted to remain low (Hoopes 2014b).

Converted Paper Product Manufacturers

Another major buyer group is converted paper product manufacturers that convert purchased paper and paperboard into *converted paperboard products* such as fillers and flats for egg cases (excluding molded pulp), bottle caps, closures and lids, placemats, tray dollies, unprinted cards, and folders; and *converted paper products* such as cigarette papers, party supplies, and insulation. The manufacture of these products is mainly a commodity business. Manufacturing processes and products are standardized, with minimal developments in differentiated product offerings over the five years to 2014 (Carter 2014; Hoover’s 2014b).

Fragmented industry. The converted paper product manufacturing industry has a low level of market share concentration, with the top four players accounting for an estimated 31 percent of industry revenue in 2014. Nearly half of converted paper products manufacturing establishments are located in the US Northeast region, including the Great Lakes, Mid-Atlantic, and New England. At the state level, the states with the most establishments are California, Ohio, Illinois, New York, Texas, and



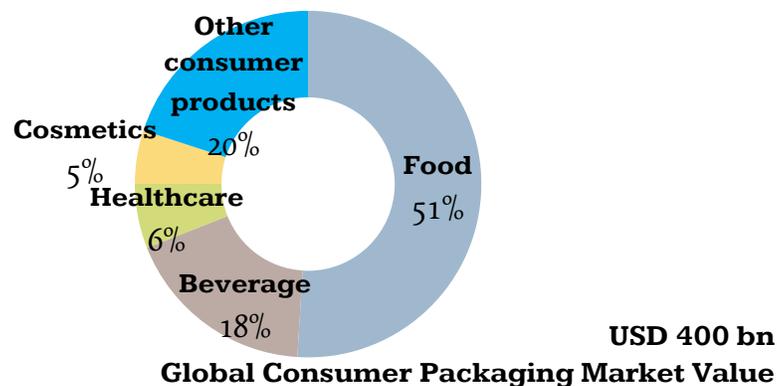
Pennsylvania. More than half of these establishments operate with fewer than 20 employees, indicating a high number of small players within the industry (Hoover’s 2014b, 2014c).

The Threat of Substitutes: Packaging & Container Markets

Given that packaging are major markets for paperboard stocks produced by paperboard mills, their relative competitiveness against other packaging materials is one of the most important driving forces in determining the success of paperboard mills and how the paperboard industry will develop in the future (Hetemäki, Hänninen, and Moiseyev 2013; Petrillo 2014b).

The global consumer packaging market value in 2012 was estimated at approximately USD400 billion. The market value rose to USD500 billion if industrial end markets are also included (Neil-Boss and Brooks 2013). Competitors within the *packaging and container (P&C) industry* in the materials sector include manufacturers (known in the materials industry as *converters*) of paper, metal, glass, and plastic containers. These companies serve a wide variety of markets, but, as shown in Figure 29, most of which rely on the food-and-beverage, household-product, and pharmaceutical sectors for the majority of business (Value Line 2015).

Figure 29 / Global Packaging by End Markets: 2012



Source: Ernst & Young (cited in Neil-Boss and Brooks 2013)



Plastics: Key Substitute Packaging Materials. Figure 30 depicts key packaging materials.²⁶ As discussed earlier, paperboard materials compete in the *rigid* packaging subsegment of paper packaging products. For cardboard product group (coated/uncoated corrugated boxes), *shipping and retail packaging* are main applications. The boxboard product group (bleached paperboard or solid bleached sulfate [SBS] grades) is used by paper and paperboard converters for many kinds of *solid consumer product packaging* such as folding solid paperboard boxes, setup paperboard, and nonfolding sanitary food containers (Advisen 2012; Hetemäki, Hänninen, and Moiseyev 2013; Highbeam Business 2014; Hoopes 2014a).

While the threat of substitutes in the rigid packaging applications can come from plastic, wood, and glass packaging materials, as shown in Figure 31, plastic packaging is a key product category in rigid packaging. Plastics have been extensively used in packaging due to their high barrier properties against moisture and air, and durability that withstand rough handling during distribution and transportation (Transparency Market Research 2014b).

²⁶ Additional examples include expanded foam polystyrene boxes, wooden pallets and boxes, and reusable corrugated plastic container (mainly serve industrial and produce packaging) (Hoopes 2014a). **Corrugated plastic** or **corriboard** refers to a wide range of extruded twin-wall plastic sheet products produced from high-impact polypropylene resin with a similar make up to corrugated fiberboard. It is a light weight, durable, recyclable material available in a wide variety of colors and thicknesses. In packaging applications, it is widely used for in the packaging of automotive and electronic parts to minimize product damages, and in reusable applications like produce and mail crates and shipping pallets (Tech Equipment Totes 2014).



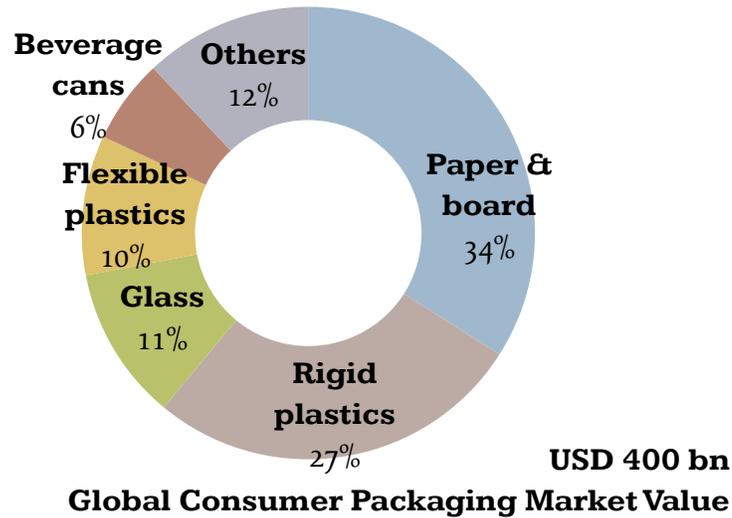
Figure 30 / Packaging Material Spectrum

Rigid Packaging					Flexible Packaging			Board	
Metal			Glass Containers	Rigid Plastic Containers	Flexible Plastics	Flexible Papers	Flexible Foils	Folding Cartons	Corrugated Containers
Beverage Can	Food Can	General Line							
 	<p>Aerosols, Trays and containers, Steel fabricated containers, Metal drums, Tanks and reservoirs</p>     	<p>Bottles, Jars and vials</p>   	<p>Bottles, Jars, Trays and containers, Tubs and pots, Pails, Pallets, Tubes, Crates, Plastic drums, reservoirs, etc.</p>      	<p>Bags and sacks, Flat pouches, Pillow pouches, Stand-up pouches, Wrapping films, Flexible intermediate bulk containers (FIBCs)</p>      	<p>Bags and sacks, Wraps and pouches, Paper laminates, etc.</p>     	<p>Foil laminates, Bags, Sachets, Pouches, Lidding, Blister packaging</p>     	<p>Used for a variety of products: pasta, toothpaste, cereal, frozen dinners, juice, milk, ice cream, cosmetics ... includes aseptic packaging and blister packs using paperboard</p>  	<p>Shipping containers, product packages, point-of-purchase displays.</p>  	

Source: TC Transcontinental (2014)



Figure 31 / Market Share by Packaging Materials: 2012



Source: Ernst & Young (cited in Neil-Boss and Brooks 2013)

Competition among substitute packaging materials depends on several factors, such as the relative price, weight, safety, recyclability, presentation, and versatility of each of these attributes that make one material more suitable for specific uses than another. Relative performance of paperboard and plastic materials differ across these factors. Key comparative performance and trends are highlighted as follows.

Secondary Packaging

Price-based competition. The rigid packaging market, the largest application market, is *price sensitive* because the purchased materials are *undifferentiated* intermediated products that represent *a significant fraction* of the buyers' procurement expenses (Porter 2008). As discussed thus far, the largest use of corrugated packaging is for *secondary shipping boxes*. Such applications are highly tactical and functional where the highest protection at the lowest cost trumps all other requirements. There is little



print requirement beyond simple one or two-color (I.T. Strategies 2013). These characteristics allow downstream users, notably in food and beverage sectors, to keep costs down by using basic, economical packaging and containers (Value Line 2015).

Raw material costs as a key driver of pricing. Costs of raw materials, in turn, are key factor affecting prices of the intermediate inputs. (See “Status of the US Paperboard Industry” and “The Power of Suppliers” sections for prices of fiber raw materials and paperboard products). Most plastic packaging products and materials are made from *plastic resin pellets*. The specific properties of different types of resin make them suitable for different kinds of packaging. Polyethylene (PE) and polyethylene (PE) account for the majority of plastic converters’ resin purchases (US Packaging and Wrapping 2013; Zacks Equity Research 2014).²⁷ The plastic pellets are considered a *commodity*, often bought and sold on *open exchanges* (US Packaging and Wrapping 2013). Prices of plastic resins are subject to fluctuations, driven by supply availability and changes in the prices of natural gas, crude oil, and other petrochemical intermediates from which resins are produced. To wit, a \$10 per barrel decline in oil generally translates to 4 cents per pound decline in polyethylene prices (Zacks Equity Research 2014). PE raw material price trends are shown in Figure 32.

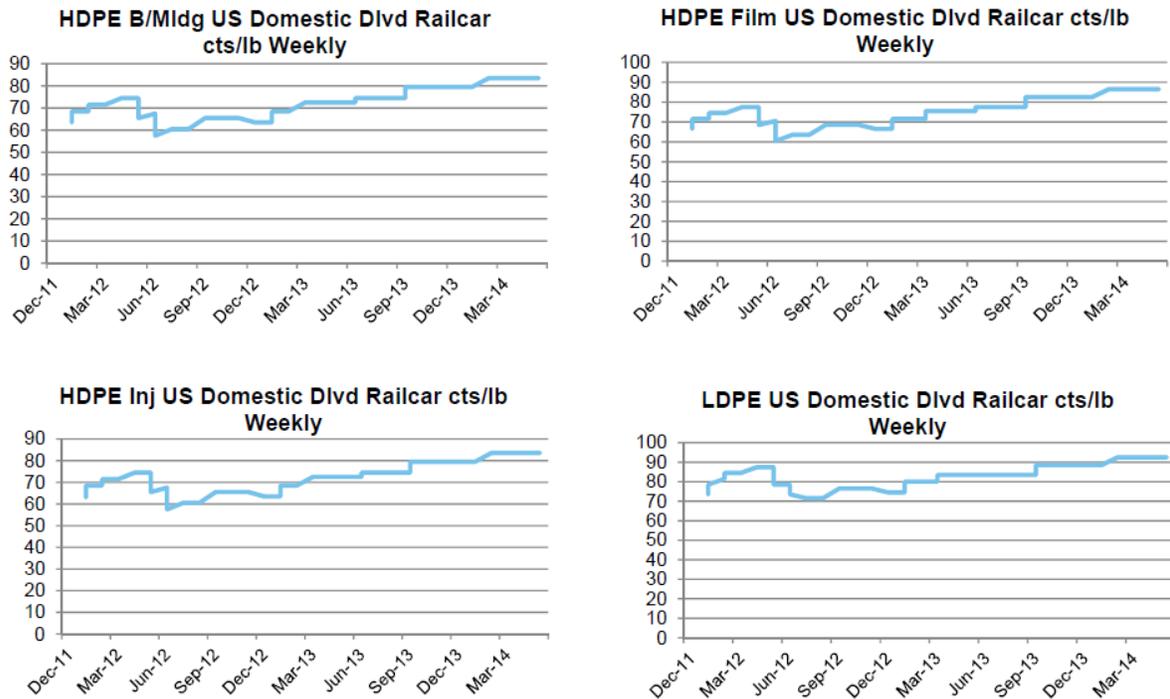
Overall, threat of substitutes in secondary packaging applications is **low**. The number of substitute products that provide the same balance of cost and functional strength as corrugated boxes, a containerboard product group, is limited. While plastic boxes offer similarly durable, they carry a significantly higher per-unit cost. Solid fiber boxes, a paperboard product group, are less expensive, but lack the durability of

²⁷ Most **common plastic resins** used in packaging are: (1) polyethylene terephthalate (PET), (2) high density polyethylene (HDPE), (3) polyvinyl chloride (PVC), (4) low density polyethylene (LDPE), (5) polypropylene (PP), and (6) polystyrene (PS) (American Chemistry Council n.d.).



corrugated boxes (Chiang 2014). The attractiveness of corrugated boxes based on price-performance tradeoffs hinders substitutes by other materials in this area of applications.

Figure 32 / Plastic Resin Pricing Trend



Source: Standard & Poor's (2014)

Primary Packaging

Boxboard and corrugated paper materials are used for *primary packaging*—the former for wide variety of consumer products, while the latter for larger goods, notably consumer electronic products. Primary packaging applications often feature color graphics printed and laminated onto the corrugated materials (called *litholamination* or *litho-lam* for short in the packaging and container industry) (I.T. Strategies 2013).

Plastics' superior aesthetic value and excellent barrier properties. Since primary packages are displayed on the shelves of consumer goods retailers, presentation



is an important feature. Rising consumer preference towards *durable* and *highly aesthetic* packaging is a significantly driver for growth of the rigid plastic packaging. Plastics have superior aesthetic value and excellent barrier properties against moisture and air that enhances the shelf life of the product that is packaged. In fact, rigid plastic containers are increasingly replacing solid fiberboard containers for the packaging of food products, particularly snack foods (Hoopes 2014b). They are also gaining popularity in pharmaceuticals due to factors such as maintenance of hygiene, reduction of fraudulent drugs in the retail market, and retention of the medicinal properties of the drug (Transparency Market Research 2014b).

Light-weight packaging trends: material content reduction & lighter-weight material alternatives. A notable trend among business end users is a move toward *light-weight packaging*, driven by increased costs of transportation and concern over the environmental impact of packaging. To put this trend in perspective, according to the Grocery Manufacturers Association (GMA), between 2005 and 2010 alone, its members cut packaging weight by 1.5 billion pounds. It is expected that GMA members will reduce packaging weight by another 2.5 billion pounds from 2011 through 2020 (Wadhvani 2014).

Consumer goods manufacturers and retailers alike are implementing packaging reduction initiatives that involve *reducing material content* of packages and/or replacing package material with a *lighter-weight alternative*. Influences of these initiatives on converters and paperboard companies are explicated below:

- ▣ **Material content reductions.** There has been increased focuses on *down gauging*, a process of using less materials to manufacture the walls of a package. Paperboard companies are making process improvements and investing in equipment designed to deliver the required lower *basis-weight* materials while maintaining strength and quality (Neil-Boss and Brooks 2013). The manufacturing of *lightweight containerboard* (basis weight of lower than 26 lbs/thousand square feet) involves a different corrugating process from regular



corrugated board. To produce products of the same or greater strength, but a lighter container, fibers are tighter together, resulting in a higher fiber content, but at a reduced weight (Packaging Technologies 2013). In the plastic sectors, there has seen a shift in rigid high-barrier packaging toward a “monomaterial” structure (e.g. monolayered PET), as opposed to extrusion-coated and waxed products (Johansson et al. 2012; Rosato 2014).

- ▣ **Light-weight alternatives.** There has been a *shift from rigid packaging towards flexible packaging* in which flexible plastics (not including plastic bags) dominate. Flexible packaging, particularly *stand-up pouches*, has been one of the fastest growing packaging segments over the past decade and new product development is continuing. According to PCI Films Consulting (2013), US demand for stand-up pouches has seen dramatic growth, increasing by 50 percent over the last five years. Demand is projected to grow by 42 percent over the five years 2013–2018 to reach almost 24 billion units in 2018. Key advantages driving the growth trend are: (1) material and transportation cost savings compared to rigid packaging; (2) optimized transfers of packaging between the converter, packaging facility, and end user; (3) environmental benefits due to fewer truck journeys required and less fuel used;²⁸ and (4) improved package designs that enhance user experience and strengthen brand loyalty (Cooper 2013; TC Transcontinental 2014).

Overall, while plastic packaging dominates in the rigid packaging segments, in terms of growth rate, paper-based materials are expected to be the fastest growing product category, driven to the large extent by technological advancement, quality improvement, and environmental advantages (Transparency Market Research 2014b).

²⁸ According to Flexible Packaging Europe, a 0.2 liter metalized flexible stand-up pouch requires half the number of standard truck loads than packaging in 0.2 liter glass bottles, due to the lower weight and less space between packages (Cooper 2013).



Trend to Watch: Bio-based Plastics

Thus far, the continued shift away from plastics, due to its harmful environmental impacts, has served to benefit paperboard packaging materials that are increasingly made from recycled fiber (Hoopes 2014a). However, technological developments in *bio-based plastic materials*, as opposed to petroleum-based plastics, have made them more environmentally friendly.

Growing bio-based plastic commercials. Retailers and manufacturers perceive eco-friendly, bio-based, compostable, and biodegradable packaging as a source of marketing advantages. Reflecting this perception, the *bio-based plastic*²⁹ manufacturing industry has experienced steady growth in the past few years. Polylactic acid-based plastics (PLA) (polymerized from lactic acid obtained from dextrose) is currently, and is projected to, continue to be one of the most common bio-based, degradable plastics (Newes et al. 2012), primarily used in food packing (Evans 2010).³⁰ Improvements in PLA-based products are continuing, whether through the use of additives (e.g. plasticizers, impact modifiers) or through new formulations.

Bio-based plastic production cost still high. Despite the commercial advances and continued improvements in PLA-based packaging, the current high production cost has restrained growth for bio-based plastics. There is still a considerable need for cost-effective methods to enhance PLA properties, especially in terms of higher gas and water vapor barrier properties, reduced brittleness, and increased thermal stability (Johansson et al. 2012).

²⁹ The majority of bio-based plastics are currently manufactured using starch as a feedstock. The current major sources of starch are maize, potatoes, and cassava. Another common feedstock is cellulose. Common cellulose sources include wood, cotton and hemp (The British Plastics Federation n.d.).

³⁰ Examples of big-name users are Coca-Cola's PlantBottle, which is made from 30 percent plant-based material, and PepsiCo that introduced its bottle made from 100 percent agricultural waste (MacKenzie 2011).



IMPLICATIONS FOR RAW BIOMASS SUPPLIERS

The analysis of the US paperboard industry offers a number of business implications for purpose-grown biomass growers who consider participating in the supply market of the industry. The denotation of the following symbols is used for the subsequent discussions.



denotes *favorable* status in the US paperboard industry (demand markets), and/or areas of *opportunities* for purpose-grown biomass as suppliers (supply markets).



denotes *unfavorable* status in the US paperboard industry, and/or areas of *challenges* for purpose-grown biomass as suppliers.



denotes trends affecting the US paperboard industry, and/or all fibrous supplier groups.

Demand Market Implications

The US paperboard industry is a *moderately stable* industry. Stability in industry circumstance attributes largely to the industry products. According to Bingham et al. (2011), product characteristics in stable industry circumstance is characterized by well-defined standards, clear product expectations, long product life cycle, and a limited number of competitors (primarily large firms) slowly pushing with innovations. However, industry dynamics arise due to continued consolidation activities that blur the boundary among supply markets, the industry itself, and demand markets.

Key resources of companies in the industry are *closely linked*. Its competitiveness depend heavily on its physical resources (forestland, mill, and recovery facility locations), sophisticated production technology (automated, high productivity), and efficient logistics (for fiber supply and finished products)—all of which reinforce each other (Bingham et al. 2011).



In general, the industry players create competitive advantage through *leverage strategy*. As Bingham et al. (2011) describe, leverage strategy bases competitive advantages on building or acquiring resources that are valuable, and leveraging them in both existing and new markets. US paperboard companies have been actively engage in vertical integrations, expanding their reach into wood fiber resources (owned forestland), recovered fiber resources (owned recycled material facilities), and key downstream markets (corrugated container and converted paperboard products).

The foregoing industry circumstance, resource relationships, and business strategies make the US paperboard industry an attractive market in certain facets, and unfavorable in others for raw biomass suppliers. Essentially, favorable characteristics are relatively stable demand in the major product group and growth opportunities both for standard and non-standard, higher-profit products. Challenges come mainly from the industry consolidation and the resulting elevation of buyer power. The implications for fiber crop growers are explicated accordingly.



Standardized raw materials and well-established product performance requirements, with stable demand of major customer markets

The US paperboard industry is a mature industry. The industry products have high level of market acceptance, with limited introduction of new industry products. This characteristic suggests standardized specifications of raw materials and well-established product performance requirements from which biomass growers can gauge in producing their products. In particular, containerboard product group (linerboard and medium) is the largest product line, primarily serving downstream corrugated secondary packaging markets. Performance requirements of these applications are relatively simple, largely emphasizing *strength* to protect goods during handling and shipping activities.

End markets of corrugated packaging with strong growth are in food markets, notably beverage products, fresh fruit and vegetables, and dairy products.



Given the nondiscretionary nature of these food products, their demand (thus demand for corrugated packaging) is relatively stable, reducing challenges associated with demand uncertainties.



Increasing popularity of more expensive corrugated products for retail-shelf-ready packaging and corrugated retail display stands

A trend toward more expensive corrugated packaging materials continues to gain traction in North America, notably for retail-ready or shelf-ready packaging, and corrugated retail display stands. Using as a tool to attract consumers in retail stores, these products require not only durability, but also aesthetic quality such as high-quality graphics, printing, and shine. US paperboard companies are focusing on quality improvement in these areas to strengthen this *non-standard, higher-margin* product line. This trend will boost market opportunities for paperboard companies and suppliers who can contribute to the quality improvement beyond cost-oriented standard markets.



Increasing number of demand-driven paperboard establishments in the Mid-Atlantic presents opportunities for suppliers in the region

The number of paperboard establishments in both the Southeast and the Mid-Atlantic is increasing in the past five years, but for different business attractions. While the former is supply-driven (large number of pulp mills and low-cost wood fiber), the latter is demand-driven (large number of cardboard box manufacturing facilities).

The development in the Mid-Atlantic region tenders unique opportunities for fiber crop growers in this region from both supply and demand perspectives. On the supply side, the fact that average hardwood and softwood fiber costs in the Northeast region are higher than in the other regions suggests a wider window for pricing that allows fiber crop growers to be price-competitive against forest wood fibers. On the demand side, paperboard mills are drawn to the region to be close



to their major customers, despite the relatively higher cost of virgin wood supply. Overall, *cost-efficient* fiber crop growers in this region could achieve comparative cost advantages against forest wood fiber suppliers in the region (due to their high prices), and those in the Southeast (due to the added costs associated with longer distance, despite lower prices).



Growing e-retailing brings growth opportunities for standard corrugated products in non-food markets

E-retailing is growing rapidly, bringing with it increases in the overall demand from online merchants for corrugated boxes used in the fulfillment and delivery of online orders. The continuing healthy growth of online shopping will propel market opportunities for corrugated shipping containers, thus containerboard product groups (medium and linerboard), beyond food markets.



Industry competitive advantages created through leverage strategies

To maintain competitive advantages via leverage strategies in the moderately dynamic paperboard industry, paperboard companies need to update their resource portfolio as the industry changes. This undertaking could mean choosing whether to redeploy existing resources in new markets, and/or acquire, partner, or develop new resources in-house. Fiber crop growers can find market opportunities as supply partners of paperboard companies looking to develop reliable, cost effective source of fibers. Case in point is Meadwestvaco's *Eucalyptus Leasing and Management Program* for hardwood fiber resources for its Evadale Texas Paperboard Mill. The extent of such partnership opportunities, however, depends on the paperboard companies' product portfolio as well as relationships to other key resources (e.g. mill locations and manufacturing technology).





Growing e-retailing brings potential threat of entry from large integrated paper companies

Just as e-retailing trends provide market opportunities for paperboard companies, it also inducing large integrated paper companies to place more emphasis on paperboard product lines in relation to other paper products. This potential threat is boosted by increased competition from paper imports, and the long-term decline in demand for printed materials (the largest single product for the paper industry and significant source of revenue) as a result of shifts towards digital media and communication. The already high level of competition in this standard market among paperboard companies could be pushed even higher with these new entrants.

The adverse effects of this development are two-fold. Since this standard product market is price sensitive, this development could place even more price pressure on pulp and fiber suppliers. Simultaneously, there is a potential threat of backward integration by large paper and paperboard companies into supply markets, turning these companies from buyers to competitors of the pulp and fiber suppliers. That only about 16 percent of wood pulp produced in the United States was market pulp during 2012–2014 corroborates the backward integration movements.



Structural change in the industry brings larger, integrated paperboard companies

Merger and acquisition activity has been a common trend over the past five years as companies have integrated their paperboard with pulp production, acquired other paperboard companies, and/or acquired packaging companies. In general, the industry is currently characterized by moderately large firms. As the industry consolidation continues, average size of firms in the industry is expected to grow.

Moreover, due to high level of competition, the US paperboard mills



industry has relatively low profit margins, resulting in price-sensitivity disposition of these buyer firms. Coupled with the commodity nature of market pulp and fiber raw materials, and advances in pulp processing technology that enable flexible choices among different fiber types, the negotiation power of buyers in the paperboard industry is increasing.

Supply Market Implications

Overall, *woody* crops may find itself in a more compatible circumstance with the paperboard industry in terms of existing and trends in manufacturing and logistics infrastructure. In contrast, the market and technical disadvantages have prevented the emergence of *nonwood* plant fibers as a source of *cost-competitive pulp* for paper and paperboard products in the United States. Both woody and nonwood crops, however, are faced with fierce competition from forest-based wood fiber and recovered fiber suppliers.

Five influential factors in choosing the types of fibers used for paperboard production are: (1) supply availability, (2) total costs of procurement (including purchased prices and logistics costs), (3) contribution to product performance requirements, (4) compatibility with existing manufacturing infrastructure, and (5) contribution to success of products in the marketplace (National Council for Air and Stream Improvement 2013). Opportunities and challenges pertinent to these influential factors are highlighted in Table 11.



Table 11 / Key Opportunities and Challenges for Purpose-grown Lignocellulosic Biomass in Serving the US Paperboard Industry

Influential Factors	Opportunities and Challenges
Supply availability	<p> Fiber</p> <ul style="list-style-type: none"> ▣ Abundant, less-intensively managed forest resources (vs. commercial-scale purpose-grown biomass plantations) ▣ Government and industry association programs to promote recycling (e.g. higher recovered rates) ▣ Large volume of wheat straw availability <p>Market pulp</p> <ul style="list-style-type: none"> ▣ Larger wood pulp production capacity vs. nonwood pulp capacity in the United States (e.g. 163,000 nonwood pulp vs. 56,078,000 wood pulp air-dried metric tons per year reported in 2014 FAO survey) <p> Tightening supply of high quality OCCs Strong export markets for OCCs increasing competition for OCCs for domestic users Geographically fragmented, small sources of agricultural residues (vs. more stable, larger volume of industrial crops)</p>
Total procurement costs	<p> Raw material price volatility Backward integrations by major buyers as forest landowners, and/or recovered material vendors for their own uses and for sales</p>
	<p> Lower density of nonwood fiber compared to wood fiber making transportation and storage costs relatively more overbearing Long-standing relationships between paperboard companies and wood fiber suppliers or pulp producers</p>
Product performance	<p> Improving bio-based plastic technology and quality of bio-based plastic packaging Increased demand for light-weight material alternatives in packaging (trends towards flexible plastics for primary packaging)</p>



Influential Factors	Opportunities and Challenges
Product performance <i>(continued)</i>	 <p>The industry's focus on improving the texture and quality of products made from reusable inputs to compete in the fast-growing recycled markets</p> <p>More heterogeneous physical properties of nonwood pulps produced from specific plants than those produced from wood pulps, producing variations in product characteristics</p>
Manufacturing infrastructure compatibility	 <p>Improvements in pulp processing technology making it easy for pulp producers to switch between using soft woods, hard woods, and recycled fiber as the major raw materials, depending on the relative costs</p>  <p>Recovered fiber (vs. virgin fiber) shares of total capacity increasing due to: (1) research focusing on the use of recycled, postconsumer paper content during pulp production; (2) continued trend of most new machines consisting of 100 percent recycled paper machines</p> <p>Small nonwood pulp production capacity in the United States, resulting in majority of current material handling, stock preparation, and pulping systems designed for wood, wood chips, and wood pulps that not compatible with most of heterogeneous agricultural fibers</p>
Product commercial success	 <p>Perceived environmental friendliness of paper-based products as a whole versus plastic-based products</p> <p>Growing perception among consumer product manufacturers and retailers for bio-based, compostable, and biodegradable packaging as a source of marketing advantages</p> <p>Fast growing flexible plastic packaging in primary packaging market</p>  <p>Growth of demand for recycled paperboard outpacing that for paperboard grades made from virgin kraft pulp inputs</p> <p>Price of recycled paperboard rising faster than that of the average paperboard industry primary product, increasing recycled paperboard sales as a percentage of industry total</p>



Influential Factors	Opportunities and Challenges
Product commercial success <i>(continued)</i>	 revenue Growing wood-derived chemical markets, prompted by a broader spectrum of recoverable co-products (e.g., nanocrystalline cellulose) from wood pulping (vs. nonwood pulping) Uses of nonwood fiber largely limiting to the manufacture of speciality and niche paper products that command premium prices in the marketplace

In the essence, biomass growers must take into consideration buying company-specific and market-specific circumstance in conjunction with their own resources in devising their business strategies. Three key strategic recommendations for biomass growers considering the possibility of participating in the paperboard industry as fiber raw material suppliers are as follows.

Strategic recommendation 1: Tailor your products

Given the wide variety of fiber crop species with heterogeneous physical properties³¹ that produce different product characteristics, biomass growers should focus on biomass types that contribute to desired product performance. Established specifications of different paperboard grades and market standards for commonly used wood fiber and wood pulp provide market-proven points of reference for this decision.

In general, a must-have quality is strength and durability. However, aesthetic quality (e.g. printing and shine) are additional attributes deemed to be important for primary packaging and retail display stand end products. Since plastic materials are chief competing materials, notably in primary packaging applications, biomass types that

³¹ Technical investigation regarding physical properties of various biomass types is beyond the scope of this paper.



perform comparatively well not only to other fiber types, but also to plastics will find themselves an auspicious market opportunity.

In addition, fiber crop growers should exploit shifts in the buyer industry as well as its key substitutes as they could open up new needs and new ways to serve existing needs. To wit, there is a gradual shift within market pulp sectors toward fluff pulp and dissolving pulp as traditional markets for paper face long-term decline, and increased interests in alternatives to wax- and polymer-coated technologies for paper and paperboard products. Growers should consider fiber crop types with these developments in mind.

Strategic recommendation 2: Segment your customers

Since independent paperboard companies do not engage in pulp production and rely on pulp inputs from external parties, they are not among potential customers for biomass growers. Rather, independent pulp mills, and integrated paperboard companies source fiber raw materials for their pulp production.

Pulp mills in the United States tend to specialize by type of pulp, suggesting the differences in preferred fiber types that are best suited each mill's specialization. As for integrated paperboard companies, they vary in terms of sizes, product portfolios, and resources that not only affect their specific procurement needs and negotiation powers, but also market opportunities for biomass growers. In the main, integrated paperboard companies occupy different positions in the spectrum of business integration. The backward integration primarily involves the pulp, forestry, and/or recycled material industries; whereas forward integration primarily involves packaging and/or converted paper product industries. Some companies also expand into related industries such as the wood-chemical industry.

Thus, while prices are a priority factor to attract customers due to the commodity nature of fiber raw materials, biomass growers may find healthier opportunities with: (1) customers who have neither their own forestland nor recovered material facilities, (2)



customers who have broader product portfolios that use a wider selection of fiber raw materials, (3) customers who seek fiber types that the growers can produce effectively due to climatic and geographic comparative advantages, and (4) customers whose demand is complementary to that of other existing customers of the growers (e.g. in terms of planting cycle, demand seasonality, etc.).

Strategic recommendation 3: Consider partnerships aimed to create cost advantage beyond prices

Companies in the US paperboard industry demonstrate characteristics of operations with closely linked resources designed to enhance the companies to leverage them to create competitive advantages in existing and new markets. In many cases, these linkages not only connect activities inside a company, but also form interdependencies between the company and its suppliers. Thus, the company's sources of cost advantage can be derived from close coordination or partnerships with suppliers.

Biomass growers should consider marketing their offerings that also include added value aimed to contribute to the customer's cost competitiveness. In other words, the growers in this case are positioning themselves based on optimal total costs, rather than lowest prices. Examples of value-added services are using preprocessing equipment to improve density of the raw materials (e.g. high density balers, wood chippers), on-farm storage facility, and transportation service arrangement (e.g. reliable transportation lead time using vehicles with efficient unloading mechanism). The ability to effectuating the added value depends largely on the growers' resources such as land locations, equipment, labor, and storage facilities. Because of the investment required, the growers should assess potential customers (see "segment your customers") to identify profitable customers such as those with complementary (not competing) resources, and modify the services to best meet their different needs.



REFERENCES

- Advisen. 2012. "Packaging 'Teaser' Industry Report." Quarter 1.
- AF&PA – American Forest & Paper Association. 2014a. "Our Products."
<http://www.afandpa.org/our-products>
- . 2014b. "American Forest & Paper Association Releases June 2014 Containerboard Statistics Report." *News*, July 24.
- . 2014c. "Statistics." www.paperrecycles.org/statistics
- American Chemistry Council. n.d. "Plastic Packaging."
- Bajpai, Pratima. 2012. "Chapter 2: Brief Description of the Pulp and Paper Making Process." In *Biotechnology for Pulp and Paper Processing*, Springer Science+Business Media, LLC, 7–14.
- Bingham, Christopher B., Kathleen M. Eisenhardt, and Nathan R. Furr. 2011. "Which Strategy When?" *Sloan Management Review* 53 (1): 71–78.
- Biofuels Digest*. 2010. "What Are – and Who's Making – 2G, 3G and 4G Biofuels?" *Biofuels Digest*, May 18.
- BIR – The Bureau of International Recycling. n.d. "Paper."
<http://www.bir.org/industry/paper/>.
- Bodimeade, Matt. 2012. "Cardboard Box Manufacturing Market Dominated by International Paper, Koch Industries and RockTenn." *Companies and Markets*, Market News, November 9. <http://www.companiesandmarkets.com/News/Paper-and-Packaging/Cardboard-box-manufacturing-market-dominated-by-International-Paper-Koch-Industries-and-RockTenn/NI5988>
- Boise Inc. 2014. Website. www.boisepaper.com/boise.html
- Boulanger, Robert. 2014. "Old Corrugated Cardboard Prices Continue to Fall." *Waste360*, September 11.



- Bowyer, Jim, Jeff Howe, Ed Pepke, Steve Bratkovich, Matt Frank, and Kathryn Fernholz. 2014. "Tree-free Paper: A Path to Saving Trees and Forests?" Report by Dovetail Partners, August 19.
- Bureau of Labor Statistics. 2014. "Economic Release: Producer Price Index." Last update September 16, 2014.
- Carlsson, Dick, Sophie D'Amours, Alain Martel, and Mikael Rönqvist. 2009. "Supply Chain Planning Models in the Pulp and Paper Industry." *INFOR* 47 (3): 167–183.
- Carter, Brittany. 2014. "Paper Product Manufacturing in the US." *IBISWorld Industry Report 32229b*, June.
- Chen, Jonathan Y., and Fank Liu. 2013. "Bast Fibres: From Plants to Products." In *Kenaf: A Multipurpose Crop for Several Industrial Applications*, Part V: Fibre and Dye, 308–325. Edited by Andrea Monti, and Efthimia Alexopoulou. London: Springer-Verlag.
- Chiang, Jesse. 2014. "Ship Shape: Paper and Packaging Prices on the Rise." IBISWorld Media Center, September 23.
- Cooper, Terrence A. 2013. "Developments in Plastic Materials and Recycling Systems for Packaging Food, Beverages, and Other Fast-moving Consumer Goods." In *Trends in Packaging of Food, Beverages and Other Fast-moving Consumer Goods (FMCG)*. Edited by Neil Farmer, 58–107, Cambridge, UK: Woodhead Publishing.
- Corrugated Packaging Alliance. 2014a. "About Corrugated."
- . 2014b. "Recycling: OCC Fact Sheet."
- Coutu, Peter. 2014. "Northeast Paper Mills Face Challenges." *Forest2Market*, Blog January 31.
- Dillon, Chip, and James Armstrong. 2013. "Containerboard – It's Finally a Real Business!" *Vertical Research Partners*, January 16.
- Domtar Corporation. 2014. Website. www.domtar.com
- EPA – US Environmental Protection Agency. 2010. "Available and Emerging Technologies for Reducing Greenhouse Gas Emissions from the Pulp and Paper Manufacturing Industry." Office of Air Quality Planning and Standards, October.



- . 2012a. “Paper Recycling.” Basic Information Details.
- . 2012b. “Paper Making and Recycling.” US Environmental Protection Agency, November 14.
- . 2014. “Paper Recycling Glossary.” Last update September 12, 2014.
- FAO – Food and Agriculture Organization of the United Nations. 2012. *The 2012 FAO Survey of World Pulp and Paper Capacities, 2011–2016*.
- . 2013. *The 2013 FAO Survey of World Pulp and Paper Capacities, 2012–2017*.
- . 2014. *The 2014 FAO Survey of World Pulp and Paper Capacities, 2013–2018*.
- FBA – Fibre Box Association. 2005. “Corrugated Recycling Process.” In *Fibre Box Handbook*. Rolling Meadows, IL: Fibre Box Association.
- Georgia-Pacific. 2014. Website. www.gp.com
- Girouard, Patrick, and Roger Samson. n.d. “The Potential Role of Perennial Grasses in the Pulp and Paper Industry.” Resource Efficient Agricultural Production (R.E.A.P.), Canada.
- Great American Group. 2013. *Paper and Corrugated Packaging Monitor*, November.
- Hall, John. 2013. “Paper Price Forecast 2014.” *My Purchasing Center*, December 9.
- . 2014. “Imports, Flat Demand Could Keep Paper Prices Down in 2015.” *My Purchasing Center*, August 11.
- Harris, Zachary. 2014a. “Recycling Facilities in the US.” *IBISWorld Industry Report 56292*, October.
- . 2014b. “Recyclable Material Wholesaling in the US.” *IBISWorld Industry Report 42393*, October.
- . 2015. “Waste Collection Services in the US.” *IBISWorld Industry Report 56211*, January.
- Hetemäki, Lauri, Riitta Hänninen, and Alexander Moiseyev. 2013. “Chapter 5: Markets and Market Forces for Pulp and Paper Products.” In *The Global Forest Sector*:



- Changes, Practices, and Prospects*, 99–128. Edited by E. Hansen, R. Panwar, and R. Vlosky, CRC Press, Taylor and Francis Group.
- Highbeam Business. 2014. “Paperboard Mills (SIC 2631).” Industry Report.
- Hoopes, Stephen. 2014a. “Paperboard Mills in the US.” *IBISWorld Industry Report 32213*, June.
- . 2014b. “Global Cardboard Box & Container Manufacturing.” *IBISWorld Industry Report C1512-GL*, May.
- Hoover’s. 2014a. “Pulp & Paper Mills.” *First Research Industry Report*.
- . 2014b. “Paper & Paper Products Manufacturing.” *First Research Industry Report*.
- . 2014c. “Converted Paper Products Manufacturing.” *First Research Industry Report*.
- Hurter, Robert W. 2001. “Nonwood Plant Fiber Uses in Papermaking.” Extracted from *Agricultural Residues*, TAPPI 1997 Nonwood Fibers Short Course Notes, updated and expanded August 2001.
http://www.paperonweb.com/Articles/plant_fiber_uses.pdf
- . 2014. “Nonwood Fibers Offer Potential Opportunity for Papermakers.” *TAPPI Journal*, June.
- IFP Energies nouvelles. 2010. “Which Biomass Resources Should be Used to Obtain a Sustainable Energy System?” Panorama 2010 Technical Report.
- Iggesund Paperboard. 2014. “The Paperboard Process.” Product Information, 2014-08-26.
- IHB/WRQ. 2014a. “Global Forest Industry Inches up in the Second Quarter of the Year.” *The Timber Network*, September 16.
- . 2014b. “Global Forest Industry Inches Up in the Third Quarter of the Year.” *The Timber Network*, December 3.
- International Paper. 2014. *2013 Annual Report*.
- ISRI – Institute of Scrap Recycling Industries. 2013. “The Scrap Recycling Industry: Paper.” www.paperonweb.com/Articles/USA_Paper_Recycling2012_ISRI.pdf



- I.T. Strategies. 2013. "A Brief Introduction to Corrugated Packaging Markets." I.T. Strategies Research on Emerging Print Markets, November.
- Johansson, Caisa, Mien Bras, Iñaki Mondragon, Petronela Nechita, David Plackett, Peter Šimon, Diana Gregor Svetec, Sanna Virtanen, Marco Giacinti Baschetti, Chris Breen, Francis Clegg, and Susana Aucejo. 2012. "Renewable Fibers and Bio-Based Materials for Packaging Applications – A Review of Recent Developments." *BioResources* 7 (2): 2506–52.
- Kinney, Suz-Anne. 2014. "Three Causes of Volatility in Old Corrugated Container Prices." *Forest2Market*, Blog posted on February 18.
- Lifshitz, Ian. 2014. "Top Five Packaging Trends for 2015." *Greener Package*, blog posted on December 12.
- MacKenzie, Jacqui. 2011. "Trends in Industrial and Retail Sustainable Packaging." *Blue Planet Green Living Blog*, April 8.
- MarketWatch. 2013. "Wood Resources International LLC: As Wood Fiber Costs Have Fallen Substantially in the West, Pulp Mills in the Region Are Becoming More Competitive With Southern Mills." Press Release, September 13.
- McKenna, Farrell. 2014. "Wood Pulp Mills in the US." *IBISWorld Industry Report 32211*, November.
- MeadWestvaco Corporation. 2014a. Website. www.mwv.com
- . 2014b. *2013 Annual Report*.
- Metafore. 2009. "Recycled Content and Virgin Fiber: Environmental, Economic and Technical Considerations for Magazine Publishers." Prepared for Magazine Publishers of America (MPA), June.
- Miller, Robert C. 2014. "Corrugated Cardboard." *Made How: How Products Are Made*, Volume 1.
- Moore & Associates. n.d. "Trends, Challenges and Opportunities in Recovered Paper Markets." Presented at Forest Products Association of Canada (FPAC) Corporate Forum on Paper and the Environment.



<http://postcom.org/eco/sls.docs/Moore%20&%20Assoc-Recovered%20Paper%20Trends.pdf>

NAICS Association. 2014. *NAICS Identification Tools*. www.naics.com

National Council for Air and Stream Improvement. 2013. “Effects of Nonwood Fiber Use.” http://www.paperenvironment.org/PDF/nonwood/NWF_Full_Text.pdf

Neil-Boss, Nick, and Ken Brooks. 2013. “Unwrapping the Packaging Industry: Seven Factors for Success.” Ernst & Young.

NewPage Corporation. 2014. Website. www.newpagecorp.com

Niemelä-Nyrhinen, Jenni, and Outi Uusitalo. 2013. “Identifying Potential Sources of Value in a Packaging Value Chain.” *The Journal of Business & Industrial Marketing* 28 (2): 76–85.

Nordström, Per-Ove, and Glen O’Kelly. 2013. “Tighter Recycled Fiber Markets.” McKinsey on Paper Number 3.

Paavilainen, Leena. 1998. “PPI (Pulp & Paper International) Magazine: European Prospects for Using Nonwood Fibers.” *RISI*. Blog posted on June 1.

Packaging Corporation of America. 2014a. Website. www.packagingcorp.com

———. 2014b. *2013 Annual Report*.

Packaging Technologies. 2013. “Lightweight Containerboard and Packaging Trends.” Packaging Technologies Inc Blog.

Paperboard Packaging Council. 2013. “The Paperboard Packaging Industry: An Overview.” Spring.

PaperIndex. 2014. “Directory of Recycled Paper/Waste Paper Suppliers.” http://www.paperindex.com/subcategories.aspx?root_id=0&cat_id=3

PCI Films Consulting. 2013. “The US Market for Stand-up Pouches to 2018.” Report Highlights, September.

Petrillo, Nick. 2014a. “Paper Mills in the US.” *IBISWorld Industry Report 32212*, June.



- . 2014b. “Global Paper & Pulp Mills.” *IBISWorld Industry Report C1511-GL*, August.
- Pollock, Tom. 2011. “What’s the Future for Alternative Fibers?” *GreenBiz*, December 23.
- Porter, Michael E. 1998. *Competitive Strategy: Techniques for Analyzing Industries and Competitors*. New York: The Free Press.
- Rainforest Alliance. 2013. *Rainforest Alliance Stewardship Standard for Alternative Natural Fibers*, Draft 1 Version 3, December 11.
- Recycling Today. 2014. “Fizzled out.” *Recycling Today*, January 6.
- Reportlinker. 2012. “US Corrugated & Paperboard Boxes Market.” Market Research Report Summary Press Release.
- RISI. 2012. “US Corrugated Box End-use Markets: Analysis and Forecast through 2016.” RISI Special Market Analysis Study Press Release.
- . 2013. *World Pulp Monthly*, January.
- . 2014. *World Pulp Monthly*, January.
- . 2015a. “PPI Pulp & Paper Week Featured Content Month-in-stats: US paper/board run at 95.5% operating rate in September.”
- . 2015b. “Price Reporting Methodology: About RISI’s Pulp Price Reporting.”
- Rock-Tenn. 2011. “Exhibit 99.1.” Presented at J.P. Morgan Diversified Industries Conference, June 8, 2011.
- . 2012. “Exhibit 99.1” Presented at Citi Basic Materials Symposium, November 28, 2012.
- . 2014. *2013 Annual Report*.
- Rosato, Don. 2014. “Green Plastic Barrier Packaging Material and Process Advances.” *Multibriefs*, July 28.
- Seger, Bernd, Jörg Kühn, and Sebastian Borner. 2012. “The Challenge of ‘Nonwood’ Pulp – Experiences from Industrial Application.” Presented at Conference ‘More to



- Cellulose Than Meets the Eye: Lignocellulose Sources, Valorization and Uses, Doorwerth, The Netherlands, February 14–15.
- Singh, Pooja, Othman Sulaiman, Rokiah Hashim, Leh Cheu Peng, and Rajeev Pratap Singh. 2013. "Using Biomass Residues from Oil Palm Industry as a Raw Material for Pulp and Paper Industry: Potential Benefits and Threat to the Environment." *Environment, Development and Sustainability* 15 (2): 367–383.
- Son, Anna. 2013. *BISWorld Industry Report NN001: Biotechnology in the US*, October.
- Song, Feng, Jinhua Zhao, and Scott M. Swinton. 2011. "Switching to Perennial Energy Crops under Uncertainty and Costly Reversibility." *American Journal of Agricultural Economics* 93 (3): 768–83.
- Standard & Poor's. 2014. "Global Packaging and Forest Products Industry Review." Standard & Poor's Ratings Services, Live Webcast and Q&A, June 26.
- Statista. 2015. "Paper and Cardboard." Statista, The Statistics Portal. www.statista.com
- Suhonen, Timo. 2013. "Fibre Market in Transition." *Paper Industry World*, March 18.
- TC Transcontinental. 2014. "Capri Packaging Fact Sheet." March 11.
- Tech Equipment Totes. 2014. "What is Polypropylene?" Portals. <http://www.techequipmenttotes.com/Portals/29/What%20is%20Polypropylene.pdf>
- The Institute for Industrial Productivity. 2010. "Recovered Fiber Pulping." Industrial Efficiency Technology Database, April.
- The World Bank. 2014. *Global Economic Monitor (GEM) Commodities: Wood Pulp*.
- The World Resources Institute and The World Business Council for Sustainable Development. 2014a. "10 Things You Should Know, Chapter 8: Has Recycled Fiber Been Used Appropriately?" *Sustainable Forest Products*.
- . 2014b. "10 Things You Should Know, Box 13. Alternative Fibers." *Sustainable Forest Products*.
- Transparency Market Research. 2014a. "Report on Paperboard Market – Global Industry Analysis, Size, Share, Growth, Trends and Forecast, 2013–2019." Press Release, July 8.



- . 2014b. “Rigid Packaging Market – Global Industry Analysis, Size, Share, Growth, Trends and Forecast 2013–2019.” Report description.
- UPM. 2011. “Making Paper.” UPM – The Biofore Company, March.
- US Packaging and Wrapping. 2013. “Plastic Packaging Prices.” Blog posted on November 15.
- Value Line. 2015. “Industry Analysis: Packaging and Container.” Value Line, Educational Articles.
- Verso Paper Corp. 2014. Website. www.versopaper.com
- Wadhvani, Anuradha. 2014. “3 Trends That Will Define Sustainable Packaging in 2015.” *Business 2 Community*, December 16.
- Weiss, Diana. 2012. “US Corrugated Box End-use Markets: Opportunities for Future Growth.” RISI, presented at AICC Spring Meeting.
- Western Container. 2013. “Paperboard and Corrugated Packaging Top Market Trends in 2013.” Blog.
- White, Marshall S., and Peter Hamner. 2005. “Pallets Move The World: The Case for Developing System-Based Designs for Unit Loads.” *Forest Products Journal* 55 (3): 8–16.
- Woodall, C. W., P. J. Ince, K. E. Skog, F. X. Aguilar, C. E. Keegan, C. B. Sorenson, D. G. Hodges, and W. B. Smith. 2011a. “An Overview of the Forest Products Sector Downturn in the United States.” *Forest Products Journal* 61 (8): 595–603.
- Woodall, C. W., R. J. Piva, W. G. Luppold, K. E. Skog, and P. J. Ince. 2011b. “An Assessment of the Downturn in the Forest Products Sector in the Northern Region of the United States.” *Forest Products Journal* 61 (8): 604–613.
- Zacks Equity Research. 2014. “Falling Oil Prices: A Boon for Plastic Packaging.” Analyst blog posted on December 19.

